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HEALTHY SAVINGS

Medical Technology and the Economic Burden of Disease

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ACKNOWLEDGMENTS

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CONTENTS

EXECUTIVE SUMMARY

The debate continues within the health policy community on the proper balance between the costs and benefits of medical technology. At a time of unprecedented change in health delivery and incentive systems and persistent concern about the cost of care, this debate has significant implications for public policy. Even with medical inflation running at a four-decade low—a condition that might suggest pressures are dissipating—the controversy is only intensifying.

Assessments of the true cost and economic benefit of medical technology (in the form of devices and diagnostics) have been hampered by the fact that direct treatment expenditures associated with technology use can be readily measured, while indirect savings, for example avoiding emergency room care and reducing hospital stays, are more difficult to capture.

Equally important, the economic benefits of reducing the burden of disease through better diagnosis, prevention, treatment, and cures extend beyond the health system to GDP gains from increased labor force participation and productivity. These gains are generated not only by patients, but by the rising participation and productivity of their informal caregivers. Yet these dividends are rarely incorporated into the evaluation of medical technologies.

In this study, we take a systematic approach to documenting the full costs and broader economic benefits of investment in representative medical technologies used to address four prevalent causes of death and disability: diabetes, heart disease, musculoskeletal disease, and colorectal cancer.[1] The medical devices and technologies analyzed for each of the four diseases examined are detailed in Table ES1.

Table ES1

Technology assessed in this study

DISEASE	DEVICE	OBJECTIVE
1) Diabetes	i) Insulin infusion pumps	Disease management
2) Heart disease	i) Angioplasty ii) Pacemaker iii) Electrocardiogram iv) Left ventricular ultrasound v) Chest x-ray	Early detection/Disease management/Cure
3) Musculoskeletal disease	i) Joint replacement surgery ii) Bone scan (MRI)	Early detection/Disease management/Cure
4) Colorectal cancer	i) Sigmoidoscopy ii) Colonoscopy	Prevention/Early detection

1. This analysis differs from the more common approach of estimating the number of quality-adjusted life years gained (QALY) from a technology and comparing an estimate of the value of a QALY (conventionally $100,000 in the U.S.) to the cost of the technology. The estimates in this paper define annual benefits in terms of actual dollars gained, either through a reduction in health costs enabled by the technology or increases in GDP.

We begin by estimating the annual net health system costs and additional impact on GDP of each technology in 2010.[2]

- We find that the net annual benefit from these technologies was $23.6 billion.
- Federal income tax revenue increased by $7.2 billion due to improved labor market outcomes.

These estimates should be considered conservative because they do not account for reduced costs from avoidance or amelioration of comorbidities, e.g., the impact of diabetes on heart and kidney disease.

Having assessed the most current net annual benefit of these technologies, we next construct three alternative trajectories through 2035 for continued technological innovation for each of the four diseases mentioned above. The first trajectory assumes reduced incentives to invest in improvement and adoption and correspondingly reduced technological progress. The second trajectory assumes continuation of the historical incentive level. The third assumes enhanced incentives.

- The results demonstrate a cumulative $1.4 trillion gain (in 2010 dollars) over a 25-year period in the "increased incentives" scenario relative to the persistence of "continued incentives."
- Conversely, the results indicate a cumulative $3.4 trillion loss (in 2010 dollars) over a 25-year period in the "decreased incentives scenario" relative to "increased incentives."

While this study does not examine specific policies that may affect incentives to invest in technology development, it does make clear that such incentives have significant consequences for the economic costs and benefits generated by the American health-care system. These should be considered in policy development, especially at a time when the market forces and policies influencing health care are changing dramatically.

The medical technologies studied generated economic returns that were substantially greater than their costs. Policies that support enhanced investment in development, improvement, and diffusion of medical technologies not only bring immense benefit to individual patients, but a brighter economic future for the country as a whole. Conversely, reduced incentives will result in large net costs and, we believe, prove to be pennywise and pound-foolish.

2. We used the annual average from 2008 through 2010 due to the small patient size in any one year and related high standard error of the sample.

Historical Experience

We find that these medical technologies are costly but provided substantial economic benefits in 2010 averaged across the population with the health condition that the technology targets.

Table ES2

Average annual savings per person affected associated with medical technology
2008-2010 ($)

TECHNOLOGY	TREATMENT EXPENDITURES	INDIRECT IMPACT	TOTAL
Insulin pump	607.7	5,278.0	5,885.8
Heart disease diagnostics and surgery	-4,533.7	6,464.0	1,930.3
MRI and joint replacement surgery	-3,887.3	28,405.2	24,517.9
Colonoscopy/sigmoidoscopy	8,840.7	141,524.2	150,364.9
Detection	903.5	96,398.5	97,302.0
Prevention	7,937.2	45,125.7	53,062.9

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

- Insulin pump use is associated with higher upfront costs than self-injection, but the net health system expenditure per population reporting a condition (PRC) was $608 lower per pump user (see Table ES2). Generally, pump users visited emergency rooms less frequently and were more able to avoid long-term side effects such as amputations, kidney failure, or blindness. Additionally, GDP per person affected, including informal caregivers, was $5,278 greater than the total for people who self-inject, due to higher workforce participation and productivity. The net benefit per insulin dependent diabetic for pump use, therefore, was $5,886: $608 in health cost savings and $5,278 in increased GDP.

- Treatment expenditures per person reporting a condition for heart disease diagnostics and surgery were $4,534 higher for technology users than non-users. However, higher survival rates and productivity gains boosted real GDP per person affected by $6,464, resulting in a net economic impact of $1,930 per person affected.

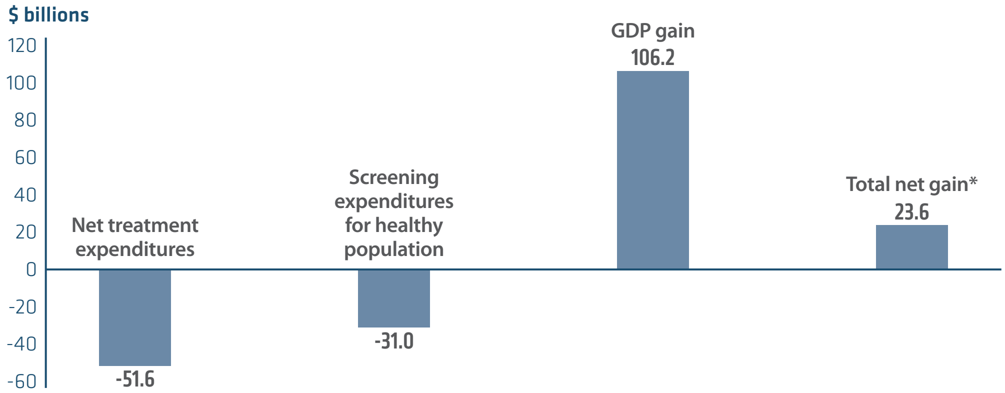
- MRI and related joint replacement surgery expenditures were $3,887 higher than for other treatments per PRC (person reporting musculoskeletal disease), but real GDP per person affected rose $28,405, contributing to a net economic impact of $24,518. However, as with heart disease, there is an adverse selection bias in the population represented by the data. The patients recommended for these procedures generally have more advanced illness, which is more costly to treat. In these cases, less expensive alternatives were either attempted and proved ineffective or the conditions had worsened before being diagnosed.

- Treatment expenditures per PRC (person with colorectal cancer or per case prevented) undergoing colonoscopy/sigmoidoscopy were $8,841 lower than those without screening due to the savings from prevention and early detection. Additionally, GDP per person affected jumped $141,524 because screening also allows the removal of polyps before they develop into colorectal cancer.

Figure ES1

Economic effect associated with four medical technology areas

Average (2008-2010)



* Total net gain is the sum of treatment expenditures compared to non-users, screening of the healthy population, and the additional GDP contribution of those receiving treatment and their caregivers.

Across these technologies, as shown in Figure ES1 above, overall treatment expenditures were $51.6 billion higher than for non-user patients. Individuals who were screened but found to not have the disease added another $31 billion to medical expenditures. That was concentrated in colorectal screening, with $17.4 billion. The total includes the cost of screening people who expressed symptoms but turned out to be healthy and those undergoing prescribed routine screening. The use of these technologies and treatments expanded GDP by $106.2 billion (relative to non-use by the same population), which can be credited to higher survival and labor force participation, less absenteeism, and greater productivity among patients and informal caregivers. The net economic gain was $23.6 billion (synthesizing treatment expenditures for the four technology areas compared to non-users, screening of the healthy population, and the additional GDP contribution of those receiving treatment).

Alternative Futures

Investing in medical technology development is a high-risk endeavor, which largely stems from the sizable R&D costs necessary as well as market and regulatory uncertainties. The environment for innovation and economic returns will determine whether the industry can compete for capital effectively, which in turn will influence the rate of technological progress and whether advances are broadly adopted. To evaluate the personal and economic impact of incentives to innovate, we prepared three alternative scenarios through 2035:

- Baseline (continued incentives)—the historical level of incentives that produced the 2008-2010 results,
- Optimistic (increased incentives), and
- Pessimistic (decreased incentives)

We do not tie the scenarios to explicit policy changes that might affect future innovations, such as medical device taxes, reimbursement rules, or consequences of the Affordable Care Act. Nevertheless, these types of policies were indirectly considered in constructing the various scenarios. If medical device taxes are reduced or repealed, reimbursement or appropriate utilization rates increase, or the costs of regulatory requirements associated with product development decline, the device industry is likely to invest more in innovation and follow the increased incentives projection. Similarly, factors that erode future profitability make the decreased incentives scenario more likely.

Our approach to projecting treatment expenditures under these alternative paths involves comparing projected outcomes resulting from different assumptions about the improvement and diffusion of disease-specific technology.

To generate these results, we used decision trees that include disease-specific Markov models. These models identify disease stages and the probability of transitioning from one stage to another. The different values for the three scenarios by disease are contingent on assumptions of the potential for technological progress and its impact on individuals' progression through the disease states. These probabilities drive the differing cost estimates for each scenario and were developed from our review of the literature and discussions with specialists. While our decision trees differ by disease, all have the same basic structure beginning with three health states: well, sick, or dead (of any cause). A probability is associated with each state and any subsequent branch of these states.

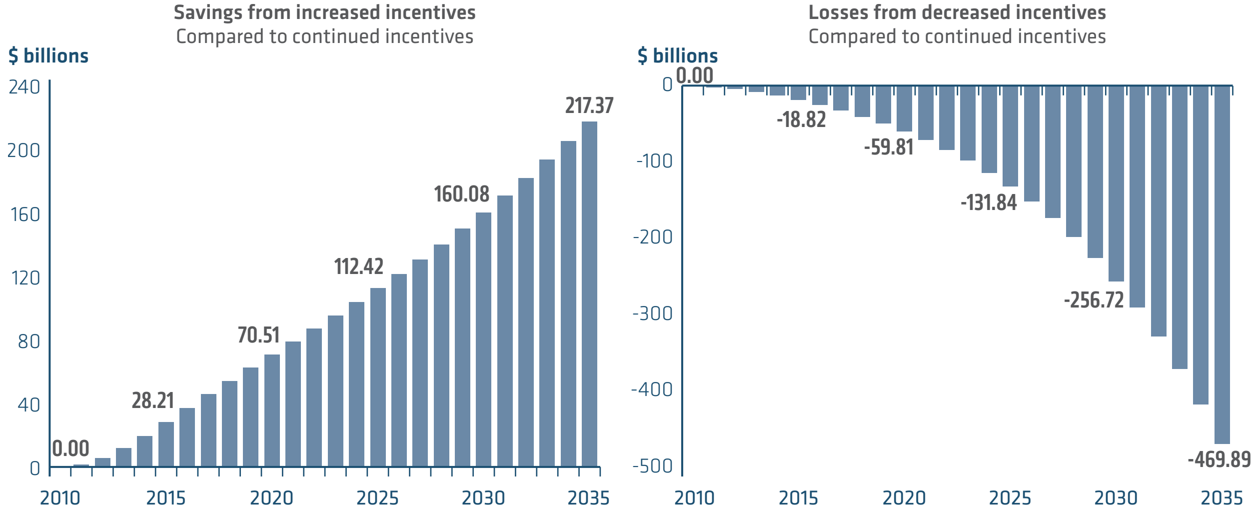
Aggregate savings stem from the increased incentives scenario relative to continued incentives. By 2035, the savings are projected to reach $217 billion. Decreased incentives result in dissavings of $470 billion.

For each projected year, the number of people reporting the relevant condition for each health state is computed. The aging of the population and rising obesity rates are the primary drivers of increasing chronic disease rates. The per-person cost of each condition and each health state is derived from the Medical Expenditure Panel Survey, compiled by the U.S. Agency for Healthcare Research and Quality, and the overall costs of the disease are calculated. The difference in economic impact among the scenarios demonstrates the benefits and losses associated with investing in medical technology innovation.

As mentioned earlier, the estimates are conservative for not considering savings from avoiding or ameliorating comorbidities. In addition, the technological improvements assumed in the model are incremental and do not consider potentially transformative technologies that could produce a greater impact on treatment economics and GDP. Hypothetical examples might include an artificial pancreas for type I diabetes, an inexpensive blood screening test for colorectal cancer, or tissue regeneration techniques to forestall or delay knee and hip replacements.

Figure ES2

Aggregate savings from medical technology



Aggregate savings, as seen in Figure ES2, stem from the increased incentives scenario compared to continued incentives. By 2035, the savings reach $217 billion. Conversely, decreased incentives result in dissavings of $470 billion.

Applying the model to each disease state produced the following results:

- Greater use of insulin pumps among the insulin-dependent PRC and improvements in efficacy will pare treatment costs and expand economic activity in the increased incentives projection relative to the other two scenarios. Increased incentives would reduce treatment expenditures by $19.6 billion and expand GDP by $205.8 billion over 25 years in 2010 dollars compared to the continued incentives scenario. Similarly, increased incentives would decrease treatment expenditures $28.9 billion and boost GDP by $297.6 billion compared to decreased incentives.

- Heart disease diagnostics and surgical procedures, assuming expanded use and efficacy, would create substantial health and economic gains through 2035. Treatment costs are $35.4 billion lower and GDP grows $773.7 billion under increased incentives relative to the continued incentives scenario. Treatment costs are $224.9 billion lower and GDP jumps $2.1 trillion with increased incentives relative to the decreased incentives scenario.

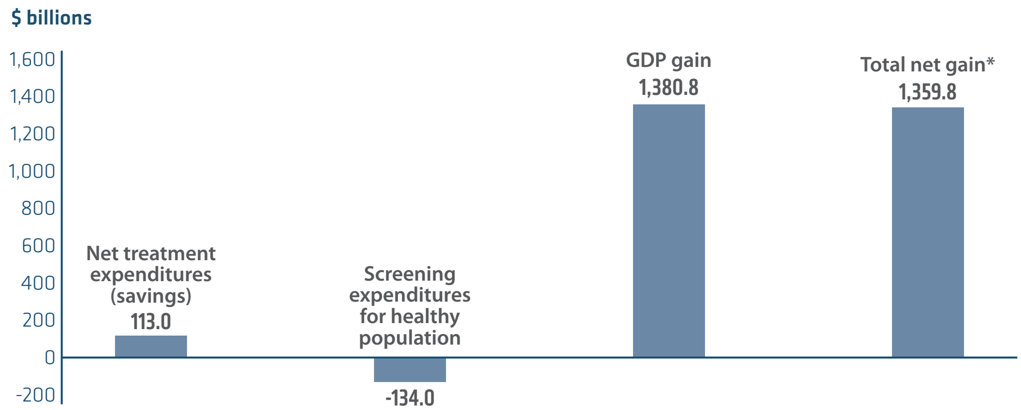
- MRI and related joint replacement surgery are projected to be increasingly common due to rising obesity and age-related disease. Treatment costs are $30.6 billion lower and GDP increases $250.4 billion in the increased incentives scenario relative to continued incentives. Treatment costs are $62.2 billion lower and GDP rises $527.7 billion in the increased incentives scenario relative to decreased incentives.

- The health and economic benefits of colonoscopy/sigmoidoscopy will be even greater in the future than today. Treatment costs over the 25 years are $27.3 billion less in the increased incentives scenario compared to continued incentives, and GDP grows by $150.8 billion in 2010 dollars. Treatment costs are $44.6 billion lower in the increased incentives scenario, and GDP elevates by $245.3 billion, compared to decreased incentives.

Figure ES3

Effect of increased medical technology incentives

Compared to continued incentives, 2010-2035 (2010 dollars)



* Total net gain is the sum of treatment expenditures compared to non-users, screening of the healthy population, and the additional GDP contribution of those receiving treatment and their caregivers.

As highlighted in Figure ES3, from 2010 to 2035, the combined health and economic benefits of the increased incentives scenario far outstrips those of continued incentives. In our four areas, $113.0 billion is saved in treatment costs and GDP rises by $1.38 trillion due to more people working and doing so more productively. Subtracting the higher costs of screening healthy people, which amounts to $134 billion, the net result is a gain of $1.36 trillion in 2010 dollars.

Similarly, from 2010 to 2035, the combined health and economic benefits generated by the increased incentives scenario surpasses those of decreased incentives by an even wider margin, with treatment cost savings of $360.5 billion and GDP gains of $3.2 trillion. Subtracting the higher costs of screening healthy people, which amounts to $197.9 billion, the net result is a $3.4 trillion boost in 2010 dollars.

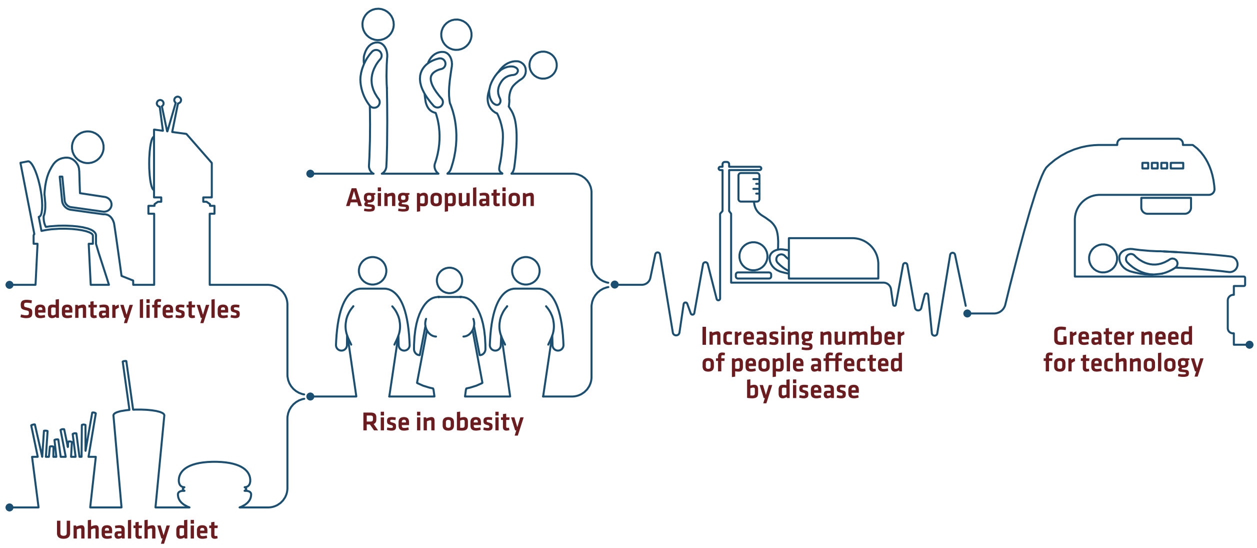
The Broader Picture

Along with measuring their impact on health costs, an evaluation of new medical technologies should incorporate the broader benefits of preventing premature death and improving the capacity of patients and caregivers to contribute to economic growth. Calculating the economic value generated by these technologies is a challenge, but applying a consistent, balanced methodology can yield useful and relevant results.

Our projections demonstrate the economic value of raising incentives to innovate in representative technologies used to diagnose and treat these diseases—a finding we believe likely applies to other technologies and ailments as well. Conversely, if the costs associated with regulatory and market conditions are higher in the United States than those of other countries, fewer medical innovations will emerge within U.S. borders. Better incentives would help spur research breakthroughs, expand the size and productivity of the workforce, create more high-paying jobs in devices and diagnostics, and contribute to the economy across the board—a healthy combination.

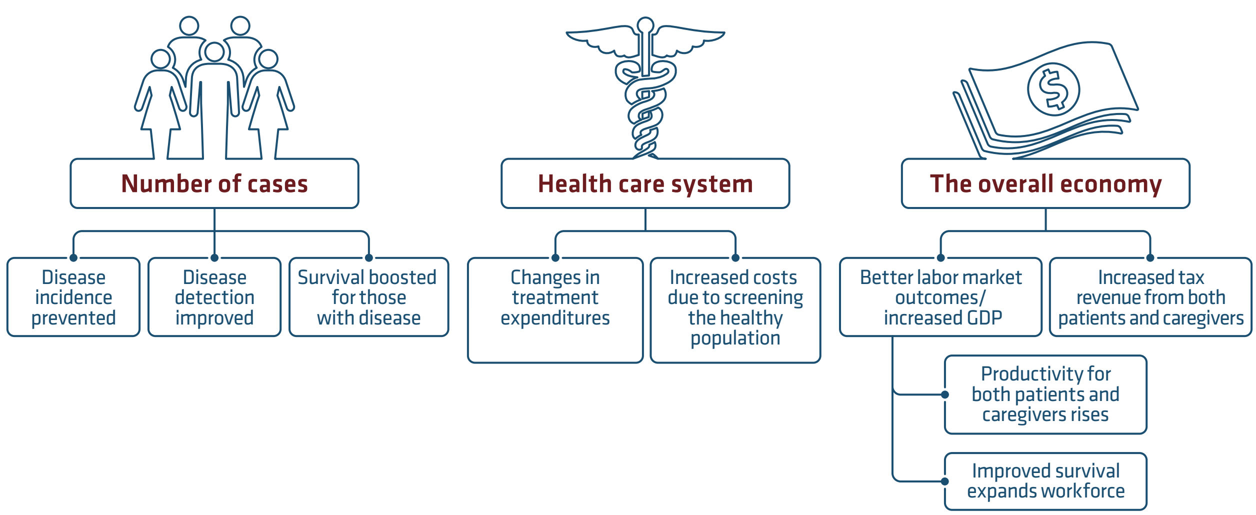
THE SCOPE OF MEDICAL TECHNOLOGY

MED-TECH ADDRESSES A GROWING NEED



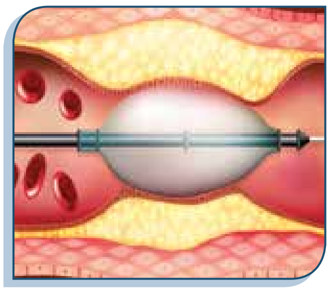
MED-TECH FACILITATES

MED-TECH'S EFFECTS



A PHYSICAL AND ECONOMIC PAYBACK

The insulin pump, an innovative technology for diabetes patients, improves management of the disease. Among users and caregivers, the average annual savings per person was $5,886 compared to non-users of the device. Most of that benefit came from savings to GDP, as patients and their caregivers missed fewer workdays and were more productive. Expanding innovation in diabetes management would increase aggregate savings by $225.4 billion.



Angioplasty, an innovative procedure used to treat heart disease, is likely to generate substantial savings in the future. This technology, in combination with electrocardiogram, echocardiogram, chest x-ray, and pacemakers, saved $1,930 per person affected annually compared to those who did not use technology. Increased incentives, which spur technology innovation and expand use, would lead to long-term savings of $809 billion compared to the continued incentives scenario.

Joint replacement can elevate quality of life for musculoskeletal disease patients and even cure disease. This technology, in conjunction with MRI screening, saved $24,518 annually among users and caregivers compared to non-users. Increasing the incentives for innovation in musculoskeletal disease technology would save $281.1 billion compared to continuing current incentives.

Colonoscopy and sigmoidoscopy detect colorectal cancer, and colonoscopy can prevent the ailment through the removal of polyps. These technologies led to an average annual savings per person affected of $97,302 compared to unscreened patients. In addition, screening that prevented colorectal cancer saved $53,063 per case. Aggregate savings associated with innovation in this field would amount to $178.2 billion due to improved detection and prevention.

Average annual savings are based on 2008-2010 data. Projections represent aggregate savings over 25 years in 2010 dollars.

OVERVIEW

As America ages and sedentary lifestyles and unhealthy diets become more common, the nation is likely to suffer a sharp rise in the prevalence of chronic disease during the 21st century. As that future unfolds, technology, in the form of advanced diagnostic and therapeutic devices, can answer the need for early detection and more effective management of illness. Cost is a crucial element of the value proposition for such technology, however, along with the benefits it brings. Deepening our knowledge of how these tools affect both treatment expense and the link between health and productivity would aid decision-making around developing these technologies and provide a more informed basis for public policy.

A review of the research on this topic brings to light fragmented and sometimes contrasting results. While much of the literature seems to demonstrate that successive generations of medical technology have prevented countless deaths and improved the quality of life for millions more, other researchers have questioned whether the overall benefits of these technical advances—early-diagnostic tests, devices, and the procedures they enable—outweigh the costs.

One group believes that medical technologies have pushed costs up because of overutilization and unnecessary, expensive testing and procedures. However, others point to the benefits of early detection, such as higher survival rates and disease prevention; reduced use of cost-intensive therapeutic settings, including fewer inpatient hospital days and emergency room visits; and economic growth through increased productivity.

Accordingly, this report undertakes a comprehensive, quantitative documentation of medical technology's impact on the economic burden of disease. It estimates changes (if any) in treatment expenditures and workforce productivity associated with these tools. Further, it projects how future innovation in this sector would affect the health-care system and the larger economy.

The utility and value of such investments are considered by examining innovations pertaining to four prevalent causes of disability and death: heart disease, diabetes, colorectal cancer, and musculoskeletal diseases.

This report uses the term "medical technology" to describe medical devices often used for therapeutic and diagnostic purposes for the diseases mentioned above. Therapeutic devices such as insulin pumps and pacemakers treat diseases or disorders. On the other hand, diagnostic devices such as colonoscopy and magnetic resonance imaging (MRI) equipment are used to identify a patient's health status before, during, or after a treatment.

These devices are typically developed through a collaboration between clinician and manufacturer in an effort to respond to an unmet need. Often, a manufacturer will modify an existing device to create a new generation of the product intended to improve patient care outcomes. As an example, the technology behind cardiac resynchronization therapy with defibrillator (CRT-D) has undergone several cycles of improvement. A device that sends electrical impulses to the heart and can detect and treat irregular heart rhythms, the CRT-D is also a tiny computer. One of the implanted wires transfers signals from the heart to external devices that aid doctors in prescribing the appropriate treatment. Now it features wireless remote monitoring, which enables the collection of diagnostics on a patient's heart disease in real time.

Over the long term, better monitoring and detection of disease reduces the need for expensive forms of care (such as emergency room visits) and raises the productivity of working people. Manufacturers and clinicians play key roles in innovating and updating devices to serve the needs of patients. However, before a device becomes available to the public, it must be approved by a regulatory agency. In the United States, the Food and Drug Administration must review and approve new devices and device modifications.

This study considers therapeutic and diagnostic devices that are widely used and have substantially affected the lives of patients and their caregivers as well as the overall U.S. economy. We also note that the effectiveness of a medical device largely depends on the type and intensity of the disease and is influenced by the skills of clinicians, the complications associated with a procedure, and patient compliance.

Table 1

Technology assessed in this study

DISEASE	DEVICE	OBJECTIVE
1) Diabetes	i) Insulin infusion pumps	Disease management
2) Heart disease	i) Angioplasty ii) Pacemaker iii) Electrocardiogram iv) Left ventricular ultrasound v) Chest x-ray	Early detection/Disease management/Cure
3) Musculoskeletal disease	i) Joint replacement surgery ii) Bone scan (MRI)	Early detection/Disease management/Cure
4) Colorectal cancer	i) Sigmoidoscopy ii) Colonoscopy	Prevention/Early detection

In this report, therefore, "medical technology" will refer to the devices listed above in Table 1. Due to the lack of sufficient data to differentiate the effects of each device, we provide evidence of the combined effect of technology on each disease. For instance, regarding musculoskeletal illness, we examine the effect of having an MRI as a diagnostic tool and/or joint replacement surgery as a means of treatment. The assumption is that this surgery is usually preceded by an MRI and often followed by one. Hence, separating the effects of the MRI as a diagnostic from the surgery is not realistic for patients undergoing surgery. At the same time, however, it is necessary to include patients whose condition was detected by an MRI at an early stage and less invasive treatment was prescribed.

Many would ask why X-ray technology is not included. X-rays are routinely used to examine musculoskeletal disease, but we chose to consider MRI because that technology offers potentially more accurate results and faster diagnosis, producing a greater impact on the cost of care and labor market outcomes.

This report starts by assessing the historical data on how devices affect the economic burden of the diseases studied. Further, we project the effects of advancing technology on the future economic burden of each disease. Three scenarios are posed to quantify potential savings generated by incentives for the future availability and advancement of these technologies: a baseline "continued incentives" scenario, an optimistic "increased incentives" scenario, and a pessimistic "reduced incentives" scenario. The study estimates these alternative pathways through 2035.

However, we do not explicitly incorporate policy changes that might affect innovations in the future, such as medical device taxes, reimbursement rules, or any consequence of the Affordable Care Act. These assumptions are implicit in various incentive scenarios. If medical device taxes are reduced or repealed, for example, or reimbursement levels increase, the device industry is likely to invest more in innovation and follow the increased incentives projection. Similarly, factors that erode future profitability make the decreased incentives scenario more likely.

The data demonstrate that the use of medical technology brings considerable economic benefits. They are expressed in the aggregate savings in treatment expenditures and prevention as well as the reduction of "indirect impact" through larger contributions to the economy. Though treatment expenditures are relatively straightforward, the concept of indirect impact is more difficult to grasp, though it is essential to accounting for the effects we are investigating.

A disease can substantially influence labor market outcomes. Employees suffering from ailments miss workdays, a situation known as absenteeism, or perform far below their potential, which is called presenteeism. Informal caregivers also may experience absenteeism and presenteeism. As a result, businesses suffer and the productivity of the entire economy declines, along with GDP. Medical devices might diminish this indirect impact (measured in terms of foregone GDP) through better disease management, prevention, or cure. For example, joint replacement surgery can relieve pain, dramatically reduce sick days, and raise productivity. This technology often improves the chances of curing a patient's condition, can extend his or her survival and can boost the economy through expanded workforce participation and stronger performance on the job.

Technology-related gains associated with heart and musculoskeletal disease were $1,930 and $24,518 per person affected, respectively. Technology did not reduce cost of care, but better quality of life and survival rates contributed to economic gains generated by higher workplace productivity.

When we discuss the economic burden associated with medical device use, we can't ignore the effect of screening the non-patient population. Although it is widely acknowledged that screening aids early detection, the technology is often considered overused, considering that the majority of people to which it is applied will not have the disease. Increasing the rate of screening raises the health-care system's outlays. This must be considered when examining the costs of a medical technology.

So to capture the effect of medical device use on the health system and the broader economy, we define the economic burden as the aggregate of disease treatment expenditures, indirect impact for individuals and informal caregivers (measured by lost GDP), and diagnostic spending for non-patient populations. Table 2 shows that for 2008 through 2010, the average annual economic burden associated with insulin pump use was $3.2 billion. Similar values for heart disease and musculoskeletal disease technology were $102.8 billion and $44.9 billion, respectively.

Colorectal cancer screening can affect the health-care system and GDP through early detection of the disease. However, an important source of value created by such screening is prevention through the removal of potentially cancerous polyps. We estimate the economic burden associated with colorectal cancer screening at $22.5 billion. It would have been much more, but the burden was offset by $12.2 billion in gains linked to prevention.

Table 2

Average annual economic burden associated with medical technology

2008-2010 ($ millions)

TECHNOLOGY	TREATMENT EXPENDITURES	INDIRECT IMPACT	HEALTHY SCREENING	TOTAL
Insulin pump	1,223	1,993	-	3,216
Heart disease diagnostics and surgery	62,604	33,685	6,522	102,812
MRI and joint replacement surgery	23,103	13,473	8,302	44,878
Colonoscopy/sigmoidoscopy	216	4,834	17,445	22,495
Detection	4,711	12,557	17,445	34,713
Prevention	-4,495	-7,723	-	-12,218

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

Although the economic burden summarizes the aggregate contributions of each device studied, the business rationale behind their use is justified by measuring the savings per person affected. "Person affected" includes patients, or the population reporting a condition (PRC), when assessing treatment expenditures. A part of this group is employed, which we refer to as the employed population reporting a condition (EPRC), and they affect the economy through foregone GDP. In addition, employed caregivers by condition (ECC) for these patients affect the labor market and in turn the economy. "Person affected," therefore, refers to one or all of the above groups as appropriate for the analysis.

For insulin pump users, Table 3 shows that savings to the health-care system and the economy was equivalent to $5,886 annually per person affected, for 2008 through 2010. The majority of savings came from the increased economic contribution of $5,278 per person affected.

Technology-related gains associated with heart and musculoskeletal disease were $1,930 and $24,518, respectively. For both of these diseases, technology did not reduce the cost of medical care. However, improved quality of life and higher survival rates contributed to significant economic gains generated by higher workplace productivity. Hence, the use of devices in these disease categories can be justified by improved labor market outcomes. As mentioned earlier, colorectal cancer screening not only facilitates early detection but has proved beneficial for prevention. Our estimates show that the annual per-person savings from such screening were $150,365, with $97,302 from early detection and $53,063 from prevention.

Table 3

Average annual savings per person affected associated with medical technology

2008-2010 ($)

TECHNOLOGY	TREATMENT EXPENDITURES	INDIRECT IMPACT	TOTAL
Insulin pump	607.7	5,278.0	5,885.8
Heart disease diagnostics and surgery	-4,533.7	6,464.0	1,930.3
MRI and joint replacement surgery	-3,887.3	28,405.2	24,517.9
Colonoscopy/sigmoidoscopy	8,840.7	141,524.2	150,364.9
Detection	903.5	96,398.5	97,302.0
Prevention	7,937.2	45,125.7	53,062.9

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

To the extent that medical technology enables employees to work longer and more productively, they contribute more in income and other taxes. Our study estimates the amount of federal income tax revenue added or lost due to changes in labor market outcomes. Technology associated with our examined diseases could have increased tax revenue by an annual average of $7.2 billion. An annual increase of $34.9 million in tax revenue could have been generated by insulin pump use. Technology use for heart disease could have generated an additional $1.5 billion in tax revenue, and $3.8 billion by technology that addresses musculoskeletal disease. Colorectal cancer screening has the potential to expand tax revenue by $1.8 billion. Of this, $1.3 billion stems from early detection.

Table 4

Federal tax revenue associated with medical technology

Compared to non-users
2008-2010 ($ millions)

TECHNOLOGY	AVERAGE (2008-2010)
Insulin pump	34.9
Heart disease diagnostics and surgery	1,474.1
MRI and joint replacement surgery	3,798.1
Colonoscopy/sigmoidoscopy	1,844.2
Detection	1,318.9
Prevention	525.3

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

Along with the evidence of considerable savings produced by the use of medical devices, there is concern about whether future innovations will be worth the investments required. To investigate, we calculated the projected economic impact for each disease, as seen in the table below. We consider three future scenarios that simulate the growth rates of technology innovation. Based on these, we conclude that more innovation in this field might result in larger numbers of patients (or PRC) and thereby increase overall treatment expenditures. However, it might pare back the average cost because better disease management reduces expensive site of service visits and creates value in the labor market.

Hence, expanding innovation in the management of diabetes will increase aggregate economic savings by $225.4 billion in 2010 dollars over 25 years. Similarly, aggregate savings from accelerating device innovations for heart and musculoskeletal ailments will raise the economic contribution to $809.1 billion and $281.1 billion, respectively. Aggregate savings associated with colorectal cancer are $178.2 billion due to early detection and prevention. By the same logic, less investment in medical technology might have the opposite effects.

Table 5

Projected economic impact by disease

2010-2035 ($ billions*)

				ABSOLUTE DIFFERENCE	
	CONTINUED INCENTIVES	INCREASED INCENTIVES	DECREASED INCENTIVES	CONTINUED-INCREASED	CONTINUED-DECREASED
Diabetes	12,342.6	12,117.2	12,443.7	225.4	-101.1
Heart disease	7,737.3	6,928.2	9,288.6	809.1	-1,551.3
Musculoskeletal disease	24,673.5	24,392.4	24,982.3	281.1	-308.8
Colorectal cancer	2,005.2	1,885.5	2,072.6	119.7	-67.4
Colorectal cancer prevented	-452.0	-510.5	-407.7	58.5	-44.2

* In 2010 dollars.

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

TECHNOLOGY AND THE ECONOMIC BURDEN OF DISEASE: HISTORICAL TRENDS

The influence of medical devices on the economic burden of disease is illuminated by studying historical trends. This report uses a cost-of-illness approach to examine trends from 2005 to 2010. "Economic burden" is defined as the aggregate of direct treatment expenditures, indirect economic impact (in terms of foregone gross domestic product), and costs for screening the healthy population. The benefit or loss of using technology is measured as the difference between the economic impact of using the technology to treat a disease and the economic effect of not doing so for the same purpose.

We calculated disease-related treatment expenditures and number of patients, which we refer to throughout as the population reporting a condition (PRC) from the Medical Expenditure Panel Survey (MEPS). That information is collected by the Agency for Healthcare Research and Quality (AHRQ), a unit of the U.S. Department of Health and Human Services. MEPS is a nationally representative sample of the noninstitutionalized civilian population with data on the provision of health services, site of service, frequency, and associated payments.

The MEPS database uses medical condition codes and ICD-9 codes to indicate the conditions for which each patient is treated. Disease-related expenditures were calculated as aggregate expenditures of visits associated with the relevant condition codes. Expenditures rather than charges were used to ensure that all costs levied on the health-care system were included. For example, expenditures were calculated for diabetes-related visits to offices, outpatient, inpatient, emergency room, and home health settings, and prescriptions for each year. The same was calculated for all other diseases. PRC was the number of unique patients with visits associated with a condition at any site of service.

Chronic diseases such as those assessed in this report are often accompanied by other ailments such as heart failure, renal diseases, blindness, etc. However, due to a lack of available data and the risk of double counting, our estimates did not take into account the economic impact associated with such comorbidities. In our assessment of per-PRC expenditures, patients are identified as technology users if they have a technology-related treatment expenditure in that calendar year. Therefore, these calculations do not capture any change in cost of care in the years following that use. If a person uses less care due to improved symptoms after joint-replacement therapy, this would not be captured in our analysis. Our approach can be seen as conservative.

The cost of screening for the non-patient population has a major impact on the health-care system, which must be included in estimating the overall economic burden tied to disease-specific medical technology. For most diseases, we used MEPS, the Healthcare Cost and Utilization Project (HCUP), scientific literature, and market research to acquire information on the number of healthy people screened and the average (unit) cost, enabling us to estimate the total cost of such screening.

Our calculation of indirect impact measures labor market outcomes related to work loss and productivity. It represents the combination of absenteeism, or lost workdays due to disease, and presenteeism, or underperformance at work for the same reason, and is quantified in terms of lost employee output, or foregone GDP. We incorporate the absenteeism and presenteeism of both patients and their informal caregivers to capture the total indirect impact of a disease.

The main source for lost workdays data associated with a disease was the National Health Interview Survey (NHIS). The survey asks a nationally representative sample health-related questions regarding medical conditions, employment, treatment, and cancer screening. The employed population reporting a condition (EPRC) and lost workdays were calculated from a survey question about whether participants had missed work due to illness or injury. A GDP-based approach was used to estimate the value of lost workdays, or absenteeism. Then presenteeism was estimated using disease-specific presenteeism-to-absenteeism ratios from a study by Goetzel et al.[3]

The number of employed caregivers by condition (ECC) and caregiver lost workdays were estimated using studies from the National Alliance for Caregiving and AARP.[4] Using a similar GDP-based approach, the value of caregiver absenteeism was calculated. Further, caregiver presenteeism was estimated using information from a study by Levy and indexed to employed patients' (EPRC) presenteeism.[5]

Once we estimated the indirect impact of the overall disease, it was necessary to estimate the indirect impact associated with the use of medical technology. In many cases, such technology can lower the indirect impact associated with a disease because of better labor market outcomes. For example, a device that eases arthritis pain can improve an employee's job performance. The difference in the indirect impact between device use and no use is the value added to or subtracted from the GDP.

DIABETES

Examining historical trends, we find that:

- The average annual U.S. (2008-2010)[6] economic impact associated with insulin pump use was $3.2 billion. To break that down, direct treatment and disease management expenditures were $1.2 billion and lost GDP amounted to $2 billion. (See Summary Chart: Diabetes.)
- Due to better disease management, the average annual (2008-2010) savings per person affected was $5,886 compared to insulin-dependent patients who did not use pumps. This is due to the smaller economic impact associated with pump use compared to other modes of insulin delivery. The greatest portion of this benefit stems from an economic gain of $5,278 per person affected amid rising productivity and fewer lost workdays.

» Diabetes affects 25.8 million Americans (more than 8 percent of population).

» 7 million of this 25.8 million are undiagnosed.

» 5.4 million Americans are insulin dependent (including all type 1 diabetics).

» Deaths from diabetes-related disorders:

- 28 percent caused by cerebrovascular disease
- 55 percent caused by renal failure

Sources: Centers for Disease Control and Prevention, American Diabetes Association, *Diabetes/Metabolism Research and Reviews.*

3. Goetzel et al. "Health, Absence, Disability, and Presenteeism Cost Estimates of Certain Physical and Mental Health Conditions Affecting U.S. Employers," *Journal of Occupational and Environmental Medicine* 46, (2004).
4. National Alliance for Caregiving (NAC) and AARP. "Caregiving in the U.S.," 2009.
5. David Levy. "Presenteeism: A Method for Assessing the Extent of Family Caregivers in the Workplace" (American Association for Caregiver Education, 2003). See also David Levy. "Presenteeism: A Method for Assessing the Extent of Family Caregivers in the Workplace and Their Financial Impact" (American Association for Caregiver Education, 2007).
6. Data was calculated annually for the period 2005-2010. Average annual economic impacts, the sum of treatment expenditures and indirect impact, are calculated for 2008-2010.

- Insulin pumps (also known as continuous subcutaneous insulin infusion, or CSII therapy) deliver the hormone to the bloodstream through a catheter placed under the skin. The device is connected to a pump (about the size of a pager) programmed to deliver a specific amount continuously, which can be monitored by the patient.
- At present, fewer than 30 percent of type 1 patients and 1 percent of type 2 patients are using insulin pumps. This technology is likely to see further adoption because of its ease of use and improved ability to regulate blood sugar.

Diabetes is a chronic disease involving the loss of sensitivity to the insulin hormone and/or loss of the pancreas' ability to produce it. There are two types of the disease. Type 1 is auto-immune, always insulin dependent, and generally occurs at an early age. Type 2 is more affected by risk factors such as diet and exercise, has an older age of onset, and is insulin-dependent primarily in severe cases. Regular dosing and monitoring is necessary for insulin-dependent patients.

Traditionally, injection is the mode of administering insulin. However, pumps are now gradually supplanting them. Although the MEPS survey collects information about the number of insulin-using diabetics, it does not distinguish by mode of administration. Bode et al. reported historical data on the number of insulin pump users, and we used interpolation to determine values for missing years. We combined this with data on insulin users from the Centers for Disease Control and Prevention (CDC) to estimate the historical percentages of pump users, which steadily increased from 2000 to 2010.[7] The rise in pump use over time may be explained by technology improvements that increased accuracy and ease of use combined with research confirming pumps' efficacy in disease management.

Figure 1

Proportion of insulin dependent diabetes patients using a pump

7. Bruce W. Bode et al., "Diabetes management in the new millennium using insulin pump therapy," *Diabetes/Metabolism Research and Reviews* 18, Suppl. 1 (2002), pp. S14-S20.

PRCs associated with sites of service were determined separately from overall insulin pump use to enable us to estimate pump-related expenditures. Initially, the proportion of pump users to total insulin users was applied across all sites of service to get a base number for pump-user PRC. However, we know that pump use affects health outcomes and therefore changes health-care utilization patterns. We accounted for this through additional percentage reductions in the pump user PRC. Scuffham and Carr[8] report that insulin pump use is associated with fewer hypoglycemic events (inpatient hospital stays and/or emergency room visits). As a result, PRC for inpatient admission falls by an estimated 43 percent for insulin pump users and PRC for ER visits 53 percent from the base number. It is logical to assume that all insulin pump users are included in the prescription-related PRC. Since some insulin users may not incur Rx expenditures over the course of a year, the use of the base number provides an upper bound.

There was no available data relating to changes in office-based and outpatient care. However, diabetic patients need to regularly visit their clinician regardless of their status. Therefore, pump use would not reduce office-based and outpatient services as much as it would reduce ER visits or inpatient admissions. We assumed a 35-percent reduction, smaller than those for ER and inpatient care. Using the above research, related expenditures were estimated using similar methodology but with different values. Aggregating expenditures by site of service enabled us to estimate the total annual treatment expenditures for diabetes.

To be comprehensive, we also wanted to quantify the indirect impact of the disease. Diabetes is a disease that can have dramatic adverse effects on labor market outcomes in terms of lower participation and productivity losses. After calculating the indirect impact associated with overall diabetes and also insulin dependent patients using previously described methods, the challenge was to estimate the indirect impact associated with using insulin pumps.

The proportion of insulin pump PRC was used to calculate associated EPRC. We assumed that the better disease management tied to pump use would improve labor market outcomes and reduce absenteeism and presenteeism. To estimate the associated reduction in absenteeism, data from a study by Scuffham and Carr[9] (demonstrating that pump use reduces hypoglycemic events 13 percent) was used to adjust for lost workdays. We acknowledge that hypoglycemic events are not the only drivers of diabetes-related labor market outcomes. However, due to lack of consistent data on other types of diabetic complications, we referred only to the hypoglycemic events.

One advantage of the reduction in diabetic complications is that patients feel less anxious and their quality of life improves, reducing presenteeism as well. Research shows that the quality of life for those who inject insulin is 5.3 percent worse than those using pumps.[10] We assumed that pump users' presenteeism was 5.3 percent less than that of diabetes patients overall.

Overall annual treatment expenditures for diabetes rose from $34.2 billion in 2005 to $51.2 billion in 2010, and the proportion of insulin-dependent diabetics increased from 20.3 to 24.4 percent. Those who are insulin dependent represented 46.4 percent of diabetes-related expenditures and 18.7 percent of the indirect impact in 2010, a significant portion of the total economic impact.

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8. P. Scuffham and L. Carr. "The Cost-Effectiveness of Continuous Subcutaneous Insulin Infusion Compared with Multiple Daily Injections for the Management of Diabetes," *Diabetes Medicine* 7 (2003) pp. 586-93.
9. Ibid.
10. Ibid.

Total treatment expenditures associated with insulin pump users are also on the rise, probably due to increased use. Average per-PRC savings to the health-care system due to using insulin pumps was $607.7 between 2008 and 2010. This per-PRC savings presents an economic rationale for their use.

We estimate that in 2010, the indirect impact for pump users and their caregivers was $2.3 billion, a small portion of the $208.8 billion that represents the total indirect impact of diabetes. Using insulin pumps increased GDP per person affected by $4,772 compared to other modes of insulin administration.

Some of these savings in treatment expenditures and indirect impact could be explained from earlier research in this field. Studies have found that insulin pump therapy has resulted in at least equivalent, if not lower, levels of HbA1c, or hemoglobin A1c.[11] Better disease management leads to maintaining those levels below 7 percent, a common target for diabetic patients.[12] Indeed, the use of insulin pumps lowers HbA1c levels 1.2 percent compared to multiple daily injections.[13] The devices more closely replicate the insulin production patterns of the pancreas, cutting the risk of diabetic complications such as nocturnal hypoglycemia (low blood sugar) and early-morning spikes in blood sugar.[14] This reduces the need for expensive inpatient and emergency room care as well as lost workdays caused by such events. Because pumps require less maintenance, workplace productivity is also improved.

Treatment expenditure data from 2010 supports the idea that insulin pumps better manage disease and generate savings. In 2010, office-based and outpatient expenditures per PRC were approximately 50 percent lower for insulin pump users, indicating that non-pump delivery methods may require closer clinician management. Poor blood sugar management is associated with a number of harmful effects, including nephropathy, neuropathy, and retinopathy, which may require surgical management after progression and increase hospital admissions. Insulin pump use appeared to reduce the probability of admission, and in fact, inpatient expenditures per PRC for pump users were 60 percent lower than for non-pump users. Further, the 80 percent reduction in per-PRC emergency room expenditures for pump users may be attributed to a lower likelihood of hypoglycemic and hyperglycemic events.

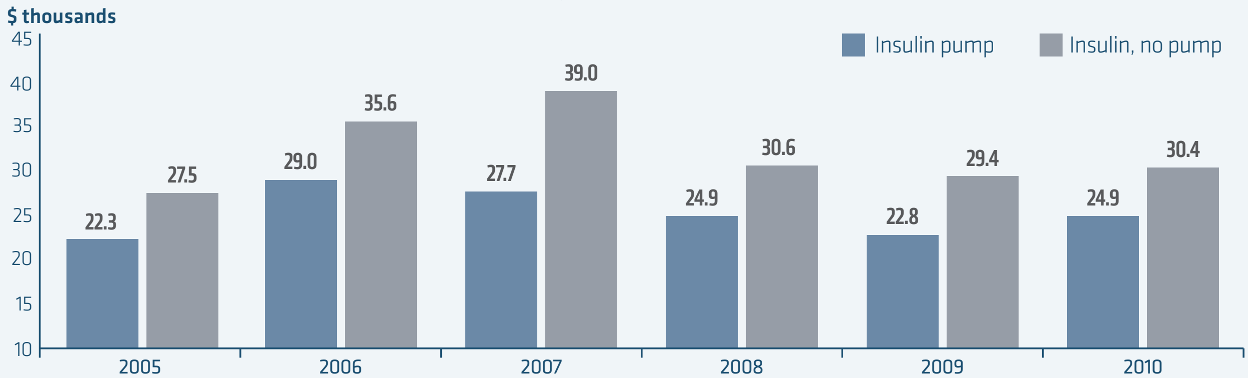
Using insulin pumps increased GDP per person affected by $4,772 compared to other modes of insulin administration.

This easing of the progression of diabetes-related complications can also explain the 50 percent reduction in average home health expenditures associated with pump use, which can facilitate tight glucose control and ultimately prevent complications that require greater nursing care. The only site of service that was more costly for insulin pump users was prescription-related expenditures; the 40 percent increase in spending in that category can be attributed to the price and maintenance of the device itself. So, even though out-of-pocket prescription expenses rise with the use of insulin pumps compared to injections, it is justified by the savings from fewer visits to expensive sites of service.

11. Bruce W. Bode, "Insulin Pump Use in Type 2 Diabetes," *Diabetes Technology & Therapeutics* 12, Suppl. 1 (2010) S17-S21.
12. Ibid.
13. Meaghan St. Charles et al., "A Cost-Effectiveness Analysis of Continuous Subcutaneous Insulin Injection versus Multiple Daily Injections in Type 1 Diabetes Patients: A Third-Party U.S. Payer Perspective."
14. Bruce W. Bode, "Insulin Pump Use in Type 2 Diabetes."

SUMMARY CHART: DIABETES

Economic impact of insulin dependent diabetes, 2005-2010*
Per person affected



* Includes treatment expenditures and indirect impacts.

AVERAGE ANNUAL ECONOMIC BURDEN, 2008-2010 ($)	
Insulin pump	24,217.5
Insulin, no pump	30,103.2
Average savings	5,885.8

Technology-related impact per person affected* ($)

YEAR	INSULIN PUMP			INSULIN, NO PUMP			ALL INSULIN		
	Treatment expenditures	Indirect impact**	Total	Treatment expenditures	Indirect impact**	Total	Treatment expenditures	Indirect impact**	Total
2005	2,544.3	19,716.1	22,260.5	3,451.9	24,068.9	27,520.8	3,408.1	29,699.2	33,107.3
2010	3,805.9	21,107.4	24,913.3	4,478.7	25,879.0	30,357.7	4,431.2	25,541.6	29,972.8
Average (2008-2010)	3,863.8	20,353.7	24,217.5	4,471.5	25,631.7	30,103.2	4,431.0	25,283.9	29,714.9

* Person affected includes population reporting a condition, employed population reporting a condition, and employed caregivers by condition.
** A lower indirect impact value implies a greater contribution to the economy.

Insulin-related economic impact ($ millions)

YEAR	INSULIN PUMP			INSULIN, NO PUMP			ALL INSULIN		
	Treatment expenditures	Indirect impact	Total	Treatment expenditures	Indirect impact	Total	Treatment expenditures	Indirect impact	Total
2005	424.2	1,093.4	1,517.6	11,338.6	26,310.6	37,649.2	11,762.7	27,404.1	39,166.8
2010	1,442.9	2,276.1	3,718.9	22,314.8	36,688.3	59,003.1	23,757.7	38,964.4	62,722.1
Average (2008-2010)	1,223.1	1,993.2	3,216.4	20,002.4	35,425.3	55,427.7	21,225.6	37,418.6	58,644.1

Insulin dependent population affected (thousands)

YEAR	INSULIN PUMP			INSULIN, NO PUMP			ALL INSULIN		
	PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***
2005	166.7	74.4	12.1	3,284.7	1,465.6	237.7	3,451.4	1,540.0	249.8
2010	379.1	146.5	25.6	4,982.4	1,925.6	336.4	5,361.5	2,072.2	362.0

* Population reporting a condition.

** Employed population reporting a condition.

*** Employed caregivers by condition.

Expenditures per PRC by site of service, 2010 ($)

	OFFICE BASED	OUTPATIENT	INPATIENT	EMERGENCY	PRESCRIPTION	HOME HEALTH	TOTAL
Diabetes	608.8	851.8	21,435.3	1,073.9	1,212.6	5,636.3	2,330.4
Insulin	873.5	681.6	15,842.4	854.8	2,419.7	7,328.3	4,431.2
Insulin pump	436.7	340.8	6,020.1	179.5	3,278.2	3,664.2	3,805.9
Insulin, no pump	894.5	698.1	16,254.9	878.1	2,353.7	7,454.3	4,478.7

Diabetes population affected (thousands)

YEAR	OVERALL DIABETES			ALL INSULIN			INSULIN-DEPENDENT DIABETES (%)		
	PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***
2005	17,019.9	7,219.0	1,171.0	3,451.4	1,540.0	249.8	20.3	21.3	21.3
2010	21,979.7	8,872.5	1,549.9	5,361.5	2,072.2	362.0	24.4	23.4	23.4

Economic impact associated with diabetes ($ millions)

YEAR	DIABETES			ALL INSULIN			INSULIN DEPENDENT DIABETES (%)		
	Treatment expenditures	Indirect impact	Total	Treatment expenditures	Indirect impact	Total	Treatment expenditures	Indirect impact	Total
2005	34,236.4	160,076.5	194,312.9	11,762.7	27,404.1	39,166.8	34.4	17.1	20.2
2010	51,222.5	208,750.2	259,972.7	23,757.7	38,964.4	62,722.1	46.4	18.7	24.1
Average (2008-2010)	46,580.8	182,304.9	228,885.7	21,225.6	37,418.6	58,644.1	45.6	20.5	25.6

HEART DISEASE[15]

Examining historical trends, we find that:

- The average annual (2008-2010) economic burden associated with using heart disease diagnostic tests and/or angioplasty was $102.8 billion. Of this amount, direct treatment expenditures added $62.6 billion to the health-care system, and indirect impact accounted for $33.7 billion in lost GDP. Further, the burden included an additional $6.5 billion related to diagnostic tests performed on the healthy population. (See Summary Chart: Heart Disease.)

- For heart disease patients, the average annual (2008-2010) savings per person affected was $1,930 compared to those who did not use this technology. Although average treatment expenditures were $4,534 higher for patients using technology, the $1,930 savings stem from the $6,464 increase in GDP per person affected.

» Heart disease is the leading cause of death in the U.S.

- 600,000 deaths per year
- More than 700,000 Americans suffer heart attacks annually.
- More than one in four heart attack patients have had prior heart attacks.

» Risk factors include obesity, aging, high blood pressure, high cholesterol, and smoking.

Source: Centers for Disease Control and Prevention.

» Angioplasty is a minimally invasive procedure in which tubing is guided through the coronary arteries with an attached deflated balloon catheter. Once the catheter reaches the blocked artery, the balloon is inflated to widen or unblock the artery. In some cases, a stent is also inserted to reduce blockage.

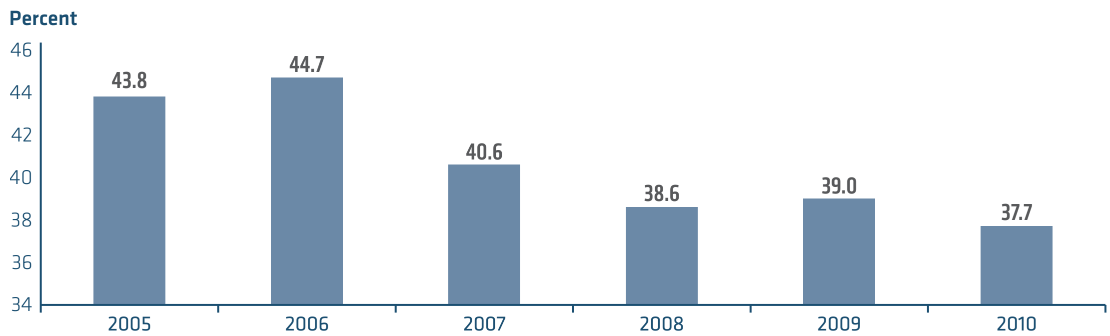
» Pacemakers may be used when the heart beats too fast, too slow, or irregularly. The small device, which is implanted in the heart tissue, sends electrical impulses that help the organ beat regularly.

Heart disease is caused by the buildup of plaque in the arteries near the heart, reducing blood flow. Potential consequences include heart attack and heart failure. A range of technology has been developed to mitigate the effects of heart disease, from diagnostic tools such as EKG, echocardiograms, and chest X-rays to therapeutic devices such as stents and pacemakers. A substantial proportion of the heart disease population uses these technologies, as seen in Figure 2.

15. Heart disease includes heart valve disorders, coronary atherosclerosis, cardiac dysrhythmias, myocardial infarction, and congestive heart failure.

Figure 2

Proportion of heart disease patients using technology



We quantified the utilization of technology and economic effects for heart disease patients. Coronary events related to this condition can hinder a patient's ability to work, with 51 percent of heart attack patients returning to their jobs within one month and 78 percent returning within six months.[16] We used this information to estimate lost workdays for heart disease patients in our calculation of indirect impact. Technology can improve patients' quality of life and reduce presenteeism. According to Rosen et al.,[17] surgical revascularization represents a potential 22.4 percent quality of life increase if it prevents a major cardiac event. Presenteeism was adjusted using this information.

PRC for heart disease in the United States expanded from 19.1 million in 2005 to 23.0 million in 2010. It is not surprising that unhealthy lifestyles and demographic effects increased that population. In 2005, about 8.4 million (43.8 percent) people used technology, with an additional 250,000 users (37.7 percent) in 2010, bringing the total to approximately 8.7 million. This decline in the percentage using technology may be due to changes in insurance coverage or increased diagnosis of milder forms of the condition that require management by medication only.

For this ailment, the aggregate economic burden increased from $220.1 billion in 2005 to $243.4 billion in 2010. The burden associated with patients using technology was $87.8 billion in 2005, which rose to $106.1 billion in 2010. The considerable increase in aggregate expenditures is due to PRC expansion for heart disease overall.

The average annual (2008-2010) treatment expenditures per heart disease PRC from using technology ($7,050) were higher than for those who did not ($2,517), an indication of technology's contribution to rising health-care costs. However, many patients who underwent surgery survived solely as a result of that costly method. Further, diagnostics can help in early detection and prevent expensive visits to hospitals and emergency rooms. In fact, inpatient expenditures per PRC were lower for heart disease patients using technology ($19,054) in 2010 compared to those who did not ($24,512). However, except for home health-care services, all other sites of service were more expensive if they used technology. Some of these differences in expenditures may be explained by the settings in which diagnostics were used. Such tests are

16. Amr E. Abbas, et al. "Frequency of Returning to Work One and Six Months Following Percutaneous Coronary Intervention for Acute Myocardial Infarction," *American Journal of Cardiology* 94, (2004).

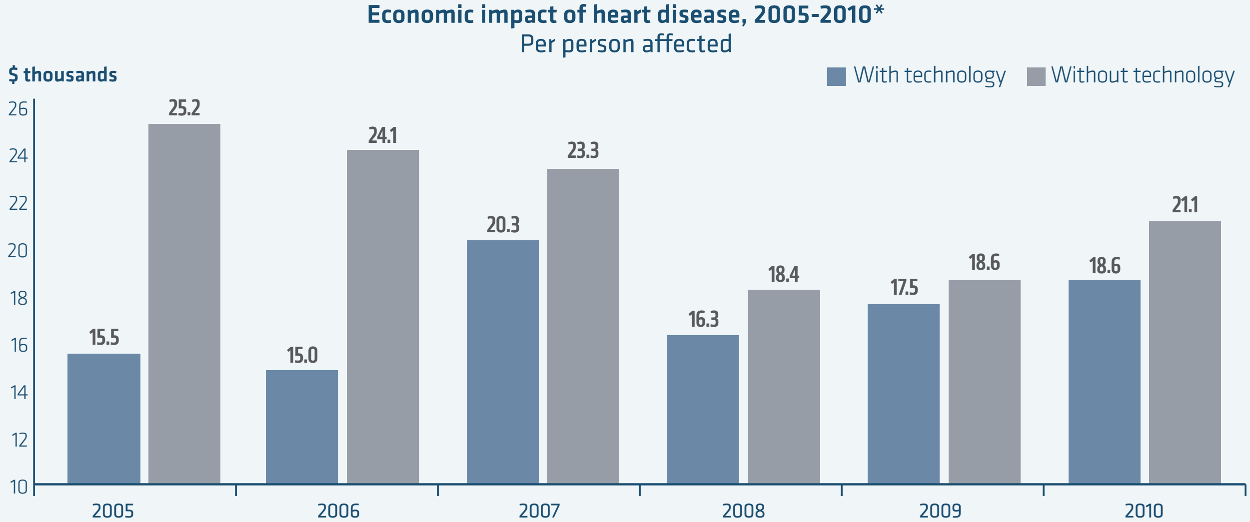
17. Virginia M. Rosen et al. "Cost Effectiveness of Intensive Lipid-Lowering Treatment for Patients with Congestive Heart Failure and Coronary Heart Disease in the U.S.," *Pharmacoeconomics* 28, no. 1 (2010).

often undertaken during office visits and in emergency rooms. Diagnostic testing is part of the guidelines for patients at risk for heart disease, and its absence might signal a lack of access to care and therefore reduced spending. Additionally, patients using surgical technology may have more severe forms of heart disease and may be more expensive to treat. This may contribute to the higher expenditures per PRC for technology users.

Although heart disease technology could not contribute to savings to the health-care system between 2005 and 2010, productivity gains could offset some of the higher treatment costs, both during the period of technology use and in the future. In 2010, the indirect impact for heart disease amounted to $130 billion, but patients who used technology accounted for only $35 billion of that amount. For a better understanding of these findings, the indirect impact per heart disease EPRC (or ECC, as appropriate) was calculated. The average (2008-2010) indirect impact per person affected is much lower for technology users than non-users. The improved labor market outcomes generated an additional $6,464 of GDP per person affected in that period. For these individuals, screening may have allowed for better detection and treatment of disease, and therapeutic technology may have reduced the time absent from work and raised productivity as well.

One criticism that has been aimed at diagnostic technology is unnecessary application or overuse. Health-care providers often recommend heart-related diagnostic tests for non-heart disease patients. This type of expenditure added an average of $6.5 billion annually to the health-care system from 2008 to 2010.

SUMMARY CHART: HEART DISEASE



* Includes treatment expenditures and indirect impacts.

AVERAGE ANNUAL ECONOMIC IMPACT, 2008-2010 ($)	
With technology	17,441.3
Without technology	19,371.6
Average savings	1,930.3

Technology-related impact per person affected* ($)

YEAR	WITH TECHNOLOGY			WITHOUT TECHNOLOGY			TOTAL		
	Treatment expenditures	Indirect impact**	Total	Treatment expenditures	Indirect impact**	Total	Treatment expenditures	Indirect impact**	Total
2005	5,529.3	10,011.0	15,540.3	2,910.0	22,309.1	25,219.0	4,056.3	16,927.2	20,983.4
2010	7,407.5	11,163.1	18,570.6	2,958.6	18,118.7	21,077.4	4,635.0	15,497.8	20,132.8
Average (2008-2010)	7,050.7	10,390.6	17,441.3	2,517.0	16,854.5	19,371.6	4,259.9	14,372.6	18,632.5

* Person affected includes population reporting a condition, employed population reporting a condition, and employed caregivers by condition.

** A lower indirect impact value implies a greater contribution to the economy.

SUMMARY CHART: HEART DISEASE *(continued)*

Heart disease economic burden ($ millions)

YEAR	WITH TECHNOLOGY				WITHOUT TECHNOLOGY			TOTAL			
	Treatment expenditures	Indirect impact	Diagnostics for healthy population	Total	Treatment expenditures	Indirect impact	Total	Treatment expenditures	Indirect impact	Diagnostics for healthy population	Total
2005	46,411.6	35,185.4	6,231.4	87,828.4	31,389.0	100,921.7	132,310.7	77,800.6	136,107.1	6,231.4	220,139.1
2010	64,368.3	35,245.4	6,508.6	106,122.4	42,520.6	94,769.8	137,290.5	106,889.0	130,015.2	6,508.6	243,412.8
Average (2008-2010)	62,604.4	33,684.9	6,522.5	102,811.8	35,844.7	89,055.1	124,899.8	98,449.1	122,740.0	6,522.5	227,711.6

Heart disease population affected (thousands)

YEAR	WITH TECHNOLOGY			WITHOUT TECHNOLOGY			TOTAL		
	PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***
2005	8,393.7	4,756.1	771.5	10,786.6	6,111.9	991.4	19,180.4	10,868.0	1,762.9
2010	8,689.6	4,329.4	756.3	14,371.7	7,160.4	1,250.8	23,061.3	11,489.8	2,007.1

* Population reporting a condition.

** Employed population reporting a condition.

*** Employed caregivers by condition.

Expenditures per PRC by site of service, 2010 ($)

	OFFICE BASED	OUTPATIENT	INPATIENT	EMERGENCY	PRESCRIPTION	HOME HEALTH	TOTAL
Heart disease	792.6	2,721.0	20,831.1	1,838.8	565.0	5,736.1	4,635.0
Any technology	982.1	3,014.0	19,054.6	1,875.8	682.4	3,868.9	7,407.5
No technology	608.2	2,233.8	24,512.8	1,587.8	505.7	7,279.3	2,958.6

MUSCULOSKELETAL DISEASE

Examining historical trends, we find that:

- The average annual (2008-2010) economic burden associated with using musculoskeletal disease-related diagnostic tests and/or joint replacement surgery was $44.9 billion. Of this amount, direct treatment expenditures added $23.1 billion to the health-care system and $13.5 billion in lost GDP. Further, the economic burden included an additional $8.3 billion in diagnostic tests performed on the healthy population. (See Summary Chart: Musculoskeletal Disease.)
- For musculoskeletal disease patients, the average annual (2008-2010) savings per person affected were $24,518 compared to musculoskeletal disease patients who did not use this technology. Although average treatment expenditures were $3,887 higher for musculoskeletal disease patients using technology, the $24,518 savings arise from the additional $28,405 increase in GDP per person affected

» Musculoskeletal disease affected more than 30 percent of the U.S. population in 2006.

» Arthritis, which constitutes a large portion of musculoskeletal disease cases, is a degenerative disease affecting nearly 30 percent of American adults in 2010.

» Arthritis affects the non-elderly too. In fact, two-thirds of people with arthritis are under age 65.

» Disability is high among rheumatoid arthritis patients.

Sources: Centers for Disease Control and Prevention, Burden of Musculoskeletal Diseases in the United States, *European Journal of Health Economics*, Milken Institute.

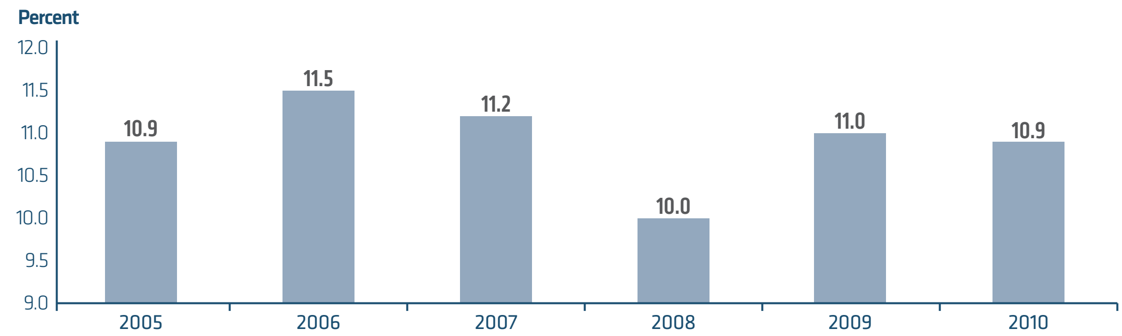
» MRI is a screening technique that can identify bone erosions in arthritis earlier and with more detail than typical X-rays.

» Joint replacement surgeries involve removing part or all of a damaged joint, such as a hip or knee, and implanting a prosthesis.

Musculoskeletal disease is a chronic condition that can disturb muscles, bones, and joints all over the body and varies in severity. Musculoskeletal diseases do not pose as high a mortality risk as other prominent chronic illnesses, but they do affect patients' ability to perform the activities of everyday living. To prevent the disease from worsening, screening technologies for early detection are often used. If it does worsen, surgical procedures such as joint replacement can greatly improve quality of life.

Figure 3

Proportion of musculoskeletal disease patients using technology



Technology can be very effective in improving outcomes for musculoskeletal disease patients. It can affect health-care system costs as well as labor market outcomes. For joint replacement surgery, about 94 percent of hip replacement patients return to work within two months, data shows, and the remaining 6 percent return within a year.[18]

We used this data to calculate lost workdays. Presenteeism is also improved by surgery. David Ruiz and colleagues estimated that knee replacement surgery added 3.4 quality-adjusted life years among patients ages 40 to 44.[19] Using this information, we adjusted presenteeism accordingly. Functional ability also increases among joint replacement surgery patients, in the range of 56 to 79 percent.[20] These positive effects help to explain why technology has been consistently used by the musculoskeletal disease population.

With the aging of the population, rising obesity, and changing work environments, the musculoskeletal disease PRC expanded from 26.3 million in 2005 to 41.1 million in 2010. Among them, about 2.9 million used technology in 2005, which climbed to 4.5 million in 2010. While the number of patients treated with technology increased, the percentage has remained relatively constant, around 10.9 percent.

Total treatment expenditures were $54.3 billion in 2005, climbing to $83.5 billion in 2010. Expenditures associated with using technology were only $16.7 billion in 2005, and rose to $27.1 billion in 2010. These increases are likely due to growth in the absolute PRC for both musculoskeletal disease in general and the technology user population. The latter group comprises 10.9 percent of the PRC. The number varied through the six years examined, but no trend is visible. Annual per-PRC treatment expenditures remained largely unchanged during this period.

Average annual (2008-2010) expenditure per PRC was higher for technology users ($5,431) than non-users ($1,544), resulting in a loss to the health-care system of $3,887. Increased expenditures per PRC associated with technology use were seen at all sites of service except home health care. Average home health expenditures per person for patients using technology were $3,106, while the average for those without technology was $5,180. Treatments are centered on supporting the activities of everyday living and may

18. Ryan M. Nunley et al. "Do Patients Return to Work After Hip Arthroplasty Surgery?" *Journal of Arthroplasty* 26, No. 6 Suppl. 1 (2011).

19. David Ruiz et al. "The Direct and Indirect Costs to Society of Treatment for End-Stage Knee Osteoarthritis," *Journal of Bone and Joint Surgery* 95 (2013), pp. 1,473-1,480.

20. F. Cushner et al. "Complications and functional outcomes after total hip arthroplasty and total knee arthroplasty: Results from the Global Orthopedic Registry (GLORY), *The American Journal of Orthopedics* 39, suppl. 9 (2010), pp. 22-28.

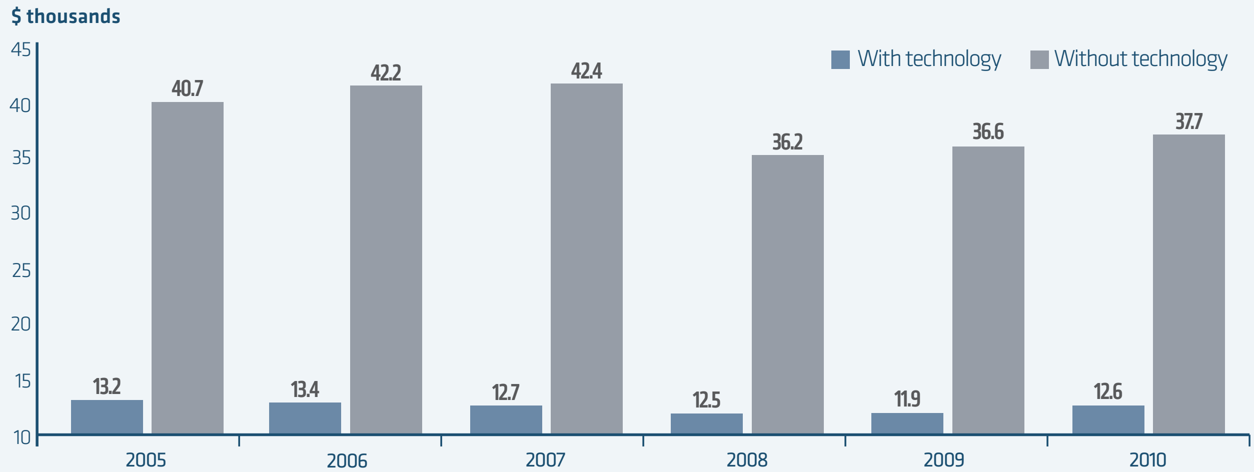
require close care by nurses; improved treatment would reduce this need. Less home care could also reflect greater use of skilled nursing facilities after inpatient surgery, lowering per-PRC home-care expenditures.

In addition, surgery may be restricted to segments of the patient population. Those who already receive frequent home care may be too frail to endure a surgical intervention, which may explain higher home health expenditures per PRC in the non-technology user population.

In 2010, the indirect impact for musculoskeletal disease amounted to $608.9 billion. Because these ailments affect the ability to perform daily activities, it follows that a large portion of the associated economic burden would be generated by negative labor market outcomes. However, the indirect impacts for patients treated with medical technology amounted to only $13 billion of that total. In 2010, the indirect impact was $6,520 for those who used technology and $36,197 for those who did not, amounting to an additional gain of $29,676 per person affected. For these individuals, treatment and screening may have shortened the time absent from work due to musculoskeletal disease and improved productivity as well.

SUMMARY CHART: MUSCULOSKELETAL DISEASE

Economic impact of musculoskeletal disease, 2005-2010*
Per person affected



* Includes treatment expenditures and indirect impacts.

AVERAGE ANNUAL ECONOMIC BURDEN, 2008-2010 ($)	
With technology	12,315.0
Without technology	36,832.9
Average savings	24,517.9

Technology-related impact per person affected* ($)

YEAR	WITH TECHNOLOGY			WITHOUT TECHNOLOGY			TOTAL		
	Treatment expenditures	Indirect impact**	Total	Treatment expenditures	Indirect impact**	Total	Treatment expenditures	Indirect impact**	Total
2005	5,826.2	7,379.7	13,205.9	1,601.3	39,056.0	40,657.3	2,062.5	35,598.2	37,660.7
2010	6,049.0	6,520.7	12,569.7	1,541.2	36,196.6	37,737.7	2,032.8	32,959.9	34,992.7
Average (2008-2010)	5,431.6	6,883.4	12,315.0	1,544.3	35,288.6	36,832.9	1,959.5	32,261.8	34,221.3

* Person affected includes population reporting a condition, employed population reporting a condition, and employed caregivers by condition.
** A lower indirect impact value implies a greater contribution to the economy.

Musculoskeletal disease economic burden ($ millions)

YEAR	WITH TECHNOLOGY				WITHOUT TECHNOLOGY			TOTAL			
	Treatment expenditures	Indirect impact	Diagnostics for healthy population	Total	Treatment expenditures	Indirect impact	Total	Treatment expenditures	Indirect impact	Diagnostics for healthy population	Total
2005	16,733.6	13,435.2	6,226.8	36,395.6	37,532.7	585,649.7	623,182.4	54,266.4	599,084.9	6,226.8	659,578.0
2010	27,088.6	13,019.0	8,685.5	48,793.0	56,376.0	595,942.2	652,318.2	83,464.5	608,961.2	8,685.5	701,111.2
Average (2008-2010)	23,103.4	13,473.4	8,301.6	44,878.4	54,913.4	587,038.9	641,952.3	78,016.8	600,512.3	8,301.6	686,830.7

Musculoskeletal disease population affected (thousands)

YEAR	WITH TECHNOLOGY			WITHOUT TECHNOLOGY			TOTAL		
	PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***
2005	2,872.1	2,461.2	399.2	23,438.7	20,085.5	3,258.1	26,310.8	22,546.7	3,657.4
2010	4,478.2	2,735.0	477.8	36,580.3	22,341.2	3,902.8	41,058.5	25,076.3	4,380.5

* Population reporting a condition.
** Employed population reporting a condition.
*** Employed caregivers by condition.

Expenditures per PRC by site of service, 2010 ($)

	OFFICE BASED	OUTPATIENT	INPATIENT	EMERGENCY	PRESCRIPTION	HOME HEALTH	TOTAL
Musculoskeletal disease	744.3	2,824.8	23,521.7	910.3	409.8	4,778.1	2,032.8
Any technology	1,401.4	3,062.5	25,126.6	978.9	322.4	3,106.3	6,049.0
No technology	650.9	2,683.2	22,168.9	897.5	421.9	5,180.0	1,541.2

COLORECTAL CANCER

Examining historical trends, we find that:

- The average annual (2008-2010) economic burden associated with screening via colonoscopy/sigmoidoscopy was $22.5 billion. Of this amount, direct treatment expenditures for colorectal cancer added $4.7 billion to the health-care system and cost $12.6 billion in lost GDP. Further, the economic burden included an additional $17.4 billion in diagnostic tests performed on healthy populations that revealed no polyps. However, colonoscopy/sigmoidoscopy screening prevented 560,000 people from developing the illness, saving the health-care system $12.2 billion and producing a gain to the economy. (See Summary Chart: Colorectal Cancer.)
- For colorectal cancer patients, the average annual (2008-2010) savings per person affected were $97,302 compared to patients who had no screening.

» Colorectal cancer is the third most frequently diagnosed cancer in the United States.

» 80 percent of new cases occur in people age 55 and over.

Sources: Centers for Disease Control and Prevention, *Health Economics*.

» Colonoscopy/sigmoidoscopy can detect and remove polyps before they become cancerous.

» Polyps can be removed by a polypectomy procedure during colonoscopy. Although not all polyps are cancerous, removing them can prevent most colorectal cancer cases.

» In 1988, only 27.8 percent of Americans age 50 and over had ever been screened, a proportion that more than doubled to 65.7 percent by 2010.

» 80 percent of reduced colorectal cancer incidence is the result of increased screening.

Sources: Centers for Disease Control and Prevention, *Health Economics*, Harvard University, Milken Institute.

In addition, screening helped in the prevention of colorectal cancer, amounting to about $53,063 per case. In aggregate (including treatment and prevention), the savings per person affected from screening were $150,365. To assess the historical trend of the effect of colorectal cancer screening on the economic burden of the disease, it is necessary to separate detection and prevention. For the historical analysis, colorectal cancer patients who had been screened were compared to those who had not, according to current guidelines.[21]

We also assessed the number of colorectal cancer cases prevented by screening and the expenditures avoided. We determined the proportion of screening performed on non-cancerous patients as well as the proportion of polypectomies due to screening non-cancerous patients from the HCUP hospital database. Assuming that one-third of growths removed in polypectomies would have turned into cancer, we applied these proportions from HCUP to our findings on colorectal cancer patients screened from MEPS to determine cases prevented and expenditures avoided.

21. The CDC recommends a colonoscopy every 10 years or a sigmoidoscopy every five years for people over 50.

In 2010, 617,000 Americans were treated for colorectal cancer, accounting for $3 billion in expenditures. As with other diseases, MEPS was used to calculate the PRC for colorectal cancer patients who generated screening and related expenditures. PRC with colonoscopies (adhering to national screening guidelines) steadily increased from 459,300 in 2005 to 556,800 in 2010. Marketing campaigns aimed at increasing prevention awareness among both providers and patients may have spurred adoption of this practice.

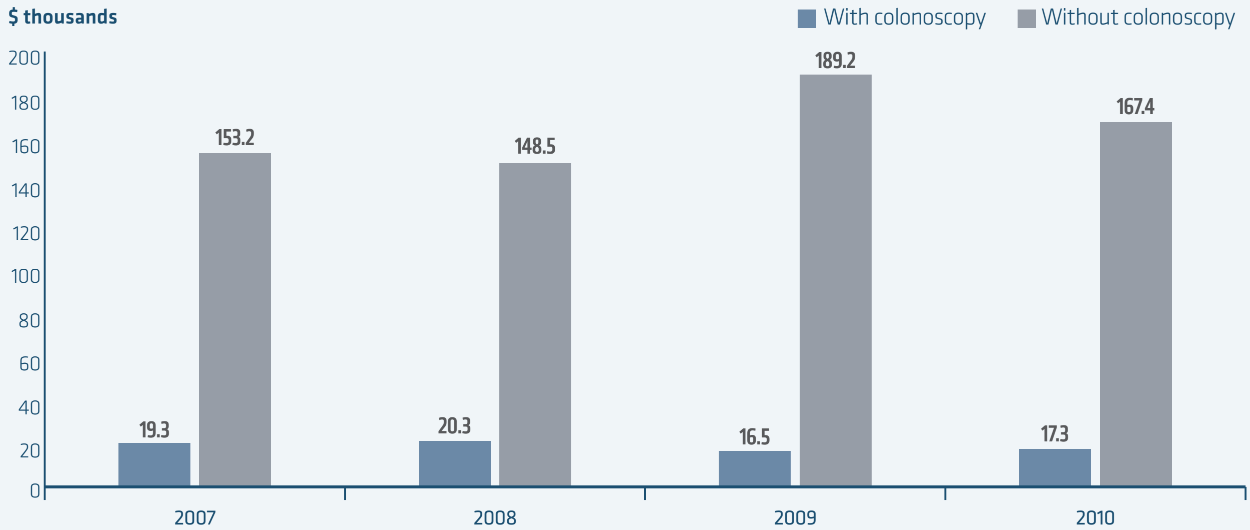
Overall expenditures per PRC were lower for those who had followed screening guidelines compared to those who had not. This may be because screening catches cancer at an earlier stage, facilitating better outcomes. In 2010, expenditures per PRC were $4,731 for patients with colorectal cancer, about $1,000 less than those unscreened.

Productivity loss among colorectal cancer patients in the workforce is substantial, and labor market participation is low. On average per annum (2008-2010), the indirect impact of colorectal cancer was $22.9 billion. A person affected by the disease who had a screening added $96,399 to GDP annually compared to the non-screened patient population. Detection at an early stage along with improved treatments lead to better outcomes, which broadly lower absenteeism and presenteeism.

While the historical analysis included patients with colorectal cancer with and without colonoscopy, the costs and effects of widespread colonoscopies on the healthy population must also be considered as a consequence of increased technology adoption. In 2010, screening prevented 554,000 people from developing colorectal cancer and saved $12 billion in health-care expenditures while increasing GDP. However, an additional $17.7 billion was spent on screening the healthy population, who would not obtain the disease.

SUMMARY CHART: COLORECTAL CANCER

Economic benefit/loss associated with colonoscopy, 2007-2010*
Per person affected



* Includes treatment expenditures and indirect impacts.

AVERAGE ANNUAL ECONOMIC BURDEN, 2008-2010 ($)	
With colonoscopy (treatment and prevention)	18,030.1
Without colonoscopy	168,394.9
Average savings	150,364.9

Economic impact per person affected* ($)

YEAR	WITH COLONOSCOPY				WITHOUT COLONOSCOPY			TOTAL			
	Treatment							Detection			
	Treatment expenditures	Indirect impact**	Total	Prevention	Treatment expenditures	Indirect impact**	Total	Treatment expenditures	Indirect impact**	Total	Prevention
2005	11,871.1	64,022.8	75,893.9	-	12,280.6	100,968.8	113,249.4	11,911.4	72,858.2	84,769.6	-
2010	4,730.6	61,156.4	65,887.1	-48,584.8	5,893.2	161,554.6	167,447.7	4,843.1	85,165.9	90,009.0	-48,584.8
Average (2008-2010)	8,578.8	62,514.1	71,093.0	-53,062.9	9,482.3	158,912.7	168,394.9	8,723.6	85,567.1	94,290.8	-53,062.9

* Person affected includes population reporting a condition, employed population reporting a condition, and employed caregivers by condition.
** A lower indirect impact value implies a greater contribution to the economy.

Total economic burden of prevention and treatment ($ millions)

YEAR	WITH COLONOSCOPY					WITHOUT COLONOSCOPY			TOTAL				
	Treatment								Treatment				
	Treatment expenditures	Indirect impact	Diagnostics for healthy population	Total	**Prevention**	Treatment expenditures	Indirect impact	Total	Treatment expenditures	Indirect impact	Diagnostics for healthy population	Total	**Prevention**
2005	5,452.6	10,836.7	14,566.3	30,855.6	-	615.4	5,393.0	6,008.4	6,068.0	16,229.7	14,566.3	36,864.0	-
2010	2,634.2	15,324.0	17,659.3	35,617.5	-12,017.9	351.5	12,761.5	13,113.0	2,985.7	28,085.5	17,659.3	48,730.5	-12,017.9
Average (2008-2010)	4,711.2	12,557.2	17,445.1	34,713.4	-12,218.3	1,149.1	10,294.7	11,443.8	5,860.3	22,851.8	17,445.1	46,157.2	-12,218.3

Population affected by prevention and treatment (thousands)

YEAR	TREATMENT WITH COLONOSCOPY			NUMBER OF CASES PREVENTED	WITHOUT COLONOSCOPY			OVERALL TREATMENT		
	PRC*	EPRC**	ECC***		PRC*	EPRC**	ECC***	PRC*	EPRC**	ECC***
2005	459.3	226.4	36.7	-	50.1	71.2	11.5	509.4	297.5	48.3
2010	556.8	339.5	59.3	554.4	59.6	106.7	18.6	616.5	446.2	77.9

* Population reporting a condition.

** Employed population reporting a condition.

*** Employed caregivers by condition.

Expenditures per PRC by site of service, 2010 ($)

	OFFICE BASED	OUTPATIENT	INPATIENT	PRESCRIPTION	HOME HEALTH	TOTAL
Overall colorectal cancer	1,124.9	7,068.1	20,877.8	532.5	8,324.0	4,843.1
With colonoscopy	934.5	7,198.5	24,281.6	605.5	8,324.0	4,730.6
Without colonoscopy	2,546.9	677.7	13,043.9	40.7	-	5,893.2

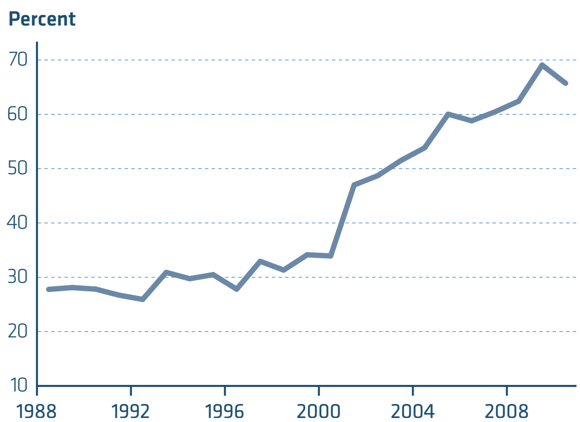
ECONOMIC IMPACT PROJECTIONS AND MEDICAL TECHNOLOGY

Medical device and technology advances exert economic impact in two primary ways: the expansion effect and the substitution effect. Technology helps in detection and makes more patients suitable for treatment, giving them a better chance of survival. As a result, the patient population increases, creating the expansion effect. That leads to an increase in aggregate health-care costs, although the average cost might fall due to fewer visits to expensive sites of service such as emergency rooms and hospitalization. It also expands the workforce, resulting in economic growth. The substitution effect, on the other hand, refers to newer technology supplanting older forms and influencing the unit cost of treatment.

As an illustration, let's consider colorectal cancer screening by sigmoidoscopy/colonoscopy. With improved technology for detecting polyps and malignant growths at earlier stages, along with greater efficacy and safety, colorectal screening in the U.S. has grown tremendously in the past two decades. As screening increased, incidence rates went up at first. However, the disease was detected earlier in many cases, likely improving overall survival rates.

Figure 4

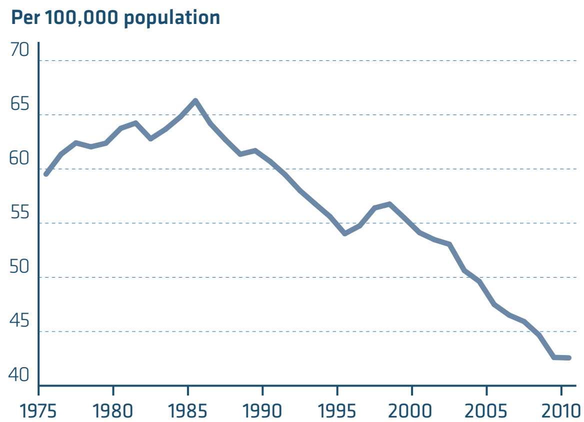
Colorectal cancer screening as proportion of population 50+



Sources: Centers for Disease Control and Prevention, Milken Institute.

Figure 5

Colorectal cancer incidence rates, age-adjusted



Source: National Cancer Institute.

Incidence rates for colorectal cancer rose modestly from the mid-1970s through the mid-1980s as colonoscopies identified more polyps and tumors, then those rates fell and have been declining ever since. Coinciding with the drop in incidence rates, mortality has been declining since 1980, with the trend accelerating since 1999.[22] Thus, the initial rise in the incidence of colorectal cancer, or expansion effect, is attributed to early detection and increased survival.

22. National Cancer Institute.

Moreover, improved technology is regularly substituted for older methods in treating established patients. The unit cost of new technologies may be higher or lower than those they replace. However, along with fostering health improvements, technology can curtail visits to expensive sites of service, such as hospitals and emergency rooms. In the case of heart attacks, the chances of survival depend on the successful opening of blocked arteries. In the late 1960s, bypass surgery, a major open-heart procedure, saved lives by grafting an artery or vein around the occluded coronary artery. An improved technology known as angioplasty was developed in the late 1970s, involving the use of a balloon catheter to break up the blockage.

Since the mid-1990s, angioplasty has increasingly incorporated the insertion of stents—small mesh tubes that hold the coronary artery open—in the area of the blockage. Later generations of stents have reduced mortality and improved overall outcomes. Further, as the technology has become less invasive, quality adjusted life year (QALY) has improved for heart disease patients. In fact, a study points out that approximately 70 percent of survival improvement is the result of progress in technology, with the remainder stemming from changes in risk factors such as smoking.[23]

With technology expanding the patient population due to early detection and better survival outcomes, it also increases aggregate treatment expenditures, even assuming constant per-patient expenses. On the other hand, increased survival means more people in the workforce. Less invasive technology may ease average treatment expenditures (depending on the disease), perhaps offsetting some of the increases discussed above. Further, this factor helps worker productivity, supporting the labor market.

Knowing how medical innovations affect future treatment expenditures is fundamental to making prudent investment decisions in the field. It's also essential to understand how a particular technology contributes to or detracts from the GDP. One objective of this report is to project the overall economic impact associated with medical technologies through 2035. Further, our report provides data-driven evidence for stakeholders to discern the ties between innovations and disease-specific economics. With this in mind, we simulate three future innovation scenarios—which influence the utilization and diffusion of medical technology—and project the economic impact associated with each.

1) Continued incentives (baseline): In this scenario, the growth in medical innovation remains at the same historical pace, along with the growth rate of its use.

2) Increased incentives (optimistic): Medical innovation advances at a higher than historical rate.

3) Decreased incentives (pessimistic): Medical innovation progresses at a lower than historical rate.

23. David M. Cutler. "The Lifetime Costs and Benefits of Medical Technology," *NBER Working Paper Series* (2007).

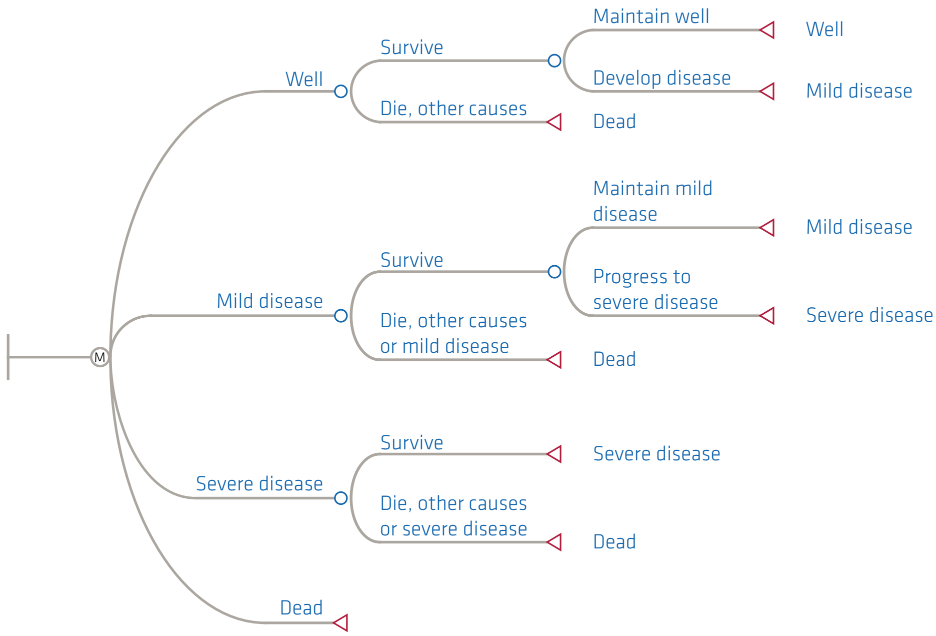
Projection of PRC

To estimate future treatment expenditures and indirect impact, we first projected the PRC and integrated other relevant data. An appropriate model for the projection of PRC associated with disease-specific technology involves a range of decision-making stages and options. We used decision trees that illustrate health processes over time to create disease-specific Markov models.

To elaborate, let's study the effect of disease A on a hypothetical cohort of 100 people in 2010 using a Markov model. Any individual can be well or have disease A. If they suffer from disease A, they can have either the mild or severe form. Suppose 50 are well, 25 have a mild form of the disease, and 25 have the severe form. Every year, of course, people in the cohort can remain in the same health state, transition into a different one, or die, and the likelihood of each event can be estimated.

Figure 6

A basic Markov decision tree



That includes the 50 individuals who are well. Assuming a 2 percent probability of death, one of them will die by the next year. Assuming a 10 percent chance of getting mild disease, about five of the remaining 49 people would acquire the ailment. The rest of the 44 people will remain well for the next year. Other branches of the decision tree such as "mild disease" or "severe disease" will follow a similar logic.

This simplified model serves as a basis for even the most complex Markov model. Ours are based on the biological progression and treatment patterns for the diseases we examined. The probabilities of the events in our models were derived from the scientific literature and MEPS data.

Projection of treatment and prevention expenditures

The projected PRC was multiplied by expenditures per PRC (from MEPS) for each health state to estimate the projected expenditure for each health state. Expenditures for each health state were aggregated to calculate total projected expenditures for each disease. We use MEPS expenditures per PRC because they incorporate costs for six sites of service related to the assessed diseases. However, we could not incorporate costs for associated diseases, such as diabetes' role as a risk factor for heart disease.

For the increased incentives scenario, the annual reduction in expenditures per PRC is applied to diabetes, heart disease, and musculoskeletal disease to account for reductions in complications and use of expensive sites of service associated with better technology use. Similarly, an annual percentage increase in expenditures per PRC is applied to the decreased incentives scenario. An annual percentage change is not assumed for colorectal cancer as it is for the other diseases because the duration and intensity of treatment vary widely depending on the stage of the disease.

With risk factors such as aging and obesity projected to increase with time, the PRC is expected to suffer more severe disease. Without improvements in medical technology, patients will make more ER visits, have more frequent complications, and be more expensive to treat on average. The difference among economic impact scenarios demonstrates benefits and losses associated with investing in technology innovation.

The following table shows the projected treatment expenditures associated with innovation through 2035, in 2010 dollars using a discount rate of 3 percent.

Table 6

Projected treatment expenditures by disease

2010-2035 ($ billions*)

				ABSOLUTE DIFFERENCE	
	Continued incentives	Increased incentives	Decreased incentives	Continued-increased	Continued-decreased
Diabetes	1,622.4	1,602.8	1,631.7	19.6	-9.3
Heart disease	2,663.6	2,628.2	2,853.1	35.4	-189.5
Musculoskeletal disease	1,983.0	1,952.4	2,014.6	30.6	-31.5
Colorectal cancer	214.7	204.1	220.7	10.6	-6.0
Colorectal cancer prevented	-120.5	-137.2	-109.2	16.7	-11.2

* In 2010 dollars.

Sources: Medical Expenditure Panel Survey, Milken Institute.

In 2010 dollars, improved technology (following the increased incentives scenario compared to continued incentives) for insulin pumps can save the health-care system $19.6 billion. However, lower incentives in device technology would increase costs by $9.3 billion. For heart and musculoskeletal diseases, the gain to the health-care system is $35.4 billion and $30.6 billion, respectively. Decreased innovation would raise care expenditures by $189.5 billion for heart disease and $31.5 billion for musculoskeletal disease. For colorectal cancer, the savings associated with innovation stem from early detection and prevention. Better technology can detect polyps earlier and remove them, preventing cancer. Aggregate savings to the health-care system due to better diagnostics are $27.3 billion, whereas lowered incentives to screen will increase the incidence of cancer, adding $17.2 billion in expenditures.

Projection of indirect impact (foregone GDP)

Improved technology also has profound labor market implications. Due to early detection, prevention, and higher quality of life, work outcomes often greatly improve for people affected by these diseases. For a comprehensive analysis, we also computed the gain and loss to GDP associated with each technology incentives scenario.

We estimated the population reporting a condition for each disease through 2035. Further, projected PRC and U.S. employment data were used to calculate employed population reporting a condition projections. Projections of employed caregivers by condition are proportional to the EPRC estimations. Similar to the historical trend methodology, a GDP-based approach was used to estimate relevant indirect impact. Except for colorectal cancer, the indirect impact in the increased incentives scenario was adjusted further downward (assumptions are similar to those used in the historical methodology) due to improved labor market outcomes. The indirect impact for decreased incentives was adjusted upward due to a projected increase in the severity of chronic disease and negative labor market effects. We did not adjust colorectal cancer's indirect impact due to variation in the severity and length of the disease.

The cumulative GDP gain in 2010 dollars associated with accelerated technology innovations in the increased incentives scenario (compared to continued incentives) is $205.8 billion for diabetes, $773.7 billion for heart disease, and $250.4 billion for musculoskeletal diseases. The contribution to GDP from colorectal cancer patients was $109 billion, and because screening also spares many people from cancer, $41.8 billion more was added to the economy.

However, considering the decreased incentives scenario (compared to continued incentives), diabetes reduced GDP by $91.8 billion. Similarly, decreased incentives lead to a GDP loss of $1.4 trillion for heart disease and $277.2 billion for musculoskeletal disease. Treatment and prevention of colorectal cancer reduced GDP by $94.5 billion.

Table 7

Projected foregone GDP by disease

2010-2035 ($ billions*)

	Continued incentives	Increased incentives	Decreased incentives	ABSOLUTE DIFFERENCE Continued-increased	Continued-decreased
Diabetes	10,720.2	10,514.4	10,812.0	205.8	-91.8
Heart disease	5,073.7	4,300.0	6,435.5	773.7	-1,361.8
Musculoskeletal disease	22,690.5	22,440.0	22,967.7	250.4	-277.2
Colorectal cancer	1,790.5	1,681.5	1,851.9	109.0	-61.5
Colorectal cancer prevented	-331.5	-373.3	-298.5	41.8	-33.0

* In 2010 dollars.

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

The following subsections elaborate on the methods and other findings for each disease. For further information, please see the Methodology section of this report available at milkeninstitute.org.

DIABETES

We created a Markov model that assumes a "well" initial state for a cohort of individuals (which includes all undiagnosed diabetics in the U.S.) and follows them over 25 years. Many are later diagnosed with diabetes and progress through the disease. As noted earlier, there are two types of diabetes. Type 1, often referred to as juvenile diabetes, is an autoimmune disease with an earlier onset. Type 2 is more common, with obesity, aging, and high cholesterol as risk factors. Type 1 diabetes generally requires insulin use upon diagnosis, and type 2 diabetes requires insulin treatment after reaching a certain level of severity. For the purposes of this model, the two types of diabetes were combined, distinguishing instead between insulin dependent and non-insulin dependent diabetes.

With the progression of the disease, many non-insulin dependent diabetics transition into insulin dependence. Injections and pumps are the most common modes of administering insulin. Those using injections can begin to use pumps at a certain point in this framework; however, once pump use is initiated, it was assumed to continue throughout the patient's life.

While anyone in the model is subject to mortality risk, diabetes poses an increased risk of death. Among diabetics, non-insulin dependent patients have a less severe form and are less subject to complications and hypoglycemic events. Therefore, their risk of death is lower than insulin-dependent diabetics. Pumps reduce the likelihood of such events by maintaining a "healthy" blood sugar level, resulting in a lower mortality risk for users than for patients who inject insulin.

The main difference among the scenarios is the probabilities associated with the initiation of pump use and the consequences of better disease management. It is assumed that improved technology will expand the population suitable for using pumps and that a higher proportion will adopt the technology. The opposite is true in the decreased incentives scenario. As such, the PRC for increased incentives assumed a higher annual takeup rate for insulin pumps, twice that of continued incentives, and the PRC for decreased incentives assumed a lower rate of use.

Further, an annual percentage reduction was applied to the per-PRC expenditures and the indirect impact due to improved disease management in the increased incentives scenario. Similarly, a percentage increase in those expenditures and indirect impact was applied to the decreased incentives scenario for the opposite reason.

Analysis of the model over a 25-year period reveals that the population reporting a condition for diabetes was 22 million in 2010, which is projected to rise to 55.6 million by 2035 in the continued incentives scenario. This dramatic increase can be attributed to the rising average age of Americans and the widening prevalence of obesity and high cholesterol. The overall diabetes PRC increases slightly in the increased incentives scenario due to the lower mortality risk associated with increasing pump use.

The increased incentives scenario is projected to have approximately 50,000 more diabetic PRC in 2035 compared to continued incentives, while decreased incentives projects 30,000 fewer. The primary change in PRC comes from changes in the population of pump users among the scenarios, representing a relatively small proportion of the overall PRC. The larger diabetic PRC in the increased incentives scenario arises from a reduction in deaths by virtue of improved care. Under decreased incentives, the narrower PRC stems from the larger number of diabetes deaths.

Compared to continued incentives, the increased incentives scenario expands insulin pump use robustly by 2035. Similarly, the decreased incentives scenario has about half the number of pump users associated with continued incentives. This follows the assumptions about technology adoption in each projection. The PRC of non-insulin dependent diabetics also remains constant across scenarios and accounts for the largest portion of diabetics. The insulin dependent category has a lower PRC because it is typically associated with the rarer auto-immune-related type 1 disease and more severe type 2.

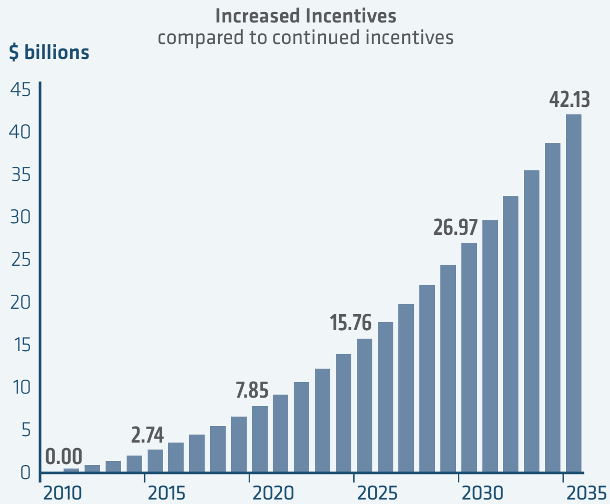
Diabetes direct treatment expenditures were $51 billion in 2010. The continued incentives scenario increases that to $131.4 billion in 2035. (See Projections: Diabetes.) Expenditures over 25 years are $19.6 billion less for the increased incentives scenario and $9.3 billion more for the decreased incentives scenario compared to the sum for continued incentives in 2010 dollars. Although overall diabetes PRC rises in the increased incentives scenario, total expenditures decrease due to the lower average expenditures per PRC associated with insulin pump use. Similarly, overall expenditures grow in the decreased incentives scenario due to larger expenditures per PRC.

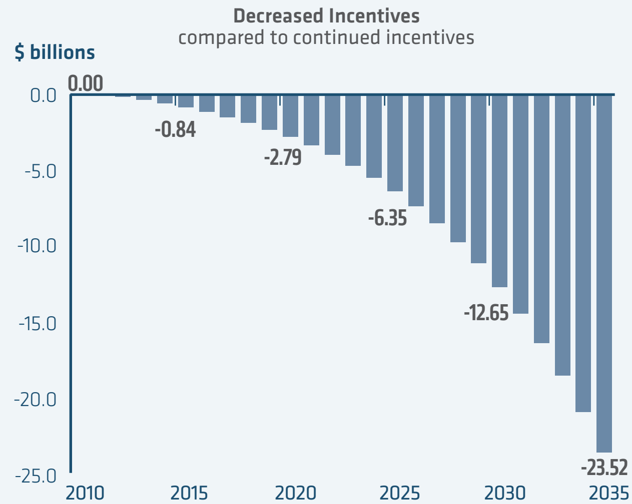
Under the continued incentives assumption that medical technology applied to diabetes will steadily advance, the total indirect impact will leap from $208.8 billion in 2010 to $1.2 trillion in 2035. With the technology assumptions in the increased incentives scenario, indirect impact will also continue to increase through 2035. However, compared to the continued incentives scenario, it will produce cumulative savings of $354.4 billion. In 2010 dollars, that amounts to $205.8 billion.

These savings may be a result of better disease management as well as technology adoption, both of which can make for a healthier and more productive workforce. Compared to the continued incentives scenario, decreasing incentives for medical technology contributes to $162.8 billion in productivity loss, or $91.8 billion in today’s dollars. Worse labor market outcomes may be attributed to more severe disease in the employed population and a relative lack of treatment options due to weaker innovation.

PROJECTIONS: DIABETES

Projected savings†: Diabetes





Economic impact of diabetes, 2010-2035 ($ billions)†

compared to continued incentives

CUMULATIVE IMPACT	INCREASED INCENTIVES	DECREASED INCENTIVES
Direct expenditures	32.5	-15.3
Gain/loss to the economy	354.4	-162.8
Due to survival	0.354	0.081
Additional gain/loss	354.1	-162.8
Total	**387.0**	**-178.1**

Projected diabetes population affected (millions)

	PRC*			ABSOLUTE DIFFERENCE		EPRC**			ABSOLUTE DIFFERENCE		ECC***			ABSOLUTE DIFFERENCE	
Year	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased
2010	21.98	21.98	21.98	0.00	0.00	8.87	8.87	8.87	0.00	0.00	1.55	1.55	1.55	0.000	0.000
2035	55.59	55.65	55.57	-0.05	0.03	22.66	22.68	22.65	-0.02	0.01	3.958	3.962	3.956	-0.004	0.002

* Population reporting a condition.

** Employed population reporting a condition.

*** Employed caregivers by condition.

Projected economic impact of diabetes ($ billions) †

	TREATMENT EXPENDITURES			ABSOLUTE DIFFERENCE		INDIRECT IMPACT			ABSOLUTE DIFFERENCE	
Year	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased
2010	51.0	51.0	51.0	0.0	0.0	208.8	208.8	208.8	0.0	0.0
2035	131.4	128.6	132.7	2.9	-1.3	1,212.9	1,173.6	1,235.1	39.3	-22.2
Cumulative (2010-2035)	2,430.8	2,398.3	2,446.2	32.5	-15.3	16,832.0	16,477.6	16,994.8	354.4	-162.8
In 2010 dollars (2010-2035)	1,622.4	1,602.8	1,631.7	19.6	-9.3	10,720.2	10,514.4	10,812.0	205.8	-91.8

† Screening expenditures for the healthy population not included.

HEART DISEASE

Heart disease involves narrowing of the blood vessels around the heart, reducing blood flow and oxygen supply. The consequences can be serious, including heart attack or cardiac arrest. The disease process was modeled in a Markov model first, followed by the effects of technology. Echocardiogram, electrocardiogram (EKG), and chest X-ray were analyzed as diagnostic tools, and angioplasty and pacemaker insertion as surgical treatments.

The incidence of heart disease is affected by a variety of risk factors, including age, smoking status, diabetes, high cholesterol, obesity, and gender. For the purpose of this model, the risks included were aging and obesity,[24] two of the most significant conditions affecting the development of the disease. With these factors projected to increase over time in the United States, we incorporated that likelihood into the model.

Incidence was calculated from Framingham risk prediction models for coronary heart disease using data from the Centers for Disease Control and Prevention and the National Health and Nutrition Examination Survey. The influence of other risks or variations in the trajectory of incidence is assessed in sensitivity analysis.

Heart disease can present with symptoms, primarily angina pectoris or chest pain, but oftentimes it is present without. Therefore there is an undiagnosed heart disease health state within the model. If disease is identified, depending on the probability of screening or identification of symptoms, a clinician can prescribe medication and lifestyle changes that can slow or stop its progression. Undiagnosed, untreated heart disease can pose high risk for acute side effects. Improvements in diagnostic testing technologies such as EKG, echocardiogram, or chest X-ray may improve a clinician's ability to identify and subsequently treat the condition, so we changed the sensitivity of diagnostic testing among incentive scenarios.

24. Smoking was not included because smoking initiation has been decreasing in the United States and might not play a significant role in projected incidence.

As the disease increases in severity, it raises the probability of acute coronary events such as myocardial infarction (heart attack) and cardiac arrest, both of which can be fatal. It was assumed that heart disease would be diagnosed by symptom identification after such an occurrence. Acute coronary events are expensive, often requiring emergency room and inpatient care, and potentially surgery. Surgery can also be planned (if heart disease is diagnosed) to prevent such an occurrence. While surgery can curb the future consequences of the disease and reduce chance of restenosis (blockage of the artery), the procedure itself involves the risk of death. However, with improvements in technology, the risk of death declines, which is also incorporated into the model.

Over 25 years, the decreased incentives scenario results in a $316.4 billion expansion in treatment expenditures for heart disease, or $189.5 billion in 2010 dollars.

The main differences among scenarios are the likelihood of undergoing planned surgery and diagnostics, the risk of death from surgery, overall heart disease death rates, the likelihood of early detection using diagnostics, and improved treatment. In the increased incentives scenario, there is more innovation and diffusion of technology through the medical field. Therefore, higher rates of adoption of both diagnostic and therapeutic technology was assumed. Similarly, lower rates of technology use were assumed in the decreased incentives scenario.

Because the technology was assumed to improve with more innovation in the increased incentives scenario, the accuracy of technology and its ability to inform proper treatment methods were assumed to improve. With better technology, the risk of death tied to surgery was assumed to decrease. Without such improvements, the risk of death would not decrease.

Changes in expenditures per PRC and indirect impact per person affected were also changed across the projections. They were adjusted downward in the increased incentives scenario to account for reduced complications and increased productivity. Similarly, expenditures per PRC and indirect impact per person affected rose to address a lack of adequate treatment options for more severe cases.

The population reporting a condition for heart disease was calculated at 23.1 million in 2010, projected to increase approximately 68 percent to 38.9 million in 2035. (See Projections: Heart Disease.) The increased incentives scenario reveals a rise in PRC over time, totaling 41.8 million in 2035, while decreased incentives reveals a PRC of 38.3 million. Increased adoption of testing technology allows more people to be diagnosed with the disease. Combined with surgeries that potentially prevent fatal coronary events, an increased PRC reveals greater access and higher quality of care. Fewer PRCs associated with the decreased incentives scenario corresponds to an increase in undiagnosed disease and incidence of death.

Heart disease treatment expenditures totaled $106.9 billion in 2010 and will increase to $180.2 billion in 2035 for the continued incentives scenario. Increased incentives will reduce aggregate expenditures $81.4 billion more than the continued incentives scenario over 25 years, equivalent to $35.4 billion in 2010 dollars. Initially the increased incentives scenario is more expensive due to a larger population of diagnosed patients obtaining treatment and reduction in mortality. However, the expenditures per PRC shrink, contributing to a cumulative savings in the 25-year period. The rising expenditures associated with the increased incentives scenario correspond to an increase in proper treatment and longer lives, both positive outcomes not directly measured in this study.

The decreased incentives scenario sees higher costs than the continued incentives scenario because, while fewer patients are obtaining treatment and fewer are alive, we assume an increase in per-PRC expenditures. Over 25 years, the decreased incentives scenario results in a $316.4 billion expansion in treatment expenditures, or $189.5 billion in 2010 dollars.

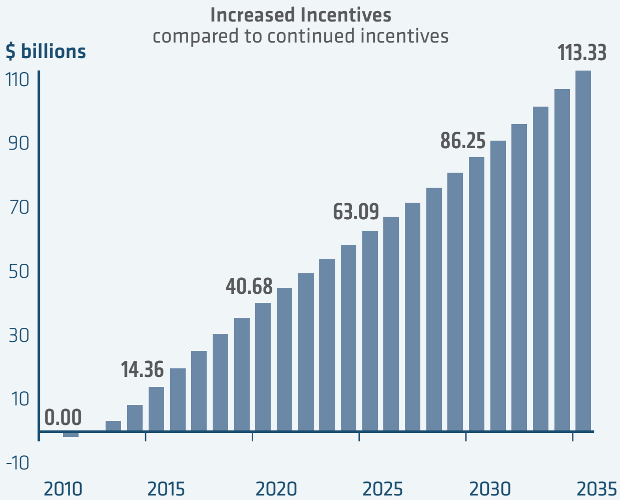
Because some of the technologies assessed include diagnostic tests, the costs of screening the healthy population must also be considered. In the continued incentives scenario, such screening costs the health-care system $238.5 billion cumulatively over 25 years. Higher screening rates in the increased incentives scenario result in an additional $21.2 billion expenditure, while the decreased incentives scenario saves $5.2 billion. This additional expenditure was not included in the economic impact estimates because these people do not have the examined diseases.

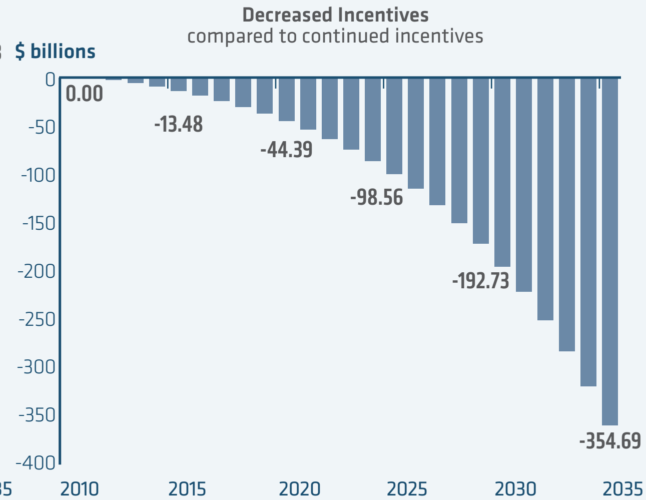
Tied to the changes in PRC, the indirect impact for heart disease will be substantial over the 25-year period and is expected to more than double under all scenarios. With the introduction of new technology under increased incentives, indirect impact will be lower amid an expansion of the labor force (due to survival) and productivity tied to improved quality of life. This will generate a cumulative $1.3 trillion gain in GDP over 25 years, $44.2 billion of which can be attributed to improved survival. This is equivalent to a $773.7 billion gain in 2010 dollars.

Decreased incentives will result in a GDP loss of $2.4 trillion, or $1.4 trillion in 2010 dollars, due to drained productivity and a decreased EPRC as more people die or exit the labor market.

PROJECTIONS: HEART DISEASE

Projected savings†: Heart disease





Economic impact of heart disease, 2010-2035 ($ billions)†

compared to continued incentives

CUMULATIVE IMPACT	INCREASED INCENTIVES	DECREASED INCENTIVES
Direct expenditures	81.4	-316.4
Gain/loss to the economy	1,263.0	-2,409.9
Due to survival	44.2	77.1
Additional gain/loss	1,218.8	-2,487.0
Total	**1,344.4**	**-2,726.4**

Projected heart disease population affected (millions)

	PRC*			ABSOLUTE DIFFERENCE		EPRC**			ABSOLUTE DIFFERENCE		ECC***			ABSOLUTE DIFFERENCE	
Year	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased
2010	23.1	23.1	23.1	0.0	0.0	11.5	11.5	11.5	0.0	0.0	2.0	2.0	2.0	0.0	0.0
2035	38.9	41.8	38.3	-2.9	0.6	19.6	21.0	19.3	-1.5	0.3	3.4	3.7	3.4	-0.3	0.1

* Population reporting a condition.

** Employed population reporting a condition.

*** Employed caregivers by condition.

Projected economic impact of heart disease ($ billions)†

Year	TREATMENT EXPENDITURES: Continued incentives	Increased incentives	Decreased incentives	ABSOLUTE DIFFERENCE: Continued - increased	Continued - decreased	INDIRECT IMPACT: Continued incentives	Increased incentives	Decreased incentives	ABSOLUTE DIFFERENCE: Continued - increased	Continued - decreased
2010	106.9	106.9	106.9	0.0	0.0	130.0	130.0	130.0	0.0	0.0
2035	180.2	166.5	209.1	13.7	-28.9	508.0	408.4	833.7	99.6	-325.7
Cumulative (2010-2035)	3,876.0	3,794.6	4,192.5	81.4	-316.4	7,781.5	6,518.5	10,191.5	1,263.0	-2,409.9
In 2010 dollars (2010-2035)	2,663.6	2,628.2	2,853.1	35.4	-189.5	5,073.7	4,300.0	6,435.5	773.7	-1,361.8

Projected expenditures on healthy population screening/diagnostics

Year	HEALTHY PEOPLE SCREENED (MILLIONS): Continued incentives	Increased incentives	Decreased incentives	SCREENING EXPENDITURES ($ BILLIONS): Continued incentives	Increased incentives	Decreased incentives
2010	21.3	21.3	21.3	6.5	6.5	6.5
2035	22.7	26.4	21.8	11.9	13.9	11.4
Cumulative (2010-2035)	587.1	634.2	575.2	238.5	259.7	233.3

†Screening expenditures for the healthy population not included.

MUSCULOSKELETAL DISEASE

Musculoskeletal disease encompasses a range of conditions. In general, it is a chronic, progressive disorder of the joints that affects quality of life and is associated with a small increase in risk of death. The musculoskeletal disease Markov model was created to assess the economic effects of device innovation in medical technology. Specifically evaluated were MRI for diagnosis and joint replacement surgery as a treatment.

Rheumatoid and osteoarthritis were used as the primary proxies for the category during the modeling process. They are assumed to begin as mild disease and progress to more severe, debilitating disease that may require more drastic surgical treatment or may render a patient disabled.

The average of the incidence rates for rheumatoid and osteoarthritis was matched with historic MEPS data and used as the incidence for musculoskeletal disease. Since musculoskeletal disease becomes more common with age and joints become more strained with higher body weight, aging and obesity were used as risk factors for increasing incidence. MRI was assessed as a potential diagnostic tool and proper identification of the disease was assumed to lead to treatment, be it a medical intervention or a lifestyle modification to reduce joint stress.

Once the disease progresses to a severe stage, a patient might require surgery. Such a procedure can succeed in relieving symptoms or may require a revision. In case of an unsuccessful revision surgery, treatment failure is assumed.

The main differences among the incentive scenarios are the likelihood of obtaining a diagnostic test and its efficacy in identifying disease, the likelihood of having surgery, the relative risk of progression from mild to severe disease with treatment, the revision rate (likelihood of requiring additional surgery) and surgical mortality rate, and the relative risk of death due to disease. We use historical trends from MEPS to inform the likelihood of diagnostic testing and surgery, and reviewed the literature to assign value to other variables.

In the increased incentives scenario, rising innovation is assumed to result in better, more accurate diagnostic and surgical technology. We project a higher rate of increase of technology use over time compared to the continued incentives scenario. As diagnostic accuracy rises, treatment improves due to better diagnostics and the mortality and revision rates decline. With improved technology reducing long-term complications and improving the ability to perform everyday living activities, the death rate due to musculoskeletal disease eases slightly in the increased incentives scenario. Under decreased incentives, technology is assumed to develop more slowly. The accuracy of diagnostic tools and the surgical mortality and revision rates all remain the same. We project a lower rate of increase for technology use compared to the continued incentives scenario. Because technology improves slowly as disease severity worsens, the effectiveness of current treatments declines and the risk of death from musculoskeletal disease slightly rises.

Musculoskeletal disease had a PRC of 41.1 million in 2010, which increases to 66.6 million by 2035 in the continued incentives scenario, primarily due to aging and obesity. (See Projections: Musculoskeletal Disease.) Increased incentives yields a slightly greater PRC of 67.3 million. That scenario restrains the disease from progressing in severity, which is associated with slightly higher mortality. A reduction in severity lowers death rates but increases overall PRC.

The PRC for musculoskeletal disease does not appear to vary widely among the incentive scenarios because the illness does not greatly increase risk of death. It does affect quality of life, however, and if PRC were adjusted to account for that, the differences would be more apparent. Additionally, the increased incentives scenario halves the number of people with undiagnosed disease or deprived of proper treatment by 2035. This represents a substantial improvement in care.

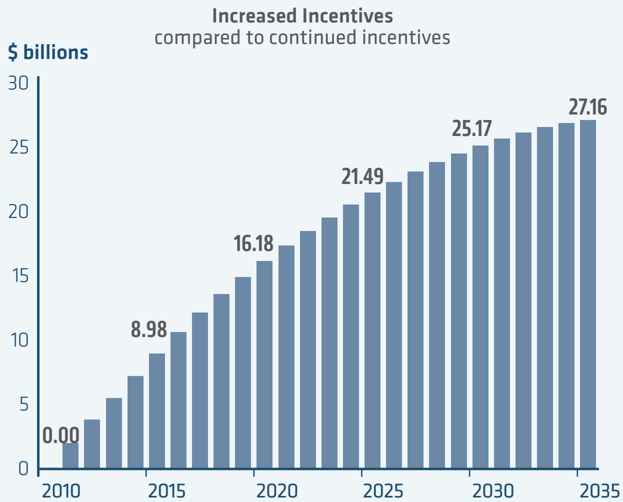
Total expenditures for musculoskeletal disease were $83.5 billion in 2010, increasing to $135.4 billion in 2035 in the continued incentives scenario. Expenditures for increased incentives are $131.3 billion by 2035, saving a cumulative $50.3 billion compared to continued incentives, or $30.6 billion in 2010 dollars. Because the PRC is higher compared to the increased incentives scenario, the savings mainly arise from the reduction in annual expenditures per PRC associated with improved technology. The decreased incentives projection produces a $52 billion increase in cumulative expenditures over 25 years due to the higher treatment costs associated with more severe disease. This equals $31.5 billion in 2010 dollars.

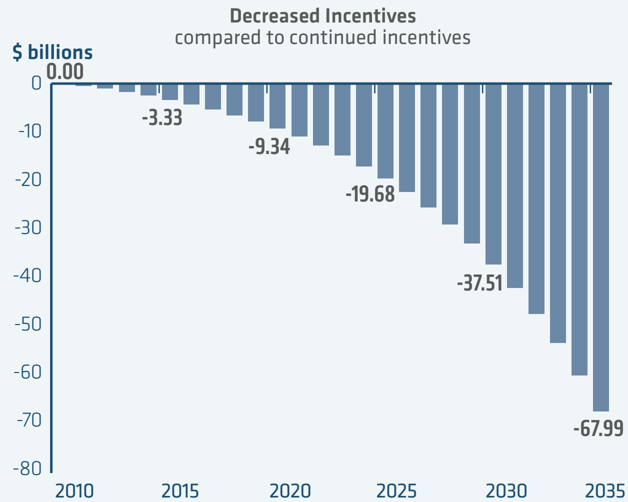
The more frequent use of MRI as a diagnostic technique will increase the likelihood that a healthy person is screened, incurring the cost of use. In 2010, $8.7 billion was spent on diagnostic MRI for the healthy population. Using rates of diagnostic testing from the model, the continued incentives scenario results in a cumulative burden of $375.6 billion over 25 years. Increasing diagnostic use in the increased incentives scenario results in $473.6 billion, while decreased incentives creates a cumulative burden of $326.6 billion for screening the healthy population.

Indirect impact for the EPRC and caregivers was also examined. The savings to GDP involving musculoskeletal disease will be substantial over the 25-year period. While the indirect impact will grow under all scenarios, progress in technology and improved survival under the increased incentives scenario will expand the workforce and reduce indirect impact. These advances will improve quality of life, which will also raise labor market participation and productivity. Cumulatively, GDP will benefit by $393.9 billion, or $250.4 billion in 2010 dollars.

PROJECTIONS: MUSCULOSKELETAL DISEASE

Projected savings†: Musculoskeletal disease





Economic impact of musculoskeletal disease, 2010-2035 ($ billions)†

compared to continued incentives

CUMULATIVE IMPACT	INCREASED INCENTIVES	DECREASED INCENTIVES
Direct expenditures	50.3	-52.0
Gain/loss to the economy	393.9	-486.4
Due to survival	4.3	6.8
Additional gain/loss	389.6	-493.2
Total	444.2	-538.5

Projected musculoskeletal disease population affected (millions)

	PRC*			ABSOLUTE DIFFERENCE		EPRC**			ABSOLUTE DIFFERENCE		ECC***			ABSOLUTE DIFFERENCE	
Year	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased
2010	41.1	41.1	41.1	0.0	0.0	25.1	25.1	25.1	0.0	0.0	4.4	4.4	4.4	0.0	0.0
2035	66.6	67.3	65.7	-0.7	0.9	41.1	41.6	40.5	-0.4	0.6	7.2	7.3	7.1	-0.1	0.1

* Population reporting a condition.

** Employed population reporting a condition.

*** Employed caregivers by condition.

Projected economic impact of musculoskeletal disease ($ billions)†

	TREATMENT EXPENDITURES			ABSOLUTE DIFFERENCE		INDIRECT IMPACT			ABSOLUTE DIFFERENCE	
Year	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased	Continued incentives	Increased incentives	Decreased incentives	Continued - increased	Continued - decreased
2010	83.5	83.5	83.5	0.0	0.0	609.0	609.0	609.0	0.0	0.0
2035	135.4	131.3	139.8	4.1	-4.4	2,289.4	2,266.3	2,353.0	23.1	-63.6
Cumulative (2010-2035)	2,889.7	2,839.4	2,941.7	50.3	-52.0	34,854.8	34,460.9	35,341.2	393.9	-486.4
In 2010 dollars (2010-2035)	1,983.0	1,952.4	2,014.6	30.6	-31.5	22,690.5	22,440.0	22,967.7	250.4	-277.2

Projected expenditures on healthy population screening/diagnostics

	HEALTHY PEOPLE SCREENED (MILLIONS)			SCREENING EXPENDITURES ($ BILLIONS)		
Year	Continued incentives	Increased incentives	Decreased incentives	Continued incentives	Increased incentives	Decreased incentives
2010	7.3	7.3	7.3	8.7	8.7	8.7
2035	10.4	14.5	8.3	21.2	29.7	17.0
Cumulative (2010-2035)	235.2	292.4	206.6	375.6	473.6	326.6

†Screening expenditures for the healthy population not included.

COLORECTAL CANCER

A Markov model was created to assess the effects of improved colorectal cancer screening technology on treatment and outcomes. The effect of screening on the colorectal cancer PRC as well as the number of cancer cases prevented through polypectomy was examined for each scenario.

Colorectal cancer originates in polyps, or abnormal growths, in the colon (also known as the large intestine) or rectum. Not all polyps have the potential to develop into colon cancer, and fewer than 10 percent actually do. It can take more than 10 years to develop into disease. Once identified, a polyp can be removed through a polypectomy, preventing a malignancy from occurring. If colorectal cancer develops, patients must go through treatment, an expensive process that severely affects his or her quality of life.

Americans are advised to begin colorectal cancer screening at age 50 and repeat at 10-year intervals. These frequencies are built into the model. Though rare, the disease can occur before 50, and we incorporated this into our model. Our model includes age-stratified incidence rates from Surveillance, Epidemiology, and End Results (SEER), a program of the National Cancer Institute (NCI). If a patient is screened and polyps are detected, normally a polypectomy is performed and a colonoscopy is ordered in three years as surveillance.

Because the time required for a precancerous polyp to progress to cancer varies by the individual, based on a literature review we estimated that one-third of polyps would do so over 30 years. Screening can also identify colorectal abnormalities that were not detected through symptom identification. Such procedures can lead to early diagnosis, which may be represented by a higher probability of detection at an earlier cancer stage.

Among our incentive scenarios, the primary difference is the implications of varied screening rates for colorectal cancer deaths. The continued incentives scenario assumes the persistence of the annual change in screening rates derived from MEPS. The annual screening rate increase is doubled in the increased incentives scenario as advanced screening technologies are deployed, and it is reduced by half in decreasing incentives. These changes in rates over time are accounted for as changes in the likelihood of the eligible population actually being screened within the model.

Colorectal cancer PRC was 616,500 in 2010, according to the utilization data in MEPS, which accounts for all patients with health-care expenditures related to the disease. SEER data reveals a prevalence of 1.2 million patients, almost double the PRC observed in MEPS. This disparity could be explained by the fact that not all patients with colorectal cancer have expenditures in the year assessed.

In the continued incentives scenario, the PRC increases from 600,000 to 1.7 million, while under increased incentives, the PRC increases to 1.4 million. (See Projections: Colorectal Cancer.) The 280,000 reduction in future PRC in the increased incentives scenario could be caused by the increased screening rate. In the decreased incentives scenario, the 160,000 additional PRC compared to the continued incentives scenario is consistent with weaker adherence to screening and therefore less cancer prevention through polypectomy.

From historical trends, it was clear that 2010 expenditures were significantly different from those of previous years, so to project expenditures we used an average of 2008-2010 per-PRC data.

Colorectal cancer treatment expenditures increase with a rising PRC. The reduction in PRC due to doubling the increase in screening rates is associated with $19 billion in cumulative savings over 25 years (which translates to $10.6 billion in 2010 dollars). On the other hand, the expanding PRC associated with decreased incentives aggregates to $10.7 billion more spending ($6 billion in today's dollars) than in the continued incentives scenario.

We further estimated the number of cancer cases prevented, along with associated reductions in the economic impact, using polypectomy data from HCUP. Since not all polyps will turn into cancer, we assumed that approximately one-third of polypectomies prevented the disease from developing. Our calculations suggest that in 2010, 554,400 cases were prevented by screening.

Polypectomy projections from the model show that in 2035, 1.1 million cases will be prevented under the continued incentives scenario, slightly fewer than under increased incentives (1.2 million). From $12.2 billion in 2010, the gain to the health-care system and GDP rises tremendously in future years, reaching $45.6 billion in 2035 in the continued incentives scenario. Compared to that projection, increased incentives generates additional savings of $90.2 billion over 25 years, or $58.5 billion in 2010 dollars.

There is a chance that colorectal cancer screening incurs costs unrelated to the disease, since the majority of the screening population is well. Tests can produce mistaken diagnoses, or false positives. MEPS data for per-PRC expenditures indirectly accounted for false positive treatment costs. However, a potential increase in such readings as a consequence of screening was not considered.

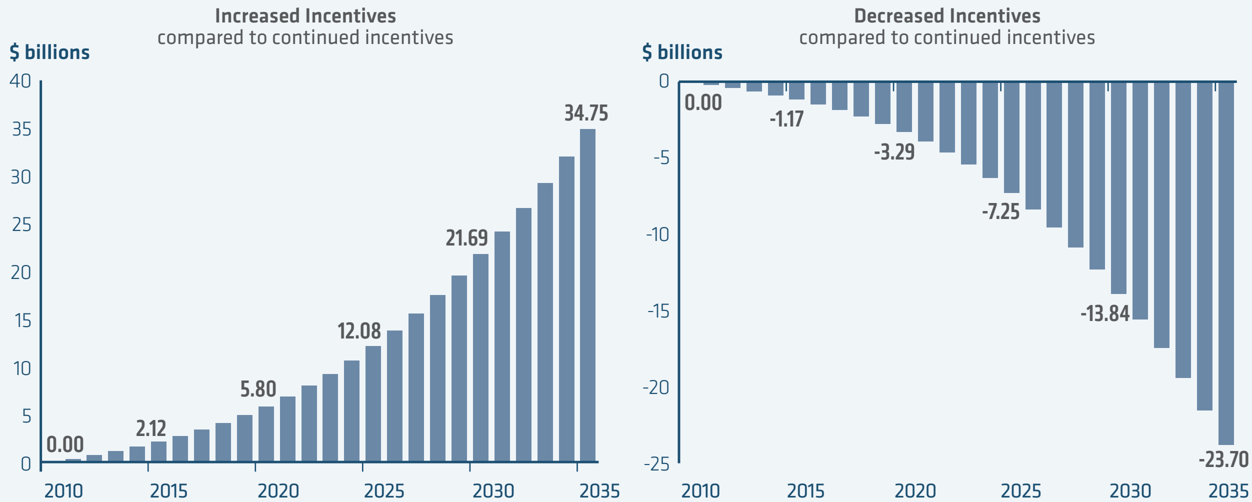
As mentioned earlier, the expenditures involved in screening the healthy population add a burden to the health-care system. Our historical estimates show that in 2010, 14.9 million people without colorectal cancer or precancerous polyps were screened, generating a cost of $17.7 billion. By 2035, this increases to 28.4 million people and costing $57.9 billion in the continued incentives scenario. A cumulative $893.2 billion, it is estimated, would be spent on screening the healthy population over 25 years. More frequent screening in the increased incentives scenario would result in a cumulative $1 trillion in spending, and decreased incentives channels $838 billion into screening the healthy population.

We also consider the indirect economic effects of colorectal cancer for each scenario. These effects stem from the employed population with colorectal cancer as well as people saved from having the disease. Between now and 2035, the indirect impact of colorectal cancer will ease as more advanced screening technologies are deployed, decreasing the cancer PRC and improving survival, and consequently limiting productivity loss. By then, the increased incentives scenario would produce a cumulative economic gain of $198.2 billion compared to the baseline scenario, $23.4 billion of which can be credited to increased survival. The economic gain would total $109 billion in 2010 dollars. In contrast, the reduced incentives scenario, involving less investment in technology, would reduce GDP by $112.4 billion compared to the baseline scenario, or $61.4 billion in 2010 dollars.

Under increased incentives, colorectal cancer prevention through screening boosts GDP by $65 billion compared to the continued incentives scenario, while the decreased incentives projection results in a loss to GDP of $53.8 billion.

PROJECTIONS: COLORECTAL CANCER

Projected savings†: Colorectal cancer treatment and prevention



Economic impact of colorectal cancer, 2010-2035 ($ billions)†

compared to continued incentives

CUMULATIVE IMPACT	INCREASED INCENTIVES	DECREASED INCENTIVES
Direct expenditures	19.0	-10.7
Gain/loss to the economy	198.2	-112.4
Due to survival	23.4	-5.6
Additional gain/loss	174.9	-106.8
Total	217.3	-123.2

Projected colorectal cancer population affected, and cases prevented (millions)

										PREVENTION		
	PRC*			EPRC**			ECC***			NUMBER OF CASES PREVENTED		
Year	Continued incentives	Increased incentives	Decreased incentives	Continued incentives	Increased incentives	Decreased incentives	Continued incentives	Increased incentives	Decreased incentives	Continued incentives	Increased incentives	Decreased incentives
2010	0.62	0.62	0.62	0.45	0.45	0.45	0.08	0.08	0.08	0.6	0.6	0.6
2035	1.69	1.41	1.85	1.23	1.03	1.35	0.22	0.18	0.24	1.1	1.2	1.0

* Population reporting a condition.

** Employed population reporting a condition.

*** Employed caregivers by condition.

Projected economic impact of colorectal cancer ($ billions)†

	TREATMENT EXPENDITURES			INDIRECT IMPACT			PREVENTION: TREATMENT EXPENDITURES AND INDIRECT IMPACT		
Year	Continued incentives	Increased incentives	Decreased incentives	Continued incentives	Increased incentives	Decreased incentives	Continued incentives	Increased incentives	Decreased incentives
2010	5.4	5.4	5.4	28.1	28.1	28.1	-12.2	-12.2	-12.2
2035	14.7	12.3	16.2	178.1	149.1	195.6	-45.6	-48.9	-40.8
Cumulative (2010-2035)	317.7	298.7	328.5	2,778.9	2,580.7	2,891.3	-697.0	-787.2	-625.5
In 2010 dollars (2010-2035)	214.7	204.1	220.7	1,790.5	1,681.5	1,851.9	-452.0	-510.5	-407.7

Projected expenditures on healthy population screening/diagnostics

	DIRECT MEDICAL EXPENDITURES: HEALTHY PEOPLE SCREENED* (MILLIONS)			DIRECT MEDICAL EXPENDITURES: SCREENING EXPENDITURES ($ BILLIONS)		
Year	Continued incentives	Increased incentives	Decreased incentives	Continued incentives	Increased incentives	Decreased incentives
2010	14.9	14.9	14.9	17.7	17.7	17.7
2035	28.4	35.5	24.8	57.9	72.4	50.7
Cumulative (2010-2035)	551.9	613.0	521.4	893.2	1,003.4	838.1

* Includes those receiving screening who did not have cancer or were not prevented from developing cancer.

†Screening expenditures for the healthy population not included.

TAX REVENUE AND MEDICAL TECHNOLOGY

In this report, we have estimated the effects on GDP due to changes in labor market outcomes associated with the use of medical devices. Consequently their use also affects the federal personal income tax revenue generated. For example, if insulin pumps reduce lost workdays and improve productivity for patients and their caregivers compared to those who inject insulin, this additional value contributed translates into greater tax revenue. To measure the tax revenue generated by the use of a technology compared to another or no technology, we estimated a wage-based indirect impact associated with the technology studied. This approach is similar to that used for GDP-based indirect impact estimates, but we used average employee wage rather than GDP. The results can be seen in the table below.

Table 8

Wage-based indirect impact associated with medical technology
($ millions)

TECHNOLOGY	2005	2010	AVERAGE (2008-2010)
Insulin pump	493.3	1,003.8	893.8
Heart disease diagnostics and surgery	15,873.8	15,544.7	15,116.0
MRI and joint replacement surgery	6,061.2	5,741.9	6,053.5
Colonoscopy/sigmoidoscopy	4,888.9	2,504.1	2,164.5
Detection	4,888.9	6,758.5	5,624.3
Prevention	-	-4,254.4	-3,459.8

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

The average annual (2008-2010) wage-based indirect impact (or the foregone labor income) by insulin pump users was $893.8 million. It was $15.1 billion and $6.01 billion, respectively, for heart disease and musculoskeletal disease patients using diagnostics and/or surgery. Similarly, colorectal cancer patients who were screened had a wage-based indirect impact of $5.6 billion. However, thanks to cases in which cancer was prevented by screening, $3.4 billion was added to the economy in the form of labor income. Thus, the total indirect impact of detection and prevention was $2.2 billion.

A portion of this foregone labor income was taxable. In 2010, the median family income in the United States was $60,236[25] and the tax rate for married couples falling within the median income level was 15 percent.[26] Applying that rate historically, we calculated lost tax revenue associated with foregone income estimated from the above table. The annual average (2008-2010) revenue lost for technology users with these four diseases was $3.6 billion.

25. Current Population Survey, United States Census Bureau.

26. "Federal Individual Tax Rates History," Tax Foundation.

If we compare alternative treatments, however, there is actually an income gain associated with using technology. The additional average annual income generated by pump users (compared to non-users) was $2,371 per person affected. Similarly, the difference in labor income between people using technology associated with heart disease and musculoskeletal disease and those who did not amounted to $2,902 and $12,749, respectively. Patients screened for colorectal cancer and their caregivers earned $43,194 more than those not screened. Further, colorectal cancer screening prevented individuals from developing cancer, which would bring in an extra $20,276 per case.

Table 9

Difference in wage-based indirect impact associated with technology

Per person affected, compared to non-users ($)

TECHNOLOGY	2005	2010	AVERAGE (2008-2010)
Insulin pump	1,963.7	2,104.5	2,371.2
Heart disease diagnostics and surgery	5,548.2	3,067.7	2,902.3
MRI and joint replacement surgery	14,290.7	13,088.2	12,748.8
Colonoscopy/sigmoidoscopy	16,668.0	63,820.8	63,470.9
Detection	16,668.0	44,279.6	43,194.4
Prevention	-	19,541.2	20,276.4

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

With medical devices/technology strengthening the labor market, these income gains generate tax revenue and expand the economy. Using a constant 15 percent tax rate, the additional revenue generated by insulin pump users is $356 per person affected. Tax revenue generated by heart disease and musculoskeletal disease patients who use technology is $435 and $1,912 per person, respectively. Similarly, additional tax revenue is $6,479 for colorectal cancer patients who were screened. Such screening also produces $3,041 in tax revenue per person affected due to prevention.

Table 10

Tax revenue generated by medical technology users

Per person affected, compared to non-users ($)

TECHNOLOGY	2005	2010	AVERAGE (2008-2010)
Insulin pump	294.6	315.7	355.7
Heart disease diagnostics and surgery	832.2	460.2	435.3
MRI and joint replacement surgery	2,143.6	1,963.2	1,912.3
Colonoscopy/sigmoidoscopy	2,500.2	9,573.1	9,520.6
Detection	2,500.2	6,641.9	6,479.2
Prevention	-	2,931.2	3,041.5

Sources: Medical Expenditure Panel Survey, National Health Interview Survey, Milken Institute.

MAIN TAKEAWAYS

As sedentary ways of life and unhealthy eating habits take their toll, severe ailments such as diabetes, cancer, and heart and musculoskeletal disease are likely to flourish among America's aging populace. We are already seeing evidence of that. While the risk spreads, however, medical technology can play a crucial role in prevention, early detection, and better management of disease.

We studied a group of technologies that have proved their effectiveness for these purposes. Our work suggests that routine measures such as colonoscopy or sigmoidoscopy might have prevented 560,000 cases of colorectal cancer annually from 2008 to 2010. Further, if we follow the continued incentives scenario into the future, about 1.1 million cases of the potentially lethal disease will be prevented in 2035. The same technology is vital to early detection efforts. Early detection of a malady improves a patient's chance of survival and may make him or her eligible for less invasive and less disruptive treatment. If heart disease, for instance, is diagnosed in its initial stages, surgery may be unnecessary and medicine the better option. Finally, after the onset of a chronic disease, it must be managed well to afford the best quality of life possible for the patient. Insulin pumps have been found more effective than injections in managing adverse effects for diabetics, such as insulin spikes.

There is a worthy economic rationale for investing in medical technology, along with waging the battle for better health and longer lifespans.

These technologies have been criticized for the costs involved in needless testing of healthy populations. Some say their widespread use has been draining the health-care system. In this study, aggregate screening expenditures on healthy people were $31 billion annually from 2008 to 2010. Annual expenses for patients using the studied technologies were $51.6 billion higher than those for non-users.

However, there are powerful benefits to consider. Due to more effective disease management, it is possible that the more expensive treatments and sites of service can be avoided, yielding savings across the system. Additionally, by extending survival in many cases and improving quality of life, these medical technologies aid patients' ability to work and labor market outcomes overall. For patients and their informal caregivers as well, fewer workdays are lost and productivity is enhanced. Indeed, during the 2008-2010 period, these factors led to an average annual GDP gain of $106.2 billion and increased federal tax revenue by $7.2 billion.

In our view, these effects are likely to fortify future GDP growth, job creation, incomes, and government revenue. In other words, there is a worthy economic rationale for investing in medical technology, if strengthening our arsenal against chronic disease is not compelling enough.

ABOUT THE AUTHORS

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Ross DeVol is chief research officer at the Milken Institute. He oversees research on international, national, and comparative regional growth performance; technology and its impact on regional and national economies; access to capital and its role in economic growth and job creation; and health-related topics. He was the principal author of "The Global Biomedical Industry: Preserving U.S. Leadership," a study that showed that the United States is still the global leader in the biomedical industry, but countries across Europe and Asia are pursuing aggressive plans to close the gap and take the high-value jobs and capital this sector creates. He was also the principal author of "An Unhealthy America: The Economic Burden of Chronic Disease," which brought to light the economic losses associated with preventable illnesses and estimated the costs avoided if a serious effort were made to improve Americans' health. DeVol is ranked among the "Super Stars" of Think Tank Scholars by International Economy magazine. He was previously senior vice president of IHS Global Insight.

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