# Causes of the Change in the Rates of Mortality and Severe Complications of Diabetes Mellitus: 1992 – 2012

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## Abstract

**Objective**—To quantify the causes of the changes in the rates of mortality and select severe complications of diabetes mellitus, type 2 (T2D) among the elderly between 1992 and 2012.

**Research Design**—A retrospective cohort study design based on Medicare 5% administrative claims data from 1992 to 2012 was used. Traditional fee-for-service Medicare beneficiaries, age 65 and older, diagnosed with T2D and living in the United States between 1992 and 2012 were included in the study. Blinder-Oaxaca decomposition was used to quantify the potential causes of the change in the rates of death, congestive heart failure (CHF) and/or acute myocardial infarction (AMI), stroke, amputation of lower extremity and end stage renal disease (ESRD) between 1992 and 2012.

**Results**—The number of beneficiaries in the analysis sample diagnosed with T2D increased from 152,191 in 1992 to 289,443 in 2012. Over the same time period, rates of mortality decreased by 1.2, CHF and/or AMI by 2.6, stroke by 1.6, amputation by 0.6 while rates of ESRD increased by 1.5 percentage points. Improvements in the management of precursor conditions and utilization of recommended health care services, not population composition, were the primary causes of the change.

**Conclusions**—With the exception of ESRD, outcomes among Medicare beneficiaries diagnosed with T2D improved. Analysis suggests that persons diagnosed with T2D are living longer with fewer severe complications. Much of the improvement in outcomes likely reflects more regular contact with health professionals and better management of care.

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**Keywords**

Diabetes Mellitus; Health outcomes; Medicare

## INTRODUCTION

The prevalence of type 2 diabetes mellitus (T2D) is increasing in the U.S. and other developed countries (1–3). Elderly individuals aged 65+ have been affected more than any other age group in the U.S. with recent estimates placing prevalence of this disease at over 25% (4, 5). Diabetes mellitus is a chronic disease that increases probabilities of onset of cerebrovascular, cardiovascular, renal, ocular, and lower extremity complications, including serious severe adverse outcomes, e.g., stroke, congestive heart failure (CHF), acute myocardial infarction (AMI), end stage renal disease (ESRD), and amputation (6, 7). Although T2D prevalence among the elderly has increased over the past 20 years, rates of stroke (8), CHF and AMI (9–11), and amputation of a lower limb (12) among elderly persons diagnosed with T2D in the U.S. have decreased. An exception to these favorable trends in severe T2D complications is ESRD (13, 14).

Several non-mutually exclusive factors may underlie observed trends in severe T2D complications. First are the changes in criteria for a T2D diagnosis that occurred in 1997(15). Improvements in ascertainment of T2D and its common complications may have led to higher rates of less severe T2D complications, as these conditions would be identified earlier. However, changes in ascertainment are not nearly as likely to have affected severe T2D complications, the onset of which is usually more evident in the form of symptoms. Second, decreased rates of severe complications may be attributable to better adherence to guidelines for T2D care. Third, greater longevity of persons with a T2D diagnosis is a potential source of increased complication rates. Fourth, care may have improved over time because of technological changes and/or improved management of T2D.

In this study we sought to quantify the relative importance of factors underlying observed trends in severe T2D complications that occurred between 1992 and 2012. We used Blinder-Oaxaca decomposition (16–18), to determine whether changes in CHF and/or AMI, stroke, amputation, and ESRD for T2D patients are due to "explained factors," such as greater adherence to T2D care standards or changes in population composition (e.g. increased age of the elderly population with a T2D diagnosis, an increase in the number of white beneficiaries), or to "unexplained factors," such as technological change and/or better disease management that is not directly measured in our data, but can be inferred from the results. The Blinder-Oaxaca composition approach has been widely used in various economic applications (17–19), but at most rarely in health services research. This study contributes to the literature by partitioning sources of changes in severe complication rates and mortality among beneficiaries with a T2D diagnosis and by specifically analyzing the role of greater use of personal health services as a reason for changes in specific T2D severe complication rates observed between 1992, the base, and 2012, the end year.

## METHODS

Data came from the 1992–2012 Medicare Part A (facility) and Part B (professional) claims and enrollment files of a nationally representative 5% sample of Medicare beneficiaries aged 65+ provided by the U.S. Centers for Medicare and Medicaid Services (CMS) as a restricted-access public use file. We excluded beneficiaries who lived outside of the U.S. or enrolled in Medicare Advantage (MA) plans at any time during the observational period. Medicare Advantage is a private insurance plan alternative to traditional Medicare. Claims data on MA plan enrollees were unavailable. The Medicare 5% claims and enrollment files contained information on beneficiary demographic characteristics, enrollment status (dates of enrollment, death, entry into an MA plan, etc.), diagnoses and procedures performed using International Classification of Diseases, 9th Revision Clinical Modification (ICD-9-CM), Current Procedure Terminology (CPT-4), and CMS medical specialty codes.

We extracted claims filed on behalf of beneficiaries with a T2D diagnosis from 1992 (N=152,191) through 2012 (N=289,443). A beneficiary was considered to have been diagnosed with T2D on the date at which at least two claims with a diagnosis of diabetes mellitus within a 180-day period was observed. We used ICD-9-CM and CPT-4 codes to identify beneficiaries with T2D complications and comorbidities (Table 1). Codes for study outcomes of stroke, CHF and/or AMI and, amputation remained consistent over the observational period. However, in 2005, a new ICD-9-CM (585.6) code was introduced to specifically identify an ESRD diagnosis; this code replaced a more general code for chronic kidney disease (585), which previously included ESRD. The number of beneficiaries diagnosed with ESRD had a substantial spike at the year of the coding change. To develop a consistent time series of ESRD among beneficiaries diagnosed with T2D, we defined persons with ESRD as having received *either* dialysis or a kidney transplant during the year. The fraction of beneficiaries with a claim containing a 585.6 diagnosis code who received either therapeutic intervention increased between 2005 and 2012 (Supplemental Digital Content Figure 1).

Our first analytic step was to compute trends in deaths, stroke, CHF and/or AMI, amputation, and ESRD by year from 1992 through 2012 among Medicare beneficiaries diagnosed with T2D. There were no indications in either T2D complication or mortality trends that would imply that 1992 and 2012 were atypical. We used Blinder-Oaxaca decomposition to explain changes that occurred between the base (1992) and end years (2012). This method allowed us to divide changes in outcomes into explained and unexplained changes. The former reflects changes in the *use* of personal health care services and in composition of the beneficiary population with a T2D diagnosis. The latter reflects changes in the *effects* of personal health care services and population composition on rates of severe T2D complications, and a residual not attributable to any of the factors explicitly included in our model.

Specifically, our decomposition analysis is based on two equations, one for the base and the other for the end year.

$$\hat{Y}^{2012} = \hat{\beta}_{0,2012} + \sum_{k=1}^{K} X_{k,2012}\hat{\beta}_{k,2012} \quad (1)$$

$$\hat{Y}^{1992} = \hat{\beta}_{0,1992} + \sum_{k=1}^{K} X_{k,1992}\hat{\beta}_{k,1992} \quad (2)$$

$\hat{Y}^t$ is the predicted outcome in year $t$, and the $X$s are explanatory variables. The subscript k refers to the $k^{th}$ explanatory variable. The $\hat{\beta s}$ are parameters associated with each explanatory variable. Equation 1 estimates the relationship between the outcome and $k$ explanatory variables as of 2012. Equation 2 does the same for 1992. The equations allow for changes in the effects of the Xs to have occurred between the base and end year. Subtracting equation 2 from equation 1, assuming $k=1$ to simplify notation, and using a bar to indicate mean values of the explanatory variable yields equation (3):

$$\hat{Y}^{2012} - \hat{Y}^{1992} = (\overline{X}_{1,2012} - \overline{X}_{1,1992})\hat{\beta}_{1,1992} + \overline{X}_{1,2012}(\hat{\beta}_{1,2012} - \hat{\beta}_{1,1992}) + (\hat{\beta}_{0,2012} - \hat{\beta}_{0,1992}) \quad (3)$$

The first term, $(\overline{X}_{1,2012} - \overline{X}_{1,1992})\hat{\beta}_{1,1992}$, is the explained component; this is the variation that can be explained by changes in $X_1$ between 2012 and 1992 and can be interpreted as the expected outcome in 2012 if the underlying causal relationship were identical in the two years. The term $\overline{X}_{1,2012}(\hat{\beta}_{1,2012} - \hat{\beta}_{1,1992}) + (\hat{\beta}_{0,2012} - \hat{\beta}_{0,1992})$, represents the change in structure that occurred between base and end years, the unexplained component. This division represents the variation accounted for by unobserved changes in the underlying causal relationship and can be interpreted as the difference in the effect of $X_1$ on the outcome in the end versus the base year. Any change in the mean outcome that cannot be attributed to specific explanatory variables is included in the difference in intercepts of $(\hat{\beta}_{0,2012} - \hat{\beta}_{0,1992})$. We implemented the Blinder-Oaxaca decomposition using StataCorp's Stata 11 oaxaca command.

Covariates (Xs) included the beneficiary's age (70–75, 75–79, 80–84, 85+. 65–69–omitted reference group), male gender, race (black, Hispanic, other. white–omitted reference group), a Charlson(20) index and indicators for insulin dependence, hypertension, lipidemia, obesity, and less severe complications of T2D, listed in Table 1. We modified the Charlson index to exclude conditions that were included separately as covariates.

Our measure of use of personal health care services as recommended by American Diabetes Association (ADA) guidelines was based on 10 measures of health service use from which we derived a single composite measure using factor analysis. The 10 individual measures, each defined for either the base or end years, were: whether a beneficiary had claims for visits to a general physician, endocrinologist, nephrologist, ophthalmologist or optometrist, cardiologist, or podiatrist and whether or not there were claims for the following tests: blood pressure, urine, HB1AC, and lipid (Table 1). Visits specific to particular specialists were based on specialty codes on the claims that are used by Medicare to identify the provider. Use of tests was based on CPT-4 codes. We used Stata 11's factor routine for this procedure. We selected the first factor as a measure of the beneficiary's health services use since it was

the only factor with an eigenvalue exceeding 1.0. Factor loadings on all component variables with the exception of podiatrist use were positive (Supplemental Digital Content Table 1).

## RESULTS

Except for ESRD, annual rates of adverse outcomes declined between 1992 and 2012 but patterns of decline differed depending on the study outcome (Figure 1). Mortality among beneficiaries diagnosed with T2D declined from 7.6% in 1992 to 6.4% in 2012. Rates of CHF and/or AMI increased from 11.6 % in 1992 to 12.6% in 2000. Since then, such rates have decreased; in 2012, 8.9% of sample persons had a diagnosis listed on a Medicare claim of CHF and/or AMI. This spike may reflect the introduction of troponin testing in 2000 which improved the ability of medical professionals to identify cases of AMI. Annual rates of stroke declined from 2.9% in 1992 to 1.4% in 2012. Annual rates of amputation of a lower limb declined gradually over the observational period. Such rates were 1.0% in 1992 versus 0.3% in 2012.

Between 1992 and 2012, the number of Medicare beneficiaries in our analysis sample with a T2D diagnosis almost doubled. Such beneficiaries in the end year were older on average, less likely to be white (likely due to a general change in demographic characteristics of the Medicare population), and had more and more severe illnesses not directly related to T2D as indicated by changes in the Charlson Index as modified for our study (Table 2). There was also growth in T2D complication rates of lesser severity. In 1992, 49% of beneficiaries had no T2D complications. By 2012, the share with no complication had decreased to 38%. The largest increase by far was in renal complications, which rose from 5% in 1992 to 24% in 2012.

Annual mortality rates declined by 1.24 percentage points (pp) between 1992 and 2012 (Table 3). The explained part of the change taken alone would have led to a 5.65pp decrease in the mortality rate among beneficiaries diagnosed with T2D. The most important component was an increase in use of recommended health care services, which accounted for 88% of the explained change (−0.0495 of −0.0565). Combined changes in population composition accounted for the remaining 12% of the explained change (−0.0070 of −0.0565).

The unexplained change was 4.41pp. The largest single unexplained factor was for the change in the intercepts (0.0557 of 0.0441), which implies that mortality rates were higher in 2012 than would be expected given the relationships existing in 1992 for reasons not associated with specific factors in our model; i.e., $(\hat{\beta}_{0,2012} - \hat{\beta}_{0,1992})$ was substantially greater than zero. Changes in population composition counteracted the sharp increase suggested by the intercept (−0.0055 of 0.0441). The estimate for health services use was also negative, implying that the beneficial effect of health services use on mortality increased (−0.0060 of 0.0441).

Rates of CHF and/or AMI fell by 2.63pp (Table 4). Based on the sum of the explained changes alone (0.0282), the rates of CHF and/or AMI would have increased between 1992 and 2012. Higher utilization of recommended health care services was the primary explained

factor acting to moderate this expected increase (−0.0272 of 0.0282). The unexplained changes taken together (−0.0545) more than offset the increase predicted from the explained portion. The largest contributors were the intercept term (−0.0201 of −0.0545), insulin dependence (−0.0143 of −0.0545) as well as less severe cardiovascular (−0.0176 of −0.0545) and renal (−0.0246 of −0.0545) complications, which are inferred from the changes in the parameters associated with these complications. A notable exception was for lipidemia (0.0361 of −0.0545) for which higher testing rates were associated with an increase in rates of CHF and/or AMI.

Rates of stroke improved by 1.61pp over the study period. Notable explained factors were the use of recommended health services (−0.0071) and hypertension (0.0048). However, the sum of the explained changes was close to zero (0.0003) and was not statistically significant. The unexplained changes accounted for the entirety of the observed improvements (−0.0163 of −0.0161). Decreases in the associations between stroke and insulin dependence (−0.0047 of −0.0163), the Charlson index (−0.0041 of −0.0163) and hypertension (−0.0071 of −0.0163) were the largest individual contributors to this improvement, while the intercept (0.0047 of −0.0163) and lipidemia (0.0095 of −0.0163) worked counter to the overall trend.

Although the decrease in amputation rates was the smallest among all the study outcomes (0.64pp), proportionally rates of amputation decreased by 206% (from 0.0095 to 0.0031), a marked improvement. The sum of the explained changes suggest a 0.24pp increase in amputations in 2012. Less severe lower extremity (0.0050 of 0.0024) and renal (0.0032 of 0.0024) complications were the primary explained factors leading to higher complication rates while use of recommended healthcare services (−0.0049 of 0.0024) was the largest protective factor. The combined unexplained changes (−0.0089) imply a decrease in amputation rates due to changes in the effects of the included factors and offset the increase predicted by the explained portion. The most important source of this improvement was from the reduced association of precursor lower extremity complications with amputation (−0.0113 of −0.0090).

ESRD rates increased by 1.50pp between 1992 and 2012. The explained changes were strongly adverse (0.0268) while the unexplained changes showed some improvement (−0.0118) but failed to fully offset the strong adverse effect. The most important explained change reflected an increase in renal complications less severe than ESRD (0.0352 of 0.0268) while increased utilization was a factor operating to decrease ESRD rates (−0.0056 of 0.0268). The reduced association between less severe renal complications and ESRD (−0.0258 of −0.0118) was the primary source of the improvement demonstrated by the unexplained factors.

## DISCUSSION

The number of Medicare beneficiaries with a T2D diagnosis increased almost two-fold between 1992 and 2012. Rates of the most severe T2D complications declined as did mortality rates of beneficiaries diagnosed with T2D. The exception among the most severe T2D complications was ESRD. Based on the mix of the T2D-diagnosed beneficiary population alone, severe complication and mortality rates should have uniformly increased.

For example, the share of beneficiaries aged 85+ was much higher in 2012 than in 1992. Two forces contributed to lower rates of severe T2D complications. The first was increased use of personal health care services recommended for care of patients diagnosed with T2D. The second were favorable changes in effects of precursor conditions, such as the reduced association between rates of less severe complications and comorbidities and more severe T2D complications. The decomposition analysis could not reveal the precise reason for these favorable changes. However a likely cause is improvements in early diagnosis, disease management, and medical technology between 2012 and 1992.

The analysis yielded several puzzling findings. First, patterns for several severe T2D complications did not apply to mortality. In particular, the beneficial effect of utilization of health care services was much greater in reducing mortality in an elderly population of persons with a T2D diagnosis than it was for severe T2D complications. Because we adjusted for population mix, the most likely reason is that medical care is more effective in forestalling death among elderly persons with a T2D diagnosis than in preventing onset of severe T2D complications.

A second unexpected finding are the positive intercept terms in all outcomes except in CHF and/or AMI, which imply a deterioration in health outcomes not attributable to the variables included in our model. The decrease in rates of CHF and AMI (9, 10) have been documented for Medicare beneficiaries in general and for persons with a T2D diagnosis in particular (21). These improvements have been attributed to better management of precursor conditions such as coronary heart disease (10), and hypertension (22, 23), including increased use of medication (24, 25), and lower smoking rates (26), all reflected in our study as changes in the intercept. The ADA has promoted a series of unified standards and measures designed to combat the increasing burden of T2D (27). Updated annually, these standards recommend such measures as regular glucose and blood pressure monitoring, HB1AC and lipid testing, regular examinations of eyes and feet as well as use of specialty care when signs of a complication are identified. Adherence to these standards has been shown to decrease the risk of many T2D complications (28, 29).

Improved control of hypertension (30) and other risk-factors, e.g., management of transient ischemic attacks (8) (TIA), and growth in statin and anti-hypertensive use (31, 32) have been major contributors to the decreased incidence of stroke (8). Although improved imaging techniques may have led to fewer stroke diagnoses, and a corresponding increase in TIA diagnosis, incidence of both TIA and stroke diagnoses have decreased (8) over time. Our study provides additional support for these findings in that we found that a large part of the unexplained decrease in stroke rates came from better management of hypertension.

The third is the increase in ESRD rates which is counter to trends in the study's other severe complication rates. Prior research has demonstrated that the rate of diabetic kidney disease (DKD)–albuminuria, impaired glomerular filtration rate, or both in persons diagnosed with T2D has increased in direct proportion to the increase in T2D prevalence in the U.S. (33). DKD is the most common cause of chronic kidney disease (CKD), the most common precursor of ESRD. Increases in these precursor conditions comprise a negative factor that can counteract any beneficial effect from technological change and/or better disease

management that might have occurred during the two decades. Moreover, increased use of medications and other interventions designed to improve management of comorbid conditions may place added stress on kidneys and predispose patients to acute kidney injury (34). The most recent U.S. Renal Data System report stated that the 69% of patients receive no nephrologist care 12 months prior to initiating dialysis(13). Lack of specialist care may also be a contributor to this trend.

A minor decrease in amputation rates among white Medicare beneficiaries diagnosed with T2D has been previously documented (12). However this trend did not extend to blacks or beneficiaries with multiple comorbidities, the percent of whom has risen according to our data. We attributed most of the unexplained decrease in amputation rates in our study to improved management of non-severe lower extremity complications. The constant, accounting for changes in unobserved factors affecting amputation probability is positive, implying that factors not in our model tended to increase the probability of an amputation.

Strengths of our study are use of data nationally representative of the U.S. elderly population for a period of 2 decades and use of decomposition analysis to investigate sources of observed changes in mortality and T2D complication rates. A wide range of outcome measures and related less severe T2D complications were included. We analyzed trends in various outcomes and their probable causes with the same data.

There are also several study limitations. First, some important health behaviors, e.g., smoking, physical exercise, diet, and medication use, were not observable in Medicare claims and enrollment data. Second, the Medicare 5% database does not contain information on Medicare Advantage enrollees and is not nationally representative of disabled persons under age 65. Therefore these two populations of interest were omitted from the analysis. Third, much of the unexplained change reflected a change in intercept terms. While generally associated with improved care management and technological change, changes in intercept terms do not reveal the specific underlying mechanisms. Fourth, Medicare claims data are designed for administrative rather than for clinical purposes. However, use of these data has been shown to provide valid measures of underlying clinical phenomena (35). Medicare claims data available for 1992–2012 do not contain information on use of medications. Our analysis assumed that screening led to increased use of effective drugs. Fourth, our study was based on diagnosis codes which raises the issue that observed trends could reflect changes in disease ascertainment. There were no breaks in the time series with changes in diagnostic criteria for T2D or for changes in coding of AMI. However, to the extent that increased awareness of the importance of early diagnosis and treatment diffused among the provider and patient communities, there plausibly could have been some corresponding increases in ascertainment rates, e.g., for lipidemia.

In sum, except for ESRD, and the fact that type 2 diabetes mellitus prevalence has risen, our findings reflect favorable developments in T2D care. Persons diagnosed with this disease are living longer and with fewer severe T2D complications. Our decomposition analysis suggests that much of the improvement in outcomes likely reflects more regular contact with health professionals and better management of care. Dealing with increased rates of renal

complications of T2D, which stand in sharp contrast to lower rates of severe cardiovascular complications of T2D, represent a challenge for the future.

## Supplementary Material

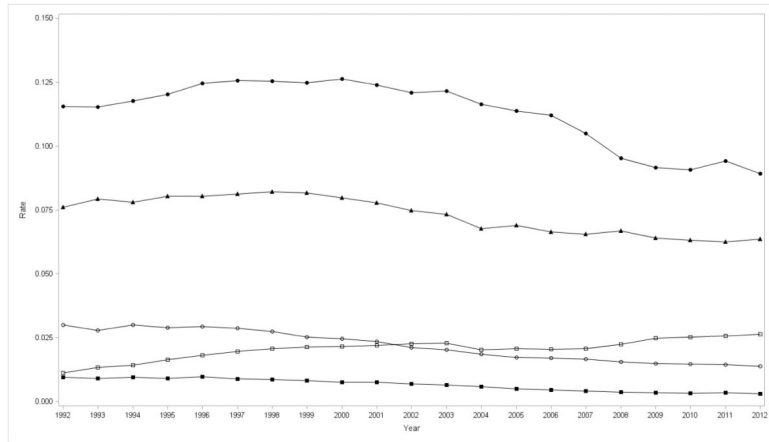Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

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**Figure 1.**
Trends in Severe Outcomes of Diabetes Mellitus
black circle – CHF and/or AMI; white circle – stroke; black square – amputation; white
square – ESRD; black triangle – mortality.

**Table 1**

List of Study Codes

| Condition | Administrative Code[*] | |
|---|---|---|
| **Diabetes Mellitus, Type 2** | ICD-9: | 250.xx |
| **Severe complications of Diabetes Mellitus** | | |
| Congestive heart failure[**] | ICD-9: | 428.xx 398.91 402.01 402.11 402.91 404.11 404.91 |
| Myocardial infarction[**] | ICD-9: | 410.xx |
| Stroke[**] | ICD-9: | 431.xx 434.01 436.xx 997.02 434.01 434.11 434.91 |
| Amputation of lower extremity | ICD-9(P): | 84.1x |
| Transplant | ICD-9: | V420 |
| | ICD-9(P): | 55.69 |
| | CPT-4: | 50360 50365 |
| Dialysis | ICD-9: | V45.11 V56.xx |
| | ICD-9(P): | 39.95 54.98 |
| | CPT-4: | 90921 90925 90960 90961 90962 90966 90970 90935 90937 90945 90947 |
| **Moderate severity cardiovascular complications** | | |
| Angina | ICD-9: | 413.xx |
| Ischemic heart disease | ICD-9: | 411.xx 414.xx |
| **Moderate severity cerebrovascular complications** | | |
| Cartotid bruit | ICD-9: | 785.9 |
| Subarachnoid hemorrhage | ICD-9: | 430.xx |
| Other/unspecified intracerebral hemorrhage | ICD-9: | 432.xx |
| Occlusion and stenosis of precerebral arteries | ICD-9: | 433.xx |
| Transient ischemic attack | ICD-9: | 435.x |
| **Moderate severity lower extremity complications** | | |
| Diabetes/w neuropathy | ICD-9: | 250.6x 357.2 355.xx |
| Diabetic amyotrophy | ICD-9: | 358.1 |
| Cellulitis | ICD-9: | 681.1x 682.6 682.7 |
| Charcot foot | ICD-9: | 707.11 |
| Osteomyelitis | ICD-9: | 730.06 730.07 730.16 730.17 730.26 730.27 |
| Gangrene | ICD-9: | 250.7x 785.4 |
| **Moderate severity renal complications** | | |
| Diabetes/w renal manifestations | ICD-9: | 250.4 |
| Proteinuria | ICD-9: | 791.0 |
| Nephrotic syndrome | ICD-9: | 581.8 |
| Chronic renal failure[***] | ICD-9: | 585.xx |
| **Moderate severity ocular complications** | | |
| Diabetes/w retinopathy | ICD-9: | 362.01 362.02 362.03 362.04 362.05 362.06 |
| Diabetic macular edema | ICD-9: | 362.07 |
| **Other comorbidities** | | |
| Insulin dependence | ICD-9: | 250.1x 250.3x 250.01 250.03 |

| Condition | Administrative Code[*] | |
|---|---|---|
| Hypertension | ICD-9: | 401.xx |
| Lipidemia | ICD-9: | 272.0 272.1 272.2 272.3 272.4 |
| Obesity | ICD-9: | 278.xx |
| **Elements of recommended health care services** | | |
| Blood pressure test | CPT-4: | 90201 90205 99211–99215 99241–99245 99301–99303 99311–99313 99321–99323 99341–99349 99350 99387 99397 99401–99404 99411 99412 9942x 99331–99333 |
| Urine test | CPT-4: | 81001 – 81005 82040 82042 82043 82044 84155 |
| HB1AC test | CPT-4: | 82985 83036 |
| Lipid test | CPT-4: | 80061 82465 83715–83719 83721 84478 |
| General physician visit | CMS | 01 08 11 70 50 97 |
| Endocrinologist visit | CMS | 46 |
| Nephrologist visit | CMS | 39 |
| Opthalmologist visit | CMS | 18 |
| Optometrist visit | CMS | 41 |
| Cardiologist visit | CMS | 06 |
| Podiatrist visit | CMS | 48 |

[*] Codes are drawn from International Classification of Disease, 9th Revision, Clinical Modification (ICD-9 for condition, ICD-9(P) for procedure), Current Procedural Terminology (CPT-4) and CMS specialty codes (CMS).

[**] Includes Part A inpatient claims only

[***] Excludes End Stage Renal Disease (ICD-9: 585.6) introduced in 2005.

**Table 2**

Sample Means

| Variable | 1992 | 2012 |
|---|---|---|
| Utilization of recommended health care services | −0.5809 | 0.2716 |
| Congestive heart failure and/or Myocardial infarction | 0.1156 | 0.0893 |
| Stroke | 0.0299 | 0.0138 |
| Amputation of lower extremity | 0.0095 | 0.0031 |
| End stage renal disease | 0.0112 | 0.0262 |
| Moderate severity cardiovascular complication | 0.3534 | 0.3699 |
| Moderate severity cerebrovascular complication | 0.0232 | 0.0191 |
| Moderate severity lower extremity complication | 0.1853 | 0.2887 |
| Moderate severity renal complication | 0.0513 | 0.2357 |
| Moderate severity ocular complication | 0.0794 | 0.0923 |
| No moderate severity diabetes complication | 0.4897 | 0.3795 |
| Insulin dependence | 0.3190 | 0.3818 |
| Charlson index | 1.0818 | 1.1979 |
| Hypertension | 0.5636 | 0.8760 |
| Lipidemia | 0.1926 | 0.8044 |
| Obesity | 0.0295 | 0.1421 |
| Age 65–69 | 0.2462 | 0.2440 |
| Age 70–74 | 0.2730 | 0.2334 |
| Age 75–79 | 0.2220 | 0.1988 |
| Age 80–84 | 0.1484 | 0.1520 |
| Age 85+ | 0.1104 | 0.1719 |
| Male | 0.3995 | 0.4207 |
| White | 0.8573 | 0.8248 |
| Black | 0.1193 | 0.1062 |
| Hispanic | 0.0028 | 0.0177 |
| Other | 0.0207 | 0.0514 |
| N | 152,191 | 289,443 |

**Table 3**

Decomposition Results for Death

| | Death |
|---|---|
| Predicted probability 2012[1] | 0.0637[**] |
| Predicted probability 1992 | 0.0760[**] |
| Total change in probability: 2012 v. 1992 | −0.0124[**] |

| | Change in Probability | |
|---|---|---|
| | Explained | Unexplained |
| Combined contribution to total change in probability: explained v. unexplained | −0.0565[**] | 0.0441[**] |
| Utilization of recommended health care services | −0.0495[**] | −0.0060[**] |
| Population Composition | | |
| Congestive heart failure and/or Myocardial infarction | −0.0043[**] | −0.0012[**] |
| Stroke | −0.0023[**] | 0.0001 |
| Amputation of lower extremity | −0.0005[**] | −0.0001 |
| End stage renal disease | 0.0023[**] | −0.0018[**] |
| Cardiovascular complication, less severe | −0.0002[**] | 0.0045[**] |
| Cerebrovascular complication, less severe | 0.0002[**] | 0.0005[**] |
| Lower extremity complication, less severe | −0.0014[**] | 0.0013[*] |
| Renal complication, less severe | 0.0114[**] | −0.0094[**] |
| Ocular complication, less severe | −0.0004[**] | 0.0013[**] |
| Insulin dependence | 0.0015[**] | 0.0002 |
| Charlson index | 0.0026[**] | 0.0013 |
| Hypertension | −0.0128[**] | 0.0256[**] |
| Lipidemia | −0.0062[**] | −0.0107[**] |
| Obesity | −0.0030[**] | 0.0024[**] |
| Age 70–74 | −0.0004[**] | −0.0019[**] |
| Age 75–79 | −0.0005[**] | −0.0032[**] |
| Age 80–84 | 0.0001[**] | −0.0038[**] |
| Age 85+ | 0.0058[**] | −0.0054[**] |
| Male | 0.0002[**] | −0.0029[**] |
| Black | 0.0001[**] | −0.0004 |
| Hispanic | −0.0007[**] | 0.0006[**] |
| Other | 0.0015[**] | −0.0029[**] |
| Intercept | | 0.0557[**] |

[**] p 0.01;

[*] p 0.05

[1]Sample size was 289,443 in 2012 and 152,191 in 1992

**Table 4**

Decomposition Results for Severe Complications of Diabetes Mellitus

| | CHF and/or AMI | | Stroke | | Amputation | | ESRD | |
|---|---|---|---|---|---|---|---|---|
| **Predicted probability 2012¹** | 0.0893** | | 0.0138** | | 0.0031** | | 0.0262** | |
| **Predicted probability 1992** | 0.1156** | | 0.0299** | | 0.0095** | | 0.0112** | |
| **Total change in probability: 2012 v. 1992** | -0.0263** | | -0.0161** | | -0.0064** | | 0.0150** | |
| | **Change in Probability** | | | | | | | |
| | Explained | Unexplained | Explained | Unexplained | Explained | Unexplained | Explained | Unexplained |
| Combined contribution to total change in probability: explained v. unexplained | 0.0282** | -0.0545** | 0.0003 | -0.0163** | 0.0024** | -0.0089** | 0.0268** | -0.0118** |
| Utilization of recommended health care services | -0.0272** | -0.0050** | -0.0071** | 0.0000 | -0.0049** | 0.0009** | -0.0056** | -0.0023** |
| **Population Composition** | | | | | | | | |
| Cardiovascular complication, less severe | 0.0027** | -0.0176** | 0.0001** | -0.0014** | 0.0000** | -0.0001 | 0.0001** | 0.0045** |
| Cerebrovascular complication, less severe | -0.0004** | 0.0014** | -0.0010** | -0.0015** | 0.0000 | 0.0000 | 0.0000 | 0.0003** |
| Lower extremity complication, less severe | 0.0039** | -0.0036** | 0.0007** | -0.0014** | 0.0050** | -0.0113** | 0.0006** | 0.0007* |
| Renal complication, less severe | 0.0424** | -0.0246** | 0.0023** | -0.0020** | 0.0032** | -0.0030** | 0.0352** | -0.0258** |
| Ocular complication, less severe | 0.0001* | -0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001** | 0.0023** |
| Insulin dependence | 0.0036** | -0.0143** | 0.0009** | -0.0047** | 0.0003** | -0.0016** | 0.0000 | 0.0059** |
| Charlson index | 0.0017** | 0.0043** | 0.0010** | -0.0041** | 0.0002** | -0.0010* | 0.0001** | 0.0035** |
| Hypertension | 0.0051** | 0.0041* | 0.0048** | -0.0071** | 0.0003* | 0.0004 | -0.0007** | -0.0038** |
| Lipidemia | -0.0140** | 0.0361** | -0.0031** | 0.0095** | -0.0016** | 0.0024** | -0.0021** | 0.0020* |
| Obesity | 0.0070** | 0.0017* | 0.0005 | -0.0003 | -0.0005** | 0.0006** | -0.0005** | 0.0006* |
| Age 70–74 | -0.0002** | -0.0024** | -0.0001** | -0.0012** | 0.0000 | -0.0002 | 0.0001** | -0.0013** |
| Age 75–79 | -0.0005** | -0.0040** | -0.0002** | -0.0014** | 0.0000 | -0.0004** | 0.0001** | -0.0021** |
| Age 80–84 | 0.0001** | -0.0032** | 0.0001** | -0.0022** | 0.0000 | -0.0003* | 0.0000** | -0.0024** |
| Age 85+ | 0.0040** | -0.0034** | 0.0011** | -0.0022** | 0.0001 | -0.0007** | -0.0008** | -0.0037** |
| Male | -0.0001** | -0.0046** | 0.0000 | -0.0005 | 0.0001** | -0.0017** | 0.0000** | 0.0006 |

|  | CHF and/or AMI | Stroke | Amputation | ESRD |
|---|---|---|---|---|
| Black | 0.0002 [**] | 0.0016 [**] | −0.0001 [**] | −0.0003 | −0.0001 [**] | −0.0007 [**] | −0.0001 [**] | 0.0023 [**] |
| Hispanic | −0.0005 [**] | 0.0002 | −0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0001 | 0.0004 [**] |
| Other | 0.0002 | −0.0010 [**] | 0.0003 [**] | −0.0005 [**] | 0.0002 [**] | −0.0004 [**] | 0.0002 [**] | 0.0003 [*] |
| Intercept |  | −0.0201 [**] | 0.0047 [**] | 0.0081 [**] | 0.0063 [**] |

[**] p 0.01;

[*] p 0.05

[1] Sample size was 289,443 in 2012 and 152,191 in 1992