Home, or nursing home?
The effect of medical innovation on
the demand for long-term care

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Abstract

During the last few decades, the fraction of elderly Americans who live in nursing homes has declined. For people age 80 and over, the 1999 nursing-home residence rate was 24% lower than the rate one would predict from the 1985 age-specific rates: 11.8% vs. 15.6%. Living in a nursing home is considerably more expensive than living in the community, so the decline in nursing home residence rates reduced the total costs incurred by Americans age 80 and over by about $10 billion in 1999.

This paper tests the hypothesis that medical innovation has reduced the age-adjusted nursing-home residence rate, and estimates the contribution of medical innovation to the decline in the rate of nursing home residence, during the period 1985-1999. I investigate the effects of two main types of medical innovation: drug innovation, and innovation in medical procedures. I use a longitudinal, disease-level, difference-in-differences research design to investigate whether the rate of nursing home residence declined more rapidly for diseases with higher rates of medical innovation. This research design controls for non-innovation determinants of nursing home residence that vary across diseases but are constant (or change slowly) over time, and for determinants of nursing home residence that change over time (e.g. Medicaid policy) but do not vary across diseases.

The dependent variable is the fraction of people with a given medical condition in a given year (1985, 1997, or 1999) who reside in a nursing home, rather than in the community. Data were obtained from the National Nursing Home Survey, the Medical Expenditure Panel Survey, MEDSTAT, and other sources.

The estimates indicate that diseases with more rapid rates of pharmaceutical innovation had larger declines in the nursing-home residence rate during the period 1985-1999. Pharmaceutical innovation is estimated to have accounted for almost three-fourths of the total decline in the age-adjusted nursing home residence rate of people 65 and over, and 56% of the decline in the rate of people age 80 and over. I estimate that 55% of expenditure on new drugs by people age 65 and over was offset by reduced expenditures on nursing home care, and that among people age 80 and over, the reduction in expenditure on nursing home care due to the use of new drugs exceeded expenditure on new drugs by 26%.

Diseases with more rapid rates of medical procedure innovation, as well as drug innovation, had larger declines in the nursing-home residence rate. However, the estimated impact of procedure innovation on nursing-home utilization is implausibly large. This is probably attributable to our inability, at present, to distinguish between truly innovative procedures and old procedures with new procedure codes, a problem we hope to resolve in future research. Controlling for the (admittedly imperfect) procedure innovation measures has virtually no effect on estimates of the impact of drug innovation.

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During the last few decades, the fraction of elderly Americans who live in nursing homes has declined. In 1985, 4.5% of Americans over the age of 65 lived in nursing homes. By 1999, this fraction had declined to 4.2%. This decline is particularly noteworthy because a growing share of the over-65 population is very old—over 80—and the tendency to live in a nursing home rises very rapidly with age. This means that the age-adjusted probability of nursing-home residence declined even faster than the overall rate in the over-65 population. Using data on the age distribution of nursing-home residents in 1985 and 1999 from the National Nursing Home Survey and on the age distribution of the entire population from the Census Bureau, I calculated age-specific nursing home residence rates in 1985 and 1999. Nursing-home residence rates in 1985 and 1999, by single year of age (age 65-95), are shown in Figure 1. I also calculated what the nursing-home residence rate would have been in 1999, given the age distribution of the population in 1999, if age-specific nursing-home residence rates had been equal to their 1985 values. Here are the results:

Nursing-home residence rates:	Age 65 and over	Age 80 and over
1985 actual	4.5%	14.8%
1999 predicted at 1985 age-specific rates	5.5%	15.6%
1999 actual	4.2%	11.8%

For people age 65 and over, the 1999 nursing-home residence rate was 23% lower than the rate one would predict from the 1985 age-specific rates: 4.2% vs. 5.5%. For people age 80 and over, the 1999 nursing-home residence rate was 24% lower than the rate one would predict from the 1985 age-specific rates: 11.8% vs. 15.6%. The age-adjusted rate of nursing home residence declined at a 1.7% annual rate during the period 1985-1999.

Living in a nursing home is considerably more expensive than living in the community. As shown in Table 1, according to the Consumer Expenditure Survey, per capita expenditure by community residents age 75 and over was $12,505 in 2002. According to the National Nursing Home Survey, average annual charges to nursing home residents age 75 and over was $42,160 in 1999.[1] The cost of living in a nursing

[1] The government pays for about 60% of the cost of nursing home care. (http://www.cms.hhs.gov/statistics/nhe/historical/t7.asp)

home was over three times as high as the cost of living in the community.[2] Reducing the rate of nursing home residence therefore reduces the average cost of living among the elderly. In 1999, there were 9.0 million Americans age 80 and over. As shown above, in 1999 the nursing home residence rate among people age 80 and over was 3.8 percentage points (= 15.6% - 11.8%) lower than it would have been if age-specific nursing home residence rates had remained at their 1985 levels. As a result of the decline in nursing home residence rates, 341 thousand (= (15.6% - 11.8%) * 9.0 million) fewer Americans age 80 and over resided in nursing homes in 1999. This reduced the total costs incurred by Americans age 80 and over by $10.1 billion (= 341,000 * ($42,160 - $12,505)) in 1999.

The long-term decline in nursing-home residence rates may be attributable to a number of economic and social factors. I hypothesize that improved health, or functional status, among the elderly is an important contributing factor, and that the improvement in health is attributable, in part, to medical innovations: new medical goods and procedures.[3]

Economists believe that new goods generally account for a significant part of economic growth. In their book *The Economics of New Goods*, Bresnahan and Gordon argue that "new goods are at the heart of economic progress." Grossman and Helpman hypothesized that "innovative goods are better than older products simply because they provide more 'product services' in relation to their cost of production" in their book, *Innovation and Growth in the Global Economy*. And in a recent paper, *Measuring the Growth from Better and Better Goods*, Bils makes the case that "much of economic growth occurs through growth in quality as new models of consumer goods replace older, sometimes inferior, models."

Suppose that an elderly person needs to reside in a nursing home when his or her health status falls below a certain threshold (H_{min}). The fraction of elderly people residing in nursing homes is then equal to the area under the health density function to the left of H_{min}. Events that shift the health density function to the right reduce the nursing-home residence rate.

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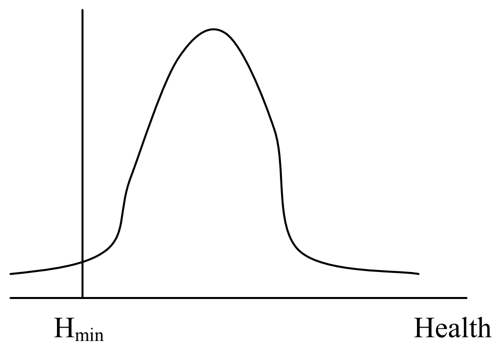
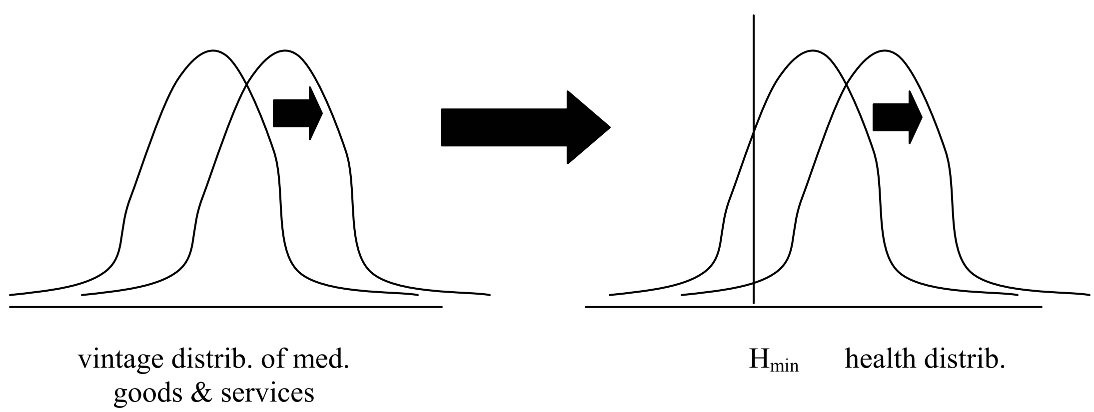
[2] Although nursing home charges may exceed nursing home costs.
[3] Poor health is the most frequent reason given by nursing home residents for their living arrangements.



Further suppose that the location of the health density function depends on the location of the vintage distribution of medical goods and services, where vintage is defined as the year of market introduction (e.g., the FDA approval year). In particular, a rightward shift of the vintage distribution results in a rightward shift of the health density function:



The aim of this paper is to test the hypothesis that medical innovation has reduced the age-adjusted nursing-home residence rate, and estimate the contribution of medical innovation to the decline in the rate of nursing home residence, during the period 1985-1999. I will investigate the effects of four types of medical innovation: drug innovation, and innovation in three types of procedures (therapeutic and preventive procedures, diagnostic procedures, and laboratory procedures).[4] Relative expenditure on prescribed

[4] These are the three types of "Health Care Activities"—"activities of or relating to the practice of medicine or involving the care of patients"—identified in the National Library of Medicine's Unified Medical Language System (UMLS) Semantic Network, one of three UMLS Knowledge Sources developed by the National Library of Medicine as part of the Unified Medical Language System project. The Network provides a consistent categorization of all concepts represented in the UMLS Metathesaurus. Therapeutic or Preventive Procedures are "procedures, methods, or techniques designed to prevent a disease or a

medicines and on the three types of procedures during 1997-2002 is shown in Figure 2. Therapeutic and preventive procedures is the largest category, accounting for 43% of expenditure. Diagnostic procedures is the second largest, accounting for 28% of expenditure. Prescription drugs and laboratory procedures account for 22% and 7% of expenditure, respectively.

I. Methodology

I will use a longitudinal, disease-level,[5] difference-in-differences research design to investigate whether the rate of nursing home residence declined more rapidly for diseases with higher rates of medical innovation. The econometric model will be of the form

$$\text{Prob}(NH_{it}) = \mathbf{\Phi}[\Sigma_j\ \beta_j\ NEW\%_{ijt} + \alpha_i + \delta_t] + \varepsilon_{it} \qquad (1)$$

where

$\mathbf{\Phi}$ = the standard cumulative normal probability distribution

$\text{Prob}(NH_{it})$ = the probability that an elderly person with disease i in year t (t = 1985, 1997, 1999) resides in a nursing home (as opposed to the community)

$NEW\%_{ijt}$ = the fraction of medical goods or procedures of type j used to treat disease i in year t that were introduced after 1985

α_i = a fixed effect for disease i

δ_t = a fixed effect for year t

ε_{it} = a disturbance

The fixed disease effects control for non-innovation determinants of nursing home residence that vary across diseases but are constant (or change slowly) over time. The fixed year effects control for non-innovation determinants of nursing home residence that

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disorder, or to improve physical function, or used in the process of treating a disease or injury." Diagnostic Procedures are "procedures, methods, or techniques used to determine the nature or identity of a disease or disorder. This excludes procedures which are primarily carried out on specimens in a laboratory." Laboratory Procedures are "procedures, methods, or techniques used to determine the composition, quantity, or concentration of a specimen, and which is carried out in a clinical laboratory. Included here are procedures which measure the times and rates of reactions."

[5] In future research, I hope to investigate this hypothesis using individual-level data.

change over time (e.g. Medicaid policy) but do not vary across diseases. Of course, for estimates of β to be consistent, it must be the case that non-innovation determinants of nursing home residence not controlled for by the fixed disease and year effects be uncorrelated with the measures of medical innovation.

There are a number of possible ways to measure the shift in the vintage distribution of medical goods and services. An obvious way is to measure the change in the *mean* vintage. But as indicated above, rather than the change in mean vintage, I will use the change in the % of medical goods and services whose vintage exceeds a certain value (1985). There are two good reasons for this, both related to incomplete data. First, vintage data are left-censored: for many procedures (and some drugs), we know only that their vintage is below a certain value. Second, we have good data on the utilization of drugs and procedures since 1997, but not before that year. Hence, we can't determine the mean vintage of drugs and procedures used in 1985, but we know the % of drugs and procedures used in 1985 that were introduced after 1985: zero!

I will calculate the fraction of medical goods or procedures of type j used to treat *all people*, not just the elderly, with disease i in year t that were introduced after 1985. Most of the drug utilization data, and the vast majority of the procedure utilization data, I have are for people under age 65.[6]

II. Data

A. Nursing home residence rates

I computed nursing home residence rates as follows:

$$Prob(NH_{it}) = N\_NH_{it} / (N\_NH_{it} + N\_COMMUN_{it})$$

where

N_NH_{it} = the number of nursing home residents (over age 65 or 80) with diagnosis i in year t

[6] Less than 1% of the outpatient procedures captured in the MEDSTAT Commercial Claims & Encounters Database I will use were performed on people age 65 and over. MEDSTAT also has a Medicare Supplemental Database, but this was not available to me.

N_COMMUN_{it} = the number of community residents (over age 65 or 80) with diagnosis i in year t

No single survey covers both nursing-home and community residents, so estimates of N_NH_{it} and N_COMMUN_{it} were obtained from two different surveys. *Nursing home residents.* N_NH_{it} was computed from the National Nursing Home Survey (NNHS). The NNHS is a continuing series of national sample surveys of nursing homes, their residents, and their staff. Nursing home surveys have been conducted in 1973-74, 1977, 1985, 1995, 1997, and 1999. These surveys were preceded by a series of surveys from 1963 through 1969, called the "residents places" surveys. Although each of these surveys emphasized different topics, they all provided some common basic information about nursing homes, their residents, and their staff. The most recent NNHS was conducted in 1999. All nursing homes included in this survey had at least three beds and were either certified (by Medicare or Medicaid) or had a State license to operate as a nursing home. The National Nursing Home Survey provides information on nursing homes from two perspectives--that of the provider of services and that of the recipient. Data about the facilities include characteristics such as size, ownership, Medicare/Medicaid certification, occupancy rate, number of days of care provided, and expenses. For recipients, data are obtained on demographic characteristics, health status, and services received. Data for the survey has been obtained through personal interviews with administrators and staff and occasionally with self-administered questionnaires in a sample of about 1,500 facilities.

The NNHS collects information on the diagnoses of nursing home residents. For example, the 1999 survey reported that 279,000 residents suffered from diabetes and 232,000 suffered from Alzheimer’s disease at the interview date (Jones (2002, Table 27).[7]

Although six nursing home surveys have been conducted (in 1973-74, 1977, 1985, 1995, 1997, and 1999), I will use data only from the 1985, 1997, and 1999 surveys, since (as explained below) these are the years for which I can construct medical

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[7] Jones A. *The National Nursing Home Survey: 1999 summary*. National Center for Health Statistics. Vital Health Stat 13(152). 2002.

innovation measures. Moreover, the first two surveys did not use ICD9 codes to code diagnoses, and the 1973-74 survey was narrower in scope than subsequent surveys—it excluded facilities providing only personal care or domiciliary care. The number of nursing home residents sampled in the years I will use are:

1985	5,238
1997	8,138
1999	8,215

Community residents. The number of community residents (over age 65 or 80) with diagnosis (condition) i in year t (N_COMMUN_{it}) was estimated from the 1987 National Medical Expenditure Survey (NMES)[8] and the1997 and 1999 Medical Expenditure Panel Survey (MEPS) condition files. These surveys provide information on household-reported medical conditions collected on a nationally representative sample of the civilian noninstitutionalized population of the United States. The number of community residents (including nonelderly residents) sampled in the years I will use are:

1987	35,000 (approx)
1997	34,551
1999	24,618

B. Measures of medical innovation

I constructed measures of two main types of medical innovation: pharmaceutical innovation, and innovation in medical procedures. The latter can be subdivided into several main categories, i.e. diagnostic procedures, laboratory procedures, and therapeutic/preventive procedures.

Pharmaceutical innovation. Data on prescribed medicines consumed in 1997 and 1999, by medical condition, were obtained from the MEPS Prescribed Medicines files.[9] The 1997 file contains data on 234,532 prescriptions, and the 1999 file contains data on 173,950 prescriptions. Each record in these files indicates the National Drug Code of the medicine and up to three ICD9 codes describing the condition for which the drug was taken. For the vast majority of prescriptions, only one ICD9 code is reported. I

[8] Because an appropriate community survey was not conducted in 1985 (the year of the NNHS survey), I will use the 1987 NMES data to estimate N_COMMUN_{it} in 1985.
[9] See http://www.meps.ahrq.gov/Puf/PufDetail.asp?ID=24 and http://www.meps.ahrq.gov/Puf/PufDetail.asp?ID=91.

determined the active ingredient(s) contained in each prescription by using the NDC to link to Multum's Lexicon. I determined the FDA approval year of each active ingredient from Mosby's Drug Consult. Let N_RX_{pit} = the number of prescriptions for product p used to treat condition i in year t. Let $POST1985_p = 1$ if product p's active ingredient was first approved after 1985, and = 0 otherwise.[10] Then

$$NEW\_DRUG\%_{it} = \Sigma_p (POST1985_p * N\_RX_{pit}) / \Sigma_p N\_RX_{pit}$$

Because MEPS Prescribed Medicines files exist for each of the years 1996-2002, we can calculate $NEW\_DRUG\%_{it}$ in each of those seven years.[11] Figure 3 shows the percent of prescriptions for all conditions that contained ingredients approved after 1985 by year during 1996-2002. The share of post-1985 drugs approximately doubled from 1996 to 2002. In 1999, the last year of the sample period we will analyze, post-1985 drugs accounted for 35.2% of all prescriptions. The share of post-1985 drugs varied considerably across diseases in 1999. Here are some quantiles of the distribution of $NEW\_DRUG\%_{i,1999}$ across two-digit ICD9 codes (N = 77):

90%	51.9%
75% Q3	35.2%
50% Median	22.1%
25% Q1	11.8%
10%	0.0%

Medical procedure innovation. Data on outpatient and inpatient medical procedures used in 1997 and 1999, by medical condition, were obtained from MEDSTAT Marketscan Data. The MarketScan databases capture person-specific clinical utilization, expenditures and enrollment across inpatient, outpatient, prescription drug,[12] and carveout services from approximately 45 large employers, health plans, and government and public organizations. The MarketScan databases link paid claims and encounter data

[10] In the case of combination drugs, let $POST1985_p = 1$ if product p's *newest* active ingredient was first approved after 1985, and = 0 otherwise.
[11] Although a MEPS Prescribed Medicines files does not exist for the year 1985, it is safe to assume that $NEW\_DRUG\%_{i,1985} = 0, \forall$ i.
[12] Unlike the MEPS prescription drug data, the MEDSTAT prescription drug data do not include ICD9 codes.

to detailed patient information across sites and types of providers, and over time. The annual medical databases include private sector health data from approximately 100 payers. Historically, more than 500 million claim records are available in the MarketScan databases.

I used data contained in two types of MEDSTAT files: the outpatient services and inpatient services files. The Outpatient Services file comprises encounters and claims for services that were rendered in a doctor's office, hospital outpatient facility, emergency room or other outpatient facility.[13] The Inpatient Services file contains the individual encounters and services that create the inpatient admission record (facility and professional claims). For example, claims for professional services rendered for an admission are found in the Inpatient Services table.

Each record in each of these files contains both ICD9 diagnosis codes and procedure codes. Up to two diagnosis codes are recorded on every Outpatient and Inpatient Service record. The American Medical Association's CPT-4 (Current Procedural Terminology, 4th Edition) coding system is the most frequently used system for classifying procedures.[14] There is space for one procedure code on each Outpatient and Inpatient Service record. Since the claims in the database are processed by approximately 100 payers or administrators, the quality of the coding does vary. Every effort is made to select the entities with the best coding.[15] The diagnosis and procedure codes are validated and edited. If data contributors submit old codes, these codes are retained in the MarketScan data and reflect their original definition.

Determining the vintage of most medical procedures is much more challenging than determining the vintage of drugs, because unlike the introduction of new drugs, the introduction of new procedures is generally not regulated by the FDA. A noisy indicator of the vintage of a procedure is the date that the CPT code for that procedure was added to the Common Procedure Coding System established by the Centers for Medicare & Medicaid Services (CMS). This date is recorded in the *Version of Physicians' Current*

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[13] A small percentage of claims in this table may represent inpatient services because the claim was not incorporated into an inpatient admission (i.e., no room and board charge was found); these generally have an "inpatient" Place of Service code.
[14] In 1997, 83% of MEDSTAT outpatient procedures and 77% of MEDSTAT inpatient procedures were coded using CPT-4 codes.
[15] See *1998 MarketScan Research Databases User Guide and Database Dictionary*.

Procedural Terminology (CPT) included in the Healthcare Common Procedure Coding System (HCPCS), 2005 produced by CMS.[16] Data on the "HCPCS Code Added Date" — the date the HCPCS code was added to the CMS Common Procedure Coding System— are included in the Unified Medical Language System Metathesaurus produced by the National Library of Medicine.[17]

Figure 4 shows the percent of 1999 procedures whose HCPCS codes had been added up until each of the years 1982-1999. These percentages are based on 34 million procedures reported in the 1999 MEDSTAT Marketscan database. Evidently, HCPCS was first established in 1982, but was not fully implemented until 1985. Most of the codes added during 1982-1985 were for procedures that had been introduced in earlier years. By the end of 1985, codes for 64% of the procedures performed in 1999 had been added to HCPCS. In each year since 1985, codes for between 1% and 5% of procedures performed in 1999 were added to HCPCS. This timing seems fortuitous for us, since it suggests that the fraction of procedures performed in 1997 and 1999 whose codes were added after 1985 (our "baseline" year) is a meaningful measure of post-1985 innovation.

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[16] Each year, in the United States, health care insurers process over 5 billion claims for payment. For Medicare and other health insurance programs to ensure that these claims are processed in an orderly and consistent manner, standardized coding systems are essential. The HCPCS was developed for this purpose. The HCPCS is divided into two principal subsystems, referred to as level I and level II of the HCPCS. Level I of the HCPCS is comprised of CPT-4, a numeric coding system maintained by the AMA. The CPT-4 is a uniform coding system consisting of descriptive terms and identifying codes that are used primarily to identify medical services and procedures furnished by physicians and other health care professionals. These health care professionals use the CPT-4 to identify services and procedures for which they bill public or private health insurance programs. Decisions regarding the addition, deletion, or modification of CPT-4 codes are made by the AMA. The CPT-4 codes are republished and updated annually by the AMA. Level I of the HCPCS, the CPT-4 codes, does not include codes needed to report medical items or services that are regularly billed by suppliers other than physicians.

Level II of the HCPCS is a standardized coding system that is used primarily to identify products, supplies, and services not included in the CPT-4 codes, for example, ambulance services and durable medical equipment, prosthetics, orthotics, and supplies (DMEPOS) when used outside a physician's office. Because Medicare and other insurers cover a variety of services, supplies, and equipment that are not identified by CPT-4 codes, the level II HCPCS codes were established for submitting claims for these items. The development and use of level II of the HCPCS began in the 1980's. Level II codes are also referred to as alpha-numeric codes because they consist of a single alphabetical letter followed by 4 numeric digits, while CPT-4 codes are identified using 5 numeric digits.
(http://www.cms.hhs.gov/medicare/hcpcs/codpayproc.asp)

[17] I corroborated the accuracy of these dates by consulting the AMA's CPT Assistant Archives 1990-2004, which identifies all CPT codes that have been introduced (or revised) since 1990.

Figure 5 shows the fraction of outpatient and inpatient procedures performed in 1997-1999 whose codes were added to HCPCS after 1985. The % of all procedures whose codes were added to HCPCS after 1985 is remarkably similar to the % of prescriptions that contained ingredients approved after 1985 (Figure 3):

Year	% of all procedures whose codes were added to HCPCS after 1985	% of prescriptions that contained ingredients approved after 1985
1997	28.9%	27.3%
1998	33.1%	32.3%
1999	36.5%	35.2%

The % of post-1985 therapeutic procedures was higher, and increased more rapidly during 1997-1999, than the % of post-1985 laboratory and diagnostic procedures.

As the following table shows, the % of post-1985 procedures in 1999, like the % of post-1985 drugs, varied considerably across diseases.

	All procedures	Lab procedures	Diagnostic procedures	Therapeutic procedures
90%	47.1%	43.6%	53.8%	57.0%
75% Q3	39.5%	32.4%	43.5%	40.8%
50% Median	30.0%	25.7%	28.7%	25.0%
25% Q1	21.4%	21.1%	19.1%	16.6%
10%	15.0%	17.0%	12.4%	8.8%

Closer inspection of the data on medical procedures reveals that some "new" procedures are probably just relabeled or reclassified old procedures, rather than true innovations. For example, the three procedures whose codes were added in 1997 which were most frequently performed in 1997 were 98940, 98941, and 98942, which correspond to different types of chiropractic manipulative treatment of the spine. Undoubtedly, this type of treatment was performed well before 1997. A new CPT code should therefore be considered a necessary condition for a medical innovation, but not a sufficient condition: all innovations have new CPT codes, but some new CPT codes are not innovations. The fraction of procedures with new CPT codes exceeds the fraction of truly innovative procedures, perhaps by a significant amount, and the degree of overstatement varies across diseases. In the future, I hope to develop a reliable method of distinguishing between truly innovative procedures and old procedures with new CPT codes.[18] For now, I will include the fraction of procedures with new CPT codes, despite the limitations of this variable. Although the coefficient on this variable is difficult to interpret, including it may provide a robustness check on the drug coefficient.

I will now proceed to test the hypothesis that diseases with above-average rates of pharmaceutical innovation (i.e. above-average percentages of post-1985 drugs in 1997 and 1999) had above-average declines in nursing home residence rates during the period 1985-1999, conditional on (imperfect measures of) rates of other medical innovation.

III. Estimates

Estimates of different versions of (eq. (1))--probit models of the nursing-home residence rate--are shown in Table 2. I estimated models for two different age groups: people age 65 and over, and people age 80 and over. Estimates of models for the first age group are shown in columns 1-4. Model 1 includes just two year dummy variables (for the years 1985 and 1997) and an intercept. (The 1999 year effect is normalized to zero.) The 1985 dummy is positive, indicating that the crude nursing-home residence rate was higher in 1985 than it was in 1999, but it is not statistically significant. Model 2 also includes fixed disease effects (which are always jointly highly significant). Now the 1985 dummy is positive and significantly different from zero, indicating that, controlling for disease, the 1985 nursing home residence rate was significantly higher than the 1999 rate. In model 3, we add the drug innovation variable—the fraction of prescriptions for drugs approved after 1985. As expected, the coefficient on NEW_DRUG% is negative and highly significant (p-value = .003). This indicates that *diseases with more rapid rates of pharmaceutical innovation had larger declines in the nursing-home residence rate during the period 1985-1999*. The 1985 dummy is not significantly different from zero in model 3, which implies that, holding constant NEW_DRUG% (i.e., in the absence of any pharmaceutical innovation), there would have been no decline in the nursing-home residence rate.

[18] Perhaps this can be done by examining the trajectory of utilization following establishment of a new CPT code. One might expect truly innovative procedures to exhibit sustained growth after introduction, and old procedures with new CPT codes to show little growth after the transition period.

We can evaluate the effect of pharmaceutical innovation on the nursing home residence rate as follows. In 1985, the sample mean nursing home residence rate among people age 65 and over was 3.6%. The change in the nursing home residence rate attributable to pharmaceutical innovation is

$$F[F^{-1}(3.6\%) + \beta_{drug} \text{ mean(NEW\_DRUG\%)}] - 3.6\%$$

where F is the standard normal cumulative distribution and F^{-1} is its inverse. The estimate of β_{drug} in column 3 is -0.3803, and the mean value of NEW_DRUG% in 1999 was 35.2%, so the reduction in the nursing home residence rate attributable to pharmaceutical innovation is 0.9%. In other words, in the absence of other trends (e.g. changing age distribution), pharmaceutical innovation would have reduced the nursing home residence rate from 3.6% in 1985 to 2.7% in 1999. We calculated earlier that the age-adjusted nursing home residence rate declined by 1.3 percentage points between 1985 and 1999. Hence, pharmaceutical innovation is estimated to account for almost three-fourths (73% = 0.9% / 1.3%) of the total decline in the age-adjusted nursing home residence rate during the period 1985-1999.

We calculated above that the average annual cost of living in a nursing home exceeded the average annual cost of living in the community by $29,655. Thus the value per person age 65 and over of the reduction in the 1999 nursing-home residence rate attributable to pharmaceutical innovation might be estimated as $277 (= 0.9% * $29,655). (This does not account for the presumably greater utility from living in the community.) According to the Medical Expenditure Panel Survey, in 1999, average expenditure on prescription drugs by people age 65 and over was $948. I estimate that just over half (54%) of this expenditure was on drugs approved after 1985, so average expenditure on new drugs was $508 (= 54% * $948). This implies that over half (55% = $277 / $508) of expenditure on new drugs by people age 65 and over was offset by reduced expenditures on nursing home care.

Model 4 in Table 2 includes the procedure innovation variable (NEW_PROC%)—the fraction of procedures performed that had CPT/HCPCS codes added after 1985—as well as the drug innovation variable. Like the coefficient on NEW_DRUG%, the coefficient on NEW_PROC% is negative and highly significant, indicating that the introduction and use of both new procedures and new drugs reduced the nursing-home residence rate.

Controlling for NEW_PROC% has virtually no effect on the estimate of β_{drug} or its standard error. The change in the nursing home residence rate attributable to the combined impact of new drugs and procedures is

$$F[F^{-1}(3.6\%) + \beta_{drug}\ \text{mean(NEW\_DRUG\%)} + \beta_{proc}\ \text{mean(NEW\_PROC\%)}] - 3.6\%$$

The mean value of NEW_PROC% in 1999 was 36%, so the estimated reduction in the nursing home residence rate attributable to the combined impact of new drugs and procedures is 1.6%. In other words, in the absence of other trends (e.g. changing age distribution), pharmaceutical and procedure innovation would have reduced the nursing home residence rate from 3.6% in 1985 to 2.0% in 1999. This is greater than the 1.3 percentage point decline in the age-adjusted nursing home residence rate between 1985 and 1999. Moreover, when we replace the fraction of all procedures that are new by its three components—the fractions of laboratory, diagnostic, and therapeutic procedures that are new—the implied impact of procedure innovation becomes even larger. I suspect that the implied impact of procedure innovation is implausibly large due to our inability, at present, to distinguish between truly innovative procedures and old procedures with new CPT codes. Even though the procedure innovation measures are imperfect, it is reassuring that controlling for them has virtually no effect on estimates of the impact of drug innovation.

The last four columns of Table 2 show estimates of the same models as those in columns 1-4, but estimated on the group of people age 80 and over. This sample is less than a third as large as the sample of people age 65 and over, but the nursing home residence rate is almost three times as high—9.8% vs. 3.6%. Model 5 shows that the crude nursing-home residence rate of people age 80 and over was significantly higher in 1985 than it was in 1999. Model 6 shows that the decline in the rate is even larger when we adjust for disease. In model 7, we add the drug innovation variable. As before, the coefficient on NEW_DRUG% is negative and highly significant (p-value = .030), and the 1985 dummy is not significantly different from zero, which implies that, in the absence of any pharmaceutical innovation, there would have been no decline in the nursing-home residence rate of people age 80 and over.

Using the method described above to evaluate the effect of pharmaceutical innovation on the nursing home residence rate of people age 80 and over, I estimate that the reduction in the nursing home residence rate attributable to pharmaceutical innovation is 2.1%. In other words, in the absence of other trends (e.g. changing age distribution), pharmaceutical innovation would have reduced the nursing home residence rate from 9.8% in 1985 to 7.7% in 1999. The age-adjusted nursing home residence rate of people age 80 and over declined by 3.8 percentage points between 1985 and 1999. Hence, pharmaceutical innovation is estimated to account for 56% = (2.1% / 3.8%) of the total decline in the age-adjusted nursing home residence rate of people age 80 and over during the period 1985-1999.

The value per person age 80 and over of the reduction in the 1999 nursing-home residence rate attributable to pharmaceutical innovation is estimated as $630 (= 2.1% * $29,655). In 1999, average expenditure on prescription drugs by people age 80 and over was $934.[19] I estimate that just over half (54%) of this expenditure was on drugs approved after 1985, so average expenditure on new drugs was $501 (= 54% * $934). This implies that, among people age 80 and over, the reduction in expenditure on nursing home care due to the use of new drugs exceeded expenditure on new drugs by 26% (= ($630 / $501) – 1).

Finally, in column 8 we include the procedure innovation variable as well as the drug innovation variable. Once again, the coefficient on NEW_PROC% is negative and highly significant; indeed, its magnitude is twice as great as it was in model 4. As before, controlling for NEW_PROC% has virtually no effect on the estimate of β_{drug} or its standard error. These estimates imply that pharmaceutical and procedure innovation would have reduced the nursing home residence rate among people age 80 and over from 9.8% in 1985 to 5.0% in 1999. This is greater than the 3.8 percentage point decline in the age-adjusted nursing home residence rate of this group between 1985 and 1999. Our inability, at present, to distinguish between truly innovative procedures and old procedures with new CPT codes is presumably the reason for the implausibly large implied impact of procedure innovation. But the drug innovation measure is not subject to this problem, the coefficient on it is essentially unaffected by inclusion of the procedure innovation measure, and the magnitude of its effect seems plausible.

[19] It is somewhat surprising that this is slightly *lower* than the average expenditure on prescription drugs by people age 65 and over ($934).

IV. Summary and conclusions

During the last few decades, the fraction of elderly Americans who live in nursing homes has declined. For people age 65 and over, the 1999 nursing-home residence rate was 23% lower than the rate one would predict from the 1985 age-specific rates: 4.2% vs. 5.5%. For people age 80 and over, the 1999 nursing-home residence rate was 24% lower than the rate one would predict from the 1985 age-specific rates: 11.8% vs. 15.6%. The age-adjusted rate of nursing home residence declined at a 1.7% annual rate during the period 1985-1999. Living in a nursing home is considerably more expensive than living in the community, so the decline in nursing home residence rates reduced the total costs incurred by Americans age 80 and over by about $10 billion in 1999.

Improved health, or functional status, among the elderly may be an important factor contributing to the long-term decline in nursing-home residence rates. In particular, an elderly person may need to reside in a nursing home when his or her health status falls below a certain threshold. Improvements in health may be attributable, in part, to medical innovations: new medical goods and procedures.

This paper has tested the hypothesis that medical innovation has reduced the age-adjusted nursing-home residence rate, and estimated the contribution of medical innovation to the decline in the rate of nursing home residence, during the period 1985-1999. I investigated the effects of two main types of medical innovation: drug innovation, and innovation in medical procedures. I used a longitudinal, disease-level, difference-in-differences research design to investigate whether the rate of nursing home residence declined more rapidly for diseases with higher rates of medical innovation. This research design controls for non-innovation determinants of nursing home residence that vary across diseases but are constant (or change slowly) over time, and for non-innovation determinants of nursing home residence that change over time (e.g. Medicaid policy) but do not vary across diseases.

The dependent variable was the fraction of people with a given medical condition in a given year (1985, 1997, or 1999) who resided in a nursing home, rather than in the community. No single survey covers both nursing-home and community residents, so estimates of this fraction were constructed using data from two different surveys: the

National Nursing Home Survey, and the Medical Expenditure Panel Survey (MEPS). Disease-specific data on drug and procedure innovation were constructed from MEPS, MEDSTAT, and other sources.

I estimated models for two different age groups: people age 65 and over, and people age 80 and over. Estimates for both groups indicated that diseases with more rapid rates of pharmaceutical innovation had larger declines in the nursing-home residence rate during the period 1985-1999. Pharmaceutical innovation is estimated to have accounted for almost three-fourths of the decline in the age-adjusted nursing home residence rate of people 65 and over, and 56% of the decline in the rate of people age 80 and over. I estimate that 55% of expenditure on new drugs by people age 65 and over was offset by reduced expenditures on nursing home care, and that among people age 80 and over, the reduction in expenditure on nursing home care due to the use of new drugs exceeded expenditure on new drugs by 26%.

Diseases with more rapid rates of medical procedure innovation, as well as drug innovation, had larger declines in the nursing-home residence rate. However, the estimated impact of procedure innovation on nursing-home utilization is implausibly large. This is probably attributable to our inability, at present, to distinguish between truly innovative procedures and old procedures with new procedure codes, a problem we hope to resolve in future research. Controlling for the (admittedly imperfect) procedure innovation measures has virtually no effect on estimates of the impact of drug innovation.

Figure 1
Nursing home residence rates,
by single year of age (age 65-95): 1999 vs. 1985

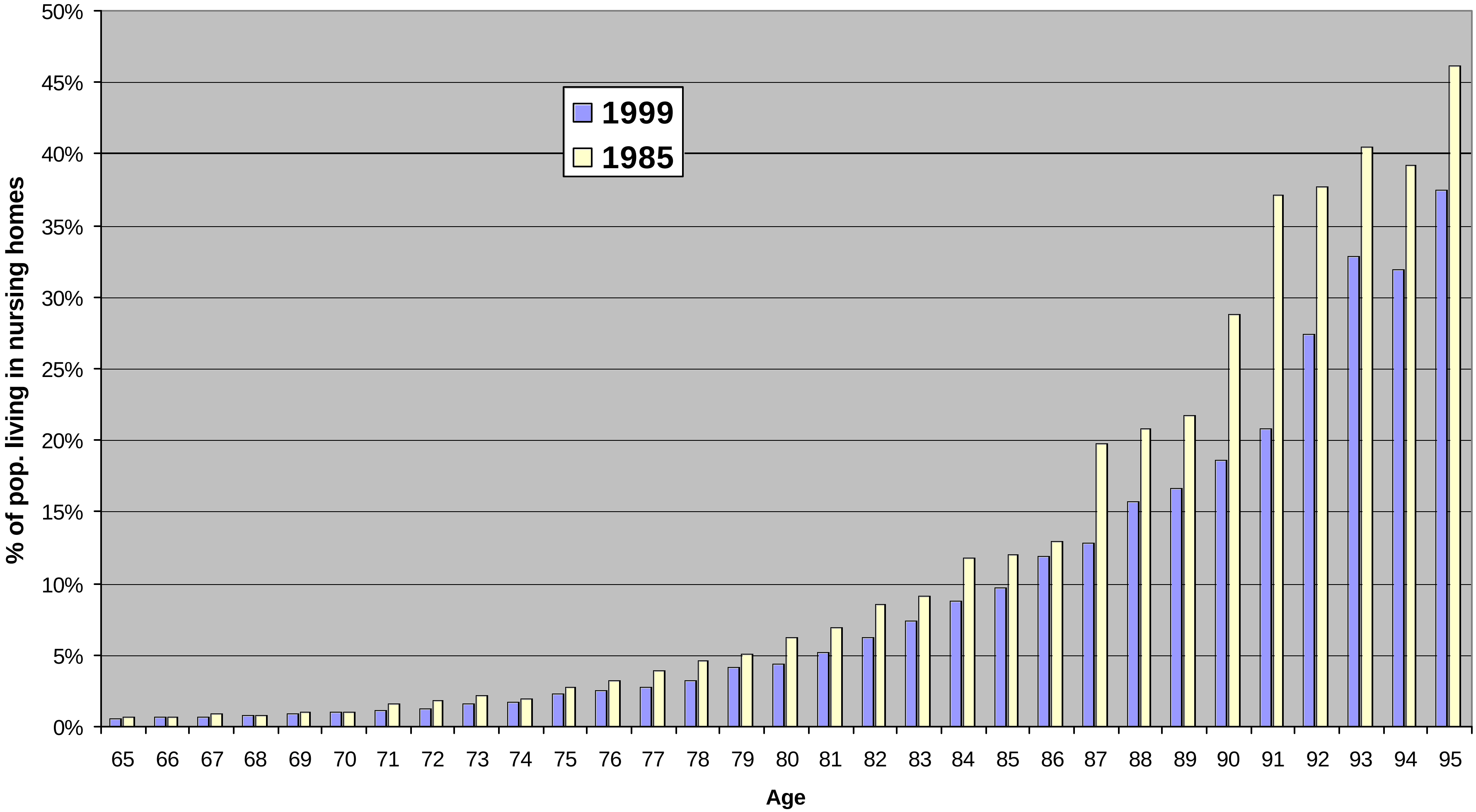


Figure 2
Relative expenditures on prescription drugs and procedures, by type

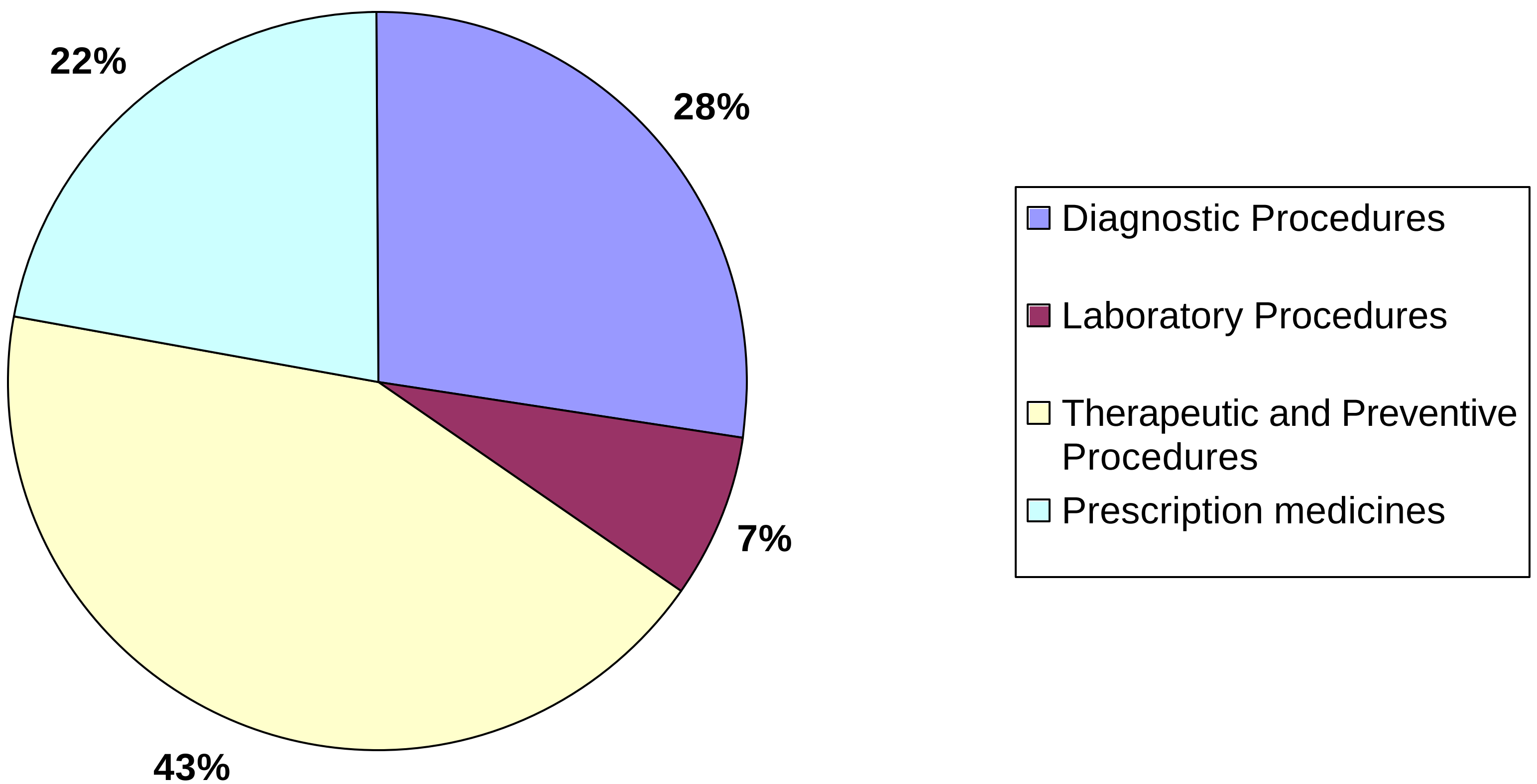


Figure 3
% of prescriptions that contained ingredients approved after 1985, by year, 1996-2002

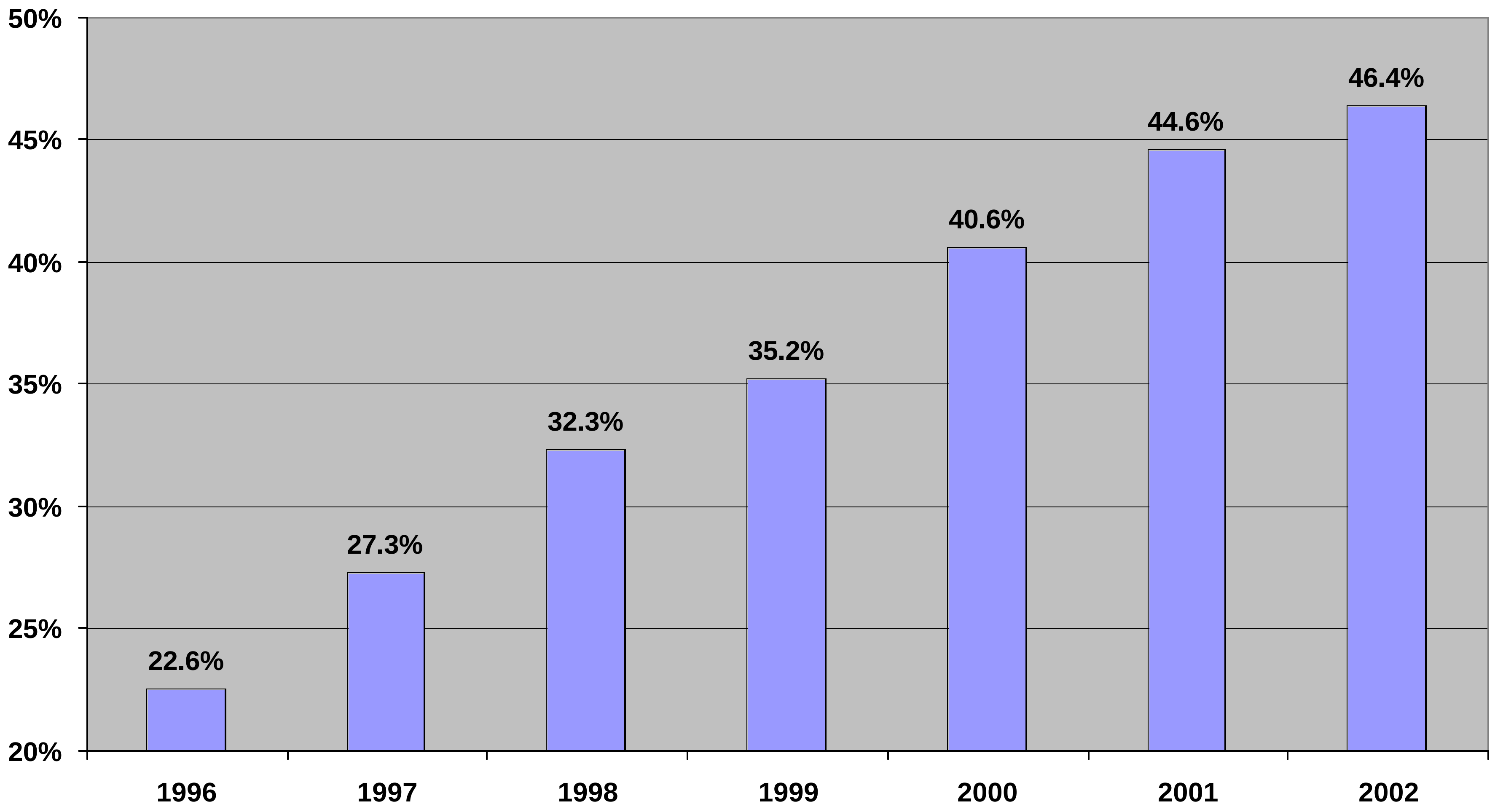
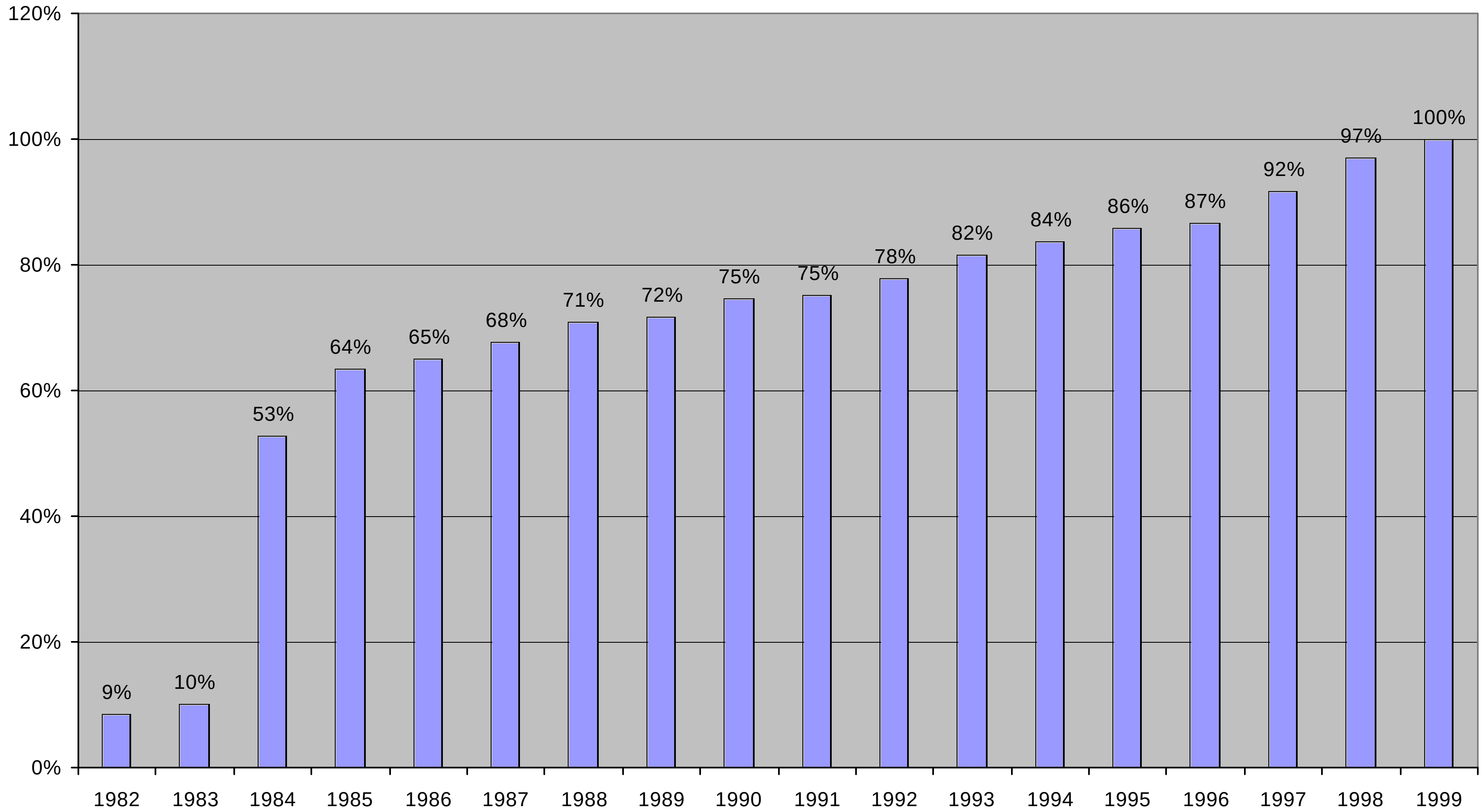


Figure 4
% of 1999 procedures whose CPT/HCPCS codes had been added by given year



Note: calculations based on 34 million procedures reported in the 1999 MEDSTAT Marketscan database.

Figure 5
% of outpatient and inpatient procedures performed in 1997-1999 whose codes were added to HCPCS after 1985

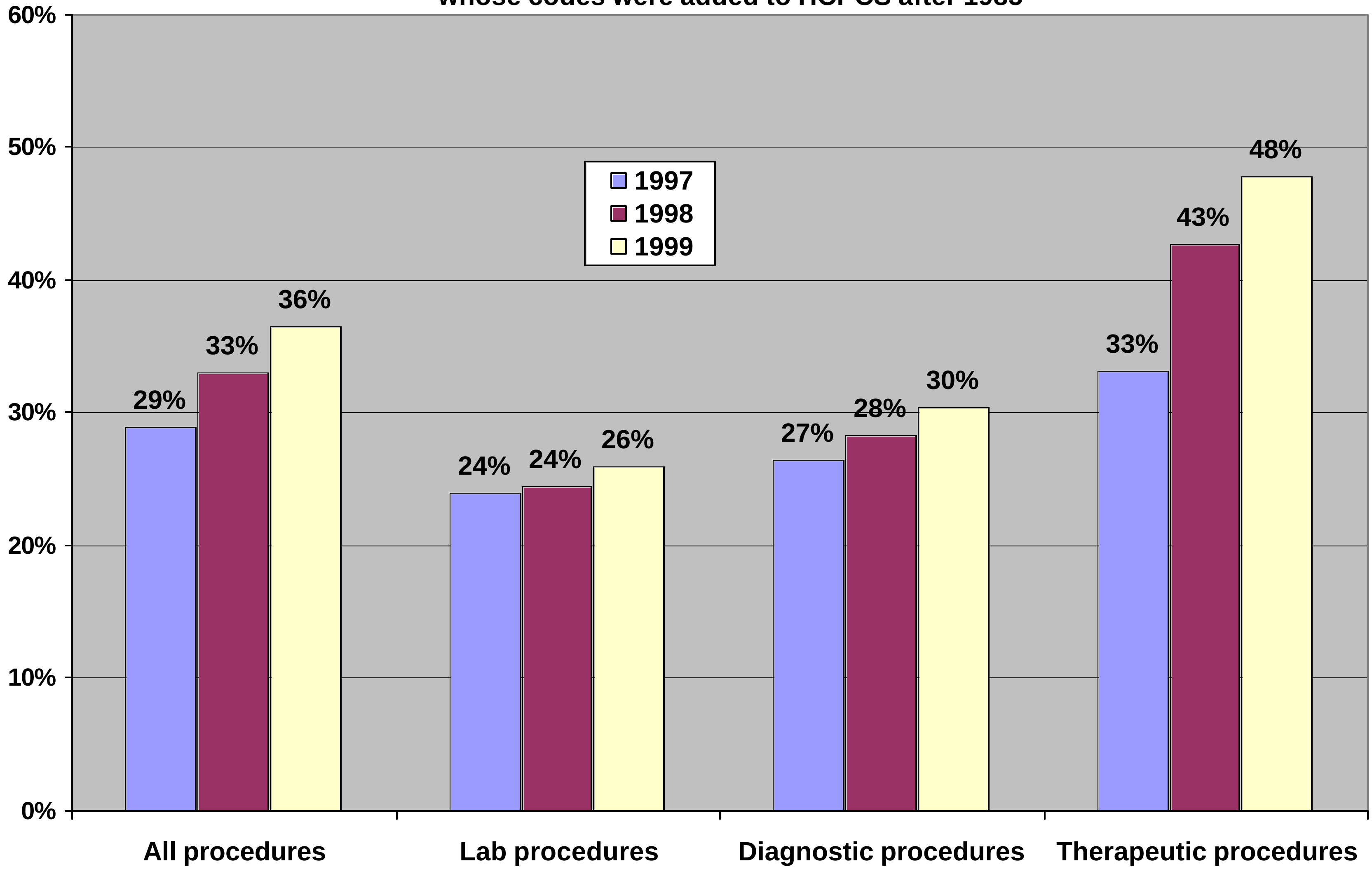


Table 1

Relative per capita expenditure of nursing-home and community residents, by age group

1	2	3	4	5	6
	Community residents			Nursing home residents	5 / 4
Age of reference person	Average annual expenditures per household, 2002	Average no. of people in household	Average annual expenditures per person, 2002	Average annual charges, 1999	
65-74	$32,243	1.5	$21,495	$41,008	191%
75 and over	$23,759	1.9	$12,505	$42,160	337%

Table 2

Estimates of probit models of the nursing-home residence rate

Model	1	2	3	4	5	6	7	8
Age group	65+	65+	65+	65+	80+	80+	80+	80+
Mean NH res. rate	3.6%	3.6%	3.6%	3.6%	9.8%	9.8%	9.8%	9.8%
No. of observations	109,072	109,072	109,072	109,072	28,324	28,324	28,324	28,324
Fixed disease effects?	no	yes	yes	yes	no	yes	yes	yes
year 1985	0.0237	0.0491	-0.0763	-0.174	0.0947	0.1325	0.0069	-0.182
Standard Error	0.0181	0.02	0.047	0.059	0.0263	0.0287	0.0675	0.084
Pr > ChiSq	0.1913	0.0143	0.1044	0.003	0.0003	<.0001	0.919	0.029
year 1997	-0.0145	-0.0077	-0.0358	-0.054	-0.0265	-0.0148	-0.0437	-0.079
Standard Error	0.0171	0.0188	0.0211	0.022	0.0241	0.0262	0.0297	0.031
Pr > ChiSq	0.3946	0.6822	0.0891	0.014	0.27	0.573	0.1412	0.011
post-1985 drug %			-0.3803	-0.393			-0.3806	-0.396
Standard Error			0.1286	0.129			0.1845	0.185
Pr > ChiSq			0.0031	0.002			0.0392	0.032
post-1985 procedure %				-0.300				-0.591
Standard Error				0.109				0.153
Pr > ChiSq				0.006				0.000
Intercept	-1.8019	-2.1766	-2.0469	-1.951	-1.3056	-1.8678	-1.7376	-1.552
Standard Error	0.0125	0.0606	0.0749	0.083	0.0177	0.0774	0.0999	0.111
Pr > ChiSq	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Note: The 1999 year effect is normalized to zero.