Editor's Note: This online data supplement contains supplemental material that was not included with the published article by Dana P. Goldman and colleagues, "Benefit Design and Specialty Drug Use," Health Affairs 25, no. 5 (2006), online at http://content.healthaffairs.org/cgi/content/abstract/25/5/1319; 10.1377/hlthaff.25.5.1319.

Technical Appendix to Benefit Design and Specialty Drug Use

Identification of patients with disease. For this study, we restricted our attention to patients with at least two primary diagnoses for cancer, kidney disease, rheumatoid arthritis, or multiple sclerosis as indicated by ICD codes. Kidney disease was defined as having chronic renal insufficiency, anemia, or end-stage renal disease.

Condition	ICD codes
Multiple sclerosis	340
Rheumatoid arthritis	714.xx
Cancer	
Breast	174.x, 198.2x, 198.81, 233.0
GI	150.x - 159.x, 197.4x - 197.9x, 230.x
Lung	162.2x - 162.9x, 197.0x - 197.2x, 231.2x
Other respiratory	162.0, 197.3, 231.0-231.1, 231.8-231.9
Uterine	179.x, 182.x, 233.2
Cervical	180.x, 233.1
Ovarian	183.x, 198.6x
Other female GU	184.x, 233.3x
Prostate	185.x, 233.4x
Other male GU	186.x, 187.x, 233.5x - 233.6x
Bladder	188.x, 233.7x
Kidney/other urinary	189.x, 198.0x - 198.1x, 233.9x
Other/unspecified	199.x, 198.3x - 198.5x, 198.7x, 234.x
Lymphoma	200.xx, 202.xx
Hodgkin's disease	201.9
Chronic lymphoid leukemia	204.1
Kidney disease	
Chronic Renal Insufficiency	
Diabetes with renal manifestations	250.4x
Gouty nephropathy	274.1x
Hemolytic-uremic syndrome	283.11
Hypertensive renal disease	403.xx, 404.xx
Atherosclerosis of renal artery	440.1x
Other aneurysm of renal artery	442.1x
Hyperplasia of renal artery	447.3x
Nephrotic syndrome	581.xx
Chronic glomerulonephritis	582.xx
Nephritis/nephropathy, not as chronic or acute	583.xx
Chronic renal failure	585.xx
Renal failure unspecified	586.xx
Renal sclerosis, unspecified	587.xx
Renal disease in pregnancy	642.1x, 646.2x
Cystic kidney disease	753.12-753.17, 753.19

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Condition	ICD codes
End-stage renal disease	
Dialysis	996.73,V45.1
Kidney transplant	996.81,V42.0
Anemia	
Iron deficiency anemia	280.xx
Other deficiency anemias	281.xx
Hereditary hemolytic anemia	282.xx
Acquired hemolytic anemia	283.xx
Other and unspecified anemias	285.xx

Identification of specialty drugs. Reimbursement codes are a component of the CMS Healthcare Common Procedure Coding System (HCPCS) and the AMA's Current Procedural Terminology (CPT) coding systems. The HCPCS and CPT Drug and Product Codes are designed to bill for products that are utilized in the physician's office, clinic or home health agency including:

- Drugs which are injected subcutaneously, intramuscularly, or intravenously;
- Selected orally administered chemotherapeutic and anti-emetic agents;
- Nutritional agents and ostomy care products;
- Drugs administered via nebulizers or other durable medical equipment

Our analysis uses all products known as J codes in the HCPCS. These are permanent codes used to report injectable drugs that ordinarily cannot be self-administered: chemotherapy, immunosuppressive drugs and inhalation solutions as well as some orally administered drugs. We identified use of J code products that are billed through both the medical claims—if they are administered in a physician's office, clinic, or home health setting—or if prescribed through the pharmacy since some drugs can be self-administered. To identify pharmacy records corresponding to J codes, a research assistant coded all possible drug names associated with a J code and then a programmer identified corresponding claims in the pharmacy records. For example, methotrexate, an antimetabolite drug helpful in treating certain diseases associated with abnormally rapid cell growth, such as breast cancer and psoriasis, and—more recently—rheumatoid arthritis, is often prescribed on an outpatient basis. Claims for J3490 (Universal code for medical billing of non-coded drugs) and J9999 (Antineoplastic drug, not otherwise classified) were excluded from the analysis.

Plan generosity towards specialty drugs. Our main interest was to estimate how use of specialty drugs responds to cost-sharing. But one cannot infer how generously a plan will cover specialty drugs—or any drug for that matter—merely by looking at its stated medical or pharmacy benefits. Multi-tier formularies are now the standard, and they offer discounts for purchases through mail-order or in-network pharmacies. Deductibles, out-of-pocket maximums, and benefit caps also complicate these calculations. These added complexities mean that the price a consumer will pay for a given drug depends not only on its tier, but also on where it is dispensed and at what time of year. In the case of biologic agents, this issue is further

confounded because many of the products are administered by a nurse or physician and paid as part of medical services.

As a consequence, we measure plan generosity as the ratio of total out-of-pcoket payments for certain categories of specialty drugs relative to total payments. For example, when we examine use of rheumatoid arthritis (RA), we compute the ratio of total out-of-pocket payments for RA-related specialty drugs divided by their total cost. The variables used in this calculation are summarized below for the plan-years (n=90) in our analysis data.

	PMPY specialty drug spending ($)		PMPY out-of-pocket spending ($)		Specialty drug copay index (%)	
Specialty Drug Type	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev
Multiple sclerosis	6.13	5.67	.41	.47	12.8	17.7
Cancer	23.39	35.42	4.67	12.16	19.5	15.9
Rheumatoid arthritis	21.28	18.21	2.27	3.13	13.4	12.6
Kidney disease	14.87	15.93	2.80	3.74	20.2	13.7

Note: All spending is annual and includes plans in both 2003 and 2004 measured in nominal dollars. PMPY=per member, per year. Cancer drugs include chemotherapeutic and renal agents.

We conducted additional analysis based on two cutoffs for plan size; that is, we ran models restricting our attention to plans with at least 10 and then 100 members who used each class of specialty products in that year. The results in general were not sensitive to this exclusion restriction, nor were they sensitive to models that weighted by the number of patients in the plan with the condition. There is considerable variability in the specialty product index across the entire sample of all beneficiaries as shown below.

Specialty Drug Index	Percentile	Centile
Multiple	0	1.6
Sclerosis	25	2.2
	50	3.9
	75	7.8
	100	91.3
Kidney	0	2.2
Disease	25	8.9
	50	15.7
	75	25.6
	100	60.4
Cancer	0	0.6
(chemotherapeutic & renal agents)	25	6.2
	50	13.7
	75	29.2
	100	73.7
Rheumatoid	0	1.5
Arthritis	25	3.8
	50	5.8
	75	15.0
	100	73.8

First stage estimates. Our analyses used a two-part model for each of the four conditions (cancer, kidney disease, multiple sclerosis, and rheumatoid arthritis). The first part of the model, including all patients with the sentinel conditions, used probit regression to estimate the probability that a patient with a particular condition used any specialty drug corresponding to that condition. So, for example, we estimated whether patients with rheumatoid arthritis used any RA-related specialty drugs. The estimates are shown in Table A1. Our models included controls for patient characteristics available in claims data: age, gender, and work status of the sponsor (active or retired), and status (primary beneficiary or dependent). Because the information in claims data are limited, we included socioeconomic measures that are likely to influence the demand and supply of specialty drugs such as urban residence and median household income in the zip code of residence. We controlled for the most common comorbid conditions based on the presence of ICD-9 diagnostic codes in the medical claims: hypertension, chronic heart failure, diabetes, asthma, lipid disorder, depression, arthritis, migraine, and gastric acid disorder.

Second stage estimates. The second part of the model used a generalized linear model with a logarithmic link function and normally distributed errors to estimate the level of drug spending among members with at least some use. We chose the generalized linear model because it predicted specialty drug expenditures better than the standard two-part model, but our conclusions are insensitive to this choice. The results were also similar when we assumed a gamma distribution rather than a normal distribution. Table A2 contains the point estimates.

Predictions. For each disease, we used the results from the two-part model to estimate a price elasticity of use, as well as an overall elasticity on spending. We used estimates from the first part of the model to predict the probability of specialty use for each person with the condition at the first and third quartiles of plan generosity. We used the second part of the model to predict spending conditional upon having at least one claim. Total spending was predicted using the product of the two. The predictions were then averaged over all individuals in that disease group and arc elasticities were computed based on the results in the following tables and the copayment quartiles shown in a previous table. Specifically, let A and B be the 25th and 75th quartiles of our plan generosity measure. For example, the cost-sharing levels were 13% (A) and 26% (B) for kidney disease. Using the probit equation, we predicted $p_i(A)$ and $p_i(B)$ for everyone in the sample. The arc elasticity was then computed as:

$$\left(\frac{\frac{\overline{p}(B)-\overline{p}(A)}{\overline{p}(B)+\overline{p}(A)}}{2}\right) \Big/ \left(\frac{\frac{B-A}{B+A}}{2}\right)$$

The terms $\overline{p}(A)$ and $\overline{p}(B)$ refer to averaged predicted rates of any spending and are computed separately for each condition. To get estimates for the elasticity of conditional use, the predictions from the second stage (the GLM model) are computed as $Cond_i(A)$ and $Cond_i(B)$, and substituted into the arc elasticity equation. To derive the elasticity of overall spending, we used

$Y_i(A) = P_i(A) \cdot Cond_i(A)$ and $Y_i(B) = P_i(B) \cdot Cond_i(B)$. The means used to compute elasticities are shown below.

	Assumed Level of Specialty Product	Mean Prediction for Patients With:			
Outcome	Generosity	Cancer	Kidney Disease	Multiple Sclerosis	Rheumatoid Arthritis
Disease-related	25th percentile	699	236	2,947	1,785
Specialty	75th percentile	694	220	2,763	1,373
Product Spending	Raw mean	679	228	2,733	1,527
Any Use	25th percentile	0.18	0.26	0.44	0.54
	75th percentile	0.16	0.25	0.43	0.51
	Raw mean	0.17	0.25	0.43	0.52
Spending	25th percentile	3,891	898	6,651	3,302
Conditional on	75th percentile	4,357	880	6,390	2,709
Use	Raw mean	4,036	895	6,379	2,946

Note: the "Assumed Level of Specialty Product Generosity" in column 2 reflects the centiles shown in a previous table. Generosity falls with increasing percentiles.

Table A1. Probit Estimation for Any Use of Specialty Products, 2003 and 2004

Variable	Cancer	Kidney Disease	Multiple Sclerosis	Rheumatoid Arthritis
Aged 35 to 44	0.4	0.36	0.33	0.36
	[0.275,0.518]	[0.277,0.434]	[0.165,0.504]	[0.227,0.493]
Aged 45 to 54	0.44	0.58	0.46	0.31
	[0.357,0.514]	[0.495,0.674]	[0.213,0.714]	[0.179,0.447]
Aged 55 to 64	0.34	0.61	0.3	0.36
	[0.251,0.427]	[0.521,0.704]	[0.114,0.491]	[0.211,0.503]
Aged 65 to 74	0.45	0.71	-0.05	0.32
	[0.337,0.569]	[0.573,0.849]	[-0.261,0.157]	[0.150,0.483]
Aged 75+	0.54	0.74	-0.66	0.15
	[0.368,0.718]	[0.559,0.919]	[-0.890,-0.429]	[-0.016,0.315]
Male	-0.06	0.12	0.01	-0.04
	[-0.082,-0.043]	[0.074,0.162]	[-0.079,0.089]	[-0.105,0.017]
Household income (x$1,000)	0	0	0	-0.01
	[-0.006,-0.000]	[-0.008,-0.001]	[-0.008,0.008]	[-0.012,-0.003]
Year 2004	0.08	0.04	0.03	0.11
	[0.004,0.154]	[0.001,0.075]	[-0.026,0.094]	[0.038,0.188]
Married	-0.07	-0.07	0.03	0.05
	[-0.104,-0.029]	[-0.130,-0.018]	[-0.051,0.107]	[-0.007,0.112]
Primary plan sponsor	-0.06	-0.03	0.07	0.07
	[-0.105,-0.024]	[-0.075,0.013]	[-0.082,0.220]	[-0.015,0.154]
Currently working	-0.22	-0.3	-0.22	-0.08
	[-0.379,-0.057]	[-0.477,-0.129]	[-0.369,-0.071]	[-0.242,0.081]
hypertension	0.11	0.2	0	-0.04
	[0.080,0.141]	[0.142,0.265]	[-0.055,0.051]	[-0.084,0.009]
chronic heart failure	1.26	1.05	0.04	-0.04
	[1.167,1.348]	[0.961,1.129]	[-0.127,0.212]	[-0.088,0.014]
Diabetes	0.49	0.59	-0.16	-0.07
	[0.446,0.528]	[0.523,0.659]	[-0.301,-0.010]	[-0.142,-0.004]
Asthma	0.07	0.09	-0.01	0.09
	[-0.051,0.199]	[0.023,0.151]	[-0.400,0.388]	[0.030,0.148]
Elevated lipid disorder	-0.14	-0.14	-0.08	-0.08
	[-0.192,-0.079]	[-0.192,-0.096]	[-0.237,0.069]	[-0.147,-0.007]
Depression	0.1	0.01	-0.01	-0.08
	[0.057,0.139]	[-0.054,0.067]	[-0.183,0.155]	[-0.166,0.010]
Osteoarthritis	0.06	0	-0.03	-0.06
	[0.003,0.108]	[-0.019,0.023]	[-0.183,0.116]	[-0.174,0.044]
Gastric acid disorder	0.01	-0.04	-0.17	0
	[-0.062,0.073]	[-0.083,-0.006]	[-0.354,0.022]	[-0.093,0.090]
Migraine	-0.14	0.1	-0.23	0.03
	[-0.214,-0.073]	[0.017,0.192]	[-0.482,0.028]	[-0.131,0.183]
Lung disease	0.32	0.15	0.11	0.08
	[0.249,0.392]	[0.104,0.204]	[-0.257,0.486]	[0.006,0.146]
Effective Medical Coinsurance (%)	0	0	0	0
	[-0.007,0.003]	[-0.006,0.002]	[-0.003,0.009]	[0.000,0.009]
HMO	0.26	0.06	-0.03	0.16
	[0.014,0.500]	[-0.086,0.212]	[-0.207,0.152]	[0.065,0.263]
POS	0.15	-0.02	0.06	0.12
	[-0.007,0.300]	[-0.090,0.056]	[-0.101,0.216]	[0.006,0.224]
Effective Coinsurance Rate (%)	0	0	-0.01	-0.01
	[-0.008,0.000]	[-0.008,0.002]	[-0.015,-0.001]	[-0.010,-0.005]
Constant	-1.3	-1.34	-0.41	-0.13
	[-1.605,-0.985]	[-1.685,-0.986]	[-0.739,-0.083]	[-0.422,0.154]

Table A2. GLM Estimation of (Log) Spending on Specialty Products, 2003 and 2004

Variable	Cancer	Kidney Disease	Multiple Sclerosis	Rheumatoid Arthritis
Aged 35 to 44	0.35	0.33	0.11	0.24
	[0.091,0.608]	[-0.167,0.832]	[-0.101,0.323]	[0.080,0.390]
Aged 45 to 54	0.35	0.08	0.11	0.27
	[-0.079,0.784]	[-0.330,0.489]	[-0.125,0.338]	[0.035,0.510]
Aged 55 to 64	0.29	-0.12	0.08	0.2
	[-0.314,0.893]	[-0.719,0.473]	[-0.127,0.296]	[-0.023,0.431]
Aged 65 to 74	-0.15	-0.78	-0.16	0.02
	[-1.315,1.024]	[-1.584,0.027]	[-0.456,0.133]	[-0.278,0.312]
Aged 75+	-0.95	-1.44	-1.61	-0.5
	[-2.133,0.226]	[-2.312,-0.561]	[-2.275,-0.955]	[-0.803,-0.207]
Male	-0.08	0.16	-0.06	0.11
	[-0.176,0.018]	[-0.095,0.416]	[-0.173,0.053]	[-0.102,0.319]
Household income (x$1,000)	0	0	0.01	0.01
	[-0.015,0.009]	[-0.003,0.013]	[0.002,0.009]	[0.001,0.012]
Year 2004	0.42	0.29	0.56	0.1
	[0.143,0.706]	[0.036,0.539]	[0.497,0.625]	[-0.044,0.248]
Married	0.04	0.02	0.01	-0.01
	[-0.154,0.235]	[-0.108,0.151]	[-0.100,0.112]	[-0.159,0.142]
Primary plan sponsor	-0.08	-0.04	0.13	-0.06
	[-0.259,0.104]	[-0.189,0.114]	[-0.027,0.283]	[-0.268,0.156]
Currently working	0.24	-0.01	0.14	-0.1
	[-0.277,0.758]	[-0.623,0.604]	[0.051,0.239]	[-0.295,0.094]
hypertension	-0.48	-0.2	0	-0.09
	[-0.740,-0.218]	[-0.438,0.037]	[-0.104,0.099]	[-0.278,0.107]
chronic heart failure	-0.53	-0.24	0.25	-0.05
	[-1.030,-0.036]	[-0.480,0.010]	[0.073,0.420]	[-0.233,0.123]
Diabetes	-0.65	-0.3	-0.22	0.01
	[-0.911,-0.379]	[-0.545,-0.053]	[-0.385,-0.047]	[-0.166,0.182]
Asthma	-0.97	-0.78	-0.08	0.17
	[-1.719,-0.213]	[-1.215,-0.339]	[-0.371,0.217]	[-0.066,0.410]
Elevated lipid disorder	-0.32	-0.48	0.07	-0.07
	[-0.725,0.080]	[-0.605,-0.358]	[-0.043,0.182]	[-0.258,0.113]
Depression	-0.52	-0.45	-0.05	-0.04
	[-0.864,-0.171]	[-0.744,-0.152]	[-0.146,0.043]	[-0.349,0.267]
Osteoarthritis	-0.41	-0.36	-0.23	-0.08
	[-0.572,-0.256]	[-0.717,0.006]	[-0.502,0.047]	[-0.279,0.110]
Gastric acid disorder	0.15	0.01	-0.53	0.15
	[-0.190,0.492]	[-0.269,0.296]	[-0.978,-0.083]	[-0.084,0.382]
Migraine	-1.06	-0.4	-0.17	-0.22
	[-1.729,-0.395]	[-1.325,0.517]	[-0.627,0.295]	[-0.744,0.297]
Lung disease	-0.28	-0.15	-0.52	-0.14
	[-0.820,0.251]	[-0.691,0.400]	[-0.683,-0.361]	[-0.666,0.387]
Effective Medical Coinsurance (%)	0.01	0	0	0
	[-0.016,0.026]	[-0.011,0.021]	[-0.004,0.006]	[-0.009,0.008]
HMO	0.25	-0.01	-0.04	0.43
	[-0.626,1.120]	[-0.449,0.432]	[-0.154,0.076]	[0.159,0.703]
POS	0.35	0.27	-0.03	0.12
	[-0.065,0.764]	[0.056,0.490]	[-0.111,0.045]	[-0.085,0.333]
Effective Coinsurance Rate (%)	0.01	0	-0.01	-0.02
	[-0.016,0.026]	[-0.041,0.037]	[-0.022,-0.001]	[-0.042,0.008]
Constant	8.46	7.27	8.12	7.88
	[7.790,9.123]	[6.091,8.450]	[7.844,8.396]	[7.436,8.318]

To assess the robustness of our findings to the inclusion/exclusion of other covariates, we ran several models with alternative specifications. The estimated elasticities were robust to such changes, as noted in the table below for rheumatoid arthritis.

Model	Overall Spending	Any Spending	Conditional Spending
Original	-0.21	-0.05	-0.16
Without comorbid conditions	-0.20	-0.05	-0.15
With medical plan characteristics such as deductibles and copayments instead of average medical generosity	-0.23	-0.04	-0.20
Without HMO and POS dummies	-0.21	-0.06	-0.15
Without household income in zip code	-0.21	-0.06	-0.15