Prescription Drug Expenditures in the U.S.: The Effects of Obesity, Demographics and New Pharmaceutical Products

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Abstract

During the period 1990-98, real per-capita expenditures on prescription drugs in the U.S. increased by 84% (1996 dollars-GDP Deflator). This paper examines the factors driving prescription drug expenditures in the U.S. and provides some quantitative measures. Panel data from all 50 U.S. states for the period 1990-98 are employed. The analysis suggests that in addition to an aging population, changes in income, obesity, and new drug approvals are important determinants of rising prescription drugs expenditures. Overall, the estimates suggest that about 8% of the increase in spending on prescription drugs over the period 1990-98 can be explained by the increase in obesity. Rising real incomes account for about 55% of the increase. Increases in the percentage of the population over 65 and new drug approvals exert a significant positive effect on per-capita prescription drug expenditures. Finally, increases in the unemployment rate exert a significant negative effect per-capita prescription drug expenditures.

JEL Codes: I11, I18, J14
Keywords: Prescription Drugs, Obesity, Health Care Spending

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1. Introduction

During the period 1990-98, real per-capita expenditures on prescription drugs in the U.S. increased by 84% (1996 dollars-GDP Deflator). Beginning in 1993, the average annual percentage increase in prescription drug spending exceeded the overall percentage increase in national health expenditures. By 1998, average annual percentage growth in prescription drug spending (compared to the previous year) was over 16% while overall spending on health care rose at less than 6%. In total, U. S. consumers spent more than $90 billion on prescription drugs in 1998, or $334 on a per-capita basis (Centers for Medicare and Medicaid Services, 2002). Not surprisingly, prescription drug coverage and its associated costs have become issues in national as well as state political campaigns.[1]

But the rising expenditures were not simply caused by higher prescription drug prices. While the CPI for prescription drugs rose by 42%, nominal per-capita expenditures on prescription drugs rose 120% over the period (U. S. Bureau of the Census, 2002). Consequently, higher rates of prescription drug consumption explain at least part of the story. Further, while overall prescription drug spending has increased rapidly, per-capita prescription drug use varies widely

[1] Anticipating some form of new regulation, the pharmaceutical industry spent at least $16 million on issue ads in the 2002 election cycle (Hitt, 2002). In particular, the industry was concerned about Democratic Party proposals that would administer prescription drug benefits through Medicare and legislation that might make generic drugs more accessible. In the 2004 presidential campaign, prescription drug costs remained a significant issue as George Bush touted the creation of a prescription drug benefit under Medicare and John Kerry argued for re-importation of prescription drugs from Canada and overhauling the Medicare drug plan.

among the fifty US states. In 1998, some states had per-capita prescription drug spending of more than $400 while other states spent half that much.

While we do not wish to absolve the pharmaceutical manufacturers, the above data suggests that arguments placing the blame for high prescription drug costs on the prices and profits of pharmaceutical manufacturers may be missing a substantial portion of the story. The literature on prescription drugs suggests a number of causes. However, Berndt (2002) notes that a shortcoming of the existing literature is the lack of quantitative estimates of the causes for increased consumption of prescription drugs since the mid-1990s. In a similar vein, Kane (1997) concludes that the effect of the managed care revolution has been difficult to separate out from the other forces affecting pharmaceuticals.

To better inform public policy, we provide some quantitative estimates of the factors that have contributed to the increase in prescription drug expenditures. We investigate the role of public health factors (obesity, smoking, and alcohol consumption rates); aging (population 65 and over); access to medical care (managed care enrollments and the relative size of the uninsured population); new pharmaceutical products; income; and unemployment on real prescription drug expenditures, using panel data from all 50 U.S. states for the period 1990-98. The estimates should allow better projections of the cost of rising elderly populations on prescription drug expenditures.

Gauging the costs of smoking, obesity, and alcohol consumption is also important. High costs associated with any of these public health problems make it easier to justify costly government programs to reduce the prevalence of smoking, obesity, and heavy alcohol consumption. Thus, public policy responses to rising prescription drug expenditures will vary based on the source of the increase. To the extent that rising prescription drug expenditures are the result of rising real income rather than public health conditions, the case for laissez faire is stronger.

We find that obesity rates, the relative size of the over 65 population, new pharmaceutical products, unemployment and real income exert a significant effect on prescription drug expenditures. Overall, the estimates suggest that about 8% of the increase in spending on prescription drugs over the period 1990-98 can be explained by the increase in obesity. In contrast, rising real incomes account for about 55% of the increase in prescription drug expenditures over the period. Despite the strong positive effect of income on prescription drug expenditures, we find no evidence that the changes in the percentage of uninsured cause changes in prescription drug expenditures. While the percentage of the population over 65 and new drug approvals exert a significant positive effect on per-capita prescription drug expenditures, an increase in the unemployment rate reduces per-capita prescription drug expenditures.

The paper is organized as follows: section 2 discusses the background literature and provides the motivation for this study, section 3 discusses the fixed effect instrumental variables model and data sources. In section 4, we present the estimates of the instrumental variables and section 5 discusses the results from the prescription drugs expenditure model. Section 6 concludes.

2. Background

A number of recent papers have explored the causes of rising prescription drug prices and expenditures (Berndt, 2001; Reinhardt, 2001; Thomas, 2001; Berndt 2002; Kaufman et al, 2002;

Sturm, 2002).[2] In general, the explanations have focused on the demand side and have identified five basic causes: prescription drug spending is a small percentage of total health expenditures; increases in the percentage of the population with insurance coverage for prescription drugs; the introduction of new blockbuster drugs; aging of the population; and public health factors. Berndt (2001) and Reinhardt (2001) argue that cost cutting efforts did not focus on prescription drugs because prescription drugs account for a small portion of total health expenditure (8% in 1998) and that increased third party drug (insurance) coverage creates problems of moral hazard.

Patients are more likely to use lower-priced generic products, if they have to pay a large portion of costs out-of-pocket rather than when it is covered by a third party. Indeed, the percentage of out-of-pocket drug spending fell from 92% in 1965 to 26% in 1998 implying an increase in prescription drug use. Lundin (2000) shows that patients with large out-of-pocket costs are more likely to choose generic drugs. Apparently, consumers with full coverage have little incentive to search for low-cost alternatives to brand name drugs. Purchases of low-cost generic drugs may also fall because of introduction and aggressive marketing of new blockbuster drugs by the pharmaceutical industry (Berndt, 2001; 2002). However, there is little systematic evidence to support this claim.

Of course, prescription drug spending may rise because of changes in the health status of the population rather than consumption choices. Thomas et al. (2001) and Kaufman et al. (2002) provide data that shows that prescription drug usage is the highest among the elderly due to a higher incidence of cardiovascular and gastrointestinal diseases and chronic conditions. For

[2] Two other strains of the literature consider the market factors that allow price discrimination in prescription drugs (Danzon, 1997; Elzinga and Mills, 1997; Frank, 2001) and the effect of insurance on prescription drug use (Coulson and Stuart, 1995; Coulson et al., 1995; Lundin 2000; Van Vliet, 2001).

example, among the elderly that spend more than $4000 annually on medications, 88% took cardiovascular medications, 57% took lipid-lowering medications and 64% took a gastrointestinal medication.

The rapid rise in obesity over the past decade has been a significant source of worry for public health officials (Nestle and Jacobson, 2000). Obesity is associated with a variety of risk factors for cardiovascular diseases such as hypertension, elevated cholesterol, and type-II diabetes, as well as cancer, stroke and osteo-arthritis and other diseases (Must et al. 1999). Using survey data from 1997-98, Sturm (2002), measures medication costs by mapping survey responses on regularly used medications to insurance claims for prescription drugs and wholesale prices for other types of medication. He finds obesity increases average medication costs for an individual by 77% and smoking (present and past) increases such costs by 28-30%. However, the analysis fails to control for insurance status, income or new drug introductions.

Other studies, such as Coulson and Stuart (1995) and Coulson et al. (1995) use subject self-reports of health status to control for health as a determinant of prescription drug use. However, such treatment of public health factors suggests that public health factors are beyond the reach of public policy. But most of these studies are based on survey data or self reports, which make it harder to generalize the results. Moreover, the studies do not provide statistical estimates of the extent to which each of these factors affects prescription drug expenditures.

Suraratdecha (1996) analyzes prescription drug spending across states for years 1980 -1990. using four independent variables: the percentage of the population that is over sixty-five, the proportion of Medicaid recipients, real income per capita, and physician services expenditures per capita (a proxy for the number of physicians per capita). Each of the variables, save physician services, has a significant positive impact on per-capita prescription drug expenditures. However, Suraratdecha does not account for public health factors and new drug introductions. Nor does the analysis fully account for insurance factors in explaining prescription drug expenditures.

In sum, the literature on prescription drug spending does not provide a comprehensive analysis of the factors underlying rising prescription drug costs. While some studies (Suraratdecha, 1996; Reinhardt, 2001; Berndt, 2001; Lundin, 2001) have estimated the effects of economic factors such as income and insurance coverage on prescription drug spending, they do not account for the role of public health factors. In addition, the analyses fail to correct for the two-way causality that exists between insurance factors and prescription drug expenditures. Other studies (Thomas, 2001; Kaufmann, 2002; Sturm, 2002) while highlighting the significance of public health factors in prescription drug spending, do not control for effects of economic variables like insurance coverage and income. Finally, some of the latter estimates are based on survey response data, which makes it harder to generalize the results

The purpose of the present study is to fill this gap in the literature by examining the role of public health factors, along with, income and insurance status on prescription drug expenditures. In addition, the study also accounts for the effect of new drug introductions, which is shown to be a significant factor. A fixed effects panel data model is used to control for state-specific differences. Our model also controls for the problem of endogeneity between prescription drug expenditures and some key explanatory variables, through an instrumental variables approach.

3. Empirical Model and Data

Empirical studies of the determinants of prescription drug expenditures in the U.S. have been conducted using a cross-section framework (e.g., Lundin, 2000; Sturm, 2002), time-series (Berndt, 2001; 2002) or a simple pooling of cross-section and time-series data (e.g. Suraratdecha, 1996). However, assuming a common intercept with cross-section and time-series data, ignores "individual effects", which can lead to biased results (Islam, 1995). To eliminate such biases, we employ a fixed-effects panel-data model to analyze prescription drug expenditures across states in the U.S. for the period 1990-98. The fixed-effects model is superior to the common intercept and random effects model in our case, based on *F-test* and Hausman test results.[3] We use state-level data because drawing lessons for public policy may be problematic with individual-level data. Cheadle et al. (1992) and Sallis et al. (1998) argue that determinants (e.g., obesity) and outcomes (e.g., drug spending) ought to be analyzed on a population basis rather than an individual basis because intervening with individuals is unlikely to bring about population-wide change.

The fixed-effects model assumes that differences across states are captured by differences in the constant term.

(1) $Drug_{it} = X'_{it}\,\delta + \alpha_i + u_{it}$

where i indexes states; t indexes year; $Drug_{it}$ represents real per-capita prescription drug expenditure; X'_{it} is a vector of explanatory variables, α_i the time-invariant, unobserved state effects; and u_{it} is the transitory error term that varies across states and time-periods. Under the assumption that α_i are constant and u_{it} is normally distributed with a zero mean, equation (1) is

[3] The random-effects regressions yield similar results, but a Hausman test rejects the null of random effects.

estimated using the *least squares dummy variable* (LSDV) method. The LSDV eliminates a major portion of the variation between the dependent and independent variables when the between-cross-section and between-time variation is large.

Based on the discussion above, we regressed real per-capita prescription drug expenditures (Drug) on per-capita income (Income), unemployment rate (Unemployment), percentage of the population over 18 years of age that is obese (Obese), percentage of the total population over 65 years of age (65+Years), percentage of the population without insurance (Uninsured), percentage of the population over 18 years of age that smokes (Smoke), per capita alcohol consumption (Alcohol), and the percentage of the total population that is enrolled in HMOs (HMO).

Measuring the effects of the introduction of new drugs by pharmaceutical companies is less straight-forward. Following, Cockburn (2004), we have included FDA approvals of new molecular entities (NMEs) as our measure of new drugs. We expect that an increase in any of the independent variables (except for Uninsured and Unemployment) would cause an increase in per-capita prescription drug use. The Uninsured variable counts individuals with either private or public (e.g., Medicaid) insurance as insured. Unfortunately, we are not able to identify the percentage of the population that has insurance coverage for prescription drugs.

A closer look at the explanatory variables, suggests that there may be an *endogeneity* problem between some key determinants of prescription drug expenditures and prescription drug expenditures. HMO, Uninsured, and 65+ Years may have two-way causality with prescription drug expenditures. HMOs have traditionally offered better coverage for prescription drugs than standard fee-for service plans. Thus, higher rates of HMO enrollment may cause higher spending on prescription drugs. On the other hand, it is also possible that individuals react to higher prescription drug costs by joining HMOs.

Similarly, one would expect two-way causality between the prescription drug expenditures and the percentage of uninsured. Uninsured individuals may reduce purchases of prescription drugs because all costs are out-of-pocket but higher prescription drug costs may make employers less able to offer insurance to employees. Likewise, an increase in the relative size of the 65+ population may increase per capita expenditures on prescription drugs but an increase in prescription drug expenditures may raise life expectancy and increase the relative size of the 65+ population. Consequently, we addressed these endogeneity biases using an instrumental variables approach. For HMO and Uninsured, we use the labor force participation rate, percentage of workforce employed at small firms, and the percentage of the population in poverty as instruments. For 65+ Years, we use expenditures on prescription drugs lagged one year and the population 55-64 lagged ten years. For example, the pop 55-64 for 1980 by state is used to estimate the population 65+ in 1990.

A series of empirical studies indicate that poverty and labor market variables determine HMO enrollment and health insurance status (Long and Marquis, 1992; Sloan and Conover, 1998; Dranove et al., 1998). Long and Marquis (1992) find that over half of all workers not offered health insurance are employed at firms with less than 10 employees. Seventy percent of uninsured workers are employed in firms with less than 25 workers. Sloan and Conover (1998) find that: 1) the probability that a worker has health insurance is inversely related to the number of employees at the worker’s place of employment; and 2) income below the poverty level reduces the probability of insurance. Dranove et al. (1998) examines data for Primary Metropolitan Statistical Areas (PMSA) and finds that managed care penetration is positively related to the percentage of the population with a college education. Consequently, we estimate the following set of equations:

(2) $HMO_{it} = Y'_{1it}\,\gamma_1 + Z'_{it}\,\delta_1 + \phi_{1i} + e_{1it}$

(3) $Uninsured_{it} = Y'_{2it}\,\gamma_2 + Z'_{it}\,\delta_2 + \phi_{2i} + e_{2it}$

(4) $65{+}\ Years_{it} = Y'_{3it}\,\gamma_3 + \phi_{3i} + e_{3it}$

where X'_{it} is a vector of control variables and Y'_{kit} is a vector of instruments (e.g., poverty rate, labor force participation) and ϕ_i and e_{it} are the state-effects and regression errors for the respective instrumental variables equations. We then save the estimated values of the dependent variable for equations (2), (3), and (4) for use in the equation for prescription drug expenditures:

(5) $Drug_{it} = \beta_1\,\widehat{HMO}_{it} + \beta_2\,\widehat{Uninsured}_{it} + \beta_3\,\widehat{65{+}Years}_{it} + Z'_{it}\,\delta_4 + \alpha_i + u_{it}$

where Z'_{it} is a vector of other exogenous variables (Obese, Smoke, Income, Unemployment, Alcohol, and NME). Equations (2) through (5) were estimated using the two-stage least squares procedure with fixed effects available in Limdep. The Limdep panel procedure for two-stage least squares automatically corrects the standard errors to reflect the use of predicted variables as covariates.

Data for the study was collected from the Centers for Medicare and Medicaid Services website (prescription drug expenditures), *The Statistical Abstract of the U.S.* (per-capita income, percentage of the population over 65, poverty rate, percentage of population with insurance coverage). Real per-capita prescription drug spending, and real per-capita income, are in 1996 dollars and include both public and private spending. In the results reported below, nominal values are converted using the GDP deflator. Converting the nominal values using the CPI had no effect on the results. Data on the employment variables are taken from the Bureau of Labor Statistics' Local Area Unemployment Statistics (unemployment rate and labor force participation) and the Census Bureau (percentage of total employment in firms with less than 20 employees).

The Centers for Disease Control and Prevention's Behavioral Risk Factor Surveillance System supplied the data on smoking and obesity rates. Obesity is based on Body Mass Index (BMI) where BMI is weight in kilograms divided by height in meters squared. An individual with a BMI $\geq$ 30 is considered obese. The alcohol consumption data is from the National Institute on Alcohol Abuse at the National Institutes of Health. The data reports annual per capita consumption of alcohol by state. All alcohol consumption (e.g., beer, wine, and spirits) is converted to an ethanol equivalent and the per capita calculation includes the population 14 years of age and older. Inter-study Competitive Edge *HMO Industry Report* provides HMO enrollment rates and data on *New Molecular Entities* is collected from the U.S. Food and Drug Administration Center for Drug Evaluation and Research.[4]

The data contains annual observations on each variable across the 50 U.S. states for each year during the period 1990-98 (9 years and 50 cross sections). While prescription drug expenditures grew steadily from 1990-1998, substantial differences among the states remained. In 1998, nominal per-capita spending on prescription drugs was highest in New Jersey ($437), West Virginia ($428), Pennsylvania ($420), and Florida ($416) and lowest in Alaska ($217), New Mexico ($231), California, ($231), and Colorado ($244). Table 1 reports means, standard deviations, and definitions for the dependent and independent variables. Missing observations on smoking and obesity rates for Alaska, Arkanasas, Kansas, Nevada, New Jersey, Rhode Island, and Wyoming reduce the number of usable observations from 450 to 437.[5] The District of Columbia is excluded because estimates of its HMO enrollment are not reliable.

[4] See also Cockburn (2004) for this data.

4. Instrumental Variables Estimates

In this section, we discuss the results from the fixed-effects regressions on HMO and Uninsured. Because newly developed drugs may take a year or so to penetrate the market, we report estimates that lag the new drug approvals (NMEs) by two years. To save space, we do not report the results of regressions for percentage of the population over 65 years. The results reported in Table 2 provide some interesting insights. The estimated values of the dependent variables in Table 2 are used as instruments in fixed effects regressions on real per-capita prescription drug spending.

HMO Equations: The results show that the rate of HMO enrollment is greater in high-income states, states with older populations, and states with higher rates of obesity. A one thousand dollar increase in per-capita income causes an increase of about 2.4 to 2.9 percentage points in HMO enrollment. A one percentage point increase in obesity causes an increase of about 0.70 percentage points in HMO enrollment. Each of these factors is consistent with the argument in Dranove (2000) that HMOs were a response to rising health-care costs. In addition, HMO enrollments are lower where labor force participation is higher. A one percentage-point increase in labor force participation causes a decrease of about 0.9 percentage points in HMO enrollment. Higher unemployment rates also lower HMO enrollments. A one percentage point increase in the unemployment rate lowers HMO enrollments by about half a percentage point.

Finally, the estimates show that new drug introductions initially have a significant positive but modest effect on HMO enrollments. An additional NME initially raises HMO enrollments by about 0.08 percentage points. Lagged one year, an additional NME raises HMO enrollments 0.1

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[5] The missing observations are: 1990 - Alaska, Arkansas, Kansas, Nevada, New Jersey, Wyoming; 1991- Kansas, Nevada, Wyoming; 1992 - Arkansas, Wyoming; 1993 - Wyoming; 1994 - Rhode Island.

percentage points. This is a substantial effect. In an average year, there are about 30 NMEs. Thus, in an average year HMO enrollments rise three percentage points because of new drug introductions.

Uninsured Equations: The percentage of uninsured is positively related to both state per-capita income and the poverty rate. A one thousand dollar increase in per-capita income causes an increase of about 0.5 percentage points in the percentage of uninsured. This likely reflects the higher health care costs that prevail in high-income areas. A one percentage-point increase in poverty causes an increase of 0.26 percentage points in the percentage of uninsured. Surprisingly, higher alcohol consumption lowers the percentage of uninsured. An increase of one gallon in the per capita consumption of alcohol lowers the number of uninsured by about 2 percentage points. Labor force participation, smoking, obesity, unemployment, new drug approvals, and percentage of employment in small firms have no statistically significant impact on the percentage of uninsured. Lagged one year, an additional drug approval raises the percentage of uninsured by 0.024 percentage points. With a two-year lag, additional NMEs have no positive effect on either HMO enrollments or the percentage that is uninsured.

5. Determinants of Rising Prescription Drug Expenditures

Table 3 shows fixed effects regression on real per-capita prescription drug spending. Columns 1 and 2 of Table 3 shows the results of a fixed-effect regression with per-capita income, unemployment, percentage of the population over 65, percentage of population uninsured, smoking rate, obesity rate, per-capita alcohol consumption, HMO enrollment rates, and new drug approvals (NMEs) as independent variables.

Poverty rate and labor force participation rate are not included as dependent variables in Table 3. In fixed effects regressions, neither poverty rate nor labor force participation rate had an impact on per-capita prescription drug expenditures. Consequently, we employ poverty rate and labor force participation rate only as instruments in the instrumental variables estimates. Because HMO enrollment and percentage of population uninsured, and percentage of the population 65 and over may exhibit two-way causality, Columns 3 and 4 of Table 3 substitute the estimated values of these variables for the actual values using the estimates in Table 2. As in Table 2, we report estimates for new drug approvals and new drug approvals lagged two years.

Because there is some evidence of serial correlation, we ran an autoregressive procedure. The results appear in column 5 of Table 3. The procedure requires a balanced panel so we interpolate the 13 (out of 450) missing values for Obese and Smoke.[6] Repeating the analysis by dropping Wyoming (four missing values) or 1990 (six missing values) does not affect the results. Because the autoregressive procedure will not run if a lagged independent variable is already in use, we used the actual value rather than the fitted value for 65+ Years in column 5. We retained the fitted value for Uninsured and HMO. In the discussion that follows, we use the estimates in column 5 as the definitive results unless indicated otherwise.

Among the public health indicators, obesity is positively related to prescription drug expenditures and is significant in all specifications. Obesity is associated with a variety of risk factors for cardiovascular disease, such as hypertension, elevated cholesterol, and type-2 diabetes, as well as an increased risk of cancer, stroke, osteoarthritis and other diseases (Must et

[6] We interpolate these values by locating the most recent year for which we have an observation for state i. For that year, we calculate the difference between the state rate and the national rate (for smoking or obesity). We then use that difference to adjust the national rate and use it for the state value. For example, Alaska 1990 is missing and Alaska's obesity rate for 1991 is 13.4, the U.S. obesity rate for 1991 is 12.6 -- a difference of 0.8. The U.S. obesity rate for 1990 is 11.6. Thus, the imputed value for Alaska in 1990 is 11.6 + 0.8 = 12.4.

al., 1999). These secondary effects of obesity typically require additional expensive medicines to treat complications and can substantially increase expenditures on prescription drugs. Surprisingly, neither smoking nor alcohol consumption has a significant effect on prescription drug expenditures. Of course, smoking rates may impact prescription drug expenditures after many years. We experimented with lags of zero to three years on the smoking variable and none of the specifications were significant. Ideally, we would have also investigated lags of ten to twenty years but we could not locate data to conduct such an analysis.

The estimates in Table 2 (column 5) show that a one percentage-point increase in the obesity rate raises per-capita prescription drug expenditures about $1.75. While obesity exerts only a modest effect on per-capita prescription drug expenditures, obesity increased dramatically from 1990-98. The U.S obesity rate was 11.6% in 1990 but by 1998 it had risen 57% to 18.3%. Thus, the increase in obesity from 1990-98 raised per-capita prescription drug expenditures about $12.[7] Overall, the estimates suggest that about 8.5% of the increase in spending on prescription drugs over the period 1990-98 can be explained by the increase in obesity.

Our estimates suggest that obesity is associated with a 76% increase in prescription drug spending. If one person in a population of 100 becomes obese and it raises per-capita spending by $1.75, obesity must have raised spending for that individual by $175. The mean per-capita prescription drug spending (1996 dollars) for our data set is $229 and 175/229 is 0.76.[8] Thus, according to our estimates, the effect of obesity on prescription drug expenditures is the same as

[7] Calculation: (18.3 – 11.6 = 6.7 and 6.7 • $1.75 = $11.72).

[8] As a robustness check, we also ran both pooled regressions and between regressions estimates. In each case, the parameter estimate for obesity is positive, significant, and slightly higher than in the fixed effects regressions reported in Table 3. These estimates show a weaker positive effect (but still significant) for income and percentage of the population over 65 compared to the fixed effects estimates. The HMO variable is not significant in either of these alternative specifications.

the estimates in Sturm (2002). Using a different data set (MEPS), Sturm found that obesity was associated with a 77% rise in prescription drug costs.

Turning to demographic factors, the results show that the percentage of the population over sixty-five is an important influence on prescription drug use. A one percentage-point increase in this population leads to an increase in real per-capita prescription drug expenditures per capita of $15.76. The relative size of the over 65 population varies a great deal among states and it accounts for much of the variation across states at any point in time. While the magnitude of this effect is large, changes in percentage of the population over 65 cannot account for the rise in prescription drug expenditures for the period 1990-98. Over the period 1990-98, the percentage of the population over 65 increased only 0.1 percentage points from 12.6% to 12.7%. However, if the projected increase in the relative size of the over 65 population does in fact materialize; it would exert a strong effect on prescription drug spending.

Because prescription drugs are likely a normal good, we expect increases in income to raise prescription drug expenditures. Income sensitivity of prescription drugs likely increased as a result of introduction of a series of so-called “lifestyle” drugs (e.g., Rogaine, Viagra). Access to medical care also likely rises with income. The estimates in Table 3 show a strong positive effect of about $23 on real per-capita prescription drug spending for every $1,000 increase in real per-capita income. Over the 1990-98 period, real per-capita income rose about $3,550. Consequently, increases in income caused an increase in real per-capita prescription drug spending of about $80. Overall, the estimates suggest that about 55% of the increase in spending on prescription drugs over the period 1990-98 can be explained by the increase in real per-capita income.

The effect of unemployment on per-capita prescription drug expenditures was more modest. The estimates in Table 3 suggest that a one percentage-point increase in the unemployment rate decreases per-capita prescription drug expenditures by about \$4. Over the period 1990-98, the U.S. average annual unemployment rate rose from 5.6 in 1990 to 7.5 in 1992 and then fell to 4.5 in 1998. Thus, the net change in the unemployment rate accounts for only a small percentage of the increase (about 2%) in per-capita prescription drug expenditures for the period 1990-98.

Access to prescription drugs is measured by the percentage of the population enrolled in HMOs and the percentage of the population uninsured. Increases in the percentage of the population without health insurance were expected to decrease the rate of prescription drug use. People without health insurance must pay full price for their prescriptions and as a result will tend to purchase less. Rather surprisingly, the uninsured coefficient is insignificant in both regressions. This is may be the result of price discrimination. Frank (2001) shows that individual cash payers at pharmacies pay roughly 30% more than managed care plans for prescription drugs. Higher prices per prescription may offset the reduction in the number of prescriptions.

From a theoretical perspective, increases in HMO membership might either increase or decrease expenditures. Because HMOs tend to have good prescription drug plans, increases in the percentage of the population covered by HMOs should increase the rate of prescription drug use (higher Q). However, HMOs are also able to obtain prescription drugs at lower prices (Frank, 2001). The estimates in column 5 of Table 3 show that an increase in HMO enrollment has no effect on prescription drug expenditures. While the estimates in columns 1 through 4 show a modest and consistent effect (a one percentage-point increase in the percentage of the population enrolled in HMOs raises per-capita prescription drug expenditures by about \$1.30), the correction for serial correlation eliminates this effect.

Finally, lagged new drug approvals (measured as *New Molecular Entities* approved by the FDA) show a stronger effect on per-capita prescription drug expenditures than contemporary new drug approvals. An additional new drug approval (NME) lagged two years raises per-capita prescription drug spending by about $0.65. We experimented with lags of zero to three years. For lags of zero and three years, we found no significant effect of new drug approvals on prescription drug expenditures. For lags of one and two years, the effect was significant and positive. We report only the two-year lag in Table 3 because the parameter estimate and the t-statistic was a bit higher for the two-year lag.

This result should be interpreted cautiously because measuring innovation as the number of NMEs does not account for differences in the medical or economic significance of each of the new molecules. Nevertheless, our estimate suggests that the effect of new drug approvals is substantial. On average, the FDA approved about 27 new drugs annually during the period 1988 to 1996. This implies that in an average year, per-capita prescription drug spending rose by about $18 solely as a result of new drug introductions. The cumulative effect of the new drug introductions on per-capita prescription drug expenditures is less certain as drugs approved in the current year may displace spending on older drugs.

6. Conclusion

During the period 1990-98, real per-capita expenditures on prescription drugs in the U.S. increased by 84% (1996 dollars-GDP Deflator). Nominal per-capita expenditures on prescription drugs rose 120% over the period while the CPI for prescription drugs rose by 42% (U. S. Bureau of the Census, 2002). This suggests that higher rates of prescription drug use must be at least part of the story. This paper provides some quantitative measures of the factors that have contributed to the increase. We examined the factors driving prescription drug expenditures using panel data from all 50 U.S. states for the period 1990-98. Results indicate that public health, population over the age of 65, new pharmaceutical products, and income are all important in explaining prescription drug expenditures.

Among public health indicators, obesity is a significant factor, but smoking and alcohol consumption are not. Overall, the estimates suggest that about 8.5% of the increase in spending on prescription drugs over the period 1990-98 can be explained by the increase in obesity. Obesity rates registered a dramatic increase (of 57%) during this period. This suggests reductions in the obesity rate could yield substantial reductions in health care spending holding health outcomes constant. Indeed, we also find that increases in the obesity rate also raise both HMO enrollments. A one percentage-point increase in obesity causes an increase of 0.7 percentage points in HMO enrollment.

Another factor that is strongly significant is the percentage of population over the age of 65. Although the percentages do not change much over the time period, it appears that the magnitude effect of the population over 65 is very large, making it a significant determinant of prescription drug expenditures. As other studies have shown, high incidence of chronic illnesses and poor health among the elderly population contribute to higher spending on prescription drugs.

The results also show that a large chunk of the increase in prescription drug expenditures is caused by rising income. Prescription drugs are normal goods and 1990-98 marks a period of relative prosperity in the U.S. The subsequent rise in real incomes accounts for about 55% of the increase in real per-capita prescription drug spending. Despite the strong effect of income on prescription drug expenditures, we find no evidence that changes in the percentage of uninsured cause changes in prescription drug expenditures. More surprising, labor force participation, unemployment, and percentage of employment in small firms have no statistically significant impact on the percentage of uninsured.

Finally, we find that new drug approvals (NMEs) cause substantial increases in per-capita prescription drug expenditures. An additional new drug approval (lagged two years) raises per-capita prescription drug expenditures by about $0.67. Given that in an average year about 27 new drugs are approved, the average annual increase in per-capita prescription drug spending caused by new drug introductions is about $18. Moreover, we find that new drug approvals (lagged one year) raise HMO enrollments and the number of uninsured.

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Table 1. Means and Standard Deviations

Variable	Mean	Standard Deviation	Minimum	Maximum
Drug	229.23	58.72	114.96	423.29
Obese	14.71	3.003	6.9	23.9
Smoke	23.2	2.88	13.2	31.7
Alcohol	2.31	0.541	1.2	4.78
Income	22.61	3.41	15.21	35.95
65+ Years	12.65	2.05	3.97	18.55
HMO	16.22	11.96	0	54.2
Uninsured	14.01	4.09	2.1	25.6
Poverty	13.17	3.94	5.23	27.63
Labor	50.93	2.78	42.45	56.76
Unemp.	5.57	1.51	2.2	11.4
Sm. Firm	21.4	3.86	15.57	34.91
NME	30.67	9.77	22	53
NME (-2)	27.33	9.72	18	53

$Drug_{it}$ = Real per-capita prescription drug expenditures (1996 dollars) for state i in year t.
$Obese_{it}$: Percentage of the population 18 years of age and over in state i that is obese (BMI $\geq$ 30) in year t.
$Smoke_{it}$: Percentage of the population 18 years of age and over in state i that smokes in year t.
$Alcohol_{it}$: per capita (population 14 years of age and older) annual consumption of alcohol (ethanol equivalent) in gallons for state i in year t.
$Income_{it}$: Real per-capita income (in thousands of 1996 dollars) for state i in year t.
HMO_{it}: Percentage of the total population enrolled in an HMO for state i in year t.
$Uninsured_{it}$: Percentage of the total population uninsured for state i in year t.
$65+Years_{it}$: Percentage of the total population 65 years and older for state i in year t.
$Poverty_{it}$: Percentage of the total population in poverty for state i in year t.
$Labor_{it}$: Labor force divided by civilian non-institutional population for state i in year t.
$Unemp._{it}$: Unemployment rate for state i in year t.
$Sm.Firm_{it}$: Percentage of total employment in firms with less than 20 employees for state i in year t.
NME_t: Number of new molecular entities approved by the FDA in year t.
$NME(-2)_t$: Number of new molecular entities approved by the FDA in year t-2.

Table 2. Fixed-effects regression results for instruments: HMO and Uninsured

	HMO	HMO	Uninsured	Uninsured
Variable	1	2	3	4
Obese	0.656***	0.685***	-0.012	-0.022
	(0.168)	(0.166)	(0.067)	(0.069)
Smoke	-0.171	-0.088	-0.0031	-0.021
	(0.160)	(0.156)	(0.064)	(0.062)
Alcohol	-1.56	-2.4	-2.09*	-2.02*
	(2.73)	(2.69)	(1.11)	(1.09)
Income	2.45***	1.95***	0.577***	0.434***
	(0.34)	(0.369)	(0.148)	(0.157)
65+ Years	2.77***	2.63***	0.012	-0.162
	(1.22)	(1.23)	(0.494)	(0.493)
Poverty	0.0938	0.0856	0.265***	0.263***
	(0.122)	(0.121)	(0.048)	(0.048)
Labor	-0.905***	-0.890***	0.016	0.0068
	(0.249)	(0.247)	(0.101)	(0.100)
Unemp.	-0.462*	-0.596**	0.151	0.119
	(0.282)	(0.289)	(0.112)	(0.112)
Sm.Firm			-0.01	0.022
			(0.210)	(0.209)
NME	0.078***		-0.0093	
	(0.024)		(0.0097)	
NME (-1)		0.107***		0.025**
		(0.030)		(0.011)
n	437	437	437	437
R^2 (Group effects)	0.74	0.74	0.83	0.83
R^2 (X-variables)	0.43	0.43	0.54	0.55
R^2 (X and Group Effects)	0.9	0.9	0.87	0.87
Adjusted R^2	0.88	0.89	0.85	0.85
F value	58.57***	59.56***	41.47***	42.01***

Dependent variables: HMO_{it}: Percentage of the total population enrolled in an HMO for state i in year t.
$Uninsured_{it}$: Percentage of the total population uninsured for state i in year t.
Standard errors in parentheses. *** = significant at 0.01, ** = significant at 0.05, * = significant at 0.1.
All cross-section estimates are suppressed.

Table 3. Fixed-effects regression results for real per-capita prescription drug spending

	Fixed Effects	Fixed Effects	IV Fixed Effects	IV Fixed Effects	AR & IV Fixed Effects
Variable	1	2	3	4	5
Obese	3.45***	2.98***	3.07***	2.75***	1.75**
	(0.664)	(0.621)	(0.833)	(0.845)	(0.91)
Smoke	-0.611	-0.056	-0.370	0.302	0.482
	(0.644)	(0.591)	(0.673)	(0.612)	(0.479)
Alcohol	-2.31	-10.95	8.97	-0.507	0.946
	(10.92)	(10.19)	(12.91)	(12.57)	(11.41)
Income	24.56***	19.09***	23.66***	19.65***	23.15***
	(1.46)	(1.55)	(2.18)	(2.34)	(2.77)
65+ Years §	24.71***	21.13***	31.01***	25.83***	15.76**
	(4.72)	(4.44)	(4.29)	(4.20)	(7.72)
HMO #	1.17***	1.30***	1.42*	1.38*	-0.157
	(0.202)	(0.187)	(0.855)	(0.787)	(0.993)
Uninsured #	0.899*	0.557	-0.021	-0.776	-0.981
	(0.499)	(0.467)	(1.83)	(1.78)	(1.46)
Unemployed	-2.21**	-3.53***	-3.10***	-4.36***	-4.38***
	(1.11)	(1.05)	(1.40)	(1.30)	(1.16)
NME	0.096		0.105		
	(0.099)		(0.119)		
NME (-2)		0.846***		0.694***	0.675***
		(0.112)		(0.124)	(0.109)
n	437	437	393	393	400
R^2 (Group effects only)	0.33	0.33	0.37	0.37	0.33
R^2 (X-variables only)	0.74	0.78	0.73	0.77	0.70
R^2 (X and Group Effects)	0.93	0.94	0.94	0.95	0.89
Adjusted R^2	0.92	0.93	0.93	0.94	0.87
F value	90.53***	104.75***	95.50***	104.95***	45.95***

Dependent variable: $Drug_{it}$ = Real per-capita prescription drug expenditures (1996 dollars) for state i in year t.
Standard errors in parentheses. *** = significant at 0.01, ** = significant at 0.05, * = significant at 0.1.
All cross-section estimates are suppressed.
= Instrument in equations (3), (4), and (5).
§ = Instrument in equations (3) and (4).