A REGRESSION-BASED MEDICAL CARE EXPENDITURE INDEX FOR MEDICARE BENEFICIARIES[1]

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ABSTRACT

We construct a disease-based price index for Medicare beneficiaries using data from the Medicare Current Beneficiary Survey from 2001-2005. We create the index by modeling total health-care expenditure as a function of the diagnoses of 27 illnesses. The coefficients from the regression are used to divide up each beneficiary's spending (following the method outlined in Trogdon et al. 2008) among his or her diagnosed illnesses. Spending for each illness is then aggregated over beneficiaries. An average price for each illness is calculated by dividing the total expenditure by the number of patients with the illness. We then use the prices to construct a Laspeyres price index for medical care indexed to 2001. This index grows at an average annual rate of about 6% from 2001 to 2005. Average nominal expenditure by Medicare beneficiaries grows at an average annual rate of 8.6% but, after nominal expenditure is deflated with the price index, average real expenditure grows by only 2.3% per year.

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1. Introduction

Health care accounted for 18% of the economy in 2011 (Hartman et al. 2013); the proper measurement of inflation and output in this sector are therefore of vital concern to policymakers and the public. There is a consensus among economic researchers in this field that the methods used by the Bureau of Labor Statistics to measure inflation in health care are not satisfactory. In particular, as the current indexes measure changes in the prices of individual services, they fail to capture the improvements in health-care productivity made possible by technological change. Research in the 1990s that constructed indexes for individual illnesses showed that inflation in health care appeared to be lower when measured at the disease level and when improved health outcomes were taken into account (Cutler et al. 1998).

This research led to a recommendation by the Committee on National Statistics of the National Research Council that government statistical agencies investigate methods for allocating health-care expenditures by disease and constructing new price indexes for health care. In response, some more recent research has investigated the effect on measured health-care inflation of disease-based price indexes (Aizcorbe and Nestoriak 2011, Dunn et al. 2010). By and large, these studies found that, when measured with a disease-based index, inflation was noticeably lower than in the standard service-based indexes.

The previous studies used data on the privately insured. This paper is the first to construct new price indexes for the publicly insured, specifically Medicare beneficiaries. Medicare, the public health insurance program for the elderly and the disabled, covers 50 million beneficiaries. Medicare spending comprises 21% of total health-care spending. In addition, Medicare is 15% of the federal budget and growth in spending on the program is expected to be a major contributor to the projected government deficit over the next 10 years (Congressional Budget Office 2013). Given its large fiscal role, measuring the real output of Medicare correctly is of paramount importance.

This paper creates a disease-based medical expenditure index for Medicare beneficiaries in 2001-05 using data from the Medicare Current Beneficiary Survey. We create the index by regressing total health-care expenditure on dummy variables for diagnoses of 27 illnesses separately for each year. The coefficients from the regression are used to divide up each beneficiary's spending (following the method outlined in Trogdon et al. 2008) and spending for each illness is aggregated over beneficiaries. An average price for each illness in each year is then calculated by dividing the total expenditure by the number of patients diagnosed with the illness. The average prices are aggregated into an overall expenditure index for health care. The prices for individual illnesses are weighted in each year's overall index with their 2001 expenditures.

This disease-based index is found to grow at an average annual rate of about 6 percent. (We use two models of health-care spending and the two estimates produced are 5.8 percent and 6.3 percent.) Nominal average spending of Medicare beneficiaries in our data grows at an average annual rate of 8.6 percent; when deflated with our expenditure index, real average Medicare spending grows at an average rate of 2.3 percent.

This index comes with certain caveats. Most importantly, it is not quality-adjusted. An ideal medical expenditure index would adjust for improvements in health outcomes resulting from improved medical care. If the productivity of health care is rising over time, a price index that captures this rise in productivity will rise more slowly (or fall) than one that does not. Cutler et al. (1998) calculated a price index for heart attacks which showed that outcomes-adjusted prices actually fell even as nominal expenditures were rising fairly rapidly.

As we are calculating a medical expenditure index aggregated over all diseases, however, we would have to adjust for outcomes separately for each illness, which would be infeasible. Therefore we do not adjust for outcomes in this first analysis.

2. Data

Our paper uses data from the Medicare Current Beneficiary Survey (MCBS), an annual survey of Medicare beneficiaries conducted by the Centers for Medicare and Medicaid Services (CMS) to follow their health, medical care, and spending on medical care from all possible sources. In the dataset, administrative medical claims data are matched with beneficiary health and utilization surveys to provide a comprehensive estimate of annual medical care expenditures, including spending not covered by Medicare. The survey covers beneficiaries enrolled in both fee-for-service (FFS) Medicare and in Medicare HMOs and who reside both in the community and in institutions. It uses stratified random sampling to represent the entire Medicare population for each year, averaging just under 12,500 beneficiaries during the years of our study, 2001-2005.

Sample beneficiaries are surveyed three times a year by an interviewer using a computer-assisted personal interviewing (CAPI) program. The CAPI program automatically directs the interviewer to the appropriate questions and performs general outlier analysis in real time. Questions range from basic demographic information to health status and health care utilization. Beneficiaries are asked to save supporting documentation for the interview, such as Explanation of Benefit forms, provider receipts, and prescription medicine bottles. For services covered by Medicare, survey responses were matched with administrative bill data to adjust for under-reporting of services and payment errors. Non-covered services, such as prescription medicines, were reviewed and edited using a variety of methods developed by MCBS staff.

The MCBS uses several forms of imputations and adjustments to estimate total beneficiary spending on medical care. For example, administrative claims data are used to supplement survey events reported with missing or incorrect payments. For our paper, a significant weakness of the survey involves the imputation for beneficiaries that die during the year, those with the greatest expenditures. The

imputation process involves using a comparable "donor" beneficiary to substitute for some or all of the survey answers. In order to avoid using the donor information for deceased beneficiaries, we only include those deceased beneficiaries who have survey data in the previous year and claims data available for the current year.

Table 1
Beneficiaries and Spending Dropped from Study Sample Due To Missing Survey or Claims Data

Year	# of Total Beneficiaries	# of Dropped Beneficiaries	% of Total Beneficiaries Dropped	% of Total Spending Dropped	Average Spending of Beneficiaries Dropped	Average Spending of Beneficiaries Kept
2001	12,864	1,228	12.7%	11.0%	$6,811	$8,008
2002	12,697	1,187	12.4%	11.8%	$8,165	$8,609
2003	12,486	1,171	12.5%	9.9%	$7,144	$9,280
2004	12,079	1,155	13.2%	9.5%	$6,959	$9,994
2005	12,029	1,159	13.1%	10.1%	$8,058	$10,754

Note: Percents and averages are weighted with the sample weights.

Study Sample

For this paper, price indexes are calculated using annual medical spending from all payers for the following events: inpatient hospital, outpatient hospital, physician services, and prescription medicine. These expenditure types have been used in previous research relating to medical care price indexes (Aizcorbe et al. 2011, Aizcorbe and Nestoriak 2011, Dunn et al. 2010). Survey answers from beneficiaries on their health status are also used, along with general demographic data. We restrict our survey sample to the following beneficiaries:

- those entitled to Medicare Part A and B for the entire year

- those that live the whole year or, for those that pass away, they must be on the survey in the previous year with available claims data (to avoid using MCBS donor data)

Our resulting sample size ranged from 11,636 beneficiaries in 2001 to 10,870 beneficiaries in 2005.

Table 2
Beneficiary Characteristics in Study Sample

Year	Percent Female	Average Age	Percent Disabled	Percent Non-White	Percent College Graduate
2001	57.3%	72.8	12.3%	14.0%	14.4%
2002	57.0%	72.8	12.4%	14.6%	14.7%
2003	56.6%	72.8	12.8%	15.4%	14.5%
2004	56.7%	72.7	13.6%	15.9%	14.9%
2005	56.7%	72.7	13.6%	15.9%	15.8%

Note: Calculations are weighted with sample weights.

Diagnosed illnesses

Our goal was to create a set of dummy variables that encode whether or not the beneficiary had been diagnosed with certain illnesses in the previous year. Diagnoses were collected once a year in the survey portion of the MCBS. As mentioned above, beneficiaries that die before the annual survey is conducted have their survey answers imputed; in order to avoid using imputed answers, we added diagnosis information from the beneficiaries' claims if they were enrolled in FFS Medicare for the entire calendar year up to when they died.

Beneficiaries had responses to one of two surveys in the dataset. If the beneficiary was residing in the community at the time of the survey, a community survey was administered directly to them which asked them about their diagnoses. The illnesses were defined verbally and in both medical and layman's terms ("hypertension/high blood pressure"). For a number of chronic illnesses (hypertension and Alzheimer's/dementia, for example), the beneficiary was asked if they had ever been diagnosed with the

illness. Since these illnesses rarely go into remission, we coded beneficiaries reporting that they had ever had these illnesses as having had them in the past year.

If the beneficiary was institutionalized at the time of the survey, a facility survey was filled out by an institution staff member from the beneficiary's MDS assessment (a form on an inpatient's health conditions filled out quarterly by nursing homes receiving Medicare funding). The facility survey asks about a greater number of illnesses than the community survey but to pool both samples together, we were restricted to the illnesses asked about in the community survey.

Appendix Table 1 lays out how community interview variables, facility interview variables, and diagnosis codes in the claims data were matched to define the diseases. The last column describes how we coded the diagnoses of beneficiaries whose survey came from the previous year and for whom we had to look at claims data for the current year.

In the end, we defined 27 conditions, which are listed in Appendix Table 1. Included in those conditions are eight cardiovascular conditions (arteriosclerotic heart disease, hypertension, myocardial infarction, angina/coronary heart disease, other heart conditions including valve problems, congestive heart failure, heart rhythm problem, and stroke) and five specific cancers (skin, lung, colon/rectal, breast, and prostate). We also included a control for whether or not they were diagnosed with any of twelve other cancers but did not calculate separate indexes for them since the prevalence of those cancers was extremely low. The remaining conditions are diabetes, arthritis (both rheumatoid and osteoarthritis), mental/psychiatric disorder, mental retardation, Alzheimer's/dementia, osteoporosis, broken hip, Parkinson's disease, emphysema/asthma/chronic obstructive pulmonary disorder (COPD), paralysis, missing limb, coma, and renal failure.

Table 3 summarizes the prevalence of these conditions in the data for 2001. Hypertension has by far the highest prevalence, with 45 percent of the sample reporting having been diagnosed with it in 2001. 24

percent of the sample report being diagnosed with arthritis and 20 percent report having diabetes. Four other illnesses (osteoporosis, emphysema/asthma/COPD, mental/psychiatric disorders, and arteriosclerotic heart disease) have prevalences of over 10 percent.

Table 3: Diagnosed prevalence in 2001

Disease	% of beneficiaries reporting having been diagnosed with disease
Hardening of arteries/arteriosclerotic heart disease	11.6
Hypertension	45.2
Myocardial infarction/Heart attack	2.8
Angina/CHD	4.4
Other heart conditions, valve problem	6.7
Congestive heart failure	4.3
Heart rhythm problem	8.4
Stroke/transient ischemic attack (TIA)	3.8
Skin cancer	4.5
Lung cancer	0.4
Colon cancer	0.6
Breast cancer	0.7
Prostate cancer	0.7
Other cancer	2.0
Diabetes	19.5
Arthritis	23.7
Mental/psychiatric disorder (excl. Alzheimers/dementia)	12.1
Alzheimers/dementia	5.6
Osteoporosis	17.3
Broken hip	1.0
Parkinsons	1.6
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	15.9
Paralysis in past year	1.8
Lost a limb	1.4
Comatose	0.6
Mental retardation (excl. Alzheimers/dementia)	2.8
Renal failure	1.3

Note: prevalences are weighted with survey weights.

3. Empirical Methods

To calculate a price for each health conditions, we model health-care spending as a function of what diagnoses are received and use the parameter estimates to allocate each beneficiary's spending to their illnesses. We will employ two models and compare the results: a one-step model with an OLS regression of health-care spending on diagnoses with all observations and a two-step model where the first step is a probit model of whether or not the beneficiary has any health-care spending and the second step is an OLS model of health-care spending on diagnoses only with the observations that have positive spending.

Our underlying model of health-care expenditure is a multiplicative model, where each condition has a multiplicative effect on health-care spending. Formally:

$$y_{it} = \exp\left(\beta_{0t} + \sum_{j=1}^{J} \beta_{jt} D_{ijt} + \varepsilon_{it}\right)$$

where *i* indexes individuals

j indexes conditions

t indexes years

y_{it} = health expenditure of individual *i* in year *t*

D_{ijt} = dummy variable for whether person *i* has condition *j* in year *t*

To estimate β_{0t} through β_{Jt}, we regress log spending on dummy variables for the 27 conditions that we defined separately for each year.

Since the model is multiplicative, however, we cannot use β_{0t} through β_{Jt} to predict the contribution of each illness directly. Rather we employ a method for dividing up each beneficiary's spending into conditions proposed by Trogdon et al (2008).

Trogdon et al. and other researchers in this field employ a concept from the field of epidemiology of the "attributable fraction." The AF is the fraction of health-care spending attributable to a risk factor or condition. Formally it is defined as:

$$AF_{ijt} = \frac{E[y_{it}|D_{ijt}] - E[y_{it}|D_{ijt}=0]}{E[y_{it}|D_{i}jt]}$$

As Trogdon et al. (2008) note, the AF for a single illness K can be calculated by predicting spending with and without the dummy variable for it set to 0:

$$AF_{ijt}$$

$$= \frac{\exp\left(\beta_{0t} + \beta_{Kt}D_{iKt} + \sum_{j\in\neg K}\beta_{jt}D_{ijt}\right) * E\left[\exp(\varepsilon_{it})\,|\vec{D}_{it}\right] - \exp(\beta_{0t} + \sum_{j\in\neg K}\beta_{jt}D_{ijt}) * E[\exp(\varepsilon_{it})\,|D_{K=0}]}{\exp\left(\beta_{0t} + \beta_{Kt}D_{iKt} + \sum_{j\in\neg K}\beta_{jt}D_{ijt}\right) * E\left[\exp(\varepsilon_{it})\,|\vec{D}_{it}\right]}$$

However, in the cases where individuals have multiple illnesses, the attributable fractions for each illness can vary depending on which order the dummy variables are changed. Instead, Trogdon et al. suggest the following procedure: first, calculate the fraction of spending attributable to all of a beneficiary's illnesses:

$$AF_{it} = \frac{\exp\left(\beta_{0t} + \sum_{j=1}^{J}\beta_{jt}D_{ijt}\right) * E\left[\exp(\varepsilon_{it})\,|\vec{D}_{it}\right] - \exp(\beta_{0t}) * E\left[\exp(\varepsilon_{it})\,|\vec{D}_{t} = 0\right]}{\exp\left(\beta_{0t} + \sum_{j=1}^{J}\beta_{jt}D_{ijt}\right) * E\left[\exp(\varepsilon_{it})\,|\vec{D}_{it}\right]}$$

Multiplying this attributable fraction by the beneficiary's spending will then give the amount of spending for each beneficiary attributable to all of his or her conditions and the problem becomes one of how to

divide up this spending. The share of spending by individual *i* that can be attributed to condition *j* which individual *i* is diagnosed with is given by:

$$S_{ijt} = \frac{\left[\exp\left(\hat{\beta}_{jt}\right) - 1\right] * D_{ijt}}{\sum_{j=1}^{J}\left\{\left[\exp\left(\hat{\beta}_{jt}\right) - 1\right] * D_{ijt}\right\}}$$

This formula is intuitively plausible: the shares are guaranteed to sum to one, an illness whose coefficient is zero has an expenditure share of zero, and illnesses' relative expenditure shares are in proportion to the sizes of their relative coefficients.

Then spending by individual i on condition j is equal to $S_{ijt} * AF_{it} * y_{it}$. The remainder of i's spending ($[1 - AF_{it}] * y_{it}$) can be attributed to spending on primary care.

There was one slight complication in applying Trogdon et al.'s method to the MCBS data. The share formula is well-behaved and gives shares strictly between 0 and 1 as long as all β's are positive. However, as will be found below, some of the illnesses included in our model have coefficients that are negative, in which case the shares are no longer bounded between 0 and 1 and can be close to infinity or negative infinity if the sum in the denominator is close to zero. Such small or large shares are clearly implausible and unintuitive. In order to avoid such implausible shares, the illnesses with negative coefficients were simply dropped when calculating the shares and no spending was attributed to them. The rationale for this approach is that we are interpreting the negative coefficients to mean that people with these illnesses are having their other illnesses treated less intensively. Splitting up their spending across only the illnesses that contribute positively to spending would therefore be the correct approach.

One-part model

In the one-part model, we estimate an OLS model of logged spending on the 27 dummy variables for conditions. To include the beneficiaries with zero spending, spending is adjusted upwards by $1:

$$\ln(y_i + 1) = \beta_0 + \sum_{j=1}^{J} \beta_j D_{ij} + \varepsilon_i$$

The regression results are reported in Appendix Table 2. Most of the conditions have positive coefficients, meaning that being diagnosed with them adds on average to a beneficiary's health-care spending. Three illnesses have negative coefficients in each year: Alzheimer's/dementia, being comatose, and mental retardation. As mentioned above, our interpretation of the negative coefficients is that individuals with these illnesses are having their other conditions treated less intensively, probably because these conditions are very hard to treat and greatly degrade quality of life.

The fraction of spending attributable to all conditions is defined as follows in the one-step model:

$$\widehat{AF}_{it} = \frac{\exp\left(\hat{\beta}_{0t} + \sum_{j=1}^{J} \hat{\beta}_{jt} D_{ijt}\right) * \hat{S} - \exp(\hat{\beta}_{0t}) * \hat{S}}{\exp\left(\hat{\beta}_{0t} + \sum_{j=1}^{J} \hat{\beta}_{jt} D_{ijt}\right) * \hat{S} - 1}$$

$\hat{S} = \frac{1}{n}\sum_{i=1}^{n} \exp(\hat{\varepsilon}_{it})$ is a smearing factor used to estimate the term $E\left[\exp(\varepsilon_{it}) \left| \vec{D}_{it} \right.\right]$ (Duan 1983).

The attributable fractions are applied to each beneficiary's spending and are split across their diagnosed illnesses as described above. The spending for each illness is then aggregated over beneficiaries.

Appendix Table 3 shows the resulting expenditures for each illness: total, per patient (i.e., those beneficiaries who were diagnosed with the illness), and per beneficiary. The per-patient expenditure will be the price that is put into the medical care expenditure index. As Appendix Table 3a shows, hypertension, with its high prevalence, has by far the highest per-beneficiary and total expenditures in 2001, but its price lies roughly in the middle. Other illnesses with high per-beneficiary and total

expenditures in 2001 are diabetes, osteoporosis, and emphysema/asthma/chronic obstructive pulmonary disease.

Two-part model

A two-part model is sometimes suggested for dealing with the significant number of beneficiaries with zero spending which can cause biased estimators (Jones 2000). In the two-part model, a probit regression is first run to determine the probability that a beneficiary has positive medical spending relative to their reported conditions and demographic data.

$$P(y_i > 0) = \Phi\left(\alpha_0 + \sum_{k=1}^{K} \alpha_k X_{ik} + \sum_{j=1}^{J} \gamma_j D_{ij}\right)$$

where *k* = demographic variables in the vector X_i

For people with non-zero spending, an OLS regression is run on the 27 dummy condition variables similar to the first model; however, $1 is not added to expenditures. The AF is then calculated using coefficients from both the probit and OLS models:

$$AF_i = \frac{\Phi\left(\alpha_0 + \sum_{k=1}^{K} \alpha_k X_{ik} + \sum_{j=1}^{J} \gamma_j D_{ij}\right) * \exp\left(\beta_0 + \sum_{j=1}^{J} \beta_j D_{ij}\right) - \Phi(\alpha_0 + \sum_{k=1}^{K} \alpha_k X_{ik}) * \exp(\beta_0)}{\Phi\left(\alpha_0 + \sum_{k=1}^{K} \alpha_k X_{ik} + \sum_{j=1}^{J} \gamma_j D_{ij}\right) * \exp\left(\beta_0 + \sum_{j=1}^{J} \beta_j D_{ij}\right)}$$

(Note that, in the two-part model, the term $E\left[\exp(\varepsilon_{it}) \middle| \vec{D}_{it}\right]$ cancels out and does not need to be estimated.) The allocation of the AF to specific conditions and subsequent predicted expenditures is then calculated the same way as the first model. Though there is not much difference between the OLS and two-part model at the overall medical price index level, at the condition-level differences can be significant. Notably, the OLS model allocated a larger share to hypertension than the two-part model, which shifted part of that spending to the intercept (which represents primary and preventative care).

4. Expenditure indexes

Appendix Table 4 reports the expenditure indexes for individual illnesses calculated as described in the previous section from the results of both models. There is little substantial difference between the indexes created by the two models. Generally, the indexes for individual illnesses rise over time. Some low-prevalence illnesses, the estimations of whose indexes rest on relatively few observations, have indexes that are very volatile or that decline, on net, over the period. Arthritis is the one illness with relatively high prevalence that has a decline in its price index from 2001 to 2005.[2]

Table 4 reports the medical care expenditure indexes from both models aggregated over all illnesses with 95% confidence intervals. The one-step model produces an index that grows at 6.3 percent annually, with a confidence interval of [4.5, 8.9]. The two-step model produces an index that grows at 5.8 percent annually, with a confidence interval of [3.7, 8.6]. The confidence intervals were calculated with a bias-corrected and accelerated bootstrap, with 15,000 repetitions. As mentioned above, the aggregate index is a Laspeyres index, to make it comparable with the CPI. When aggregated therefore, the indexes for individual illnesses are weighted in each year with their respective prevalences in 2001.

[2] The decline is likely related to a reduction in use of COX-2 inhibitors due to concerns over their safety that emerged during this period. Vioxx, a major drug in this class that was used for arthritis, was withdrawn from the market entirely in 2004.

Table 4				
	Expenditure index (2001=1)			
Year	**One-part model**	**Confidence intervals**	**Two-part model**	**Confidence intervals**
2002	1.07	[1.01, 1.15]	1.07	[1.01, 1.17]
2003	1.10	[1.01, 1.17]	1.11	[1.03, 1.22]
2004	1.17	[1.08, 1.23]	1.16	[1.07, 1.25]
2005	1.25	[1.18, 1.35]	1.23	[1.15, 1.34]
Average annual growth rate	**6.3%**	**[4.5%, 8.7%]**	**5.8%**	**[3.7%, 8.6%]**

Note: Confidence intervals were calculated with a bias-corrected and accelerated bootstrap with 15,000 repetitions.

How does these estimates compare with other measures of medical-care inflation during this period? The CPI for medical care grew at an annual rate of 4.6 percent from 2001 to 2005 (table 5). Our indexes actually grow slightly faster than the CPI, although the CPI is still within the 95% confidence interval for both indexes. Generally, we expect disease-based indexes to grow more slowly than service price indexes, so this result is surprising.

Table 5	
Year	**Consumer Price Index for medical care**
2001	278.2
2002	292.1
2003	303.0
2004	315.8
2005	329.2
Average annual growth rate 2001-2005	**4.6%**

Source: Bureau of Labor Statistics

It is possible, however, that the slowness of the growth of the CPI relative to our index may be due to the different coverages of the indexes: the CPI covers all patients and only covers the portion directly paid by them, while our index only covers Medicare patients but covers all of their spending. To explore this, we calculated a service price index from our data as follows. We calculated a price index separately for each category of service *s*:

$$SPI_s = \frac{c_s^t x_s^1}{c_s^1 x_s^t}$$

where c_s^t= total expenditure on service *s* in year *t*

x_s^t = total number of events for service *s* in year *t*

The categories of service are inpatient hospital, outpatient hospital, physician, and prescribed medicine.

We then aggregated this index using the 2001 expenditure shares as weights. Table 6 shows the four sub-indexes and the aggregate index. The aggregate SPI grows at 5.9 percent per year, in other words at about the same rate as the MCE index. Compared to the CPI, the SPI is probably overstated since it is not adjusted for substitutions. For example, the CPI would track the prices of specific drugs while this SPI would rise if more expensive drugs were substituted for cheaper ones since it merely measures the average price of drugs used. In the end, it appears that, contrary to our expectations, inflation as measured by the MCE rises faster than inflation as measured by service prices.

Table 6

Year	**Inpatient**	**Medical practitioner**	**Outpatient hospital**	**Prescribed medicine**	**Aggregate index**
2001 expenditure share	36.9%	33.7%	12.0%	17.3%	100%
	Service price indexes (2001=1)				
2002	1.065	1.023	1.069	1.077	1.053
2003	1.179	1.092	1.076	1.133	1.129
2004	1.180	1.184	1.221	1.242	1.197
2005	1.228	1.165	1.332	1.319	1.235
Average annual growth rate	**5.7%**	**4.1%**	**8.3%**	**8.0%**	**5.9%**

5. Discussion and conclusion

We created a disease-based expenditure index for Medicare which estimates inflation in Medicare to be about 6 percent per year from 2001 to 2005. This estimate lies more or less in the middle of previous disease-based estimates of medical inflation in the privately insured: Aizcorbe et al. (2011), using the MEPS, estimated to be inflation to be between 6.6 and 6.9 percent annually, while Aizcorbe and Nestoriak (2011) and Dunn et al. (2010), both using claims data, estimate it to be in the neighborhood of 3.6 to 3.7 percent annually. As noted in the introduction, this paper is the first to calculate a disease-based index medical care expenditure index for the publicly insured.

The expenditure index is a powerful tool for understanding the sources of growth in Medicare spending per beneficiary. Nominal spending per beneficiary rose 8.6 percent per year during the period 2001 through 2005; when deflated with our price index, spending rises only 2.3 percent per year. Deflating removes the component of growth due to price growth, leaving the part of spending growth due to growth in prevalence of diagnosed illness. Therefore about 27 percent of the growth in nominal spending is due to growth in prevalence and much of remainder (other than a small cross-term) is due to growth in price.

The growth in prices can be broken down further into growth in input prices and growth in quantity of services provided (or intensivity of treatment). The former is reflected by the SPI we calculated of 5.9 percent per year and it suggests that all, or more than all, of the growth in the price of treating an illness is due to growth in the average prices of services and drugs. Growth in quantity of services provided therefore seems to play a very small role. As discussed above, the SPI may be overstated but the medical care CPI's annual growth of 4.6 percent also suggests that a good portion of medical price growth is from the growth of input prices. Measuring and decomposing this growth into these sources is important because excessive growth in input prices and excessive growth in quantity of services are

likely to have very different policy solutions. Further work with claims data should help elucidate the sources of growth in input prices.

There are both some advantages and disadvantages to our approach of using the MCBS and a regression-based method to calculate the prices for illnesses and the expenditure index. The largest advantage is that the MCBS is the only source of data on the diagnoses and health-care spending of beneficiaries enrolled in Medicare private plans. These beneficiaries made up a sizable and shifting share of Medicare enrollees: about 17 percent of Medicare enrollees were enrolled in a Medicare HMO in 2000 and that share declined to about 12 percent by 2005 (Kaiser Family Foundation 2010). In addition, it has been well established that enrollment in Medicare HMOs is strongly related to a beneficiary's health status. If we constructed an index using only data from FFS beneficiaries (which would be the alternative to using the MCBS), measured price changes over time would not just reflect true price changes but also the shifting average health status of FFS beneficiaries as beneficiaries on the margin of enrolling in a Medicare HMO shifted in and out.

Disadvantages of using the MCBS include that we were forced to drop some beneficiaries because they were lacking surveys or claims data for the year in which they died. In future work, we plan to construct a price index with Medicare claims data which will have the advantage of covering all FFS beneficiaries but which will omit private plan enrollees.

The other primary disadvantage of our index is that it is not quality-adjusted for changes in health outcomes that result from changes in medical care. The unadjusted annual inflation rate of about 6 percent is quite high when compared with other measures of inflation during this time. The CPI for all items grew at an average annual rate of 2.3 percent during this period and the deflator for the services category of the Personal Consumption Expenditures (PCE) portion of GDP grew at an annual rate of 3.3 percent. If we were to adjust our measure for improvements in health outcomes, we would probably

obtain a lower estimate of inflation. However, doing so would require carefully-formed assumptions about how much health care contributes to life expectancy at the beginning of the period as well as how much it contributes to the increase in life expectancy over the period.

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Appendix Table 1

Illness	Community interview variable	Facility interview variable	Clinical classification system (CCS) or ICD-9 code	Coding of beneficiaries who do not have survey in current year
Hardening of arteries/arteriosclerotic heart disease*	OCARTERY	ASHD	ICD-9 codes beginning with 414.0	Answered yes to previous year's survey or have ICD9 code in current year
Hypertension	D_HBP	HYPETENS	CCS 98, 99	Answered yes to survey or have CCS code in current year
Myocardial infarction/Heart attack	D_MYOCAR	MYOCARD and must have inpatient event in past year	CCS 100	Have CCS code in current year
Angina/CHD*	D_CHD	CRDVTYPE	ICD9 codes in CCS 101 except 414.0	Have CCS code in current year
Other heart conditions, valve problem	D_OTHHRT or D_VALVE	CARDIOV and CRDVTYPE="NO"	CCS 96, 97, 103, 104, 105, 107	Have CCS code in current year
Congestive heart failure	D_CFAIL	HRTFAIL	CCS 108	Have CCS code in current year
Heart rhythm problem	D_RHYTHM	CARDDYSR	CCS 106	Have CCS code in current year
Stroke/transient ischemic attack (TIA)	D_STROKE	STROKE or TIA	CCS 109, 112	Have CCS code in current year
Skin cancer	D_CSKIN	CNRSKIN	CCS 22, 23	Have CCS code in current year
Lung cancer	D_CANCER and OCCLUNG	CNRLUNG	CCS 19	Have CCS code in current year

Colon/rectal cancer	D_CANCER and OCCCOLON	CNRBOWEL	CCS 14, 15	Have CCS code in current year
Breast cancer	D_CANCER and OCCBREST	CNRBREAS	CCS 24	Have CCS code in current year
Prostate cancer	D_CANCER and OCCPROST	CNRPROST	CCS 29	Have CCS code in current year
Other cancer	D_CANCER and one or more of (OCCOVARY, OCCSTOM, OCCCERVX, OCCKIDNY, OCCBRAIN, OCCTHROA, OCCBACK, OCCHEAD, OCCFONEC, OCCBLAD, OCCUTER, OCCOTHER)	CNROVARY or CNRCERVI or CNRSTOMA or CNRBLADD or CNRUTERU or CNROTHER	CCS 11, 12, 13, 16, 17, 18, 20, 21, 22, 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45	Have CCS code in current year
Diabetes	OCDIABTS	DIABMEL	CCS 49, 50	Answered yes to previous year's survey or have CCS code in current year
Arthritis	OCARTHRH or D_ARTHRD	ARTHRIT	CCS 202, 203	Answered yes to previous year's survey or have CCS code in current year

Mental/psychiatric disorder	D_PSYCH	ANXIETY or DEPRESS or MANICDEP or SCHIZOPH	CCS 69, 70, 71, 72, 74	Answered yes to previous year's survey or have CCS code in current year
Mental retardation (excl. Alzheimer's/dementia)	OCMENTAL	MENTAL	CCS 65	Answered yes to previous year's survey
Alzheimer's/dementia	OCALZHMR	ALZHMR or DEMENT	CCS 68	Answered yes to previous year's survey or have CCS code in current year
Osteoporosis	OCOSTEOP	OSTEOP	CCS 206	Answered yes to previous year's survey or have CCS code in current year
Broken hip	D_BRKHIP	HIPFRACT	CCS 226	Have CCS code in current year
Parkinson's	OCPARKIN	PARKNSON	CCS 79	Answered yes to previous year's survey or have CCS code in current year

Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	OCEMPHYS	EMPCOPD or ASTHMA	CCS 127, 128	Answered yes to previous year's survey or have CCS code in current year
Paralysis in past year	D_PPARAL	HEMIPLPA or PARAPLEG or QUADPLEG	CCS 82	Have CCS code in current year
Lost a limb	OCAMPUTE	MISSLIMB		Answered yes to previous year's survey
Comatose	Code all as not comatose	COMATOSE	CCS 85	Have CCS code in current year
Renal failure	ESRD	RENTFAIL	CCS 157, 158	Answered yes to previous year's survey or have CCS code in current year

Appendix Table 2a: Parameter estimates for one-part model (OLS)

	Year				
	2001	**2002**	**2003**	**2004**	**2005**
Variable					
Hardening of arteries/arteriosclerotic heart disease	0.316	0.306	0.334	0.283	0.222
	(0.051)	(0.053)	(0.052)	(0.054)	(0.055)
Hypertension	0.574	0.560	0.491	0.537	0.584
	(0.032)	(0.032)	(0.032)	(0.033)	(0.033)
Myocardial infarction/Heart attack	0.473	0.44	0.582	0.484	0.606
	(0.100)	(0.099)	(0.097)	(0.105)	(0.113)
Angina/Coronary heart disease	0.313	0.214	0.248	0.24	0.263
	(0.084)	(0.082)	(0.085)	(0.087)	(0.089)
Other heart conditions, valve problem	0.340	0.311	0.420	0.364	0.298
	(0.068)	(0.069)	(0.070)	(0.071)	(0.075)
Congestive heart failure	0.204	0.079	0.094	-0.210	0.002
	(0.086)	(0.087)	(0.085)	(0.090)	(0.090)
Heart rhythm problem	0.465	0.399	0.263	0.368	0.488
	(0.060)	(0.061)	(0.061)	(0.063)	(0.065)
Stroke/transient ischemic attack TIA	0.277	0.319	0.244	0.348	0.346
	(0.086)	(0.088)	(0.086)	(0.092)	(0.093)
Skin cancer	0.521	0.415	0.466	0.527	0.476
	(0.075)	(0.072)	(0.071)	(0.071)	(0.070)
Lung cancer	0.791	0.180	0.567	0.487	0.61
	(0.251)	(0.254)	(0.262)	(0.219)	(0.217)
Colon cancer	1.255	0.829	0.649	0.865	0.792
	(0.206)	(0.248)	(0.236)	(0.190)	(0.226)
Breast cancer	0.723	0.710	0.520	0.732	0.823
	(0.192)	(0.191)	(0.201)	(0.196)	(0.195)
Prostate cancer	0.805	0.500	0.737	0.638	0.796
	(0.185)	(0.178)	(0.169)	(0.188)	(0.174)
Other cancer	0.360	0.838	0.664	0.624	0.297
	(0.121)	(0.117)	(0.110)	(0.127)	(0.120)
Diabetes	0.544	0.588	0.591	0.592	0.568
	(0.040)	(0.040)	(0.039)	(0.040)	(0.040)
Arthritis	0.254	0.276	0.228	0.204	0.162
	(0.037)	(0.037)	(0.036)	(0.036)	(0.041)

Mental/psychiatric disorder excl. Alzheimers/dementia	0.362	0.374	0.313	0.383	0.349
	(0.050)	(0.050)	(0.048)	(0.049)	(0.051)
Alzheimers/dementia	-0.212	-0.179	-0.194	-0.120	-0.078
	(0.071)	(0.070)	(0.069)	(0.071)	(0.070)
Osteoporosis	0.479	0.447	0.366	0.427	0.431
	(0.042)	(0.041)	(0.039)	(0.040)	(0.040)
Broken hip	0.496	0.684	0.826	0.535	0.512
	(0.155)	(0.160)	(0.173)	(0.164)	(0.152)
Parkinsons	0.355	0.501	0.337	0.478	0.417
	(0.127)	(0.124)	(0.121)	(0.128)	(0.122)
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	0.462	0.478	0.493	0.535	0.489
	(0.044)	(0.044)	(0.043)	(0.043)	(0.043)
Paralysis in past year	0.347	0.398	0.300	0.338	0.319
	(0.121)	(0.119)	(0.121)	(0.127)	(0.128)
Lost a limb	0.392	0.443	0.192	0.321	0.167
	(0.134)	(0.126)	(0.127)	(0.134)	(0.140)
Comatose	-0.566	-0.348	-0.547	-0.491	-0.800
	(0.214)	(0.227)	(0.205)	(0.245)	(0.249)
Mental retardation excl. Alzheimers/dementia	-0.346	-0.515	-0.544	-0.588	-0.475
	(0.097)	(0.098)	(0.099)	(0.105)	(0.106)
Renal failure	1.386	1.524	1.407	1.667	1.275
	(0.142)	(0.138)	(0.140)	(0.137)	(0.136)
Intercept	7.105	7.187	7.350	7.343	7.474
	(0.025)	(0.026)	(0.026)	(0.027)	(0.027)
Observations	11,636	11,510	11,315	10,924	10,870
R-squared	0.181	0.180	0.171	0.178	0.165

Note: Dependent variable is log(health-care spending + $1). Standard errors are reported in parentheses.

Appendix Table 2b: Regression results for first step of two-part model (probit)

	Year				
	2001	**2002**	**2003**	**2004**	**2005**
Variable					
Hardening of arteries/arteriosclerotic heart disease	0.407	0.446	0.588	0.378	0.207
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Hypertension	0.922	0.849	0.764	0.965	1.032
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Myocardial infarction/Heart attack	*	-0.048	*	*	*
		(0.005)			
Angina/Coronary heart disease	0.318	0.018	0.502	*	0.181
	(0.007)	(0.005)	(0.007)		(0.006)
Other heart conditions, valve problem	0.904	0.246	0.47	*	0.619
	(0.008)	(0.004)	(0.005)		(0.006)
Congestive heart failure	0.491	-0.097	-0.319	-0.554	-0.127
	(0.008)	(0.005)	(0.004)	(0.004)	(0.005)
Heart rhythm problem	0.522	0.464	-0.069	0.566	0.508
	(0.005)	(0.004)	(0.003)	(0.005)	(0.005)
Stroke/transient ischemic attack (TIA)	-0.215	-0.144	-0.303	0.044	0.188
	(0.004)	(0.004)	(0.003)	(0.004)	(0.005)
Skin cancer	0.654	0.762	0.837	*	*
	(0.005)	(0.006)	(0.006)		
Lung cancer	*	-1.023	*	*	*
		(0.008)			
Colon cancer	*	*	0.159	0.166	*
			(0.012)	(0.009)	
Breast cancer	0.075	*	*	*	*
	(0.010)				
Prostate cancer	*	-0.106	*	*	*
		(0.006)			
Other cancer	0.423	0.859	*	*	*
	(0.008)	(0.008)			
Diabetes	0.681	0.755	0.522	0.545	0.436
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Arthritis	0.297	0.25	0.231	0.325	0.22
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Mental/psychiatric disorder (excl. Alzheimers/dementia)	0.16	0.095	-0.076	0.256	0.31
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Alzheimers/dementia	-0.389	-0.184	-0.231	-0.378	-0.2
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Osteoporosis	0.683	0.596	0.378	0.177	0.498
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Broken hip	-0.059	*	*	0.405	*
	(0.007)			(0.010)	
Parkinsons	0.131	0.183	0.015	0.17	0.231
	(0.005)	(0.005)	(0.004)	(0.005)	(0.006)

Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	0.513	0.564	0.587	0.628	0.631
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Paralysis in past year	0.332	0.066	-0.002	0.145	-0.062
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Lost a limb	0.173	0.955	-0.05	0.149	-0.179
	(0.005)	(0.011)	(0.005)	(0.005)	(0.005)
Comatose	-1.25	-0.145	*	*	*
	(0.008)	(0.011)			
Mental retardation (excl. Alzheimers/dementia)	0.122	-0.172	-0.191	-0.286	0.02
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
Renal failure	*	*	*	*	*
Race (omitted category: white)					
American Indian	-1.004	-0.172	0.347	-0.033	-0.152
	(0.004)	(0.006)	(0.009)	(0.006)	(0.005)
Asian or Pacific Islander	-0.227	0.005	-0.109	0.351	0.599
	(0.003)	(0.004)	(0.004)	(0.005)	(0.006)
Black	-0.372	-0.518	-0.395	-0.345	-0.202
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Don't know/More than one/Other	-0.261	-0.009	0.244	-0.193	0.071
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Age	-0.016	-0.038	-0.015	-0.04	-0.034
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age^2	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log Income	0.143	0.118	0.091	0.153	0.109
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Education (omitted category: high school graduate)					
Without high school diploma	-0.091	-0.014	0.007	-0.118	-0.17
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
College graduate	0.204	0.384	0.391	0.356	0.245
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Census Division (omitted category: South Atlantic)					
Middle Atlantic	-0.107	-0.019	0.094	0.000	-0.052
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
E North Central	-0.118	-0.081	-0.019	-0.361	-0.252
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
W North Central	-0.218	0.046	-0.046	-0.134	0.081
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
New England	-0.209	-0.168	0.112	-0.145	-0.125
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
E South Central	-0.202	-0.088	0.135	-0.183	-0.24
	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
W South Central	-0.247	0.015	0.084	-0.149	-0.09
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Mountain	-0.379	-0.123	-0.027	-0.039	-0.414
	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)

Pacific	-0.396	-0.248	-0.130	-0.214	-0.354
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Puerto Rico	0.897	0.384	0.412	0.571	5.399
	(0.011)	(0.007)	(0.008)	(0.009)	(247.834)
Hispanic	0.020	-0.214	0.059	0.074	0.01
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)
Female	0.241	0.172	0.230	0.262	0.182
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Intercept	0.529	1.486	1.179	1.428	1.488
	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)
Observations	11,636	11,510	11,315	10,924	10,870

Dependent variable: dummy variable for positive health-care spending

Note: Some disease dummy variables (marked with *) perfectly predicted positive spending and were dropped from the probit regression. Individuals with these illnesses in those years were assigned a predicted probability of positive spending of 1.

Appendix Table 2c: Regression results for second step of two-part model

	Year				
	2001	**2002**	**2003**	**2004**	**2005**
Variable					
Hardening of arteries/arteriosclerotic heart disease	0.265	0.249	0.270	0.232	0.194
	(0.039)	(0.040)	(0.040)	(0.040)	(0.040)
Hypertension	0.357	0.340	0.316	0.302	0.313
	(0.025)	(0.024)	(0.025)	(0.025)	(0.025)
Myocardial infarction/Heart attack	0.433	0.459	0.506	0.461	0.543
	(0.076)	(0.074)	(0.075)	(0.079)	(0.083)
Angina/Coronary heart disease	0.339	0.225	0.230	0.219	0.282
	(0.064)	(0.062)	(0.066)	(0.065)	(0.066)
Other heart conditions, valve problem	0.277	0.285	0.367	0.305	0.255
	(0.052)	(0.052)	(0.054)	(0.054)	(0.055)
Congestive heart failure	0.183	0.126	0.169	-0.060	0.041
	(0.065)	(0.066)	(0.066)	(0.068)	(0.067)
Heart rhythm problem	0.406	0.344	0.273	0.301	0.428
	(0.046)	(0.046)	(0.048)	(0.047)	(0.048)
Stroke/transient ischemic attack (TIA)	0.337	0.338	0.330	0.371	0.324
	(0.066)	(0.066)	(0.067)	(0.070)	(0.069)
Skin cancer	0.389	0.285	0.352	0.371	0.295
	(0.057)	(0.054)	(0.055)	(0.054)	(0.052)
Lung cancer	0.749	0.443	0.545	0.445	0.555
	(0.192)	(0.193)	(0.202)	(0.165)	(0.160)
Colon cancer	1.125	0.728	0.663	0.857	0.679
	(0.157)	(0.186)	(0.183)	(0.143)	(0.167)
Breast cancer	0.693	0.611	0.455	0.617	0.695
	(0.147)	(0.143)	(0.155)	(0.147)	(0.143)
Prostate cancer	0.674	0.549	0.625	0.543	0.659
	(0.141)	(0.135)	(0.131)	(0.141)	(0.128)
Other cancer	0.328	0.714	0.579	0.565	0.270
	(0.092)	(0.088)	(0.085)	(0.095)	(0.088)
Diabetes	0.430	0.471	0.504	0.502	0.475
	(0.031)	(0.030)	(0.030)	(0.030)	(0.030)
Arthritis	0.179	0.211	0.173	0.133	0.117
	(0.029)	(0.028)	(0.028)	(0.028)	(0.031)
Mental/psychiatric disorder (excl. Alzheimers/dementia)	0.348	0.358	0.330	0.304	0.273
	(0.038)	(0.038)	(0.037)	(0.037)	(0.038)

Alzheimers/dementia	-0.141	-0.184	-0.143	-0.009	-0.068
	(0.055)	(0.053)	(0.054)	(0.054)	(0.052)
Osteoporosis	0.337	0.305	0.266	0.344	0.289
	(0.032)	(0.031)	(0.030)	(0.030)	(0.030)
Broken hip	0.479	0.592	0.726	0.486	0.390
	(0.119)	(0.120)	(0.133)	(0.124)	(0.112)
Parkinsons	0.320	0.459	0.333	0.413	0.329
	(0.097)	(0.093)	(0.094)	(0.097)	(0.090)
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	0.381	0.373	0.397	0.428	0.381
	(0.033)	(0.033)	(0.033)	(0.033)	(0.032)
Paralysis in past year	0.306	0.389	0.335	0.327	0.345
	(0.092)	(0.090)	(0.094)	(0.096)	(0.095)
Lost a limb	0.421	0.329	0.240	0.342	0.263
	(0.103)	(0.094)	(0.099)	(0.101)	(0.104)
Comatose	-0.310	-0.323	-0.559	-0.512	-0.672
	(0.166)	(0.171)	(0.158)	(0.184)	(0.184)
Mental retardation (excl. Alzheimers/dementia)	-0.233	-0.308	-0.347	-0.344	-0.383
	(0.075)	(0.076)	(0.078)	(0.081)	(0.080)
Renal failure	1.366	1.495	1.381	1.638	1.284
	(0.109)	(0.103)	(0.108)	(0.103)	(0.100)
Intercept	7.463	7.562	7.650	7.714	7.89
	(0.020)	(0.020)	(0.020)	(0.021)	(0.021)
Observations	11,363	11,251	11,094	10,702	10,646
R-squared	0.205	0.2072	0.199	0.204	0.185

Dependent variable: Log(health-care spending)

Appendix table 3a: Estimated expenditures by illness in 2001 ($)

	One-part model			Two-part model		
	Estimated expenditures					
Disease	Total	Per patient	Per beneficiary	Total	Per patient	Per beneficiary
Hardening of arteries/arteriosclerotic heart disease	2,307,804	1,696	198	2,297,639	1,688	197
Hypertension	14,896,391	2,892	1,280	10,667,899	2,071	917
Myocardial infarction/Heart attack	1,325,798	4,092	114	1,408,257	4,346	121
Angina/CHD	1,217,671	2,369	105	1,574,540	3,063	135
Other heart conditions, valve problem	1,742,416	2,242	150	1,676,123	2,157	144
Congestive heart failure	710,066	1,317	61	762,269	1,414	66
Heart rhythm problem	3,000,065	2,982	258	3,052,467	3,034	262
Stroke/transient ischemic attack (TIA)	842,112	1,733	72	1,217,966	2,506	105
Skin cancer	1,352,135	2,631	116	1,189,135	2,313	102
Lung cancer	389,759	8,120	33	418,578	8,720	36
Colon cancer	878,741	12,923	76	872,461	12,830	75
Breast cancer	373,743	4,731	32	405,395	5,132	35
Prostate cancer	511,706	6,020	44	487,985	5,741	42
Other cancer	653,208	2,865	56	694,890	3,048	60
Diabetes	6,436,514	2,916	553	5,975,813	2,708	514
Arthritis	3,148,387	1,172	271	2,652,396	987	228
Mental/psychiatric disorder (excl. Alzheimers/dementia)	3,079,558	1,889	265	3,453,838	2,119	297
Alzheimers/dementia	0	0	0	0	0	0
Osteoporosis	4,530,262	2,307	389	3,709,632	1,889	319
Broken hip	482,572	3,522	41	537,173	3,921	46
Parkinsons	326,740	1,667	28	340,573	1,738	29
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	4,845,133	2,597	416	4,709,079	2,524	405
Paralysis in past year	530,499	2,174	46	542,074	2,222	47
Lost a limb	444,747	2,762	38	552,492	3,432	47
Comatose	0	0	0	0	0	0
Mental retardation (excl. Alzheimers/dementia)	0	0	0	0	0	0
Renal failure	4,381,656	25,927	377	4,783,567	28,305	411
Intercept (primary and preventive care)	34,706,067	.	2,983	39,131,510	.	3,363

Appendix table 3b: Estimated expenditures by illness in 2002 ($)

	One-part model			Two-part model		
	Estimated expenditures					
Disease	Total	Per patient	Per beneficiary	Total	Per patient	Per beneficiary
Hardening of arteries/arteriosclerotic heart disease	2,245,214	1,796	195	2,175,218	1,740	189
Hypertension	15,579,763	2,964	1,354	10,941,029	2,081	951
Myocardial infarction/Heart attack	1,265,302	3,721	110	1,527,657	4,493	133
Angina/CHD	829,484	1,568	72	1,044,434	1,974	91
Other heart conditions, valve problem	1,726,929	2,214	150	1,863,368	2,389	162
Congestive heart failure	287,965	536	25	553,268	1,030	48
Heart rhythm problem	2,552,800	2,545	222	2,580,760	2,573	224
Stroke/transient ischemic attack (TIA)	1,031,242	2,148	90	1,270,486	2,647	110
Skin cancer	1,112,070	2,004	97	903,229	1,627	78
Lung cancer	84,444	1,836	7	248,893	5,411	22
Colon cancer	395,517	7,755	34	401,450	7,872	35
Breast cancer	501,592	6,192	44	492,828	6,084	43
Prostate cancer	354,214	3,768	31	433,687	4,614	38
Other cancer	1,962,548	8,143	171	1,865,426	7,740	162
Diabetes	8,491,541	3,668	738	7,982,232	3,448	694
Arthritis	3,784,622	1,368	329	3,455,435	1,249	300
Mental/psychiatric disorder (excl. Alzheimers/dementia)	3,516,275	2,165	305	3,877,753	2,388	337
Alzheimers/dementia	0	0	0	0	0	0
Osteoporosis	4,647,198	2,206	404	3,724,529	1,768	324
Broken hip	799,105	6,054	69	794,770	6,021	69
Parkinsons	617,244	3,011	54	644,000	3,141	56
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	5,361,020	2,938	466	4,907,585	2,689	426
Paralysis in past year	630,957	2,565	55	713,871	2,902	62
Lost a limb	690,258	3,614	60	620,032	3,246	54
Comatose	0	0	0	0	0	0
Mental retardation (excl. Alzheimers/dementia)	0	0	0	0	0	0
Renal failure	5,827,536	31,844	506	6,234,738	34,070	542
Intercept (primary and preventive care)	36,493,065	.	3,171	41,531,229	.	3,608

Appendix table 3c: Estimated expenditures by illness in 2003 ($)

	One-part model			Two-part model		
	Estimated expenditures					
Disease	Total	Per patient	Per beneficiary	Total	Per patient	Per beneficiary
Hardening of arteries/arteriosclerotic heart disease	2,738,995	2,152	242	2,538,207	1,994	224
Hypertension	14,671,475	2,846	1,297	10,536,895	2,044	931
Myocardial infarction/Heart attack	2,046,686	6,073	181	1,983,442	5,886	175
Angina/CHD	880,831	1,870	78	945,815	2,008	84
Other heart conditions, valve problem	2,531,315	3,393	224	2,483,233	3,329	219
Congestive heart failure	410,125	758	36	863,180	1,596	76
Heart rhythm problem	1,854,120	1,950	164	2,203,306	2,317	195
Stroke/transient ischemic attack (TIA)	916,400	1,933	81	1,398,095	2,950	124
Skin cancer	1,455,278	2,656	129	1,255,398	2,291	111
Lung cancer	246,411	6,484	22	264,820	6,969	23
Colon cancer	449,620	8,175	40	498,318	9,060	44
Breast cancer	328,396	4,829	29	324,161	4,767	29
Prostate cancer	620,751	6,534	55	588,354	6,193	52
Other cancer	1,698,819	6,688	150	1,648,211	6,489	146
Diabetes	9,463,196	4,074	836	9,091,070	3,914	803
Arthritis	3,353,759	1,185	296	2,949,114	1,042	261
Mental/psychiatric disorder (excl. Alzheimers/dementia)	3,310,263	1,985	293	3,841,548	2,303	340
Alzheimers/dementia	0	0	0	0	0	0
Osteoporosis	4,353,428	1,965	385	3,584,827	1,618	317
Broken hip	836,174	7,742	74	813,933	7,536	72
Parkinsons	345,378	1,677	31	379,032	1,840	33
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	5,854,935	3,208	517	5,333,530	2,922	471
Paralysis in past year	507,150	2,224	45	618,289	2,712	55
Lost a limb	235,397	1,293	21	338,734	1,861	30
Comatose	0	0	0	0	0	0
Mental retardation (excl. Alzheimers/dementia)	0	0	0	0	0	0
Renal failure	6,054,847	32,907	535	6,375,019	34,647	563
Intercept (primary and preventive care)	40,113,513	.	3,545	44,420,735	.	3,926

Appendix table 3d: Estimated expenditures by illness in 2004

	One-part model			Two-part model		
	Estimated expenditures					
Disease	Total	Per patient	Per beneficiary	Total	Per patient	Per beneficiary
Hardening of arteries/arteriosclerotic heart disease	2,172,191	1,800	199	2,152,243	1,783	19
Hypertension	16,941,167	3,182	1,551	11,142,841	2,093	1,02
Myocardial infarction/Heart attack	1,357,971	4,732	124	1,543,176	5,377	14
Angina/CHD	831,221	1,799	76	925,734	2,004	8
Other heart conditions, valve problem	2,012,475	2,900	184	2,023,413	2,916	18
Congestive heart failure	-660,756	-1,301	-60	-256,235	-504	-2
Heart rhythm problem	2,407,282	2,681	220	2,342,350	2,608	21
Stroke/transient ischemic attack (TIA)	1,104,108	2,654	101	1,392,979	3,349	12
Skin cancer	1,794,699	3,171	164	1,516,135	2,679	13
Lung cancer	342,205	5,610	31	362,499	5,943	3
Colon cancer	774,567	9,805	71	857,456	10,854	7
Breast cancer	415,205	5,323	38	404,332	5,184	3
Prostate cancer	456,990	5,376	42	451,421	5,311	4
Other cancer	1,393,722	6,669	128	1,453,875	6,956	13
Diabetes	9,039,191	3,951	827	9,040,206	3,951	82
Arthritis	3,003,306	1,071	275	2,412,253	861	22
Mental/psychiatric disorder (excl. Alzheimers/dementia)	3,912,398	2,423	358	3,633,558	2,250	33
Alzheimers/dementia	0	0	0	0	0	
Osteoporosis	5,422,117	2,470	496	5,152,576	2,347	47
Broken hip	564,059	4,740	52	597,008	5,017	5
Parkinsons	630,549	3,446	58	627,708	3,430	5
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	6,591,542	3,610	603	6,221,083	3,407	56
Paralysis in past year	545,537	2,585	50	605,834	2,871	5
Lost a limb	425,259	2,625	39	544,497	3,361	5
Comatose	0	0	0	0	0	
Mental retardation (excl. Alzheimers/dementia)	0	0	0	0	0	
Renal failure	6,966,651	40,504	638	7,425,929	43,174	68
Intercept (primary and preventive care)	40,056,769	.	3,667	45,927,553	.	4,20

Appendix table 3e: Estimated expenditures by illness in 2005 ($)

	One-part model			Two-part model		
	Estimated expenditures					
Disease	Total	Per patient	Per beneficiary	Total	Per patient	Per beneficiary
Hardening of arteries/arteriosclerotic heart disease	1,743,319	1,508	160	1,889,113	1,634	174
Hypertension	20,440,177	3,820	1,880	13,032,843	2,436	1,199
Myocardial infarction/Heart attack	1,688,328	6,700	155	1,772,703	7,035	163
Angina/CHD	1,061,318	2,390	98	1,405,846	3,166	129
Other heart conditions, valve problem	1,769,542	2,677	163	1,862,963	2,818	171
Congestive heart failure	9,652	19	1	205,863	402	19
Heart rhythm problem	3,661,744	4,219	337	3,871,470	4,460	356
Stroke/transient ischemic attack (TIA)	1,252,997	2,934	115	1,400,886	3,281	129
Skin cancer	1,761,557	3,006	162	1,347,526	2,300	124
Lung cancer	559,750	8,481	51	587,476	8,901	54
Colon cancer	561,683	8,916	52	560,513	8,897	52
Breast cancer	599,958	7,999	55	594,909	7,932	55
Prostate cancer	729,254	7,927	67	706,143	7,675	65
Other cancer	655,645	2,901	60	730,183	3,231	67
Diabetes	9,799,118	4,287	901	9,837,174	4,303	905
Arthritis	2,033,666	995	187	1,863,694	912	171
Mental/psychiatric disorder (excl. Alzheimers/dementia)	3,446,111	2,364	317	3,260,033	2,236	300
Alzheimers/dementia	0	0	0	0	0	0
Osteoporosis	6,061,182	2,675	558	4,946,207	2,183	455
Broken hip	723,268	5,203	67	658,569	4,738	61
Parkinsons	573,212	2,769	53	537,899	2,599	49
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	7,256,525	3,719	668	6,843,566	3,508	630
Paralysis in past year	579,744	2,828	53	736,235	3,591	68
Lost a limb	251,654	1,656	23	490,942	3,230	45
Comatose	0	0	0	0	0	0
Mental retardation (excl. Alzheimers/dementia)	0	0	0	0	0	0
Renal failure	5,616,487	31,732	517	6,315,125	35,679	581
Intercept (primary and preventive care)	44,735,735	.	4,116	52,113,746	.	4,794

Appendix table 4a: Medical care expenditure indexes by disease 2001-2005

		One-part model				
		Medical care expenditure index (2001=1)				
Disease	2001 expenditure share	2002	2003	2004	2005	Average annual growth rate
Hardening of arteries/arteriosclerotic heart disease	0.040	1.059	1.269	1.061	0.889	-0.028
Hypertension	0.255	1.025	0.984	1.100	1.321	0.080
Myocardial infarction/Heart attack	0.023	0.909	1.484	1.156	1.637	0.159
Angina/CHD	0.021	0.662	0.789	0.759	1.009	0.002
Other heart conditions, valve problem	0.030	0.987	1.513	1.293	1.194	0.048
Congestive heart failure	0.012	0.407	0.575	-0.987	0.014	-0.246
Heart rhythm problem	0.051	0.853	0.654	0.899	1.415	0.104
Stroke/transient ischemic attack (TIA)	0.014	1.240	1.116	1.532	1.694	0.173
Skin cancer	0.023	0.762	1.010	1.205	1.143	0.036
Lung cancer	0.007	0.226	0.799	0.691	1.044	0.011
Colon cancer	0.015	0.600	0.633	0.759	0.690	-0.078
Breast cancer	0.006	1.309	1.021	1.125	1.691	0.173
Prostate cancer	0.009	0.626	1.085	0.893	1.317	0.079
Other cancer	0.011	2.842	2.335	2.328	1.013	0.003
Diabetes	0.110	1.258	1.397	1.355	1.470	0.117
Arthritis	0.054	1.167	1.011	0.914	0.849	-0.038
Mental/psychiatric disorder (excl. Alzheimers/dementia)	0.053	1.146	1.050	1.282	1.251	0.063
Alzheimers/dementia	0.000	.	.	.	.	.
Osteoporosis	0.078	0.956	0.852	1.071	1.160	0.040
Broken hip	0.008	1.719	2.198	1.346	1.477	0.119
Parkinsons	0.006	1.806	1.006	2.067	1.661	0.165
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	0.083	1.131	1.236	1.390	1.432	0.108
Paralysis in past year	0.009	1.180	1.023	1.189	1.301	0.075
Lost a limb	0.008	1.308	0.468	0.950	0.599	-0.100
Comatose	0.000	.	.	.	.	.
Mental retardation (excl. Alzheimers/dementia)	0.000	.	.	.	.	.
Renal failure	0.075	1.228	1.269	1.562	1.224	0.056

Appendix table 4b: Medical care expenditure indexes by disease 2001-2005

		Two-part model				
		Medical care expenditure index (2001=1)				
Disease	2001 expenditure share	2002	2003	2004	2005	Average annual growth rate
Hardening of arteries/arteriosclerotic heart disease	0.043	1.031	1.181	1.056	0.968	-0.008
Hypertension	0.198	1.005	0.987	1.011	1.176	0.044
Myocardial infarction/Heart attack	0.026	1.034	1.354	1.237	1.618	0.155
Angina/CHD	0.029	0.645	0.656	0.654	1.034	0.008
Other heart conditions, valve problem	0.031	1.107	1.543	1.352	1.307	0.077
Congestive heart failure	0.014	0.729	1.128	-0.357	0.284	-0.179
Heart rhythm problem	0.057	0.848	0.764	0.860	1.470	0.117
Stroke/transient ischemic attack (TIA)	0.023	1.056	1.177	1.336	1.309	0.077
Skin cancer	0.022	0.703	0.990	1.158	0.994	-0.002
Lung cancer	0.008	0.620	0.799	0.681	1.021	0.005
Colon cancer	0.016	0.614	0.706	0.846	0.693	-0.077
Breast cancer	0.008	1.186	0.929	1.010	1.546	0.136
Prostate cancer	0.009	0.804	1.079	0.925	1.337	0.084
Other cancer	0.013	2.540	2.129	2.282	1.060	0.015
Diabetes	0.111	1.273	1.445	1.459	1.589	0.147
Arthritis	0.049	1.265	1.055	0.872	0.923	-0.019
Mental/psychiatric disorder (excl. Alzheimers/dementia)	0.064	1.127	1.087	1.062	1.055	0.014
Alzheimers/dementia	0.000	.	.	.	.	.
Osteoporosis	0.069	0.936	0.857	1.243	1.156	0.039
Broken hip	0.010	1.536	1.922	1.279	1.208	0.052
Parkinsons	0.006	1.808	1.059	1.974	1.495	0.124
Emphysema/asthma/chronic obstructive pulmonary disease (COPD)	0.087	1.066	1.158	1.350	1.390	0.097
Paralysis in past year	0.010	1.306	1.221	1.292	1.617	0.154
Lost a limb	0.010	0.946	0.542	0.979	0.941	-0.015
Comatose	0.000	.	.	.	.	.
Mental retardation (excl. Alzheimers/dementia)	0.000	.	.	.	.	.
Renal failure	0.089	1.204	1.224	1.525	1.261	0.065