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**Article**

## New drugs: Health and economic impacts

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## Education Expansion in Developing Countries

Making primary education universal is a common goal for developing countries, but what are the effects of policies designed to greatly expand enrollment? Indonesia's experience is that an aggressive school building program raises enrollment but then depresses the return to education when the more educated cohorts hit the labor market [8710, 7860]. Incentives for school building can lead to an inefficient number of schools even though they raise enrollment [see Michael Kremer, Sylvie Moulin, and Robert Namunyu, "The Political Economy of School Finance in Kenya," August 2002]; and changes in school resources that seem incredibly cheap by American standards also raise enrollment substantially [8481, 7399]. If there is any theme in the evidence, it is that greater resources for schools in developing countries bring more children and *more marginal* children into school, so that researchers find it harder to identify improvements in achieve-

ment than to identify increases in enrollment.

## Technology

So far, I have not mentioned "education production functions" (the attempt to estimate the relationship between school inputs and outputs) which once were the staple fare in the economics of education. Many of the studies described above have education production functions embedded in them, but recent work scarcely resembles the conventional linear regression of a test score on a series of school characteristics. This is not because researchers have gotten tired of class size or school spending, but because recent work tends to exploit interesting policy or natural experiments or carefully explores the foundations and implications of different education production functions [9054, 8918, 9040, 7820, 7656, 7349]. Technology is the one truly *new* school input. Program members have studied the effects of computers in the classroom [7424], of federal internet subsidies [9090], and even, in developing countries, of flip-charts [8018]. So far, the evidence seems to

suggest that technology has at best weak effects on achievement. Undoubtedly, much more evidence will be forthcoming in this area as technology spreads and our measures of it improve.

## In Conclusion

Education-related research is likely to remain a growth area in economics for some time, largely because of the importance of skills for understanding economic growth and income inequality. However, other conditions are favorable as well. Education is an excellent area for the arbitration and elaboration of existing theory: many of the problems are inherently rich, amenable to analysis, and under-studied. It is also unusually easy to observe the behavior of key "actors" because they operate in a semi-public domain. (It is much easier to find out what a private college does than what a private firm does.) Data availability is improving continuously — partly because of technology, partly because of accountability, and partly because economists gain better access as they become ever more significant contributors to the field.

## Research Summaries

### New Drugs: Health and Economic Impacts

Frank R. Lichtenberg\*

Many economists believe that new goods are at the heart of economic progress, and that innovative goods are

better than older products because they provide more "product services" in relation to their cost of production. The pharmaceutical industry has among the highest propensities to generate new goods; it is one of the most R and D-intensive industries in the economy. Moreover, in part because of extensive FDA regulation, there is unusually good data about the launch and diffusion of new pharmaceutical

goods. I have used these data to perform a number of econometric studies at the individual, disease, and country level, in order to assess the health and economic impacts of the development and use of new drugs.

Most of my studies are based on data covering all medical conditions (diseases) and all drugs. Therefore, they provide evidence about the health and economic impacts of new drugs in

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general, not about specific drugs or their impacts on particular diseases.<sup>1</sup>

I hypothesize that people may obtain several kinds of benefits from using newer, as opposed to older, pharmaceutical products: longer life; reduced limitations on activities (including work); and reduced total medical expenditure. In this article, I describe some of the studies I have conducted to estimate the magnitude and value of these benefits, and compare them to the cost of using newer drugs.

## Increased Longevity

In one study using aggregate time-series data<sup>2</sup>, I examine the impact of new drugs' approvals on the longevity of Americans. Between 1960 and 1997, life expectancy at birth increased approximately 10 percent, from 69.7 to 76.5 years. Some economists believe that the value of life extension during this period nearly equaled the gains in tangible consumption. While life expectancy has tended to increase since 1960, there have been substantial fluctuations in the rate of increase. Growth in real per capita income also doesn't account for these fluctuations: the period in which life expectancy increased most rapidly (1973-5) was a period of dismal macroeconomic performance.

However, there is a highly statistically significant relationship between the number of new molecular entities (NMEs) approved by the FDA and increased longevity: *the periods during which the most new drugs have been approved by the FDA tend to be the periods in which longevity grew most rapidly.* This suggests that the greater the number of drugs that are available to physicians and consumers, the higher longevity will be. The estimates indicate that the average new drug approval increases the life expectancy of people born in the year that the drug is approved by .016 years (5.8 days). This may sound insignificant, but since there are approximately 4 million births per year in the United States, the average new drug approval increases the total expected life-years of the cohort by 63.7 thousand years (4 million births times .016 years/birth). New drug

approvals in a given year also increase the life expectancy of people born in future years, but by a smaller amount (because of obsolescence of drugs). I estimate that *current and future generations will live a total of 1.2 million life-years longer because of the average new drug approval.*

The cost to the pharmaceutical industry of bringing a new drug to market is often estimated to be about \$500 million. Hence, cost per life-year gained is \$424 (\$500 million / 1.2 million life-years). According to Murphy and Topel, this is a small fraction of the economic value of a life year, which they estimate to be on the order of \$150,000.

In another study using longitudinal, disease-level data<sup>3</sup>, I examine the impact of new drugs' approvals on mean age at death. I compute the stock of drugs available (that is, previously approved by the FDA) to treat a given condition in a given year by combining FDA data with data from First DataBank's National Drug Data File. The estimates indicate that approval of standard-review drugs — drugs whose therapeutic qualities the FDA considers to be similar to those of already marketed drugs — has no effect on longevity. But, approval of priority-review drugs — those considered by the FDA to offer significant improvements in the treatment, diagnosis, or prevention of a disease — has a significant positive impact on longevity. Increases in the stock of (labeled and unlabeled) drugs to treat a condition increase the mean age at which people die from that condition, and reduce the probability of dying before the age of 65.

The increase in the stock of priority-review drugs is estimated to have increased mean age at death by 0.39 years (4.7 months) during the period 1979-98. Ten percent of the total increase in mean age at death was attributable to the increase in the stock of priority-review drugs. The social rate of return on investment in pharmaceutical R and D is on the order of 18 percent. This rate of return reflects only the value of increased longevity among Americans; foreigners also benefit<sup>4</sup>, and the evidence suggests that there may be additional benefits of new drugs to

Americans, including reduced limitations on work and other activities, and reduced hospital expenditure.

## Reduced Activity Limitations

Another study using longitudinal, condition-level data<sup>5</sup> examines the effect of changes in both the average quantity and the average vintage (FDA approval year) of drugs consumed on work limitations. The estimates indicate that conditions for which there were above-average increases in utilization of prescriptions during 1996-8 tended to have above-average reductions in the probability of missed work-days. The estimated value to employers of the reduction in missed work-days exceed the employer's increase in drug costs.

The estimates are also consistent with the hypothesis that an increase in a condition's mean drug vintage reduces the probability that people with that condition will experience activity and work limitations, and reduces their average number of restricted-activity days. The estimates imply that activity limitations decline at the rate of about one percent per year of drug vintage, and that the rate of pharmaceutical-embodied technical progress with respect to activity limitations is about 18 percent per year. Estimates of the cost of the increase in drug vintage necessary to achieve reductions in activity limitations indicate that increases in drug vintage tend to be very "cost-effective."

Suchin Virabhak and I also examine the effect of drug vintage on activity limitations and perceived health status at the individual level<sup>6</sup>. We find that people who used newer drugs had better post-treatment health than people using older drugs for the same condition, after controlling for pre-treatment health, age, sex, race, marital status, education, income, and insurance coverage. They were more likely to survive, their perceived health status was higher, and they experienced fewer activity, social, and physical limitations. People consuming newer drugs tend to experience greater increases (or smaller declines) in physical ability than

people consuming older drugs. Most of the health measures indicate that the effect of drug vintage on health is higher for people with poor initial health than it is for people with good initial health. Therefore, in contrast to other kinds of technical progress (for example, information technology), which tends to increase economic inequality, pharmaceutical-embodied technical progress has a tendency to reduce inequality as well as promote economic growth, broadly defined.

## Reduced Total Medical Expenditures

I have performed several studies to assess the impact of pharmaceutical use in general on the demand for inpatient hospital care and overall medical expenditures. My first study on this issue<sup>7</sup> was based on disease-level data: I constructed a database of information about utilization of pharmaceuticals, ambulatory care, and hospital care, by disease, at two points in time (1980 and 1991 or 1992). I controlled for the presence of "fixed (diagnosis) effects" by analyzing relationships among growth rates of the variables. My main findings were:

- The number of hospital bed-days declined most rapidly for those diagnoses with the greatest increase in the total number of drugs prescribed and the greatest change in the distribution of drugs.
- An increase of 100 prescriptions is associated with 16.3 fewer hospital days.
- A \$1 increase in pharmaceutical expenditure is associated with a \$3.65 reduction in hospital care expenditure (ignoring any indirect cost of hospitalization), but it may also be associated with a \$1.54 increase in expenditure on ambulatory care.
- Diagnoses subject to higher rates of surgical innovation exhibited larger increases (or smaller declines) in hospitalization.
- My second study on this issue<sup>8</sup> was based on individual-level data, most of which were obtained from the 1996 Medical Expenditure Panel Survey (MEPS), which collected detailed data

from 23,230 people on use and expenditures for office and hospital-based care, home health care, and prescribed medicines. The MEPS Medical Conditions file contains summary information about each medical condition a person has, including the number of hospital events, emergency room events, outpatient events, office-based events, and home health events associated with the condition. The MEPS data enable us to control for many important attributes including sex, age, education, race, income, insurance status, who paid for the drug, the condition for which the drug was prescribed, and how long the person has had the condition. Moreover, the fact that many individuals in the sample have multiple medical conditions means that we can even control for unobserved individual characteristics — such as her physician's "practice style" — by estimating a model that includes "individual effects."

I examine the relationship between the age of the drug and the number and cost of non-drug medical events associated with the condition. Hospital stays are the most important of these, since they account for almost 42 percent of total medical expenditure. The estimates reveal that *people consuming newer drugs had significantly fewer hospital stays than people consuming older drugs*. Replacing a 15 year-old drug with a 5.5 year-old drug would increase the cost of the prescription by \$18, but would reduce the expected number of hospital stays by 0.006, that is about 6 fewer stays per thousand prescriptions. Since the average expenditure on a hospital stay in MEPS is \$7588, one might expect a reduction in hospital expenditure of \$44 ( $=0.00659 \times \$7588$ ) compared to an increase in drug cost of \$18. However, the reduction in hospital expenditure from the use of newer drugs is even larger than this (\$56) because newer drugs are associated with shorter, as well as fewer, hospital stays.

The estimates indicate that reductions in drug age tend to reduce *all* types of non-drug medical expenditure, although the reduction in inpatient expenditure is by far the largest. This reduction of \$71.09 in non-drug expenditure is much greater than the

increase in prescription cost (\$18.00), so *reducing the age of the drug results in a substantial net reduction in the total cost of treating the condition*.

It is sometimes suggested that, because generic drugs tend to be less expensive than branded drugs, allowing people to use only generic drugs might be an effective means of reducing health expenditure. Generic drugs tend to be much older than branded drugs. Suppose that, instead of consuming the actual mix of 60 percent branded and 40 percent generic drugs, people had to consume only generic drugs. This would increase the mean age of drugs consumed by 31 percent, from 29 years to 38 years. My estimates indicate that *denying people access to branded drugs would increase total treatment costs, not reduce them, and would lead to worse outcomes*.

<sup>1</sup> One exception is F. R. Lichtenberg, "The Effect of New Drugs on HIV Mortality in the U.S., 1987-1998," *Economics and Human Biology, forthcoming*.

<sup>2</sup> F. R. Lichtenberg, "Sources of U.S. Longevity Increase, 1960-1997," *NBER Working Paper No. 8755, January 2002*.

<sup>3</sup> F. R. Lichtenberg, "Pharmaceutical Knowledge-Capital Accumulation and Longevity," in C. Corrado, J. Haltiwanger, and D. Sichel, eds., *Measuring Capital in the New Economy*, University of Chicago Press, *forthcoming*.

<sup>4</sup> I am currently applying a similar approach to data on all OECD and some non-OECD countries.

<sup>5</sup> F. R. Lichtenberg, "The Effect of Changes in Drug Utilization on Labor Supply and Per Capita Output," *NBER Working Paper No. 9139, September 2002*.

<sup>6</sup> F. R. Lichtenberg and S. Virabhak, "Pharmaceutical-Embodied Technical Progress, Longevity, and Quality of Life: Drugs as Equipment for your Health," *NBER Working Paper No. 9351, November 2002*.

<sup>7</sup> F. R. Lichtenberg, "Do (More and Better) Drugs Keep People Out of Hospitals?" *American Economic Review, 86 (May 1996)*, pp. 384-8.

<sup>8</sup> F. R. Lichtenberg, "Are the Benefits of Newer Drugs Worth Their Cost? Evidence from the 1996 MEPS," *Health Affairs, 20 (5) (September/October 2001)*, pp. 241-51.