Availability of New Drugs and Americans' Ability to Work

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Objective: *The objective of this work was the investigation of the extent to which the introduction of new drugs has increased society's ability to produce goods and services by increasing the number of hours worked per member of the working-age population.* ***Methods:*** *Econometric models of ability-to-work measures from data on approximately 200,000 individuals with 47 major chronic conditions observed throughout a 15-year period (1982–1996) were estimated.* ***Results:*** *Under very conservative assumptions, the estimates indicate that the value of the increase in ability to work attributable to new drugs is 2.5 times as great as expenditure on new drugs.* ***Conclusions:*** *The potential of drugs to increase employee productivity should be considered in the design of drug-reimbursement policies. Conversely, policies that broadly reduce the development and utilization of new drugs may ultimately reduce our ability to produce other goods and services.* (J Occup Environ Med. *2005;47:373–380*)

Employer-provided health insurance is an important source of coverage for health care expenditures in the United States. Expenditures on private health insurance accounted for the largest share of increased health care spending in 2002.[1] As employers re-examine their health insurance costs, numerous questions arise about the value of these expenditures and their impact on employees' health and their ability to perform productively in their jobs. One recent study noted that costs associated with health-related inability to work and reduced performance at work are greater than direct medical expenditures for many prevalent chronic conditions.[2]

Several case studies have examined the impact of specific new drugs on workplace productivity.[3] Some examples include case studies of terbutaline, glipizide, and triptans. Sumatriptan and rizatriptan were approved for migraines in 1992 and 1998, respectively. In randomized, controlled trials of subcutaneous sumatriptan and oral rizatriptan, the difference between the triptan and control groups in average time lost (absenteeism plus presenteeism) was statistically significant. The median values for the time saved per migraine attack by using a triptan were 0.64 hours absenteeism, 0.6 hours presenteeism, and 1.1 hour total time.[4–8]

Glipizide, a second-generation sulfonylurea, was approved in 1984 for diabetes. The health economic benefits of glipizide in patients with type 2 diabetes were tested in a 12-week, randomized, double-blind, placebo-controlled trial. Glipizide reduced absenteeism considerably: the rate ratio for days of work missed in the

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placebo and glipizide groups (ie, the proportion of days of work missed during the study in the placebo group divided by the proportion of days of work missed in the glipizide group) was 4.8 (95% confidence interval [CI] = 2.0–11.9). In addition, the glipizide patient group had higher retained employment during the trial than the placebo group (97% vs. 85%; *P* value 0.001). Productivity losses from absenteeism per worker per month by the end of the study were $24 for men in the glipizide group versus $115 in the placebo group (based on an average wage of $116 per day for men; Bureau of the Census.)[9]

Terbutaline, a beta-agonist, was approved by the Food and Drug Administration (FDA) in 1974 for asthma. The effect of inhaled terbutaline on productivity was tested in an open-label, single group, pretest-posttest trial of people with asthma in primary care. The number of work or school days missed due to asthma decreased by 57%, from 1.0 per patient in the week before beginning inhaled terbutaline treatment to 0.4 per patient in the fourth and final week of treatment ($P < 0.001$).[10]

Although these and similar studies were well done and extremely useful, it is difficult to estimate from them the average or aggregate effect of new drugs on productivity. In this work, I will use a different approach that suggests how new drugs in general affect productivity.

Previous case studies were based on (relatively small) samples of individuals with the same condition at the same time. My analysis will be based on data on approximately 200,000 individuals with 47 major chronic conditions observed throughout a 15-year period (1982–1996). Previous studies performed *within-condition* analysis: they compared people with a given condition who were taking a drug to people with the same condition who were not taking the drug. I will perform *between-condition* analysis: I will, in effect, examine whether people with conditions for which many new drugs were introduced exhibited greater increases in ability to work than people with conditions for which few new drugs were introduced, controlling for other factors.

Measuring Ability to Work by Condition and Year

The number of days worked per member of the working-age population depends on two variables: the number of days worked per employed person, and the fraction of the working-age population that is employed. The National Health Interview Survey (NHIS) allows us to measure both days of work missed by employees and the fraction of the population that is unable to work, by condition and year. The NHIS is the principal source of information on the health of the civilian noninstitutionalized population of the United States and is one of the major data collection programs of the National Center for Health Statistics. Although the NHIS has been conducted continuously since 1957, the content of the survey has been updated about every 10–15 years. The survey remained the same during the period 1982–1996. During that period, it collected information from 1,017,164 working-age Americans on 133 chronic conditions and impairments. In particular, it collected information about whether each person was unable to work, mainly due to one of the chronic conditions, and (for currently employed persons) about the number of workdays missed in the 2 weeks preceding the interview as the result of each chronic condition.

Each respondent to the survey was asked about a subset of the 133 conditions. There are six groups of conditions: skin and musculoskeletal, impairments, digestive, miscellaneous, circulatory, and respiratory. Each respondent was asked about the conditions in one of the six groups. Hence, about 170 thousand (≈1017,164/6) people were asked about circulatory conditions, 170,000 people were asked about respiratory conditions, etc. If the person said that he or she suffered from one or more of the conditions, information about the condition(s) were recorded in the NHIS Conditions File. The average condition prevalence rate in the NHIS is about 2.7%: for the entire 1982–1996 period, the average number of records per condition is about 4650, which is about 2.7% of the potential number of records per condition (170 thousand). We were able to obtain data on the number of drugs approved for 47 conditions or groups of conditions.* Hence, we have data on approximately 200,000 chronic conditions borne by people age 18–69 during 1982–1996. Approximately two thirds of the working-age population was employed; we have data on approximately 126,000 chronic conditions borne by employed people.

The percent of people who reported that they were unable to work because of a medical condition declined from 7.1% in 1982 to 6.3% in 1990 and then increased to 7.2% in 1994. These fluctuations appear to be correlated with changes in aggregate economic conditions, as measured by the adult unemployment rate: people are more likely to report that they are unable to work because of a medical condition when the unemployment rate is high.† All of the models we will estimate will include fixed year effects, so they will control for changes in aggregate economic conditions.

As shown in Table 1, among 47 sample conditions, the top 5 condi-

*These 47 conditions account for 75% of all chronic conditions, 57% of chronic conditions causing inability to work, and 50% of work-loss days from chronic conditions.

†In the regression of % unable to work on the unemployment rate and a time trend, both coefficients are positive and significant. The coefficient on the unemployment rate is 0.21, its t-statistic is 3.24, and *P* value is 0.007.

TABLE 1
Sample Conditions Listed in Declining Order of Frequency

Condition	*N*	%	Cum N	Cum %	% Unable to Work
Sinusitis	27,457	12.6	27,457	12.6	0.1%
Arthritis	22,668	10.4	50,125	22.9	6.8%
Hypertension	22,428	10.3	72,553	33.2	3.7%
Allergic Rhinitis	18,029	8.2	90,582	41.4	0.1%
Gastrointestinal Disorders - other	14,264	6.5	104,846	47.9	1.0%
Skin disorders - other	11,148	5.1	115,994	53.0	0.2%
Migraines	8,726	4.0	124,720	57.0	0.8%
Bronchitis	7,884	3.6	132,604	60.6	0.8%
Headaches	7,315	3.3	139,919	64.0	0.5%
Cardiovascular Disease	7,152	3.3	147,071	67.3	10.4%
Asthma	6,820	3.1	153,891	70.4	3.9%
Dermatitis	6,381	2.9	160,272	73.3	0.2%
Peripheral Vascular Disease	6,200	2.8	166,472	76.1	0.7%
Diabetes	5,269	2.4	171,741	78.5	13.3%
Bursitis/Tendonitis	4,024	1.8	175,765	80.4	1.3%
Ulcers	3,855	1.8	179,620	82.1	2.7%
Acne	3,174	1.5	182,794	83.6	0.0%
Thyroid Disorders	3,005	1.4	185,799	85.0	1.7%
Anemia	2,873	1.3	188,672	86.3	1.4%
Kidney Disorders	2,704	1.2	191,376	87.5	3.5%
Arrhythmias	2,466	1.1	193,842	88.6	4.3%
Psoriasis	1,934	0.9	195,776	89.5	0.8%
Gout	1,739	0.8	197,515	90.3	0.1%
Menstrual Disorders	1,724	0.8	199,239	91.1	3.4%
Infectious Disease - other	1,695	0.8	200,934	91.9	6.4%
Stroke	1,496	0.7	202,430	92.6	24.3%
Female Reproductive Disorders	1,388	0.6	203,818	93.2	0.8%
Recurrent Urinary Tract Infections	1,385	0.6	205,203	93.8	0.3%
Urology/Nephrology Disorders - other	1,314	0.6	206,517	94.4	1.5%
Atherosclerosis	1,198	0.6	207,715	95.0	0.0%
Skin Cancers - Melanoma	1,192	0.6	208,907	95.5	0.6%
Respiratory Disorders - other	1,191	0.5	210,098	96.1	5.6%
Glaucoma	1,166	0.5	211,264	96.6	6.0%
Musculoskeletal Disorders - other	954	0.4	212,218	97.0	12.6%
Gall Bladder Disorders	920	0.4	213,138	97.5	1.5%
Epilepsy	877	0.4	214,015	97.9	24.4%
Lung Disorders	772	0.4	214,787	98.2	9.5%
Circulation Disorders	629	0.3	215,416	98.5	10.8%
Thrombosis	609	0.3	216,025	98.8	7.9%
Liver Disorders	602	0.3	216,627	99.1	10.3%
Eye Disorders - other	549	0.3	217,176	99.3	6.9%
Neurological Disorders - other	471	0.2	217,647	99.5	10.0%
Breast Cancer	438	0.2	218,085	99.7	0.5%
Multiple Sclerosis	204	0.1	218,289	99.8	45.5%
Cancer - Digestive/GI	177	0.1	218,466	99.9	27.6%
Lung Cancers	121	0.1	218,587	100.0	42.7%
Prostate Cancer	110	0.1	218,697	100.0	21.1%

tions, which jointly account for almost half of all workdays lost, are sinusitis, arthritis, hypertension, allergic rhinitis, and gastrointestinal disorders–other. Seven of the nine most frequent conditions have low rates of inability to work (rates at or less than 1.0%). Two fairly prevalent diseases with high rates of inability to work are cardiovascular disease (10.4%) and diabetes (13.3%). The (less common) disorders with the highest rates of inability to work are multiple sclerosis (45.5%), lung cancers (42.7%), cancer–digestive/GI (27.6%), epilepsy (24.4%), stroke (24.3%), and prostate cancer (21.1%).

Measuring the Number of Drugs Previously Approved, by Condition, Year, and "Therapeutic Potential"

I hypothesize that the ability of people with a given condition to work is greater, the greater the number of drugs previously approved to

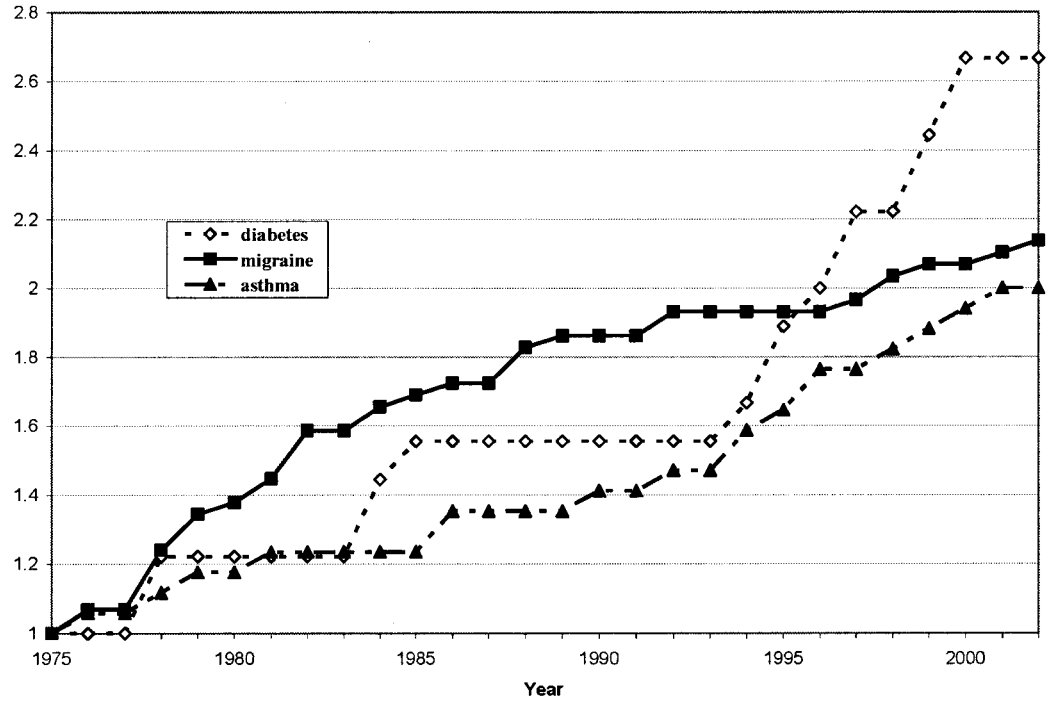

Fig. 1. Cumulative number of drugs approved for three conditions relative to the cumulative number of drugs approved for that condition in 1975.

treat their condition. In principle, ability to work should depend more closely on drugs *utilized* for a condition than it does on drugs *approved* for a condition. However, data on drug utilization are much more limited than data on drug approvals.‡

I will therefore examine the effect of previous drug *approvals* on ability to work. When the FDA approves a drug, it announces the uses (indications) for which the drug is approved. Figure 1 shows the cumulative number of drugs approved for three highly prevalent conditions—asthma, diabetes, and migraines—during 1975–2002, relative to the cumulative number of drugs approved for that condition in 1975. These conditions exhibit significant variability with respect to the magnitude and timing of growth in the stock of drugs. Between 1975 and 1983, diabetes had the smallest increase in the stock of drugs: its stock increased 22.2%, compared with a 23.5% increase for asthma and a 58.6% increase for migraines. Between 1984 and 1995, diabetes ranked second in growth, and since 1996, it has ranked first.

When the FDA receives a New Drug Application, it assesses the drug's "therapeutic potential," and classifies it as either a "priority-review" drug—one that the FDA believes represents a "significant improvement compared with marketed products, in the treatment, diagnosis, or prevention of a disease"—or a "standard-review" drug—one that "appears to have therapeutic qualities similar to those of one or more already marketed drugs." This classification is probably subject to error, especially because it is made *before* the drug's review.

Nonetheless, one might expect the approval of a priority-review drug to have a greater impact on ability to work than the approval of a standard-review drug. We will explore this possibility by estimating two versions of the model: one in which ability to work depends on the total number of previously-approved drugs, and one in which it depends only on the number of previously-approved priority-review drugs.§ In the first case, we are treating standard-review drugs as equivalent in value to priority-review drugs; in the second case, we are treating standard-review drugs as having no additional therapeutic value.¶

‡Some data on drug utilization by condition can be constructed from a physician survey, the National Ambulatory Medical Care Survey (NAMCS). However, this survey contains data on drugs prescribed by physicians, not on drugs actually consumed by patients. In addition, this survey was not conducted during the years 1982–1984 and 1986–1988, and the drug utilization data are subject to considerable sampling error: in 1997, NAMCS sampled just 1 of every 31,000 physician office visits. Furthermore, the relationship between new drug *use* and ability to work may be subject to reverse causality: employed people may have greater access to new drugs via employer-sponsored health insurance.

§We used unpublished data provided by the FDA to classify drugs as priority- or standard-review. The number of drugs in the two categories is approximately equal.

¶If the true ratio of the impact of standard-review drugs to the impact of priority-review drugs is between 0 and 1, estimates of the two models should provide upper and lower bounds of the combined effect. I also used an alternative approach, that is, to include both the log of the

Because it takes time for new drugs to be widely diffused throughout the health care system,‖ the health of the population should be more closely related to the lagged stock of drugs than it is to the current stock of drugs. We will test for this by estimating the relationship at different assumed lags. In previous work based on international data, I found that the stock of drugs has its largest impact on per capita pharmaceutical *expenditure* with a lag of about 4 or 5 years.[11] One might therefore expect a lag of about 4 or 5 years between the stock of drugs and health indicators.

Statistical Model of Ability to Work

I use multiple regression analysis to assess the effect of the stock of drugs (cumulative number of drugs approved for a condition) on ability to work.

The dependent variables of the regressions are measures of person j's inability to work due to condition i in year t

(i = 1,. . . ,47; t = 1982,. . . , 1996). Two dependent variables are of primary interest: 1) whether someone is unable to work, and if so, this condition is the main cause of this inability (UNABLE WORK); and 2) for currently employed persons, the number of workdays missed in the past two weeks due to this condition (WLDAYS). I will also estimate models of several other variables:

- whether someone is limited in work, and if so, this condition is the main cause of this limitation (LIMITED WORK)
- whether someone has ever been hospitalized for this condition (EVER HOSP)
- the number of days of restricted activity in the past two weeks due to this condition (RADAYS)

The explanatory variables are the logarithm of the number of drugs approved to treat condition i by the end of year t-k (k = 1,. . . ,5); a vector of attributes (eg, age, sex, race, education, veteran status, and region) of person j in year t; a fixed effect for condition i; and a fixed effect for year t.

I present estimates based on the average of the results using the stock of all drugs (ALL DRUG) in years 3–5 (ie, the cumulative number of approved drugs lagged by 3 to 5 years). Estimates based on the average of the results for priority drugs (PRI DRUG) in years 3–5 are discussed but not presented, because most of the results suggested that the difference between the effect of priority- and standard-review drugs on ability to work was not statistically significant.

Value of Increase in Ability to Work Attributable to Increase in Lagged Stock of Drugs

Table 2 shows calculations of: 1) how much the introduction of new drugs reduced the annual rate of growth (or increased the annual rate of decline) of the productivity measures during the sample period; and 2) how much greater the inability to work in 1996 would have been in the absence of the post-1982 increase in the lagged stock of drugs.

Reduction in Inability to Work

The estimates imply that the growth in the lagged stock of all drugs reduced the probability of being unable to work due to the 47 sample conditions by 1.8% per year during the period 1982–1996. I estimate that, if the probability of being unable to work had not been reduced by new drug introductions during 1982–1996, this probability would have been 29% higher in 1996 than it actually was—5.2% instead of 4.0%.

This estimate seems plausible, if we consider the following: between 1982 and 1996, the probability of a person age 20 surviving to age 65 increased by 2.3 percentage points—from 79.8% to 82.1%.[12] In several studies, I have provided evidence that pharmaceutical innovation contributed to this increase in longevity.[13–16] Presumably, the initial health status of people whose lives were extended by medical innovations was worse than that of people who would have survived in the absence of these innovations.** Therefore, if new drugs had simply increased survival and had not increased the functional status of those enabled to survive, the additional survivors would have been unable to work. Because the survival rate increased by 2.3 percentage points, it is plausible that, if the probability of being unable to work had not been reduced by new drug introductions during 1982–1996, the unconditional probability (among survivors) of being unable to work due to the 47 sample conditions (which accounted for 57% of individuals unable to work because of chronic conditions) would have increased by 1.2 percentage points.††[17]

According to the Bureau of Labor Statistics, in 1996 average employer cost for employee compensation (in-

total number of drugs and the fraction of these drugs that were priority-review drugs in the same model. If the coefficient on the second variable is significant, this indicates that we can reject the null hypothesis of equal effects of the two types of drugs.

‖As an illustration, alendronate (Fosamax) was approved by the FDA in 1995. Its US sales rank increased steadily from 167 in 1996 to 55 in 1999. Atorvastatin (Lipitor) was approved by the FDA in 1996. Its US sales rank increased from 62 in 1997 to 3 in 1999.

**The average number of medical conditions reported by people in 1990–1996 was 4.2% higher than the average number reported in 1982–1989.

††Changes in the Social Security Disability Insurance and Supplemental Security Income programs perhaps also contributed to this increase. Between 1984 and 2000, the share of nonelderly adults receiving benefits from the Social Security Disability Insurance (DI) and Supplemental Security Income (SSI) programs rose from 3.1 to 5.3%. Autor and Duggan[17] traced this growth to reduced screening stringency and to the interaction between growing wage inequality and a progressive benefits formula, a rising earnings replacement rate.NOTEREF Ref93894223 h * MERGEFORMAT.

TABLE 2
Calculation of Value of Reductions in Inability to Work and Work-Loss Days in 1996 Attributable to 1982–1996 Increase in Lagged Stock of Drugs

	Average Value in 1996 (across all conditions)	Average Value in 1996 (47 sample conditions)	Annual Rate of Decline Attributable to Increase in Drug Stock, 1982–1996	Estimated % Increase in 1996 if no Post-1982 Increase in Lagged Drug Stock	Estimated 1996 Level if no Post-1982 Increase in Lagged Drug Stock	Estimated Absolute Increase in 1996 if no Post-1982 Increase in Lagged Drug Stock	Value of Estimated Absolute Increase in 1996 if no Post-1982 Increase in Lagged Drug Stock
			Estimates Based on Average of Estimated Effect for 3 to 5 Year Lags in Stock of all Drugs				
Unable to work*	7.0%	4.0%	1.8%	29.1%	5.2%	1.2%	$395
Limited in work†	11.4%	5.7%	2.0%	32.5%	7.6%	1.9%	
Wldays‡	4.8	0.98	1.0%	14.4%	1.12	0.1	$19
Radays§	14.4	5.1	1.5%	22.4%	6.2	1.1	
Unable to work + wldays							$415

Note: All estimates are adjusted for estimated effect of increase in drug stock on condition prevalence.

* The 47 sample conditions account for 57% of those unable to work because of chronic conditions.

† The 47 sample conditions account for 50% of those reporting limitations in work due to chronic conditions.

‡ Mean WLDAYS associated with both chronic and acute conditions in 1996 was 4.80 days. Mean WLDAYS associated with acute conditions alone was 2.84 days; so mean WLDAYS associated with chronic conditions alone was 1.96 days. The 47 sample conditions account for 50% of WLDAYS due to chronic conditions; 50% * 1.96 days = 0.98 days.[xxxii,xxxii]

§ Mean RADAYS associated with both chronic and acute conditions in 1996 was 14.4 days. Mean RADAYS associated with acute conditions alone was 6.1 days; so mean RADAYS associated with chronic conditions alone was 8.3 days. The 47 sample conditions account for 61% of RADAYS due to chronic conditions; 61% * 8.3 days = 5.1 days.

cluding fringe benefits) was about $131/day, or $34,000/year. Hence the per capita annual value of the estimated reduction in the probability of being unable to work at all was about $395 (= (5.2% − 4.0%) * $34,000).

Reduced Work-Loss Days

The estimates imply that the growth in the lagged stock of all drugs reduced the number of work-loss days of people employed by 1.0% per year during the period 1982–1996. This implies that, had the lagged stock of drugs not increased after 1982, average workdays lost due to the 47 sample conditions would have been 14.4% higher in 1996 than it actually was—1.12 instead of 0.98 days per year. The value per employee of the estimated reduction in work-loss days was about $19 (= (1.12 −0.98) * $131). The sum of the value of the reduced probability of being unable to work and of the reduced workdays missed per employee is $415 (= $395 + $19).

Priority-Review Drugs

The estimated coefficients on priority-review drugs (not presented) were about 50% larger than the estimated coefficients on all drugs, which suggests that priority-review drugs had a larger impact on ability to work than standard-review drugs. However, the estimated difference between the effects of priority-review and standard-review drugs was statistically significant only for the number of workdays missed in the past two weeks. The 1982–1996 increase in the stock of priority-review drugs was associated with a cumulative reduction of 0.42 work-loss days per employee per year.

Cost/Benefit of New Drugs

Data from the Medical Expenditure Panel Survey allow us to estimate average expenditure in 1996 on "new drugs" (drugs approved after 1978) used for the 47 sample chronic conditions.‡‡ Average spending on all prescription drugs by people age 18–64 was $255 in 1996. Expenditure on drugs approved after 1978 was $116, that is, just under half of their total drug expenditure. Medical Expenditure Panel Survey data indicate that the 47 sample chronic conditions account for 44% of total prescription drug expenditure. Hence, we estimate that average expenditure on new drugs for the 47 sample chronic conditions per working-age person was $51 (= 44% * $116).§§ The estimated benefit of the new drugs, in terms of the value of the increase in workforce participation

‡‡The preceding calculations were based on the 5-year lagged drug stock, and 1978 is 5 years before the beginning of our sample period.

§§Less than half (44%) of drug expenditure in 1997 was for drugs used primarily for long-term treatment of chronic conditions; 20% of drug expenditure was on drugs used primarily for short-term treatment of acute conditions; the remaining 36% of expenditure was on drugs used for both acute and chronic conditions.

and hours ($415), is eight times as great as the estimated cost of the new drugs.

Discussion

Because of data limitations, the models we estimated included measures of only one type of medical innovation: new drugs. In principle, we would have liked to include measures of other medical innovations, such as new medical devices and diagnostic and surgical procedures, but these data are not available.

There are two possible ways to address this data limitation. First, one could confine the analysis to pharmaceutical-intensive conditions: conditions for which the ratio of pharmaceutical innovation to other medical innovation is likely to be high. Using data from the 1996 Medical Expenditure Panel Survey, I computed, for each of the 47 sample conditions, the average number of prescriptions a person had for the condition over the course of a year. I then defined two groups of conditions: "high-rx conditions" (high rx = 1)—those with above-median average number of Rx's—and "low-rx conditions" (high rx = 0)—those with below-median average number of Rx's. I then estimated models that included an interaction term between the cumulative stock of drugs and high rx. Some of the estimates indicated that increases in the stock of drugs increased ability to work only in the case of high-rx conditions—conditions for which the relative importance of other medical innovation is likely to be low. However other estimates indicated that there was not a statistically significant difference between the effects of increases in the stock of drugs on ability to work in high-rx and low-rx conditions.¶¶

A second way to correct for the effect of other medical innovation is to make an adjustment based on the relative magnitudes of pharmaceutical and other medical innovation. Suppose that, in reality, ability to work depends on both new drugs and other medical innovations, but the model we estimate includes only the first variable. If the rates of pharmaceutical and other medical innovation are positively correlated across conditions—conditions with high rates of new drug introductions also have high rates of other medical innovations—then the β values we have estimated will overstate the effect of new drugs per se. It is not clear that there *is* a positive correlation: new drugs and other medical innovations may be substitutes, rather than complements.|||| However, for the sake of argument, suppose that the correlation is positive. Indeed, suppose that there is a *perfect* positive correlation, and that the estimates capture the effect of medical innovation in general, not just new drugs. Under certain reasonable assumptions, we can still identify the contribution of new drugs per se to ability to work.

Suppose that the marginal health benefit of an expenditure on pharmaceutical R&D is equal to the marginal health benefit of the same expenditure on other biomedical R&D. Then the fraction of the overall health benefits of biomedical research attributable to new drugs is equal to the ratio of pharmaceutical R&D expenditure to total biomedical R&D expenditure. In the United States in 1995, pharmaceutical industry R&D expenditure accounted for at least 28% of total health R&D expenditure and more than half of industry health R&D expenditure.*** If only 28% of the estimated effect of new drug approvals on ability to work is attributable to new drugs (and the remaining 72% is attributable to other medical innovations), then we should multiply the benefit estimates computed by 28%. This would reduce the estimate of the gross benefit of new drugs to $116 (= 28% * $415). This estimate, which is based on conservative assumptions, is still more than twice the average expenditure by working-age Americans in 1996 on new drugs used to treat the 47 sample chronic conditions.

I can also think of several reasons why we may be underestimating the value of the impact of new drugs on ability to work. First, new drugs have probably increased output per hour worked, as well as the number of hours worked. Second, I assumed that the social cost of a person's absence from work is the person's wage rate. However if production is team-based, a firm's output is reduced by more than 1% when 1% of its employees are absent.[18] Third, new drugs may have reduced morbidity among children and the elderly, and therefore the amount of time working-age people need to devote to caring for them.

This analysis has provided estimates of the average or aggregate benefits of new drugs. It does not provide evidence about the merits of any particular drug or even of any class of drugs, but does suggest that policies that broadly reduce the development and utilization of new drugs may ultimately reduce our ability to produce other goods and services.

To summarize, the estimates are very consistent with the hypothesis that the probability of being unable to work, limited in work, and having ever been hospitalized, and the number of work-loss days and restricted-activity days, are all inversely related to the stock of drugs (total and/or

¶¶The high- versus low-rx-intensive difference was significant in the unable-to-work and limited-in-work equations, but not in the other equations.

||||If the correlation is negative, we would *underestimate* the benefit of new drugs per se.

***The NSF estimate for R&D expenditure by the pharmaceutical industry in 1995 was $10.2 billion, and the PhRMA estimate for R&D expenditure by the pharmaceutical industry in 1995 was $11.9 billion. That year the total health R&D expenditure was $35.8 billion and industry health R&D expenditure was $18.6 billion. Pharmaceutical R&D may have accounted for a lower share of total health R&D expenditure in earlier years.

priority-review) approved 3 to 5 years earlier.

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