Do (More and Better) Drugs Keep People Out of Hospitals?

By FRANK R. LICHTENBERG*

Case studies of a number of specific drugs have shown that these drugs reduced the demand for hospital care and, in some cases, led to decreases in mortality. For example, according to the Boston Consulting Group (1993), operations for peptic ulcers decreased from 97,000 in 1977, when H2 antagonists were introduced, to 19,000 in 1987; this is estimated to have saved $224 million in annual medical costs. The recent Scandinavian Simvastatin Survival Study indicated that "giving the drug simvastatin to heart patients reduced their hospital admissions by a third during five years of treatment. It also reduced the number of days that they had to spend in the hospital when they were admitted, and reduced the need for bypass surgery and angioplasty" (*New York Times*, 1995a). But treatment with the $2/day pill that lowered cholesterol did not actually save money: hospital costs were $8 million lower among the 2,221 volunteers who got the drug, but the medicine itself cost $11 million. On the other hand, the clot-dissolving drug T.P.A., "costs $2,000 to administer to each stroke victim, but has the potential to save much more in long-term care for those who are helped" (*New York Times,* 1995b).

Other case studies have indicated that government-imposed rationing of pharmaceuticals led to increased use of hospital care. Stephen Soumerai et al. (1991) analyzed the effect of limits imposed by the New Hampshire Medicaid program on the number of reimbursable medications that a patient can receive on rates of admission to nursing homes and hospitals. Imposition of the reimbursement cap resulted in an approximate doubling of the rate of nursing-home admissions among chronically ill elderly patients.

While these studies are valuable, the extent to which their findings apply to pharmaceutical use in general is unclear. Moreover, these studies have yielded mixed results about (or have not addressed) the issue of whether the reduction in hospital cost was outweighed by the increase in pharmaceutical cost. In this paper I describe a few of the results of an econometric analysis of the effect of changes in the quantity and type of pharmaceuticals prescribed by all kinds of physicians, to all kinds of patients throughout the United States, on rates of hospitalization, surgical procedure, mortality, and related variables. The complete results are reported in Lichtenberg (1996). The unit of analysis is an International Classification of Diseases (ICD9) two-digit disease or diagnosis; I control for the presence of "fixed (diagnosis) effects" by analyzing *growth rates* of the variables. To perform the analysis, I first construct a data base on diagnosis-level inputs and outcomes at two points in time (1980 and either 1991 or 1992).

I. Construction of a Longitudinal Data Base on Diagnosis-Level Inputs and Outcomes

I obtained data on drugs prescribed by physicians in outpatient visits, by disease, from the 1980 and 1991 National Ambulatory Medical Care Survey (NAMCS) Drug Mentions files produced by the National Center for Health Statistics (NCHS). NAMCS is a random sample of approximately 30,000–50,000 outpatient visits that provides information about patient diagnoses, drugs prescribed by the physician during the visit, and other information about both the patient and the doctor. The Drug Mentions files provide detailed data on the drugs prescribed in the (roughly 60 percent of) office visits in which at least one drug is prescribed.

Each record in the Drug Mentions file includes a code for the specific drug prescribed, codes for up to three diagnoses (four-digit codes from ICD9, clinical modification), and a "drug weight" (a weight for computing population estimates of drug mentions from the survey data). When multiple diagnoses

* Columbia University, Graduate School of Business, 3022 Broadway, Mail Code 9120, New York, NY 10027-7004, and National Bureau of Economic Research. I am grateful for financial support from Pfizer, Inc.

were cited in a given record, I simply "allocated" the mention of a drug equally across diagnoses. I constructed population (weighted) estimates of the number of drug mentions, by (two-digit) diagnosis and specific drug. Let N_{ijt} represent the population estimate of the number of mentions of molecular entity (drug) i associated with two-digit diagnosis j in year t (t = 1980, 1991). Then $N_{\cdot jt} = \Sigma_i N_{ijt}$ denotes the total number of mentions of all drugs associated with diagnosis j in year t, and $n_{ijt} = N_{ijt}/N_{\cdot jt}$ denotes drug i's share in total drugs prescribed for diagnosis j in year t. Let QUANTITY = $(N_{\cdot j,91}/N_{\cdot j,80})$ represent the ratio of total quantity of drugs prescribed for diagnosis j in 1991 to the corresponding quantity in 1980.

I constructed the following index of the degree of dissimilarity of drugs prescribed in 1980 and 1991, or "novelty" of drugs prescribed in 1991, relative to those prescribed in 1980:

$$(1)\quad (\text{NOVELTY})_j = 1 - \frac{\sum_i n_{ij,80} n_{ij,91}}{\left[\left(\sum_i n_{ij,80}^2\right)\left(\sum_i n_{ij,91}^2\right)\right]^{1/2}}.$$

This index is bounded between 0 and 1; a value of 0 indicates no novelty (i.e., perfect similarity of the two distributions), and a value of 1 indicates complete novelty (i.e., zero similarity). In 1980, the most frequently prescribed drug was hydrochlorothiazide, which received an estimated 3.54 percent of the 743 million drug mentions; by 1991, this drug's share of total mentions had declined by half, to 1.75 percent. Amoxicillin was the most frequently prescribed drug in 1991; its share of total mentions was 3.71 percent having risen from 1.50 percent in 1980.

As equation (1) indicates, NOVELTY is calculated from estimated proportions of patients with a given diagnosis in a given year taking each specific drug. Because these proportions are subject to sampling error, the *expected value* of NOVELTY under the null hypothesis of no change in the distribution of drugs is inversely related to the (average) number of drug mentions for the diagnosis (MENT): relatively uncommon diagnoses are likely to have higher values of NOVELTY than common diagnoses. It is therefore appropriate to control for sample (diagnosis) size; I do this by defining an "adjusted novelty" index ADJNOV as the *residual* from the regression of log(NOVELTY) on log(MENT).

To analyze the relationship between changes in the pattern of drug utilization and changes in the utilization of other medical inputs and mortality, I computed disease-level aggregate statistics from six additional NCHS data sets: the NAMCS 1980 and 1991 patient files, the 1980 and 1992 National Hospital Discharge Survey (NHDS) files, and the 1980 and 1991 Vital Statistics-Mortality Detail files.

The NAMCS patient files provide estimates of the number of outpatient visits by disease, as well as the frequency of ambulatory surgical procedures and the frequency of referrals. The NHDS is a survey of discharge records in a random sample of short-stay hospitals; one can estimate from it the number of hospital stays (discharges), nights (or days), inpatient surgical procedures, and hospital deaths, by diagnosis, in both 1980 and 1992. The NHDS files disclose the specific surgical procedures performed in the course of hospital stays. This enabled me to construct measures of the novelty of *surgical procedures* analogous to the measures of drug novelty described above. The adoption of new surgical procedures is expected to stimulate hospital admissions, and the adoption of new drugs is expected to reduce them.

The last two files used are the 1980 and 1991 Vital Statistics-Mortality Detail files. Unlike the other data sets used, these are complete *censuses* as opposed to surveys: they include records (from death certificates) of each of the approximately 2 million U.S. deaths per year. Each record indicates the underlying cause of death (diagnosis) and the age at death, so that one can obtain (sampling-error-free) data on the number of deaths and mean age at death, by disease.

II. Econometric Specification

The primary objective is to examine the relationship between changes in drug utilization and changes in inpatient care utilization and mortality. When examining this relationship,

it is essential to control for changes in the incidence of diseases in the population. If the number of people suffering from a particular disease is increasing especially rapidly, one would expect both the number of drug mentions and the number of hospital stays associated with that disease to rise faster than average: exogenous changes in disease incidence are likely to induce a positive correlation between drug growth and hospital-admissions growth. I attempt to control for changes in disease incidence by including as a regressor the growth rate in the number of patients diagnosed with the disease by physicians in outpatient visits (calculated from the NAMCS patient files). Because drugs are prescribed in about 60 percent of office visits, the correlation across diagnoses between the growth of patients (or visits) and the growth rate of drug mentions is very high—about 0.80. When the growth in visits is included in the regression, the coefficient on the growth in drug mentions essentially reveals the effect of changes in the number of drug mentions *per person visiting the doctor with that diagnosis* on the number of hospital admissions per person visiting the doctor with that diagnosis. To the extent that the growth in outpatient visits is an imperfect indicator of true changes in disease incidence, the coefficient on changes in drug quantity is likely to be biased upward: one is less likely to observe a negative association between this variable and the growth in hospital stays, even if one really exists. In this respect, the hypothesis tests are likely to be "strong tests."

The type of model estimated is of the form

$$(2)\quad \ln Y_{j,91} - \ln Y_{j,80} = \beta_0 + \beta_1 \ln(\text{QUANTITY})_j + \beta_2 \ln(\text{ADJNOV})_j + \beta_3 \ln(\text{SURGNOV})_j + \beta_4 \ln(\text{VISITS})_j + \varepsilon_j$$

where Y is a variable such as the number of hospital admissions, total hospital bed-days, surgical procedures performed, or deaths; j denotes the two-digit ICD9 diagnosis; QUANTITY is the ratio of 1991 to 1980 drug mentions; ADJNOV is the adjusted index of drug dissimilarity described above; SURGNOV is the index of surgical procedure dissimilarity; VISITS is the ratio of 1980 to 1991 outpatient visits; and ε is a disturbance. If Y is defined as the number of hospital bed-days, then the hypothesis that, ceteris paribus, higher pharmaceutical utilization and innovation reduced growth in the demand for hospital bed-days implies that $\beta_1 < 0$ and $\beta_2 < 0$. Estimation of this equation determines whether diagnoses with above-average pharmaceutical innovation tended to exhibit above-average declines in hospital stays. Factors other than pharmaceutical innovation (e.g., changes in government and private health-insurance reimbursement policies) may have affected the average or aggregate incidence of hospitalization. If these unmeasured determinants of hospitalization did not vary much across diagnoses (or, if they did, were uncorrelated with ADJNOV), we will obtain unbiased estimates of the parameters of equation (2).

One would expect the disturbances of equation (2) to be heteroscedastic. In particular, one would expect the estimated growth rates for less common diagnoses to be further away from the mean growth rate (in both directions). This is indeed the case: the squared deviations of the dependent variables of equation (2) from their respective sample means is strongly inversely related to several measures of diagnosis size—especially the number of deaths reported in the mortality detail files. I therefore estimated equation (2) using weighted least squares, with weights equal to $\{(1/\text{DEATHS}_{j,80}) + (1/\text{DEATHS}_{j,91})\}^{-1}$. Diagnoses that are reported to have caused a larger number of deaths will receive greater weight in analyzing the relationship between pharmaceutical utilization and innovation and changes in hospitalization and mortality.

III. Empirical Results

I have estimated equation (2) via weighted least squares for a number of dependent variables; due to space limitations, here I report only estimates of the total hospital bed-days

(DAYS) equation (t statistics in parentheses; $R^2 = 0.332$, $N = 93$):

$$\ln(\text{DAYS})_{j,91} - \ln(\text{DAYS})_{j,80} = -0.252 - 0.641 \ln(\text{QUANTITY})_j - 0.337 \ln(\text{ADJNOV})_j + 0.280 \ln(\text{SURGNOV})_j + 0.541 \ln(\text{VISITS})_j + e_j.$$
$$(3.22) \quad (4.17) \qquad (3.92) \qquad (3.18) \qquad (2.67)$$

The estimates indicate that there is a strong inverse relationship between the growth in total hospital bed-days and both the growth in total drug mentions and the index of pharmaceutical innovation: 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. The growth in bed-days is *positively* (and significantly) related to the extent of surgical innovation: the more dissimilar the 1980 and 1991 distributions of surgical procedures (presumably because of the adoption of new surgical techniques), the greater the increase in hospital utilization. One-third of the cross-diagnosis variation in the growth of hospital bed-days is explained by the regressors. These estimates suggest that increases in drug consumption and novelty reduce the utilization of inpatient care; other estimates (not reported here) indicate that this does not come at the expense of higher mortality, and there is even some evidence that mortality is also reduced. Other estimates also reveal a significant negative correlation between the increase in the number of referrals (conditional on the number of office visits) and the increase in drug mentions (as well as the surgical novelty index). The greater the increase in the probability that the visited doctor prescribes a drug (or the expected number of drugs prescribed), the lower the increase in the probability that he or she refers the patient to another physician.

I also find significant negative effects of ln(QUANTITY) and ADJNOV on the growth in inpatient surgical procedures. In principle, it is possible that the reduction in inpatient surgical procedures associated with greater pharmaceutical utilization and novelty could be offset (partially or completely) by an increase in outpatient procedures; perhaps only the *locus* of performance of procedures changed (from hospital to doctor's office). The evidence does not support this conjecture: the change in ambulatory procedures appears to be unrelated to all of the regressors.

The estimates imply that, holding constant the novelty of drugs and surgical procedures and the number of outpatient visits, an increase of 100 prescriptions is associated with 16.3 fewer hospital days. Using the following data on aggregate U.S. health expenditure in 1991 contained in the OECD Health Database, I can also attempt to estimate the effect of changes in pharmaceutical expenditure on inpatient care (and total health) expenditure:

Pharmaceutical expenditure:	\$60.7 billion
Hospital care expenditure:	\$346.5 billion
Ambulatory care expenditure:	\$224.7 billion
Physicians' services expenditure:	\$142.0 billion

The parameter estimates imply that a 10-percent increase in drug mentions is associated with a 6.4-percent reduction in hospital bed-days. Therefore, it is reasonable to suppose that a 10-percent increase in pharmaceutical *expenditure* is associated with a 6.4-percent reduction in hospital care *expenditure*. (This estimate may be conservative because the surgery elasticity is larger in magnitude than the bed-days elasticity, and cost per bed-day is likely to increase with procedures per bed-day.) Since total expenditure on hospital care is 5.7 times as large as total pharmaceutical expenditure, this implies that a \$1 increase in pharmaceutical expenditure is associated with a \$3.65 reduction in hospital-care expenditure. This estimate implies that, if changes in pharmaceutical utilization had no other effects on health care costs, a \$1 increase in pharmaceutical

expenditure would reduce total health-care expenditure by $2.65. But there are at least two reasons to believe that changes in pharmaceutical utilization *would* affect other costs, in both directions.

An increase in pharmaceutical utilization may necessitate an increase in ambulatory-care utilization: a physician is required to prescribe the drugs. The slope coefficient from the (weighted) regression of the growth in office visits on the growth in drug mentions is 0.656: a 10-percent increase in drug mentions is associated with a 6.6-percent increase in office visits. If a 10-percent increase in drug expenditure would increase "expenditure on physicians' services" by 6.6 percent, a $1 increase in drug expenditure would be associated with a $1.54 increase in expenditure on physicians' services; this would offset 42 percent of the estimated reduction in inpatient expenditure.

On the other hand, "hospital care expenditure" measures only the *direct* costs of hospitalization; it does not reflect the value of the patient's lost work and leisure time that presumably often accompanies hospitalization and surgery. If the indirect cost of hospitalization is, say, 25 percent as large as the direct cost, then the reduction in the "social" (direct plus indirect) hospitalization cost per dollar of increased pharmaceutical expenditure is 20-percent larger than the $3.65 figure calculated above.

The negative coefficient on ln(ADJNOV) indicates that there are benefits (in the form of hospital-cost reductions) of pharmaceutical novelty per se (i.e., of changes in the distribution of prescriptions, by drug). It is more difficult, however, to assess the *cost* of changing the distribution of drugs. R&D expenditures by pharmaceutical firms represent a substantial part of these costs. According to the National Science Foundation, in 1991 these firms spent $6.1 billion on R&D. This is a very substantial amount, but it is only 1.8 percent of national expenditure on hospital care in that year. Thus pharmaceutical R&D spending would reduce total health expenditure (including pharmaceutical R&D) if it reduced hospital expenditure by as little as about 2 percent.

IV. Summary and Conclusions

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. The estimates imply that 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.

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