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THE EFFECT OF DRUG VINTAGE ON SURVIVAL: MICRO EVIDENCE FROM PUERTO RICO'S MEDICAID PROGRAM

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ABSTRACT

Using micro data on virtually all of the drugs and diseases of over 500,000 people enrolled in Puerto Rico's Medicaid program, we examine the impact of the vintage (original FDA approval year) of drugs used to treat a patient on the patient's 3-year probability of survival, controlling for demographic characteristics (age, sex, and region), utilization of medical services, and the nature and complexity of illness. We find that people using newer drugs during January-June 2000 were less likely to die by the end of 2002, conditional on the covariates. The estimated mortality rates are strictly declining with respect to drug vintage. For pre-1970 drugs, the estimated mortality rate is 4.4%. The mortality rates for 1970s, 1980s, and 1990s drugs are 3.6%, 3.0%, and 2.5%, respectively. The actual mortality rate is about 16% (3.7% vs. 4.4%) lower than it would have been if all of the drugs utilized in 2000 had been pre-1970 drugs. Estimates for subgroups of people with specific diseases display the same general pattern.

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Clinical studies of specific new drugs have shown that these drugs increase survival rates. Here are three examples:

- Stenestrand et al (2001) studied the impact on survival of statin treatment following acute myocardial infarction. They found that 1-year mortality was 9.3% in the no-statin group and 4.0% in the statin treatment group.
- Grier et al (2003) found that adding two experimental drugs to the standard four-drug chemotherapy regimen has significantly improved survival in patients with non-metastatic Ewing's sarcoma, a highly malignant bone cancer of children and young adults. The overall survival rate increased from 61 percent to 72 percent for Ewing's sarcoma patients with localized disease who underwent the experimental six-drug chemotherapy.
- The journal U.S. Pharmacist (2002) reported that patients suffering from advanced metastatic melanoma who were treated with a combination of an investigational agent, Ceplene, and interleukin-2 (IL-2) had twice the survival rate as patients who were treated with IL-2 only. The patients were enrolled in a three-year study. The study also showed that the Ceplene/IL-2 combination significantly increased survival in a subpopulation group of advanced metastatic melanoma patients with liver metastases. The rate of survival in this group was six times that of the group given IL-2 only.

Also, I have performed several studies using aggregate data (Lichtenberg (2002-2004)) that indicated that the introduction of new drugs has increased longevity. The objective of the present study is to examine the impact of the vintage (original FDA approval year) of drugs used to treat a patient on the patient's probability of survival, using micro data on virtually all drugs and diseases from Puerto Rico's Medicaid program, which covers about 1.5 million people.[1, 2]

I. Econometric framework

To determine the effect of the vintage distribution of a person's prescribed medicines on probability of death, conditional on demographic characteristics (age, sex, and region), utilization of medical services, and the nature and complexity of illness, I will estimate the following model:

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[1] I am grateful to the Puerto Rico Health Insurance Administration (ASES) for providing me access to the data. ASES does not necessarily endorse or accept the conclusions of this study.

[2] I hypothesize that survival also depends on the vintage (year of invention or market introduction) of medical products and services other than drugs, such as laboratory tests and radiological and surgical procedures. Unfortunately our ability to measure the vintage of these other products and services is much more limited than out ability to measure the vintage of drugs. I plan to address this issue in future research.

$$DIED_i = \beta_{1970} POST1970_i + \beta_{1980} POST1980_i + \beta_{1990} POST1990_i + \gamma Z_i + \varepsilon_i$$

where:

$DIED_i$ = 1 if individual i died during the period 2000-2002
= 0 otherwise
$POST1970_i$ = the fraction of individual i's prescribed medicines whose active ingredients were approved by the FDA after 1970
$POST1980_i$ = the fraction of individual i's prescribed medicines whose active ingredients were approved by the FDA after 1980
$POST1990_i$ = the fraction of individual i's prescribed medicines whose active ingredients were approved by the FDA after 1990
Z_i = a vector of covariates
ε_i = a disturbance

Suppose individual A consumed only medicines approved in 1985. For that individual, POST70 = POST80 = 1, and POST90 = 0. Hence $E(DIED_A \mid Z_A) = \beta_{1970} + \beta_{1980}$. Suppose individual B consumed only medicines approved in 1995. For that individual, POST70 = POST80 = POST90 = 1. Hence $E(DIED_B \mid Z_B) = \beta_{1970} + \beta_{1980} + \beta_{1990}$, and $E(DIED_B \mid Z_B) - E(DIED_A \mid Z_A) = \beta_{1990}$. The parameter β_{1990} may be interpreted as the difference between the death probability of people consuming only post-1990 medicines and that of people consuming only pre-1991 medicines. More generally:

If all drugs consumed by individual i contained ingredients approved in…	…then $E(DIED_i \mid Z_i)$ =
1965	k
1975	$k + \beta_{1970}$
1985	$k + \beta_{1970} + \beta_{1980}$
1995	$k + \beta_{1970} + \beta_{1980} + \beta_{1990}$

where k is a constant.

Hence

The parameter…	…may be interpreted as this difference:
β_{1970}	1970s drugs vs. pre-1970 drugs death probability
β_{1980}	1980s drugs vs. 1970s drugs death probability
β_{1990}	1990s drugs vs. 1980s drugs death probability

II. Data and measurement

ASES provided me with all medical and pharmacy claims of ASES beneficiaries during the period January 1-June 30, 2000. There were about 12.2 million claims.

Demographic information. The following demographic variables could be determined from the claims records:

- The person's sex
- The person's age
- The geographic region in which services were provided

Unfortunately, we lack data on other personal attributes, such as education and income. But unobserved heterogeneity with respect to income is limited by the fact that, to be eligible for Medicaid in Puerto Rico, annual income of a family of four could not exceed $16,440 (in the year 2002).

Person's utilization of services.

- The person's number of medical claims (physician encounters)
- The person's number of hospital admissions
- The person's number of pharmacy claims

Vintage distribution of pharmacy claims. Each pharmacy claim[3] included the National Drug Code (NDC). I determined the active ingredient(s) contained in each NDC from Multum's Lexicon. I determined the earliest FDA approval date of each active ingredient from standard commercial pharmaceutical databases, i.e. Gold Standard Multimedia's Clinical Pharmacology 2000 and Mosby's Drug Consult. Using this information, I calculated, for each pharmaceutical claim, the values (0 or 1) of POST70, POST80, and POST90. I then calculated, for each individual, the *average* values of

[3] I examined outpatient pharmacy claims (which contain NDC codes), but not hospital and medical claims for drugs administered by providers (e.g. chemotherapy), which contain J-codes and other HCPCS codes. In future research I plan to account for all drug claims.

POST70, POST80, and POST90, i.e. the fraction of the individual's Rx's that were for drugs approved after 1970, 1980, and 1990.

Nature of person's illnesses. The medical claims include ICD9 (diagnosis) codes. I grouped these codes into the following 15 broad disease groups:[4]

Disease category	ICD9 codes	Disease group
1	001-139	infectious and parasitic diseases
2	140-239	neoplasms
3	240-279	endocrine, nutritional and metabolic diseases, and immunity disorders
4	280-289	diseases of the blood and blood-forming organs
5	290-319	mental disorders
6	320-389	diseases of the nervous system and sense organs
7	390-459	diseases of the circulatory system
8	460-519	diseases of the respiratory system
9	520-579	diseases of the digestive system
10	580-629	diseases of the genitourinary system
11	680-709	diseases of the skin and subcutaneous tissue
12	710-739	diseases of the musculoskeletal system and connective tissue
13	740-759	congenital anomalies
14	760-779	certain conditions originating in the perinatal period
15	780-799	symptoms, signs, and ill-defined conditions

I then calculated $DISEASE\_SHARE_{ij}$ (j = 1, 2,…, 15): the fraction of person i's diagnoses that were in each disease category. For example, if all of person i's diagnoses were diabetes, then $DISEASE\_SHARE_{ij} = 1$ if $j = 3$ and $DISEASE\_SHARE_{ij} = 0$ if $j \neq 3$. If person i had 3 circulatory diagnoses and one digestive diagnosis, then $DISEASE\_SHARE_{ij} = 0.75$ if $j = 7$, $DISEASE\_SHARE_{ij} = .25$ if $j = 9$, and $DISEASE\_SHARE_{ij} = 0$ for all other j.

In addition to measuring the shares of diagnoses in each disease category, I calculated the person's "effective number" of diseases. Rather than simply counting the number of disease categories in which a person's diagnoses fell, I computed the following index:

$$N\_DISEASE_i = 1 / \Sigma_j DISEASE\_SHARE_{ij}^2$$

[4] I excluded women with diagnoses of complications of pregnancy, childbirth, and the puerperium (ICD9 codes 630-677) from the sample.

If all of a person's diagnoses fell in one disease category, then $N\_DISEASE_i = 1$. If half of a person's diagnoses fell in one disease category, and half fell in a second category, then $N\_DISEASE_i = 2$. If 90% of a person's diagnoses fell in one disease category, and 10% fell in a second category, then $N\_DISEASE_i = 1 / (.9^2 + .1^2) = 1.22$.

Mortality. The Department of Health provided me with a list of (encrypted) social security numbers of all Puerto Rican residents who died during the period 2000-2002. I merged this list with the January 1-June 30, 2000 ASES claims data; this allowed me to determine whether or not an ASES beneficiary who had utilized services during January 1-June 30, 2000 had died by the end of 2002:

$DIED_i = 1$ if person i died by the end of 2002

$= 0$ otherwise

Descriptive statistics. Sample means of the variables are shown in the following table.[5]

Variable	**Sample mean**
male	40.7%
age	34.7
DIED	3.1%
POST70	63.1%
POST80	29.7%
POST90	8.2%
Number of medical claims	4.2
Number of pharmacy claims	4.6
Number of hospital claims	0.24
N_DISEASE	1.76
infectious and parasitic diseases	4.3%
neoplasms	1.1%
endocrine, nutritional and metabolic diseases, and immunity disorders	6.9%
diseases of the blood and blood-forming organs	1.0%
mental disorders	4.7%
diseases of the nervous system and sense organs	5.6%
diseases of the circulatory system	9.0%

[5] For all variables except POST70, POST80, and POST90, the sample size is approximately 794,000. For POST70, POST80, and POST90, the sample size is approximately 542,000: about a third of beneficiaries had no pharmaceutical claims.

diseases of the respiratory system	16.9%
diseases of the digestive system	4.6%
diseases of the genitourinary system	6.8%
diseases of the skin and subcutaneous tissue	2.8%
diseases of the musculoskeletal system and connective tissue	6.8%
congenital anomalies	0.4%
certain conditions originating in the perinatal period	0.1%
symptoms, signs, and ill-defined conditions	7.5%

The three-year mortality rate is 3.1%. This seems consistent with published mortality data for Puerto Rico. According to the United Nations, the crude (annual) death rate in Puerto Rico during 2000-2005 under "medium variant" mortality assumptions is 8.3 per 1,000 population.[6] This implies a three-year mortality rate of approximately 2.49% (= 3 * 0.83%). Mortality of ASES beneficiaries may be somewhat higher than that of other residents of Puerto Rico.

We can compare the vintage distribution of drugs used by ASES beneficiaries to the vintage distribution of drugs used by all Americans and by American Medicaid beneficiaries using the 2000 Prescribed Medicines file of the Household Component of the Medical Expenditure Panel Survey (MEPS), which is conducted by the Agency for Healthcare Research and Quality. This comparison is shown in Figure 1. The fraction of ASES Rx's that were approved after 1970 (63.2%) is similar to the fraction of U.S. Medicaid Rx's that were approved after 1970 (61.7%). However, the fractions of ASES Rx's that were approved after 1980 and 1990 (29.7% and 8.2%) are much smaller than the fractions of U.S. Medicaid Rx's[7] that were approved after 1980 and 1990 (48.4% and 25.5%). Use of older drugs in Puerto Rico's Medicaid program may be partly attributable to the fact that, in Puerto Rico, the physician bears the costs of the drugs—the cost is deducted from the physician's capitation payment.

[6] *Source*: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2002 Revision* and *World Urbanization Prospects: The 2001 Revision*, http://esa.un.org/unpp, 25 May 2003; 12:23:46 PM.

[7] We consider any Rx for which Medicaid paid at least part of the cost to be a Medicaid Rx.

III. Empirical results

OLS estimates of the mortality model based on the entire population of ASES beneficiaries with pharmaceutical claims (N = 539,750) are shown in Table 1.[8] The dependent variable is DIED: a dummy variable equal to one if the person died during 2000-2002, otherwise equal to zero.[9] In addition to the three drug-vintage variables (POST70, POST80, and POST90), the model includes: three utilization variables (number of medical, pharmacy, and hospital claims), 15 diagnosis category variables, the index of the number of diseases (N_DISEASE), 9 region dummy variables, and 200 single-year-of-age-by-sex dummy variables (not shown to conserve space).

The coefficients of all three drug-vintage variables are negative and highly significant (p-value < .0001), which is consistent with the hypothesis that ASES beneficiaries using newer drugs during January-June 2000 were less likely to die by the end of 2002, conditional on the covariates. Before considering the implications of the drug-vintage coefficients in detail, we will discuss salient features of the coefficients on the covariates.

The coefficients on all three utilization variables are positive and highly significant: people who used more medical services during January-June 2000 were more likely to die by the end of 2002. For example, one additional medical claim (physician visit) is associated with a .0031 (about 8%) increase in the probability of death. Although utilization of medical services presumably reduces mortality, *given initial (pre-treatment) health status*, people in the worst initial health utilize the most medical services. Including the three utilization variables (as well as the diagnosis category and demographic variables) is therefore likely to control for initial health status, which is unobserved and might be correlated with drug vintage (although the sign of the potential correlation is not clear).

The coefficients on the diagnosis category variables indicate differences in mortality rates associated with different diagnoses. They are plotted in Figure 2. By a large margin, people diagnosed with neoplasms had the highest mortality rate. Diseases

[8] Due to the large number of regressors (described below), I estimated a linear probability model, rather than a probit model.

[9] The mean of the dependent variable is 3.7%. This is higher than the 3.1% figure reported above, which included ASES beneficiaries with no pharmacy claims.

of the blood and blood-forming organs and diseases of the skin and subcutaneous tissue are two other high-mortality conditions. The lowest-mortality conditions include mental disorders, diseases of the nervous system and sense organs, and diseases of the musculoskeletal system and connective tissue.

The coefficient on N_DISEASE is negative and highly significant, which is somewhat surprising. This indicates that, conditional on the distribution of diagnoses a person had (and other covariates), the greater the effective *number* of diseases the person had, the lower the probability of death.

The coefficients on the region dummy variables indicate differences in mortality rates associated with different regions. They are plotted in Figure 3. The mortality rate in Suroeste is almost 1.5 percentage points higher than the mortality rate in the second-highest region, Este. The regions with the lowest mortality rates are Montana, Guayama, and Arecibo.

Estimates by condition. In addition to estimating the model using data on the entire population of ASES beneficiaries with pharmaceutical claims, I also estimated the model separately for people with three specific diagnoses: (1) diseases of the circulatory system; (2) endocrine, nutritional and metabolic diseases, and immunity disorders (primarily diabetes); and (3) neoplasms. All three of these conditions exhibit relatively high mortality rates (above 6%), and the first two are highly prevalent (affecting at least one-sixth of the population). There were more than 2600 deaths in each group of people.

Rather than reporting the complete set of estimates (as in Table 1) for each group, we report just the coefficients of the three drug-vintage variables, as well as means of key variables for each group, in Table 2.

The first column of Table 2 shows estimates for the entire population (copied from Table 1). The coefficients of the three drug-vintage variables (lines 11, 12, and 13) indicate *differences* between the mortality rates of people using drugs of different vintages. By combining these coefficients with the average mortality rate (line 3) and the vintage distribution of drugs (lines 7-10), we can infer the (*levels* of) mortality rates of people using drugs of different vintages.[10]

[10] As argued above, if the mortality rate of people using pre-1970 drugs is equal to k, then the mortality rate of people using 1970s drugs is $(k + \beta_{1970})$, the mortality rate of people using 1980s drugs is

The vintage-specific mortality rates are shown in lines 14-17 of Table 2 and plotted in Figure 4. The estimated mortality rates are strictly declining with respect to drug vintage. For pre-1970 drugs, the estimated mortality rate is 4.4%. The mortality rates for 1970s, 1980s, and 1990s drugs are 3.6%, 3.0%, and 2.5%, respectively. The differences in mortality rates are highly statistically significant (p-value < .0001).

We can use these estimates to compare the actual mortality rate in the ASES population (resulting from the actual vintage distribution of drugs) to what the mortality rate would have been, given alternative hypothetical vintage distributions of drugs. We consider two such alternative distributions:

- POST1970 = 0%: this would have characterized the distribution of drugs in 1970
- The vintage distribution of U.S. Medicaid Rx's in 2000

The results of these calculations are shown in Figure 5. The actual mortality rate is about 16% (3.7% vs. 4.4%) lower than it would have been if all of the drugs utilized in 2000 had been pre-1970 drugs. There would have been almost 3800 more deaths in the ASES population during 2000-2002 if all of the drugs utilized in 2000 had been pre-1970 drugs. This suggests that new drugs introduced during 1970-2000 reduced the mortality rate by about 0.58% (= (1 / 30) * ln(4.4% / 3.7%)) per year.

I would like to compare this figure to time-series mortality data for Puerto Rico during the period 1970-2000. I don't have time-series data on the age-adjusted mortality rate of Puerto Rico during this period, but I do have data on the age-adjusted mortality

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$(k + \beta_{1970} + \beta_{1980})$, etc. To determine these mortality rates, we simply need to solve for k. The overall mortality rate is the weighted average of these mortality rates, weighted by the percentage of people using drugs from each period:

$$MORT_{AVG} = (DRUG\%_{PRE1970} * k) + (DRUG\%_{1970s} * (k + \beta_{1970})) + (DRUG\%_{1980s} * (k + \beta_{1970} + \beta_{1980})) + (DRUG\%_{1990s} * (k + \beta_{1970} + \beta_{1980} + \beta_{1990}))$$

where

$MORT_{AVG}$ = mean(DIED)
$DRUG\%_{PRE1970}$ = mean(1 – POST70)
$DRUG\%_{1970s}$ = mean(POST70 – POST80)
$DRUG\%_{1980s}$ = mean(POST80 – POST90)
$DRUG\%_{1990s}$ = mean(POST90)

$$k = MORT_{AVG} - ((DRUG\%_{1970s} * \beta_{1970}) + (DRUG\%_{1980s} * (\beta_{1970} + \beta_{1980})) + (DRUG\%_{1990s} * (\beta_{1970} + \beta_{1980} + \beta_{1990})))$$

rate of the U.S. during the period 1979-1998 (see Figure 6).[11] The age-adjusted mortality rate of the U.S. declined at an annual average rate of 0.71% during the period 1979-1998 (and, due to the large jump between 1979 and 1980, it declined at an annual average rate of 0.92% during the period 1980-1998). Moreover, in both Puerto Rico and the U.S., life expectancy increased much more rapidly in the 1970s than it has done since 1980.[12] Therefore, our estimates' implication that new drugs introduced during 1970-2000 reduced the mortality rate by about 0.58% per year is not implausible. At the same time, the estimates imply that the introduction of new drugs accounted for a significant fraction of the long-run decline in Puerto Rican mortality.

As noted earlier, percentages of post-1980 and post-1990 Rx's are much lower in ASES than they are in U.S. Medicaid. The estimates imply that if the ASES vintage distribution were the same as U.S. Medicaid's, ASES's mortality rate would have been 5.3% lower (3.5% vs. 3.7%), and there would have been almost 1100 fewer deaths in the ASES population during 2000-2002.

Estimates by disease group. Columns 2-4 of Table 2 present estimates of the model for each of three groups: (1) people with diseases of the circulatory system; (2) people with endocrine, nutritional and metabolic diseases, and immunity disorders (primarily diabetes); and (3) people with neoplasms. Estimated vintage-specific mortality rates, by condition, are shown in Figure 7. With only one exception (post-1990 drugs for people with neoplasms), within each group the coefficients of all three drug-vintage variables are negative and highly significant, which is consistent with the

[11] Source: CDC Wonder 1979-1998 Compressed Mortality data,

[12] Life expectancy at birth, both sexes:

Period	Puerto Rico	U.S.
1970-1975	72.2	71.5
1975-1980	73.4	73.3
1980-1985	73.8	74
1985-1990	74.6	74.4
1990-1995	73.9	74.9
1995-2000	74.9	76.2

Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2002 Revision* and *World Urbanization Prospects: The 2001 Revision*, http://esa.un.org/unpp, 25 May 2003; 5:45:45 PM.

hypothesis that ASES beneficiaries using newer drugs during January-June 2000 were less likely to die by the end of 2002, conditional on the covariates.

IV. Summary

The Puerto Rico Health Insurance Administration (ASES) contracts with private managed care organizations to provide health care services for approximately 1.5 million people, or 40% of the population of Puerto Rico. We examined the impact of the vintage (original FDA approval year) of drugs used to treat a patient on the probability of survival, conditional on demographic characteristics (age, sex, and region), utilization of medical services, and the nature and complexity of illness, using ASES data covering over half a million people. I could not control for education and income, but to be eligible for Medicaid in Puerto Rico, annual income of a family of four could not exceed $16,440 (in the year 2002).

We found that ASES beneficiaries using newer drugs during January-June 2000 were less likely to die by the end of 2002, conditional on the covariates. The estimated mortality rates are strictly declining with respect to drug vintage. For pre-1970 drugs, the estimated mortality rate is 4.4%. The mortality rates for 1970s, 1980s, and 1990s drugs are 3.6%, 3.0%, and 2.5%, respectively. The differences in mortality rates are highly statistically significant (p-value < .0001).

The actual mortality rate is about 16% (3.7% vs. 4.4%) lower than it would have been if all of the drugs utilized in 2000 had been pre-1970 drugs. This suggests that new drugs introduced during 1970-2000 reduced the mortality rate by about 0.58% per year. This is not implausible, in light of the time-series data on mortality. The introduction of new drugs appears to have accounted for a significant fraction of the long-run decline in Puerto Rican mortality.

Percentages of post-1980 and post-1990 Rx's are much lower in ASES than they are in U.S. Medicaid. The estimates imply that if the ASES vintage distribution were the same as U.S. Medicaid's, ASES's mortality rate would have been 5.3% lower (3.5% vs. 3.7%). Use of older drugs in Puerto Rico's Medicaid program may be partly attributable to the fact that, in Puerto Rico, the physician bears the costs of the drugs—the cost is deducted from the physician's capitation payment.

In addition to estimating the model for the entire ASES population, we estimated the model separately for three groups: (1) people with diseases of the circulatory system; (2) people with endocrine, nutritional and metabolic diseases, and immunity disorders (primarily diabetes); and (3) people with neoplasms. With only one exception, within each group the coefficients of all three drug-vintage variables were negative and highly significant.

In this study, we did not control for the effect of the vintage of medical products and services other than drugs on survival, and this may have affected our estimates of the effect of drug vintage. We plan to address this issue in future research.

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Figure 1
Comparison of vintage distributions of ASES Rx's, all U.S. Rx's, and U.S. Medicaid Rx's

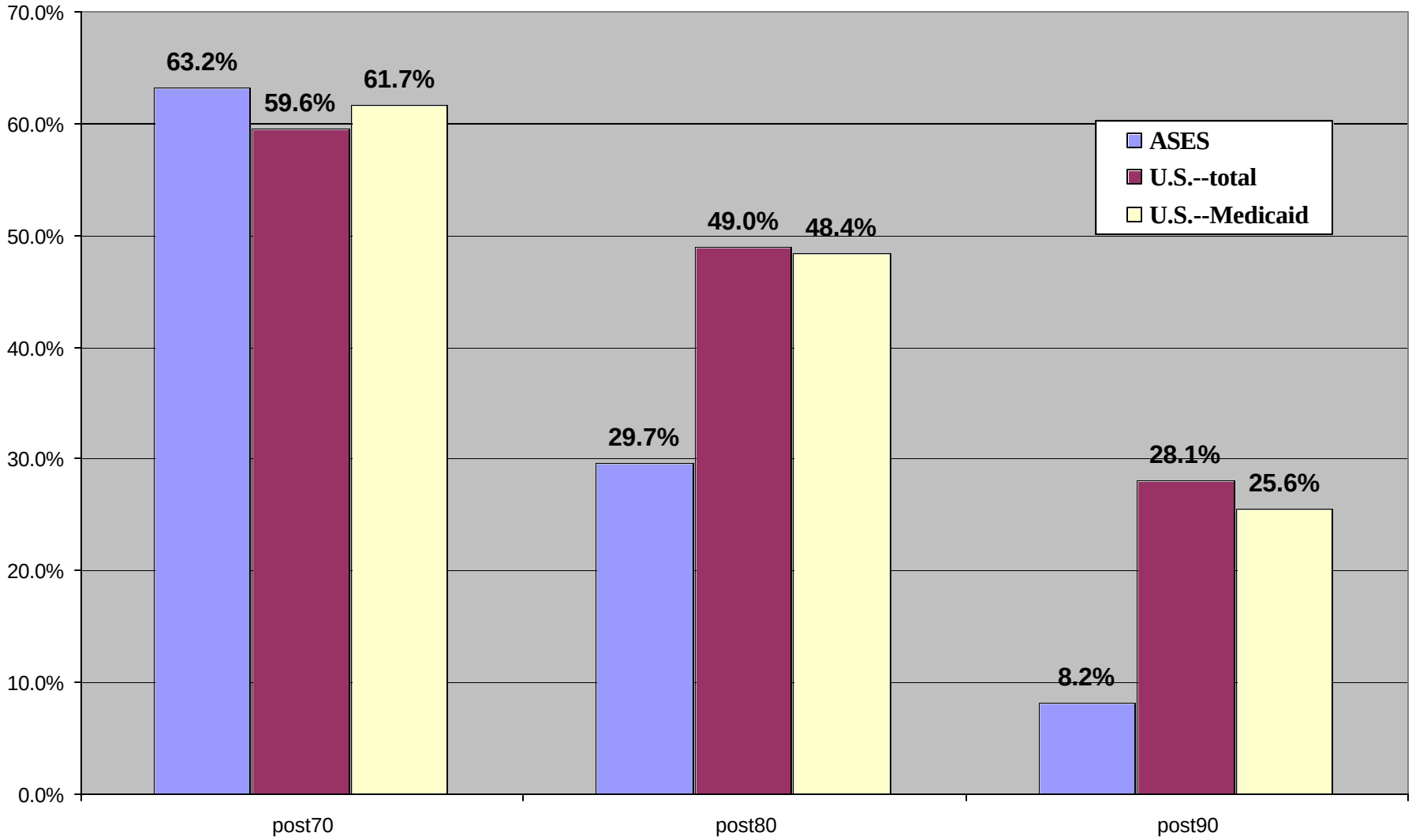

Figure 2
Estimated coefficients on diagnosis category variables

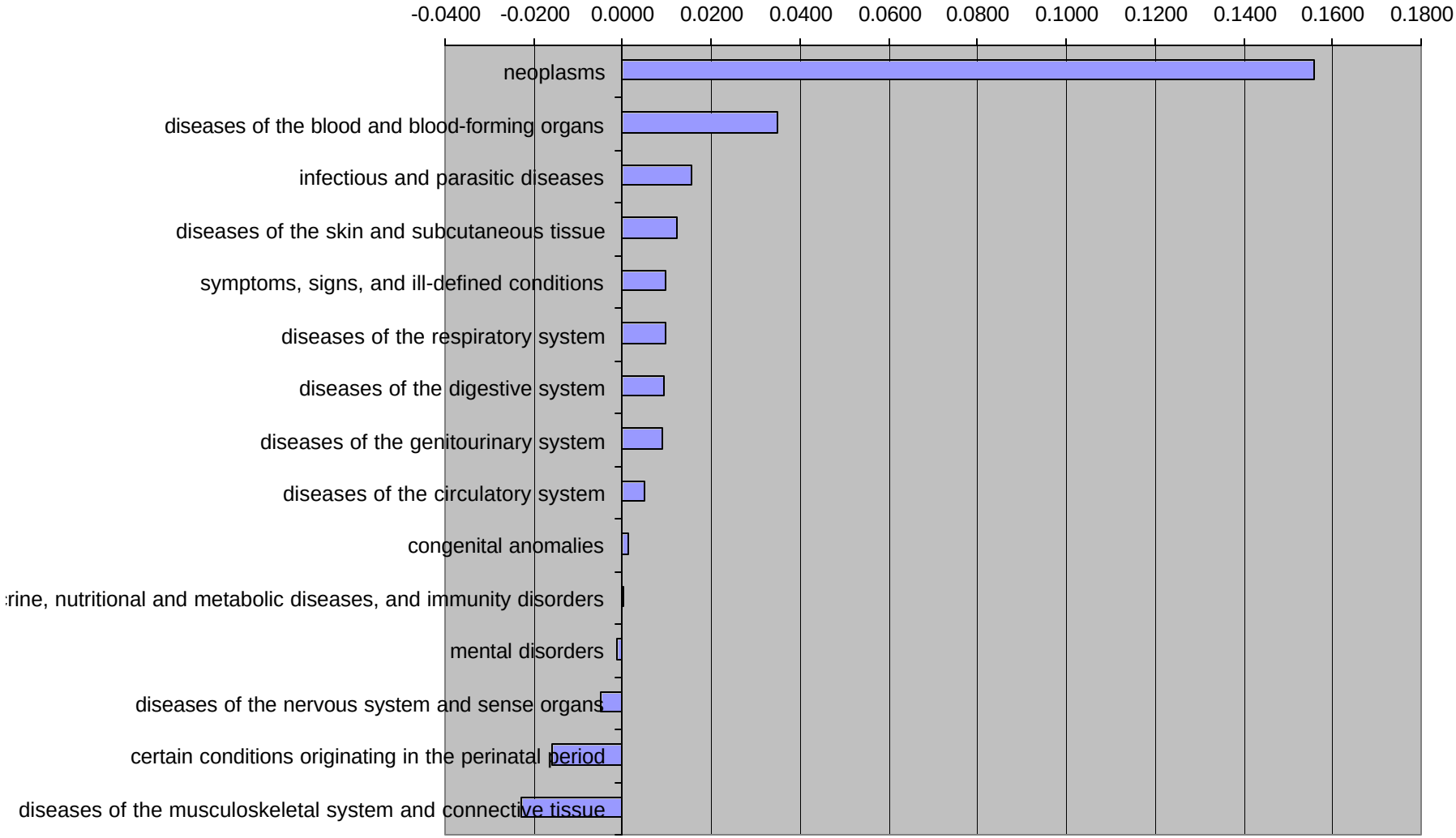

Figure 3
Estimated coefficients on region dummy variables

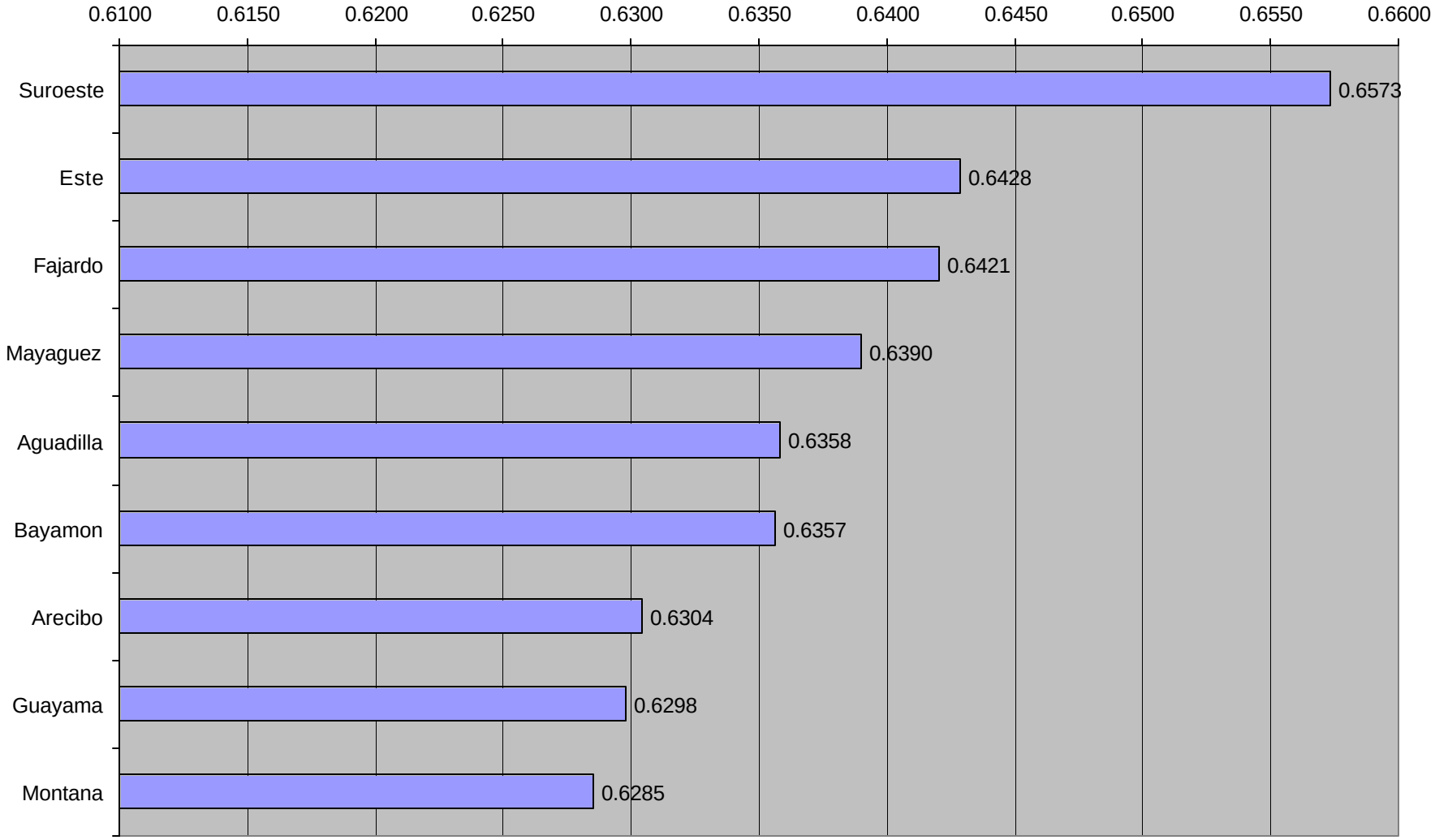

Figure 4
Estimated vintage-specific mortality rates, entire ASES population

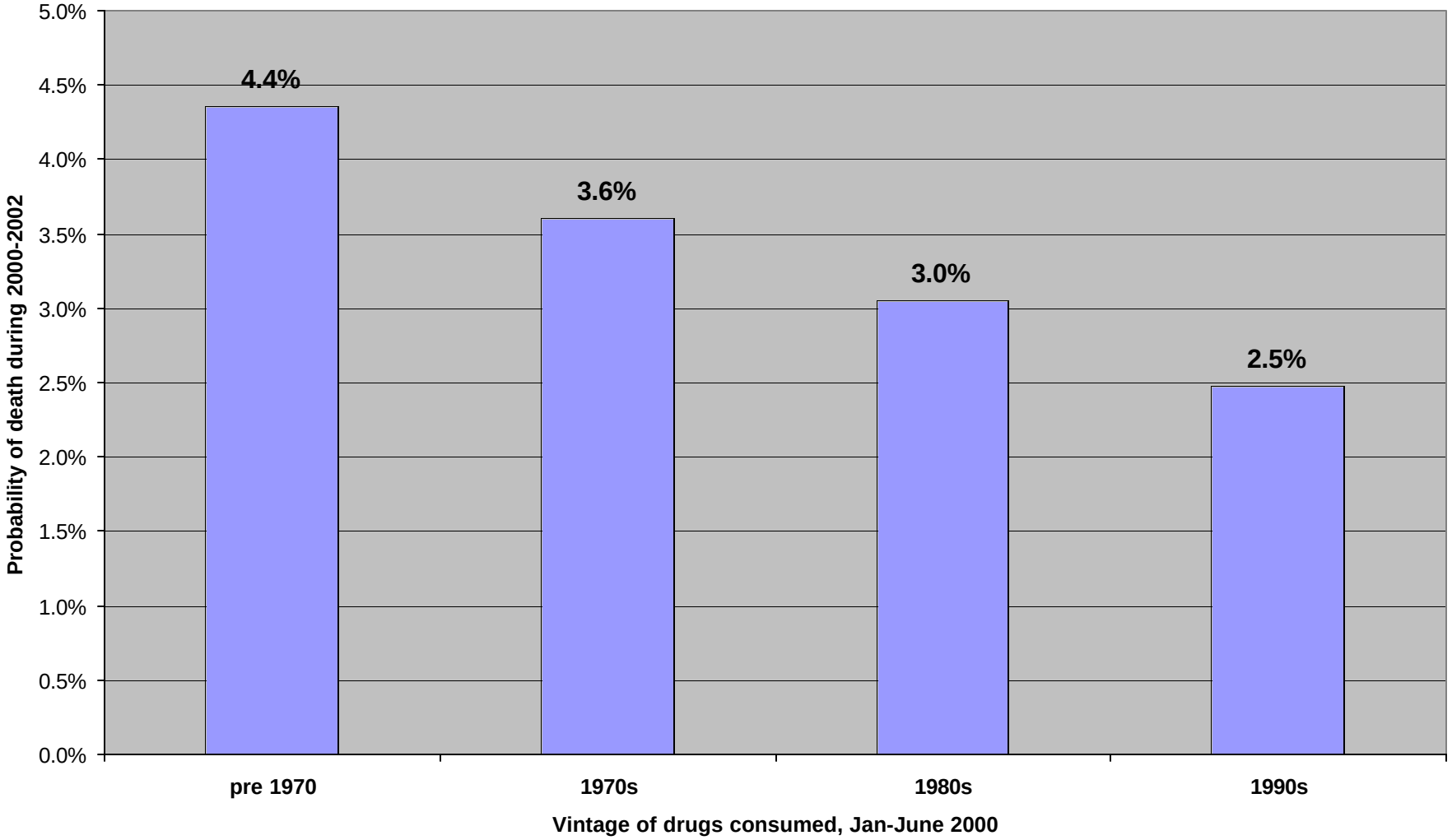

Figure 5
Actual vs. hypothetical ASES mortality rates

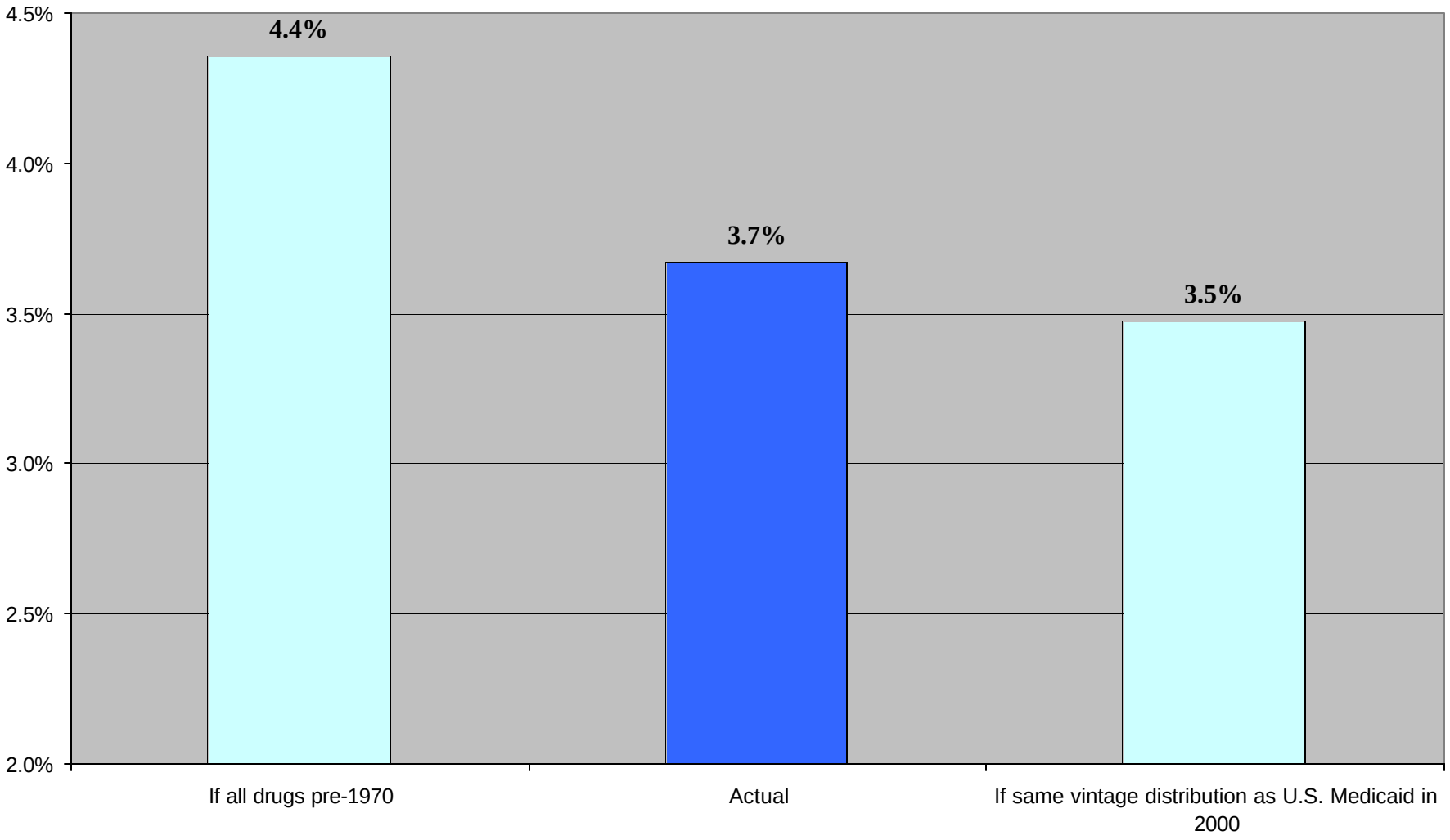

Figure 6
Age-adjusted 3-year death rate, U.S., 1979-1998

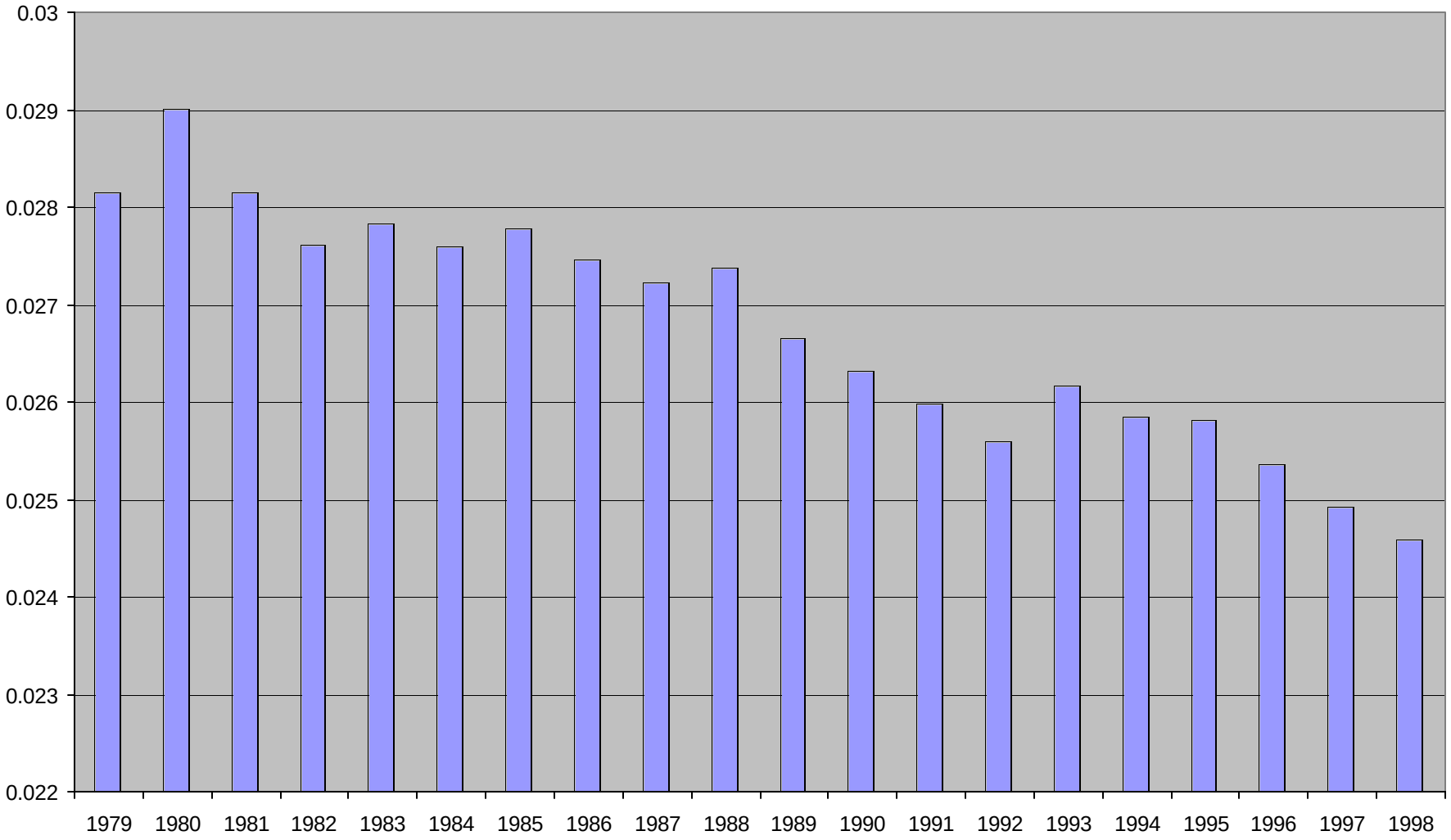

Figure 7
Vintage-specific mortality rates, by condition

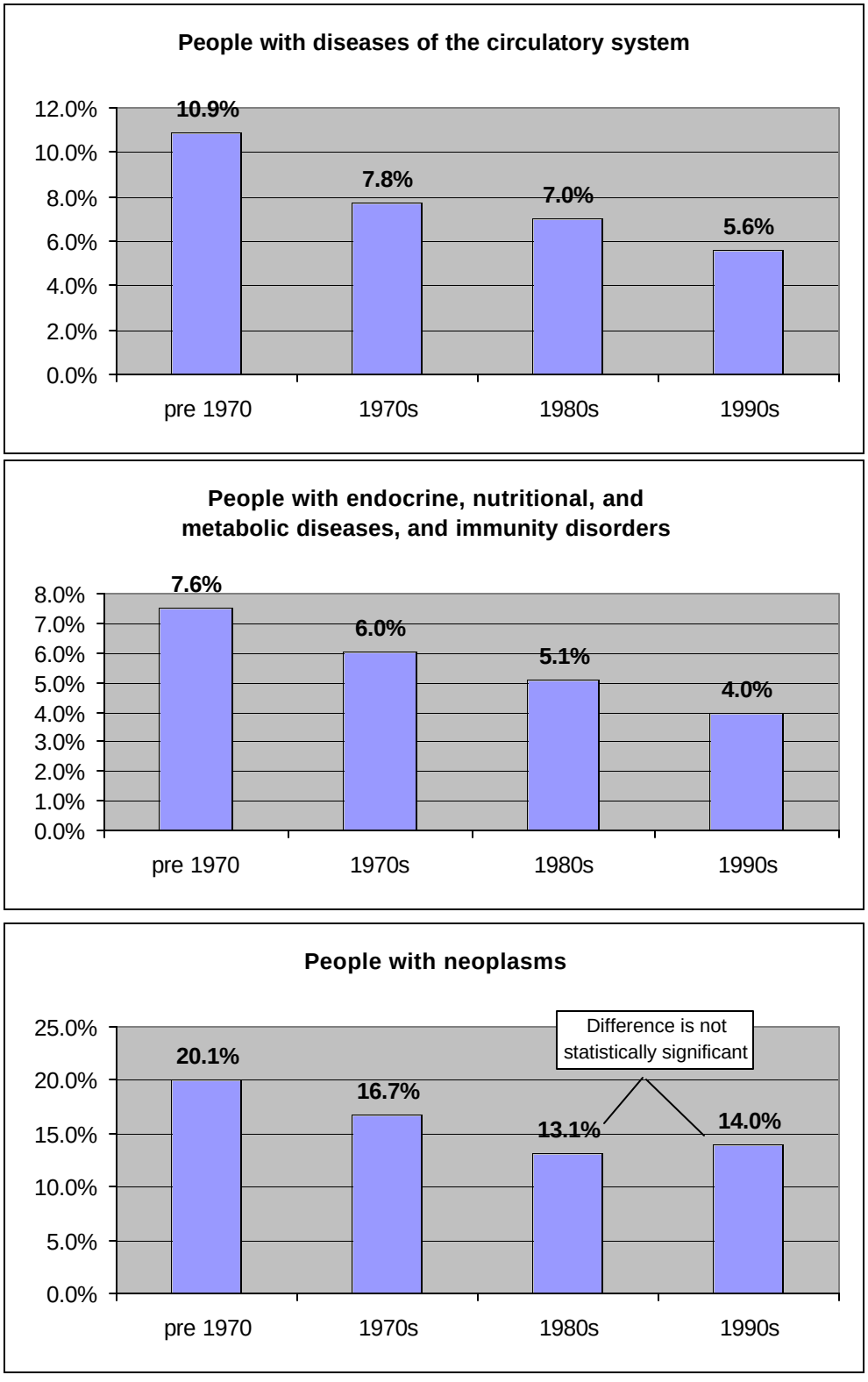

Table 1
Estimates of mortality model, full sample

Variable	Estimate	Standard error	t Value	Pr > |t|
Drug vintage variables				
POST70	-0.0075	0.0009	-8.29	<.0001
POST80	-0.0056	0.0010	-5.48	<.0001
POST90	-0.0057	0.0014	-3.98	<.0001
Utilization variables				
Number of medical claims	0.0031	0.0000	72.20	<.0001
Number of pharmacy claims	0.0011	0.0000	28.59	<.0001
Number of hospital claims	0.0053	0.0001	49.05	<.0001
Diagnosis category variables				
infectious and parasitic diseases	0.0157	0.0017	9.28	<.0001
neoplasms	0.1558	0.0029	54.48	<.0001
endocrine, nutritional and metabolic diseases, and immunity disorders	0.0003	0.0014	0.19	0.8487
diseases of the blood and blood-forming organs	0.0350	0.0035	10.03	<.0001
mental disorders	-0.0011	0.0014	-0.77	0.4386
diseases of the nervous system and sense organs	-0.0049	0.0015	-3.35	0.0008
diseases of the circulatory system	0.0048	0.0013	3.78	0.0002
diseases of the respiratory system	0.0096	0.0010	9.25	<.0001
diseases of the digestive system	0.0092	0.0017	5.55	<.0001
diseases of the genitourinary system	0.0091	0.0014	6.39	<.0001
diseases of the skin and subcutaneous tissue	0.0121	0.0019	6.34	<.0001
diseases of the musculoskeletal system and connective tissue	-0.0229	0.0014	-16.28	<.0001
congenital anomalies	0.0012	0.0051	0.23	0.8191
certain conditions originating in the perinatal period	-0.0157	0.0109	-1.45	0.1479
symptoms, signs, and ill-defined conditions	0.0096	0.0014	6.73	<.0001
N_DISEASE	-0.0014	0.0002	-8.42	<.0001
Region dummy variables				
Aguadilla	0.6358	0.0382	16.63	<.0001
Arecibo	0.6304	0.0382	16.49	<.0001
Bayamon	0.6357	0.0382	16.62	<.0001
Este	0.6428	0.0382	16.81	<.0001
Fajardo	0.6421	0.0382	16.79	<.0001
Guayama	0.6298	0.0382	16.47	<.0001
Mayaguez	0.6390	0.0382	16.71	<.0001
Montana	0.6285	0.0382	16.43	<.0001
Suroeste	0.6573	0.0383	17.18	<.0001

N = 539,750. The dependent variable is a dummy variable equal to one if the person died during 2000-2002, otherwise equal to zero. The model also included 200 single-year-of-age-by-sex dummy variables.

Table 2
Drug-vintage coefficients and related estimates, by disease group

Line	Column	1	2	3	4
		Entire population	**People with diseases of the circulatory system**	**People with diseases of the endocrine, nutritional and metabolic diseases, and immunity disorders**	**People with neoplasms**
1	N (Number of beneficiaries with pharmacy claims)	539,750	114,656	91,087	15,758
2	Number of deaths	19,820	9,486	5,513	2,634
	means				
3	died	3.7%	8.3%	6.1%	16.7%
4	post1970	63.2%	69.2%	67.5%	65.9%
5	post1980	29.7%	39.7%	37.5%	34.4%
6	post1990	8.2%	10.9%	9.9%	9.5%
	vintage distribution				
7	pre 1970	36.8%	30.8%	32.5%	34.1%
8	1970s	33.5%	29.5%	30.1%	31.5%
9	1980s	21.5%	28.8%	27.6%	24.9%
10	1990s	8.2%	10.9%	9.9%	9.5%
	vintage coefficients				
11	POST1970	-0.0075	-0.0311	-0.0154	-0.0339
	std. error	0.0009	0.0037	0.0035	0.0113
	t-statistic	-8.29	-8.42	-4.36	-2.99
	p-value	<.0001	<.0001	<.0001	0.0028
12	POST1980	-0.0056	-0.0075	-0.0095	-0.0359
	std. error	0.0010	0.0037	0.0035	0.0122
	t-statistic	-5.48	-2.05	-2.68	-2.94
	p-value	<.0001	0.0405	0.0074	0.0032
13	POST1990	-0.0057	-0.0143	-0.0109	0.0092
	std. error	0.0014	0.0046	0.0047	0.0172
	t-statistic	-3.98	-3.14	-2.32	0.53
	p-value	<.0001	0.0017	0.0204	0.5929
	Implied mortality rates				
14	pre 1970	4.4%	10.9%	7.6%	20.1%
15	1970s	3.6%	7.8%	6.0%	16.7%
16	1980s	3.0%	7.0%	5.1%	13.1%
17	1990s	2.5%	5.6%	4.0%	14.0%