

# Policy Analysis

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## *Bending the Productivity Curve Why America Leads the World in Medical Innovation*

by Glen Whitman and Raymond Raad

### Executive Summary

The health care issues commonly considered most important today—controlling costs and covering the uninsured—arguably should be regarded as secondary to innovation, inasmuch as a medical treatment must first be invented before its costs can be reduced and its use extended to everyone. To date, however, none of the most influential international comparisons have examined the contributions of various countries to the many advances that have improved the productivity of medicine over time. We hope this paper can help fill that void.

In three of the four general categories of innovation examined in this paper—basic science, diagnostics, and therapeutics—the United States has contributed more than any other country, and in some cases, more than all other countries combined. In the last category, business models, we lack the data to say whether the United States has been more or less innovative than other nations; innova-

tion in this area appears weak across nations.

In general, Americans tend to receive more new treatments and pay more for them—a fact that is usually regarded as a fault of the American system. That interpretation, if not entirely wrong, is at least incomplete. Rapid adoption and extensive use of new treatments and technologies create an incentive to develop those techniques in the first place. When the United States subsidizes medical innovation, the whole world benefits. That is a virtue of the American system that is not reflected in comparative life expectancy and mortality statistics.

Policymakers should consider the impact of reform proposals on innovation. For example, proposals that increase spending on diagnostics and therapeutics could encourage such innovation. Expanding price controls, government health care programs, and health insurance regulation, on the other hand, could hinder America's ability to innovate.

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**None of the best-known international health care comparisons consider contributions to medical innovation.**

## Introduction

The debate over how to reform America's health care sector often involves comparisons between the United States and other countries, and with good reason. Looking at other countries can help us learn which policies, if any, to emulate, and which to avoid.

There have been many attempts at international health care system comparisons. Among the most influential are the *World Health Report 2000* published by the World Health Organization,<sup>1</sup> several studies published by the Commonwealth Fund,<sup>2</sup> and individual measures such as infant mortality and "mortality amenable to health care."<sup>3</sup> Generally in these studies, the United States performs poorly in comparison to Europe, Australia, and Japan. Therefore, scholars often use the studies to argue for adding even more government regulations to our already highly regulated health care system.<sup>4</sup>

However, these studies suffer from several problems. First, they often rely on unadjusted aggregate data—such as life expectancy, or mortality from heart disease—that can be affected by many non-health care factors, including nutrition, exercise, and even crime rates. Second, they often use process measures, such as how many patients have received a pap smear or mammogram in the past three years. Process measures tell us what doctors do, but provide only an indirect measure of doctors' productivity. Third, some of these studies inappropriately incorporate their own biases about financing in their statistics, which makes market-driven health systems appear worse even if their outcomes are similar or better.<sup>5,6</sup>

An additional limitation of these studies is the omission of any measure of innovation. None of the best-known studies factor in the contribution of various countries to the advances that have come to characterize the current practice of health care in the developed world.

Every single health care test or treatment must be invented at some point. We would be

living in a different world today were it not for the remarkable genius and hard work of health care inventors in the past, as well as investments from government health agencies and pharmaceutical and medical device companies. The health care issues commonly considered most important today—controlling costs and covering the uninsured—arguably should be regarded as secondary to innovation, inasmuch as a treatment must first be invented before its costs can be reduced and its use extended to everyone.

But shouldn't innovation show up in other health care measures? If the United States is making the most headway in creating cancer medications, for instance, then shouldn't cancer care be better in the United States? Not necessarily. Most innovations are created by only a few people, but once created they can generally be used all over the world. For example, the bulk of the development of balloon angioplasty was done by a handful of physicians—most notably Andreas Greutzig in Switzerland, with some help from U.S. physicians. Once developed, however, this procedure was used well beyond these two countries to improve the care of patients with heart attacks. Similarly, the work of Michael Brown and Joseph Goldstein at the University of Texas Southwestern Medical Center was essential to the development of the cholesterol drugs called statins, which have helped to reduce deaths from strokes and heart attacks all over the world.<sup>7</sup>

Therefore, measuring health care costs and health outcomes across countries is not sufficient. The costs of medical innovation typically appear only in the innovating nation's health expenditures, but the health improvements that those innovations generate improve the health-outcomes statistics of many countries. Consider, for example, the frequent claim that European health systems achieve similar health outcomes to those of the United States at a much lower cost. That claim fails to consider that higher U.S. spending levels could be generating innovations that improve health outcomes in Europe and around the world. If we care about progress,

we should include innovation as a separate measure, so that policymakers can adequately factor innovation into discussions of health care reform.

## How to Measure Innovation

Two properties of innovations make them difficult to measure. The first is that not all advances are equal; some require more ingenuity than others. Take two similar drugs—captopril and enalapril—both of which are useful for treating high blood pressure and heart failure. Captopril was the first of its kind, developed at a time when no one—including the physicians and scientists working on it—knew whether such a drug was even possible. The development of enalapril, on the other hand, although an achievement in and of itself, was greatly assisted by the knowledge that captopril had been developed first and was effective.<sup>8</sup> Therefore, we cannot do justice to innovation by using simple output metrics such as the number of new drugs that are developed each year.

The second important property of innovation is that new ideas and products are often unpopular or controversial when they are first developed. A particularly well-known example is the discovery that the bacterium *Helicobacter pylori* causes stomach ulcers, a finding the medical community initially resisted. And there are other examples, such as laparoscopic surgery and CT scanning, both of which were regarded with skepticism at first. This does not necessarily reflect negatively upon health care practitioners; it is important to expose new ideas to a high standard before they are widely used. However, this property makes it very difficult to measure new innovations (e.g., a new drug or specialty hospitals), because there is controversy over which of them will turn out to be effective.

Therefore, we conclude that innovation is best measured by looking at advances that have withstood the test of time and are widely regarded as having had important positive effects on health care. This means, unfortu-

nately, that many important innovations will have to be left out because they are not considered the cream of the crop or have been developed too recently, but we believe this method is most likely to yield a meaningful measure of innovation.

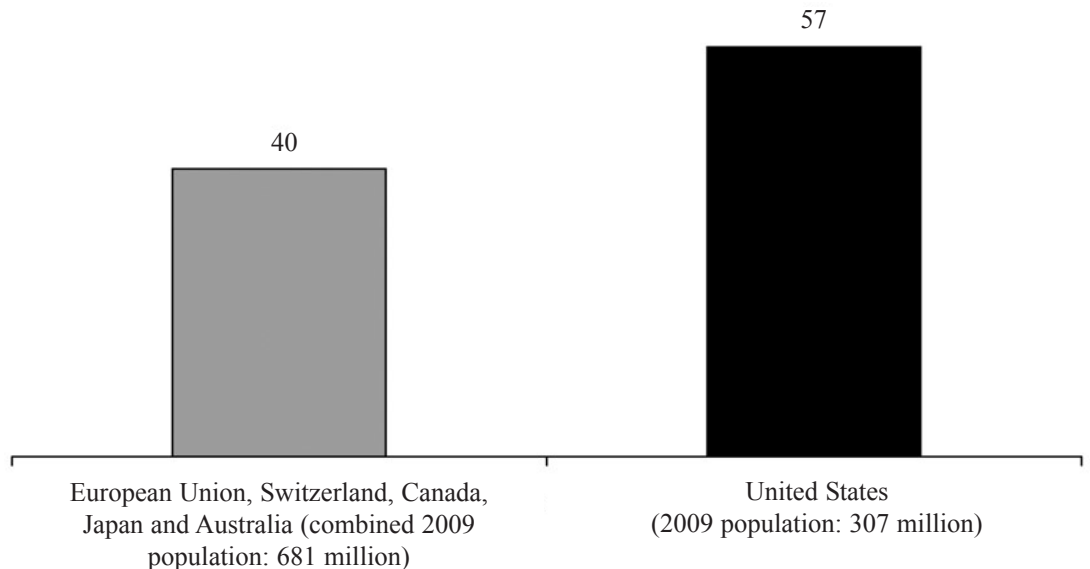
Our basic approach in this paper is to identify significant innovations in the field of health care, and then to identify who pioneered them and where. This approach is susceptible to some valid objections. The first objection is that, like life expectancy and infant mortality, a variety of factors other than health care policy may affect innovation. The patent system, the tax code, the general business climate, the quality of universities, and other country characteristics can affect the amount and variety of innovation.

The second objection is that, even if we restrict our attention to the impact of health policies, innovation in one country can be affected by the policy choices of other countries. For instance, pharmaceutical companies in other countries might invest in new drugs with the expectation of marketing them in the United States, and U.S. pharmaceutical companies might invest in new drugs with the expectation of marketing them abroad. In this regard, it may prove difficult to isolate the effects of any given country's policies on innovation.

Nevertheless, we suspect the amount of innovation that comes out of a given country does reflect something real about its health care structure, including the amount of investment in new ideas, the willingness to accept novelty, and the talent that the country's health care sector attracts. We consider it important to acknowledge the critical role of innovation in the health care debate, and therefore also important to make an effort to isolate the contributions of various countries. We offer the statistics in this paper with the hope that they will stimulate discussion. We do not claim that cross-country differences in innovation are solely attributable to differences in health care policies, but we do think health care policy is an important part of the story.

**Innovation is best measured by looking at advances that have withstood the test of time and are widely regarded as having had important positive effects on health care.**

**Figure 1**  
**Nobel Prize in Medicine and Physiology Recipients by Country of Residence, 1969–2008**



Sources: Nobel Prize Internet Archive, CIA *World Factbook*. Two recipients are listed as being from both the United States and another country.

## Types of Innovation

An innovation is any new way of doing or understanding something, and it is particularly important when it is an improvement over previous ways. Most health care innovations fall within one of the following categories.

**Basic Medical Sciences.** These are advances in our understanding of the human body and of diseases—what doctors call “pathophysiology.” One example is the discovery that the human immunodeficiency virus (HIV) causes the disease AIDS.

**Diagnostics.** These are advances that help us determine what disease an individual has or what has gone wrong with his or her body. They often take the form of either a device or a test. For example, CT scanners can help us discover whether someone has cancer, and certain blood tests help us determine whether someone has had a heart attack.

**Therapeutics.** These are advances that help to treat someone with a disease. They often take the form of drugs, devices, or procedures.

Two recent examples are anti-depressants, such as Prozac, and laparoscopy, which makes many surgeries safer and less invasive.

**Business Models.** These are advances in the way that health care is organized and delivered. They can take many forms. A recent example is nurse practitioner-staffed retail clinics, which allow patients to receive care for certain common complaints at a lower cost and greater convenience than at many doctors’ offices.<sup>9, 10, 11</sup>

## Innovation in Basic Medical Sciences

Of the four classes of innovations, advances in the understanding of the body and of disease are typically the furthest removed from direct benefit to patients. It is rare that a scientific breakthrough provides a new therapy for patients without further advances. However, basic science discoveries often provide the basis for other advances in health care and can be among the greatest gifts to human life.

**A large number of Nobel prizes in medicine have been awarded to American scientists in recent history.**

One way to measure the “cream of the crop” in contributions to basic medical science is to count the number of Nobel prizes in medicine and physiology. This award is international in scope, so it is presumably not biased for or against any particular country. A large number of Nobel prizes have been awarded to American scientists in recent history. Of the 95 recipients in the past 40 years, 57 (60 percent) were from the United States, while 40 (42 percent) were from the European Union countries, Switzerland, Canada, Japan, or Australia—countries whose combined population is more than double that of the United States.<sup>12</sup> (See Figure 1. Two recipients are listed as both from the United States and another country.) In 33 of those 40 years, at least one scientist from the United States received the award, while in only 25 of those years was there at least one non-American recipient.<sup>13</sup>

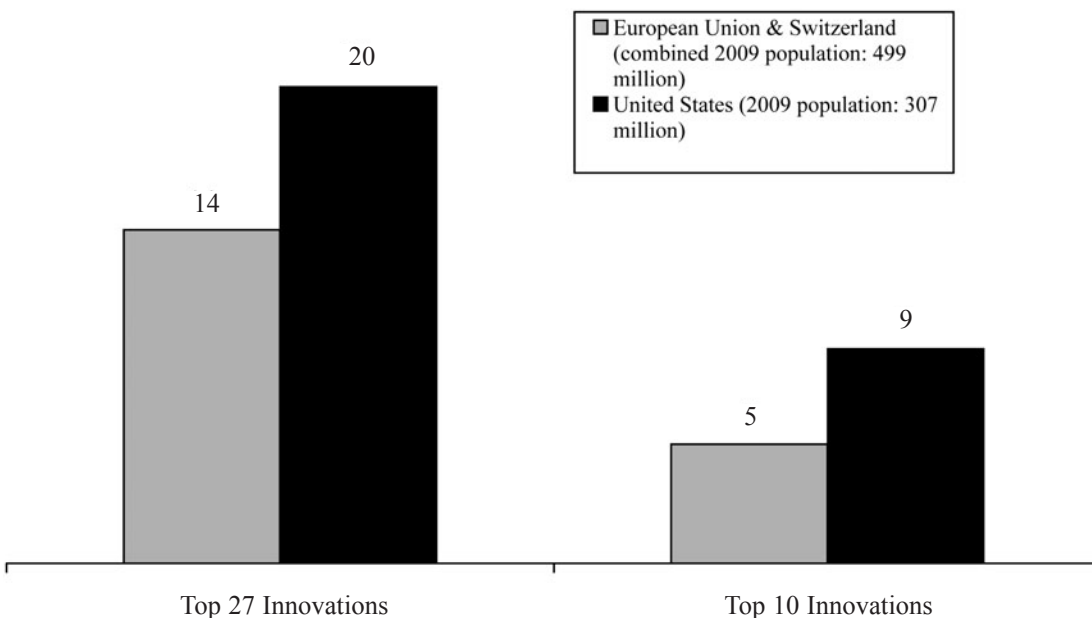
Why are Americans disproportionately represented among Nobelists in the field of medicine? Presumably the United States provides an environment that encourages basic medical

research. One major contributor is the great investment in basic science research in the United States relative to other countries. Much, but not all, of that funding comes from the National Institutes of Health, which has a current annual budget of over \$30 billion, as compared to its counterparts in Europe, which spend \$3–\$4 billion in total. Private-sector contributions also matter, and there is some indication that U.S. spending in this category is also higher, though reliable figures are not available.<sup>14, 15</sup>

There are likely to be other contributing factors as well. Thomas Boehm, a scientist who has worked in Boston, Vienna, and Berlin, argues that the research environment in the United States is not only wealthier, but also more meritocratic, more supportive of risky new ideas, and more tolerant of waste, which is often a necessary component of progress. He argues that these factors explain the large number of European-born scientific researchers in the United States (about 400,000).<sup>16</sup>

**The United States has contributed to more top diagnostic and therapeutic innovations than any other country.**

**Figure 2**  
**Top Medical Innovations by Country of Origin, 1975–2000**



Note: More than one country shares credit for some innovations.



**Why does  
the United  
States attract  
high-quality  
innovators?**

## **Innovation in Diagnostics and Therapeutics**

A well-known and widely cited list of top medical diagnostic and therapeutic innovations was published in a paper in 2001 by Victor Fuchs, economics professor at Stanford, and Harold Sox, professor of medicine at Dartmouth. The authors searched through the two top medical journals—the *New England Journal of Medicine* and the *Journal of the American Medical Association*—and picked out the 30 innovations that were most frequently the principal focus of a published study over the previous 25 years (i.e., since 1975). They then surveyed 225 leading primary care physicians about the effects of these innovations on patients, and used the responses to rank the 30 innovations by importance. The list, in rank order, is in Table 1.

Though this list is not necessarily and unambiguously *the* top 30 innovations since 1975, we are convinced that it cannot be too far off the mark. Each item on the list has transformed, or at least significantly contributed to, the care of at least one disease. Though surveyed physicians were invited to recommend additions, only 2 percent of respondents did so, and no specific addition was recommended by more than one physician.<sup>17</sup>

We looked into the history of each of these innovations to find out where and when most of the significant work that led to its invention was done. Specifically, we looked for where the product was first developed to the point that it could be used on patients, and where the scientific advances that were crucial to its development were made. In the case of drug classes, we focused on the first drug developed in each class.

For those innovations with particularly long and complex histories, we tried our best to focus on the most significant advances in recent history (approximately 1970s to the present). For example, in studying the history of mammography, we found that it was developed through the work of many scientists, engineers, and physicians over the course of a

century. However, historians divide its development into three periods, the most recent of which is the 1970s to the present; therefore, we focused on that period.<sup>18</sup>

Of the list of 30 innovations, at least one country is listed for all but two,<sup>19</sup> and all but one have been advanced significantly in the last 40 years.<sup>20</sup> Of the remaining 27 innovations, work performed in the United States significantly contributed to the invention or advancement of 20, including nine of the top 10. These numbers are greater than those for any other country. In comparison, the European Union plus Switzerland, whose combined population is more than 50 percent larger than that of the United States,<sup>21</sup> contributed significantly to 14 total innovations, including five of the top 10 (see Figure 2).<sup>22, 23</sup>

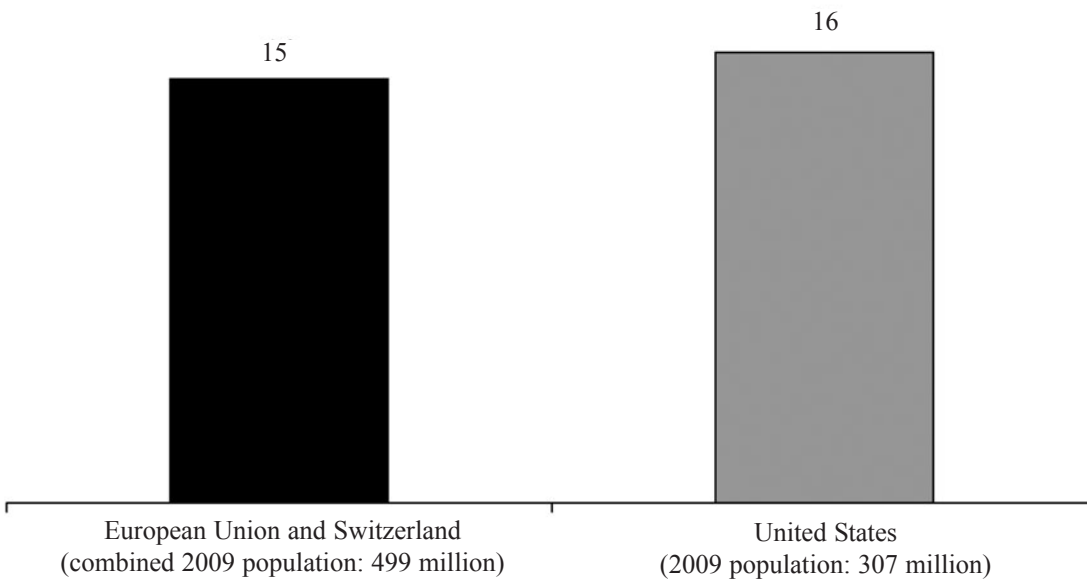
### **Pharmaceuticals**

A second list of top innovations has also been developed—this time of drugs only. Massachusetts Institute of Technology economists Iain Cockburn and Rebecca Henderson constructed a list of 21 “impact drugs,” those that had the most impact on therapeutic practice between 1965 and 1992.<sup>24</sup> More recently, three economists working with the Manhattan Institute—Joseph DiMasi, Christopher-Paul Milne, and Benjamin Zycher—updated this list by merging it with the 25 brand-name drugs most prescribed in the United States in 2007.<sup>25</sup> The result is a list of 37 drug classes. Seventeen of these classes are also included in the top 30 innovations in Table 1, while 20 are new.

For each of the 37 drug classes, we chose one or more representative drugs. In most cases, we chose the first developed or marketed version as the sole representative drug, because the first drug of each class is usually the most difficult to develop. However, for four of the classes, we chose two drugs because of one of the following reasons:

- The first to be developed differed from the one listed in the Cockburn and Henderson paper as having the widest impact on patient care.<sup>26</sup>

**Figure 3**  
**Top 29 Pharmaceutical Innovations by Country of Origin, 1968–2007**



Note: More than one country shares credit for some innovations.

- There were two separate innovative drugs in the same class that were developed independently and reached the market at about the same time.<sup>27</sup>

Additionally, in the case of interferons, no representative was chosen because the technology to produce several of them was developed at the same time.

We then looked into the history of the development of these drugs, this time focusing on which companies or laboratories were able to synthesize them and bring them to market.

We excluded eight of the 37 drug classes because they received initial FDA approval more than 40 years ago.<sup>28</sup> The results for the remaining 29 classes are in Table 2. As the table makes clear, the U.S. contribution has been significant. Sixteen of the 29 representative drug classes were developed in the United States, while 15 were developed in the E.U. or Switzerland.<sup>29</sup> (See Figure 3. We credit two of the 29 drug classes to both the United States and a European country.) Again, all of these figures should be interpreted in light of

America’s notably smaller population.<sup>30</sup>

Although we have focused on the most significant pharmaceutical innovations, similar results seem to hold for new drugs in general. In a 2006 article, economists Henry G. Grabowski and Y. Richard Wang compiled a list of all drugs introduced to the world market between 1982 and 2003 and divided them by country of origin. Although European firms introduced a greater total number of new drugs to the global market than American firms did, they introduced a similar number of new drugs relative to population. With respect to first-in-class drugs (which are, in general, more innovative), American firms produced a greater number than European firms, despite Europe’s larger population. The difference between American and European performance was more pronounced during the latter half of the time period.<sup>31</sup> Only time will tell which of these drugs will prove most beneficial to patients, but these data provide at least preliminary evidence that American firms continue to contribute significantly to the development of innovative pharmaceuticals.

**In a dynamic sense, Americans’ rapid and extensive use of new medical innovations subsidizes the development of new technologies.**

**In effect, Americans contribute disproportionately to the production of a public good, while other nations take a relatively free ride.**

### **Explaining America's Leading Role**

Why is the United States over-represented in the development of new diagnostics and therapeutics? What factors encourage innovation in these areas? Perhaps a part of it is the quality of the innovators. But this answer is unsatisfying, for it only leads to more questions: Why does the United States attract high-quality innovators? And what environmental factors allow innovators in the United States to be so productive?

Although many factors are surely relevant, one likely contributor is differences in monetary compensation. Other things being equal, individuals and firms will tend to invest more in medical innovation when (a) they expect a larger return; (b) the returns will last for a longer period of time; and (c) the returns arrive sooner rather than later.

There is little doubt that the United States is responsible for a disproportionate share of the monetary returns to medical innovation. In recent years, the United States has accounted for 45 percent of worldwide pharmaceutical sales, as compared to Europe's 27–31 percent and Japan's 9–12 percent.<sup>32,33</sup> The population of Europe is 150 percent that of the United States, and Japan 42 percent, so the greater contribution of the United States cannot be attributed to its large population. The fact is that Americans spend more per capita on pharmaceuticals. Critics often describe this as a defect of the American system—but with regard to encouraging innovation, we must consider it a feature.

The United States is also over-represented as a base of operations for top pharmaceutical firms. Of the top 15 pharmaceutical firms by pharmaceutical revenues, eight are based in the United States, six in Europe, and one in Japan.<sup>34</sup> The list of top pharmaceutical companies by total revenues is even more skewed: seven of the top 12 are based in the United States and five in Europe.<sup>35</sup> This is unlikely to be a coincidence. Although the firms might have located in the United States for historical reasons or because of a superior business climate, being near their most important market is at least a contributing factor.

Americans pay more for pharmaceuticals because of the nature of our health care system. Single-payer and other centrally organized health care systems, like those in much of Europe, are characterized by a great deal of monopsony (buyer) power that pushes down compensation. Prices for prescription drugs in Europe are 35 percent to 55 percent lower than in the United States.<sup>36</sup>

In addition to pushing down prices, centrally organized health care systems also limit the use of new drugs, technologies, and procedures. Those systems “control costs by upstream limits on physician supply and specialization, technology diffusion, capital expenditures, hospital budgets, and professional fees.”<sup>37</sup> The result is that those countries use new innovations less extensively than the United States.

To take just one example, a cross-national comparison of heart attack care from 1989 to 1998 found that the United States experienced both faster adoption and more rapid diffusion of new heart treatments (including cardiac catheterization, coronary artery bypass graft, and primary angioplasty) than other developed countries. Japan displayed a similar but less pronounced tendency to adopt early and expand use quickly. A number of other countries, including Canada, Australia, Belgium, Italy, Singapore, Taiwan, and possibly France, experienced late adoption but relatively fast growth in treatment rates thereafter. Those countries with the strictest supply-based restrictions on health care, most notably the United Kingdom and the Nordic countries, experienced both late adoption and slow growth in treatment rates.<sup>38</sup>

The greater openness of the U.S. system to the adoption of new technologies and treatments is also evidenced by its having twice as many MRI scanners per capita as most other developed nations, and having three times as many cardiac surgery units and catheterization labs in the 1990s.<sup>39</sup>

### **Overuse?**

Is all the U.S. spending on new diagnostics and treatments worth it? Medical innovations



definitely have aggregate benefits that outweigh their aggregate costs. Yet there is also good reason to believe they are overused in the United States. While the average benefits of the innovations may be quite high, the marginal benefit of extending their use to more and more patients could be quite low.<sup>40</sup> So in a static sense, the U.S. health care sector might be regarded as inefficient.

In a dynamic sense, however, the story is different. Americans' rapid and extensive use of new medical innovations creates a much higher expected monetary return, thereby subsidizing the development of new technologies. And the rest of the world gets an even better deal, since they can take advantage of the new technologies later and at lower cost. In effect, Americans contribute disproportionately to the production of a public good, while other nations take a relatively free ride.

## Business-Model Innovations

Business-model innovations are improvements in the way medicine is organized or delivered, in an attempt to improve its quality, reduce its cost, or both. Some examples are the development of outpatient dialysis in the 1960s, the integrated system of care developed by Kaiser Permanente, and more recently, the emergence of nurse practitioner-staffed clinics. This type of innovation is not unique to for-profit enterprises, so it should be a concern for all types of health systems, from market-based systems to single-payer systems. In fact, some of the changes that the left-leaning Commonwealth Fund recommends for health care, such as increased use of electronic medical records and changes to improve coordination of care, fall into this category.

In most industries, business models change over time, especially in tandem with new technologies. Yet, unlike the innovation types discussed above, there is no list of major recent business-model innovations that have transformed health care. In fact, most medical care today in developed coun-

tries is delivered through the same two business models that were dominant a century ago: general hospitals and physician practices.<sup>41</sup>

If health care were a competitive market, we might conclude from the continued dominance of general hospitals and physician practices that they are highly efficient at meeting the needs of consumers. However, there are substantial barriers to competition in health care, so we cannot assume existing models are efficient.

Moreover, there is evidence that the dominant business models are not particularly efficient. Recent studies have documented a more than three-fold difference in health spending across regions within the United States, without any corresponding difference in quality, indicating that health care can be delivered more efficiently in at least some of these regions.<sup>42, 43</sup> The rise in health costs has led to a growing phenomenon of "medical tourism"—Americans and citizens of other developed countries traveling abroad, often to undeveloped countries, to obtain similar quality health care at a lower cost than is available at home.<sup>44, 45</sup>

Several scholars have recently argued that the dominant business models in health care contribute to our high costs and poor coordination of services, and that new models are necessary to reduce costs and increase value.<sup>46, 47, 48</sup> Harvard Business School professor Regina Herzlinger, for example, argues for the value of specialty hospitals and other "focused factories." However, such progress has been slow. Although some consider the growth in specialty hospitals to be significant, a study by the General Accounting Office in 2003 found a total of only 78 specialty hospitals, compared with 4,908 general hospitals.<sup>49</sup>

Even for those who do not agree with the specifics of Herzlinger's ideas, the lack of business-model innovation in health care should be cause for concern. Some new business models that promise to deliver higher-quality care at a lower cost have emerged. Nurse practitioner-staffed clinics are an example. But these models have barely gotten off the

**The dominant business models in health care contribute to high costs and poor coordination of care; new models are necessary to reduce costs and increase value.**

**Entrepreneurial physicians and others who develop and implement new business models are often opposed by their peers and the government.**

ground. The combination of these factors make us question whether general hospitals and individual physician practices—which evolved a century ago when medicine was very different from what it is today—continue to be ideal for modern health care.

Given the lack of progress in this area across most developed nations, it would not be particularly worthwhile to compare countries. Instead, we would like to reflect on some of the many factors that have hindered the growth of new business models in health care.

### **Resistance to Entrepreneurship**

Entrepreneurial physicians and others who develop and implement new models are often opposed by their peers and the government. For example, despite a lack of evidence that physician-owned specialty hospitals offer inferior care, and even some evidence that their care is better than general hospitals, general hospitals and other groups have lobbied for regulatory roadblocks to impede specialty hospitals. Congress has repeatedly enacted temporary moratoria on Medicare payments to specialty hospitals, which severely limits their growth.<sup>50</sup> The health care reforms currently under consideration in Congress may further limit the growth of specialty hospitals.<sup>51</sup>

### **Payment Systems**

Business models are not sustainable if they lose money, which means that new business models can only work if some payer is willing to recognize their virtues and pay for them. Unfortunately, the dominant health care purchasers—Medicare, Medicaid, and the private insurers who follow Medicare’s fee schedule (which all have interests that are not necessarily aligned with their patients’ interests)—resist paying for new business models. In the words of Clayton Christensen, professor at Harvard Business School:

Caregivers who do things the way they’ve always been done, or who make improvements within the present archi-

ture of care, can get paid for what they do. Those who wish to disrupt the system by changing the very architecture of care, however, often are stymied by the specter that there literally is no money to be made from doing it.<sup>52</sup>

This system even discourages improvements and traps care in high-cost business models because its fees are based on the cost rather than the value of care. A good example is dialysis treatment for end-stage kidney disease. We now have the technology for patients to get this treatment at home—rather than at a dialysis center—at significantly lower cost and in a manner that better matches human physiology. Yet, despite improvements in this technology, home hemodialysis is becoming less frequent. One of the major reasons is that we have a single-payer system for dialysis that rewards physicians for recommending high-cost dialysis centers rather than their cheaper alternative.<sup>53, 54, 55, 56, 57</sup>

### **Medical Licensing**

New business models, especially those that seek to reduce cost, may need to rely on mid-level clinicians such as nurse practitioners to perform services usually performed by primary care physicians, and to rely on primary care physicians to do what is usually done by specialists. This type of pattern is one that Christensen found in a wide variety of industries: “Many of the most powerful innovations that disrupted other industries did so by enabling a larger population of less skilled people to do in a more convenient, less expensive setting things that historically could be performed only by expensive specialists in centralized, inconvenient locations.”<sup>58</sup> Yet medical licensing is an obstacle to such progress because it allows groups of physicians and other clinicians to determine what tasks their competitors may perform. For example, despite the lack of any data showing worse outcomes when patients are treated by nurse practitioners rather than physicians, a majority of states still prohibit nurse practitioners from practicing independently.<sup>59</sup>

## Conclusion

The health care debate should address more than just covering the uninsured and controlling costs. It should also consider whether proposed policies will promote or hinder the ability of creative individuals to innovate.

For example, proposals that increase spending on diagnostics and therapeutics could encourage such innovation. On the other hand, imposing price controls on pharmaceuticals and health insurance would tend to reduce innovation.<sup>60</sup> Experience with Medicare demonstrates that expanding government's role as purchaser of health care services, either by expanding existing government programs or creating new programs, would tend to reduce innovation in health care delivery.<sup>61</sup> Experience with the nascent reforms in Massachusetts suggests that enabling government to specify the terms of private health insurance contracts also tends to reduce innovation in health care delivery.<sup>62</sup>

In 2007, former Clinton administration labor secretary Robert Reich captured the potential for health care reform to influence medical innovation when he candidly told an audience that "us[ing] the bargaining leverage of the federal government in terms of Medicare, Medicaid . . . to force drug companies and insurance companies and medical suppliers to reduce their costs . . . means less

innovation, and that means less new products and less new drugs on the market, which means you are probably not going to live that much longer than your parents."<sup>63</sup>

Unfortunately, consideration of policy factors that contribute to or hinder health care innovation has been limited, at least partly because international comparisons of health care systems generally do not include measures of innovation. We hope that this paper can be a start in reversing this trend.

In three of the four general categories of innovation examined in this paper—basic science, diagnostics, and therapeutics—the United States has contributed more than any other country, and in some cases, more than all other countries combined. In the last category, business models, we lack the data to say whether the United States has been more or less innovative than other nations; innovation in this area appears weak across all nations.

In general, Americans tend to receive more new treatments and pay more for them—a fact that is usually regarded as a fault of the American system. That interpretation, if not entirely wrong, is at least incomplete. Rapid adoption and extensive use of new treatments and technologies create an incentive to develop those techniques in the first place. When the United States subsidizes medical innovation, the whole world benefits. That is a virtue of the American system not reflected in comparative life expectancy and mortality statistics.

**Table 1**  
**Thirty Leading Medical Innovations and Their Place of Origin**

Rank	Innovation <sup>64</sup>	Country of Origin	Approximate Timeframe	Type
1	MRI and CT scanning <sup>65,66</sup>	UK and U.S.	1970s	Diagnostic
2	ACE inhibitors <sup>67,68,69</sup>	U.S.	1970s–1980s	Therapeutic
3	Balloon angioplasty <sup>70,71</sup>	Primarily Switzerland, with significant work in the U.S.	1970s	Therapeutic
4	Statins <sup>72,73,74</sup>	Japan, U.S.	1970s–1980s	Therapeutic
5	Mammography <sup>75,76</sup>	Several, including U.S., Sweden, Finland, UK	1970s–1980s	Diagnostic

*Continued*

**Table 1 Continued**  
**Thirty Leading Medical Innovations and Their Place of Origin**

Rank	Innovation <sup>64</sup>	Country of Origin	Approximate Timeframe	Type
6	Coronary Artery Bypass Graft Surgery <sup>77, 78, 79, 80, 81</sup>	Russia, U.S.	1960s–1970s	Therapeutic
7	Proton pump inhibitors and H2 blockers <sup>82, 83, 84</sup>	Sweden, UK (U.S.-based company)	1970s–1980s	Therapeutic
8	SSRIs and recent non-SSRI antidepressants <sup>85, 86, 87, 88, 89</sup>	U.S.	1970s–1980s	Therapeutic
9	Cataract extraction and lens implant <sup>90, 91, 92, 93, 94</sup>	U.S.	1960s–1970s, and further developments recently	Therapeutic
10	Hip <sup>95, 96, 97</sup> and Knee replacement <sup>98, 99, 100, 101</sup>	Burma, UK, U.S.	1960s–1970s	Therapeutic
11	Ultrasonography <sup>102, 103</sup>	Indeterminate		Therapeutic
12	Gastrointestinal endoscopy <sup>104, 105, 106</sup>	Japan, U.S.	1957–1990s	Therapeutic
13	Inhaled steroids for asthma <sup>107, 108, 109</sup>	UK	1960s	Therapeutic
14	Laparoscopic surgery <sup>110, 111, 112</sup>	France, Germany, U.S.	1960s–1990s	Therapeutic
15	NSAIDs and Cox-2 inhibitors <sup>113, 114</sup>	U.S.	1980s–1990s	Therapeutic
16	Cardiac enzymes <sup>115, 116, 117, 118</sup>	Japan, Germany	1950s–1980s	Diagnostic
17	Fluoroquinolones <sup>119</sup>	Japan, Germany, U.S.	1970s–1980s	Therapeutic
18	Recent hypoglycemic agents <sup>120, 121, 122, 123, 124</sup>	U.S., Japan	1940s–1990s 1970s–1990s	Therapeutic
19	HIV testing and treatment <sup>125, 126, 127, 128, 129</sup>	U.S., France, Switzerland, UK (U.S. facility)	1960s (synthesis); 1980s–1990s, most of the development	Both
20	Tamoxifen <sup>130, 131</sup>	UK	1960s–1970s	Therapeutic
21	PSA testing <sup>132, 133</sup>	U.S.	1979–early 2000s	Diagnostic
22	Long-acting and parenteral opioids <sup>134</sup>	Germany	1916 <sup>135</sup>	Therapeutic
23	<i>Helicobacter pylori</i> testing and treatment <sup>136</sup>	Australia	1970s–1980s	Both
24	Bone densitometry <sup>137, 138, 139</sup>	U.S.	1960s–Present	Diagnostic
25	Third-generation cephalosporins <sup>140, 141, 142, 143</sup>	U.S.	1940s–1980s	Therapeutic
26	Calcium channel blockers <sup>144, 145</sup>	Germany	1960s–1970s	Therapeutic
27	IV-conscious sedation	No information available		Therapeutic
28	Sildenafil (Viagra) <sup>146, 147, 148</sup>	UK (U.S.-based company)	1980s	Therapeutic
29	Nonsedating antihistamines <sup>149, 150</sup>	U.S.	1970s–1990s	Therapeutic
30	Bone marrow transplant <sup>151, 152, 153, 154, 155</sup>	U.S., Canada	1950s–1990s	Therapeutic

**Table 2**  
**Leading Pharmaceutical Innovations & Place of Origin (Rows in bold indicate items that do not appear in Table 1)**

Drug Class	Drug	Company	Location of Company Headquarters	Location of Research Facility	Year of FDA Approval
Angiotensin converting enzyme inhibitors <sup>156, 157, 158</sup>	captopril (Capoten)	Squibb	U.S.	U.S.	1981
<b>Angiotensin II antagonists</b> <sup>159, 160, 161</sup>	<b>losartan (Cozaar)</b>	<b>Merck</b>	<b>U.S.</b>	<b>U.S.</b>	<b>1995</b>
Calcium channel blockers <sup>162, 163</sup>	nifedipine (Procardia)	Bayer	Germany	Germany	1981
Statins <sup>164, 165, 166, 167</sup>	lovastatin (Mevacor)	Merck	U.S.	U.S.	1987
<b>Fibrates</b> <sup>168, 169, 170</sup>	<b>clofibrate (Astromid-S)</b> <b>gemfibrozil (Lopid)</b>	<b>I.C.I.</b> <b>Parke-Davis</b>	<b>UK</b> <b>U.S.</b>	<b>Unclear</b> <b>UK</b>	<b>1967</b> <b>1981</b>
<b>Cholesterol absorption inhibitors</b> <sup>171, 172</sup>	<b>ezetimibe (Zetia)</b>	<b>Schering-Plough</b>	<b>U.S.</b>	<b>Unclear</b>	<b>2002</b>
H2 blockers <sup>173, 174</sup>	cimetidine (Tagamet)	Smith Kline French	U.S.	UK	1977
Proton pump inhibitors <sup>175, 176</sup>	omeprazole (Prilosec)	Astra	Sweden	Sweden	1989
Serotonin selective reuptake inhibitors <sup>177, 178, 179, 180</sup>	fluoxetine (Prozac)	Eli Lilly	U.S.	U.S.	1987
Serotonin norepinephrine reuptake inhibitors <sup>181, 182</sup>	venlafaxine (Effexor)	Wyeth	U.S.	Unclear	1993
<b>Bronchodilators</b> <sup>183, 184, 185</sup>	<b>albuterol (Ventolin)</b>	<b>Allen and Hanbury</b>	<b>UK</b>	<b>UK</b>	<b>1969* (launch)</b>
Inhaled corticosteroids <sup>186, 187, 188, 189</sup>	beclomethasone (Beclovent)	Glaxo	UK	Unclear	1980 (patent)
<b>Leukotriene receptor antagonists</b> <sup>190, 191</sup>	<b>montelukast (Singulair)</b> <b>zafirlukast (Accolate)</b>	<b>Merck</b> <b>Astrazeneca</b>	<b>U.S.</b> <b>Sweden</b>	<b>Unclear</b> <b>Unclear</b>	<b>1998</b> <b>1996</b>
Cox-2 inhibitors <sup>192, 193</sup>	celcoxib (Celebrex)	G. D. Searle	U.S.	Unclear	1998
Third-generation cephalosporins <sup>194, 195, 196, 197</sup>	cefotaxime (Claforan)	Hoechst-roussel	Germany	Unclear	1981
<b>Imidazole and triazole antifungals</b> <sup>198, 199</sup>	<b>fluconazole (Diflucan)</b> <b>ketoconazole (Nizoral)</b>	<b>Pfizer</b> <b>Janssen</b>	<b>U.S.</b> <b>Belgium</b>	<b>UK</b> <b>Belgium</b>	<b>1990</b> <b>1981</b>

*Continued*



**Table 2 Continued**

**Leading Pharmaceutical Innovations & Place of Origin (Rows in bold indicate items that also appear in Table 1)**

Drug Class	Drug	Company	Location of Company Headquarters	Location of Research Facility	Year of FDA Approval
<b>Antivirals (herpes simplex/zoster)</b> <sup>200, 201</sup>	<b>acyclovir (Zovirax)</b>	<b>Burroughs Wellcome</b>	<b>UK</b>	<b>U.S.</b>	<b>1982</b>
HIV antiretrovirals <sup>202, 203, 204, 205</sup>	zidovudine (AZT, Retrovir)	Burroughs Wellcome	UK	U.S.	1987
<b>Cytomegalovirus (CMV) antivirals</b> <sup>206</sup>	<b>foscarnet (Foscavir)</b>	<b>Astra</b>	<b>Sweden</b>	<b>Sweden</b>	<b>1991</b>
Oral hypoglycemic agents <sup>207, 208, 209, 210, 211</sup>	metformin (Glucophage) pioglitazone (Actos)	Bristol-Myers Squibb Takeda	U.S. Japan	U.S. Japan	1995 1999
Selective estrogen receptor modulators <sup>212, 213, 214</sup>	tamoxifen (Nolvadex)	I.C.I.	UK	UK	1977
<b>Chemotherapy agents</b> <sup>215, 216</sup>	<b>cisplatin (Platinol)</b>	<b>Bistol-Myers</b>	<b>U.S.</b>	<b>U.S.</b>	<b>1978</b>
<b>5-HT3 blockers</b> <sup>217, 218</sup>	<b>ondansetron (Zofran)</b>	<b>Glaxo</b>	<b>UK</b>	<b>UK</b>	<b>1991</b>
PDE5 blockers <sup>219, 220, 221</sup>	sildenafil (Viagra)	Pfizer	U.S.	U.K.	1998
Nonsedating antihistamines <sup>222, 223</sup>	loratadine (Claritin)	Schering-Plough	U.S.	U.S.	1993
<b>5-alpha reductase inhibitors</b> <sup>224, 225, 226</sup>	<b>finasteride (Proscar)</b>	<b>Merck</b>	<b>U.S.</b>	<b>U.S.</b>	<b>1992</b>
<b>Triptans (selective 5-HT1 agonists)</b> <sup>227, 228</sup>	<b>sumatriptan (Imitrex)</b>	<b>Glaxo</b>	<b>UK</b>	<b>UK</b>	<b>1992</b>
<b>Interferons</b> <sup>229, 230</sup>	<b>several</b>	<b>Berlex/Chiron, Biogen, Genentech, Roche</b>	<b>Germany, Switzerland, U.S.</b>	<b>Germany, Switzerland, U.S.</b>	<b>1993</b>
<b>Bisphosphonates</b> <sup>231, 232</sup>	<b>etidronate (Didronel)</b>	<b>Proctor and Gamble</b>	<b>U.S.</b>	<b>U.S.</b>	<b>1977</b>

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20. In the case of long-acting opioids, most of the significant advances were in the beginning of the 20th century. In recent history, there have been new preparations and slight advances (i.e., Oxycotin by Purdue Pharmaceuticals in the United States), but they are relatively minor compared to the initial development of the first long-acting opioids. We therefore chose not to include these examples alongside the more transformative innovations in the table.
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23. In the cases in which an innovation was developed at a foreign facility of a firm, the credit was given to the country in which the facility was located. If, instead, we give the credit to the country in which the firm is based, then there was a significant contribution from the United States to 22 of the 27 innovations, including all of the top 10, and a significant contribution from the E.U. or Switzerland to 13 of 27, including 5 of the top 10.
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27. This was true of the following classes: leukotriene receptor antagonists and the oral hypoglycemic agents.

28. The excluded classes were beta blockers, platelet aggregation inhibitors, MAOIs, NSAIDs, long-acting opioids, immunosuppressants, fluoroquinolones, and thyroid-stimulating hormones.

29. Three of the classes have both the United States and a European country listed. In the cases in which a drug was developed at a foreign facility of a pharmaceutical firm, the credit was given to the country in which the facility was located. If, instead, we give the credit to the country in which the pharmaceutical firm is based, then there was a significant contribution from the United States in 18 of 29 cases, and a significant contribution from the E.U. or Switzerland in 15 cases. Whenever we were unable to find the specific facility where a particular drug was developed, we assumed that it was developed at a facility in the country in which the company was based at the time.

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they received initial FDA approval more than 40 years ago. The results for the remaining 29 classes are in Table 2. As the table makes clear, the U.S. contribution has been significant. Sixteen of the 30 representative drugs were initially developed in the United States, while 15 were developed in the E.U. or Switzerland. (We credit two of the 29 drug classes to both the United States and a European country.) Again, all of these figures should be interpreted in light of the European Union's notably larger population.

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