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Gaps in Receipt of Regular Eye Exams among Medicare Beneficiaries Diagnosed with Diabetes or Chronic Eye Diseases

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Abstract

Objective—To examine a wide range of factors associated with regular eye exam receipt among elderly individuals diagnosed with glaucoma, age-related macular degeneration, or diabetes mellitus (DM).

Design—Retrospective analysis of Medicare claims linked to survey data from the Health and Retirement Study (HRS).

Participants—The sample consisted of 2,151 Medicare beneficiaries who responded to the HRS.

Methods—Medicare beneficiaries with at least 1 of the 3 study diagnoses were identified by diagnosis codes and merged with survey information. The same individuals were followed over 5 years divided into 4 15-month periods. Predictors of the number of periods with an eye exam evaluated were beneficiary demographic characteristics, income, health, cognitive, and physical function, health behaviors, subjective beliefs about longevity, the length of the individual's financial planning horizon, supplemental health insurance coverage, eye disease diagnoses and low vision/blindness at baseline. We performed logit analysis of the number of 15-month periods in which beneficiaries received an eye exam.

Main Outcome Measures—The primary outcome measure was the number of 15-month periods with an eye examination.

Results—Only one third of beneficiaries with the study's chronic diseases saw an eye care provider in all 4 follow-up periods despite having Medicare. A quarter only obtained an eye exam at most during 1 of the 4 15-month follow-up periods. Among the 3 groups of patients studied, utilization was particularly low for persons with diagnosed DM and no eye complications. Age, marriage, education and a higher score on the Charlson index were associated with more periods with an eye exam. Male gender, being limited in Instrumental Activities of Daily Living at baseline, distance to the nearest ophthalmologist, and low cognitive function were associated with a reduction in frequency of eye exams.

Conclusions—Rates of eye exams for elderly persons with DM or frequently occurring eye diseases, especially for DM, remain far below recommended levels in a nationally representative sample of persons with health insurance coverage. Several factors, including limited physical and

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cognitive function, and greater distance to an ophthalmologist, but not health insurance coverage, account for variation in regular use.

Regular eye exams for persons diagnosed with diabetes mellitus (DM) or chronic eye diseases are important for detecting potentially treatable vision loss. Monitoring, surveillance, and evaluation of visual health are widely recognized as prerequisites for effective, accessible, and high quality individual and population-based health services.[1]

Lack of health insurance coverage has been cited as a reason for underutilization of eye care services,[2–6] and government-mandated insurance coverage for such services has been recommended.[3] However, in spite of universal coverage for eye care services in Medicare, especially among persons diagnosed with chronic conditions of the eye and chronic conditions leading to eye complications, such as DM, many elderly persons in the U.S. fail to obtain regular eye care.[7]

Previous studies have identified gaps in use of eye care. A study of longitudinal rates of annual eye exams of Medicare beneficiaries with diagnoses of DM, glaucoma, and age-related macular degeneration (AMD) using Medicare claims data from the 1990s reported that only 50–60% of beneficiaries diagnosed with DM had eye exams in a 15-month period.[7] Of those followed for a least 75 months after a DM diagnosis, about three quarters had 1 or more 15-month gaps in exam receipt during follow-up. Receipt of regular eye exams was more frequent among beneficiaries with a glaucoma diagnosis. Among beneficiaries diagnosed with AMD, regular receipt was somewhere between rates for glaucoma and DM. That study did not analyze reasons for differences in rates of receipt of regular eye exams.

Other research has assessed eye care utilization among persons at high risk for vision loss and reasons for lack of use.[2] Factors considered in previous studies as possibly responsible for lack of use have included black race and Hispanic ethnicity,[8–11] lower literacy levels, and lower educational attainment, lack of health insurance[3] and geographic access barriers.[7, 12–16]

Although there have been studies on the utilization of eye care[12, 17] there is ample room for expanding the current state of knowledge on the subject. Existing studies often fail to use multivariate analysis, or include explanatory variables that are likely to be proxies for more fundamental reasons for underutilization. For example, educational attainment, measured by the number of years of schooling completed, may be a proxy for innate cognitive function, a greater propensity to consider long-term consequences of present decisions, and the value the individual attaches to the benefit of improved vision. Some individuals, particularly elderly persons, may not place a high value on benefits from treatment likely to occur in the distant future since their own expected longevity is short and they have other chronic conditions to be treated.

Much of the previous empirical analysis of utilization of eye care services has relied on cross sectional data with a look-back period of a year.[3] However, gaps in utilization can only be accurately measured when examined over a longer time period with longitudinal data. The underlying concept is receipt of regular eye care, not whether or not the person had a visit in the time span of a year.

Often reports of use and diagnoses have been from patients. There is evidence that self-reports tend to overestimate utilization of vision care.[18, 19] Actual diagnoses and reports of receipt of diagnostic and therapeutic procedures are likely to be more reliable.[18, 19] Having a better understanding of the impediments to receipt of regular eye exams is a first step in the design of effective interventions to improve the situation.

Using longitudinal data from the Health and Retirement Study (HRS) merged with Medicare claims data, this study documented gaps in the receipt of regular eye exams and assessed the roles of a broad range of determinants of regular receipt of eye care exams over a 5-year follow-up period. Medicare beneficiaries included in our study entered the analysis sample with a diagnosis of DM, glaucoma, or AMD recorded as of the baseline year 1998, 2000, or 2002. HRS interviews conducted in 1998, 2000, and 2002 provided information on personal attributes of the beneficiary; claims data provided diagnostic information and evidence on frequency of eye exams during follow-up.

METHODS

Data

The Health and Retirement Study (HRS) collects data on income, employment, health insurance, physical and cognitive function, and health-related behaviors. Survey responses from HRS were merged with Medicare claims data using a cross-walk file provided by HRS. Both the cross-walk file, needed to link personal identifiers from the HRS with Medicare claims, and the claims data were obtained from the Centers for Medicare and Medicaid Services on a restricted use basis.

The HRS is a national longitudinal data fielded every other year starting in 1992. Originally, HRS surveyed persons aged 51–61 and their spouses/partners who could be of any age. By 1998, persons in the 51–61 age range were 57–67. In 1998, the Aging Dynamics of the Oldest-Old (AHEAD), a survey of persons aged 70+ in 1993, conducted in 1993 and 1995, was combined with the HRS. We used data from Medicare Part B claims from 1993–7 for the 1998 baseline, from 1993–9 for the 2000, and from 1993–2001 for the 2002 baselines to identify beneficiaries with the study's diagnoses. We used Part B claims filed by ophthalmologists and optometrists over a 5-year follow-up period to measure eye exam frequency during follow-up. Medicare is a national health insurance program that serves Americans who reside within the geographical borders of the U.S. Most Medicare beneficiaries qualify by being older than 65.

Claims data included information on diagnoses (International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)), procedures (Current Procedural Terminology (CPT-4), Healthcare Common Procedure Coding System (HCPCS)), Center for Medicare and Medicaid Services (CMS) provider specialty codes, and dates of service. Institutional review board approval was obtained for this study from Duke University Office of Research Support.

Sample Selection

We identified individuals diagnosed with AMD, glaucoma, or DM at baseline (Table 1). We excluded individuals under 68 years of age at the baseline date to allow at least 3 years of look-back. Moreover, we excluded individuals enrolled in a Medicare Advantage (MA) plan (private plans available to beneficiaries in Part C in lieu of traditional Medicare plans). The public use claims file did not include claims for care rendered to beneficiaries in MA plans. Finally, we excluded persons who died within 5 years of baseline.

From an initial sample of 10,826, 2,151 individual Medicare beneficiaries satisfied our study's sample inclusion criteria. To measure receipt of eye exams, we created 4 15-month time periods, starting from the baseline year. We used a 15- rather than a 12-month period to allow for unforeseen difficulties in scheduling or attending appointments.[7]

Model Specification

To measure the receipt of eye exams we created a continuous variable ranging from 0, never examined, to 4, examined in all 15-month periods.[7] Eye exams were based on the presence of specific procedure codes or codes for other encounters coupled with specialty codes for ophthalmologists or optometrists (Table 2). Since we sought to measure monitoring and surveillance, rather than the quantify receipt of services, a beneficiary was credited with at most 1 eye exam during a given 15-month period.

We included several categories of factors, measured at baseline, likely to affect receipt of an eye exam as explanatory variables.

Demographic and socioeconomic characteristics of the beneficiary--age, gender, marital status, household income, supplemental insurance to Medicare through either a private insurer or Medicaid, and educational attainment, measured in years of schooling completed, were obtained from the HRS. Older age, female gender, being married, higher household income, having additional insurance, and more years of education were expected to increase frequency of eye exam receipt.[20, 21]

An individual's health and functional status was measured by the Charlson Comorbidity Index as well as the presence of at least one Activity of Daily Living (ADL) or Instrumental Activity of Daily Living (IADL) limitation. We used data on diagnoses and procedures from claims from 1993 to each beneficiary's baseline year to create the Charlson Comorbidity Index value for each beneficiary in the sample. The Charlson Index is a widely-used measure of morbidity and disability conditions.[22] The ADL and IADL limitation covariates came from the HRS. Poorer health and functional status was expected to reduce the probability of eye exam receipt.

The ability and desire of a beneficiary to invest in future health and well-being by utilizing preventive care is likely to be affected by both the cognitive function of the individual as well as his subjective life expectancy. The HRS measured cognitive function as: (1) immediate and (2) delayed word recall; (3) a working memory measure based on serial 7s subtraction (subtracting 7 from 100 5 times, with respondents receiving 1 for each correct subtraction); and (4) a count of correct responses to various questions measuring knowledge,

language and orientation (e.g., date of interview, thing used to cut paper, current U.S. president, counting backwards starting from 20 to 10, etc.).[23] We summed scores from the 4 separate measures. The total score ranged from 0 to 35 with 35 signifying the highest level of cognitive function. Persons with relatively low cognitive function may place a lower value on good vision, e.g., read less often,[24] be less future-oriented or be less able to comprehend the potential consequences of not getting recommended care.[25]

To measure perceived life expectancy, we used information on the subjective likelihood of living another 10 years provided by the HRS. Persons with a short life expectancy have less time on average to experience vision loss from a chronic eye disease and the loss, if it occurs, may be expected to be of shorter duration. Hence, persons with a short-perceived life expectancy would be less likely to decide to have an eye exam.

Beneficiaries are likely to vary in the extent to which they value being healthy. To measure this source of differences in regular eye exam receipt, we constructed a preventive health index and an index for unhealthy behaviors. This index was the sum of binary variables for whether or not an individual reported receiving a cholesterol test and a flu shot, a prostate exam for men, and, alternatively for women, either a mammogram or pap smear in the 2 years before the HRS interview. Adding these 3 variables, the preventive health index ranged from 0 for no preventive exams to 3 for receiving all exams. To construct the unhealthy behavior index, we added binary variables for whether or not the person currently smoked, consumed more than 2 drinks of alcohol per day on average, or was physically inactive (participated in vigorous activities or exercises less than 3 times per week) to form an index of unhealthy behavior with a maximum of 3 affirmative responses.

In addition to the beneficiary's subjective belief about survival, the person's time horizon for considering the costs and benefits of obtaining personal health care services may reflect the time horizon the person uses in making financial decisions. The HRS asked, "In planning your saving and spending, which of the following time periods is most important to you, the next few months, the next year, the next few years, the next 5–10 years, or longer than 10 years?" We created a continuous variable set to 0.25 for individuals answering the next few months, 1 for the next year, 2.5 for the next few years, 7.5 for the next 5–10 years, and 12.5 for 10+ years. The value 7.5 is the mid-point between 5 and 10 years. The values 2.5 and 12.5 years were set at 5-year intervals from 7.5 years. Given that the mean of the analysis sample was 77 years, 12.5 years was a long period for planning purposes for persons in our analysis sample. Individuals with shorter planning horizons should place a lower value on benefits from personal health care services expected to accrue in the distant future, since they are generally more focused on costs and benefits of decisions accruing in the near term.

We used data from the Medicare 5% public use claims file, a nationally representative sample of Medicare beneficiaries, to measure distance in miles between the center of a beneficiary's zip code of residence and the center of the zip code in which the nearest ophthalmologist and the nearest optometrist were located. Individuals living in a zip code with an eye care provider were considered to be 0 miles distant. Based on these calculations, we created 2 binary variables for a beneficiary living more than 20 miles away from the

nearest ophthalmologist and nearest optometrist. Part of the cost of the eye exam is the time one needs to take to get to the provider; therefore beneficiaries living farther from eye care providers face a higher cost of eye exams.

The final category of explanatory variables included indicators for eye-related comorbidities at baseline. DM with no eye-related complications and no other eye-related comorbidities was the omitted reference group. We included binary variables for background diabetic retinopathy, proliferative diabetic retinopathy, glaucoma, cataract, blindness/low vision, and a residual indicator consisting of all diagnosis codes in the "Disorders of the Eye and Adnexa" section of the ICD-9-CM manual not otherwise included above (Table 2).

RESULTS

Only 37 percent of beneficiaries in the sample had eye exams in all 4 periods (Table 3). A quarter of beneficiaries only had 0 or 1 period with exams during the 5-year follow-up period.

Nearly three quarters of beneficiaries in the 0 exam group were diagnosed with diabetes mellitus, a much higher proportion than for glaucoma and AMD groups. Beneficiaries with 0 or 1 period with eye exams during follow-up tended to have lower income, were less likely to have supplemental private health insurance coverage, had lower educational attainment and lower cognitive function. Overrepresented in this group were men, blacks, and beneficiaries with 1 or more IADL limitations.

In multivariate analysis using the ordered logit procedure (Table 4, col. 1), older persons (odds ratio (OR)=1.02: 95% confidence interval (CI): 1.002–1.04), married persons (OR=1.34; 995% CI 1.01–1.79), those with higher educational attainment (OR=1.03; 95% CI=1.004–1.06) and higher values on the Charlson Index (OR=1.03; 95% CI: 1.01–1.06) tended to have more periods with exams. Being male (OR=0.72; 95% CI: 0.60–0.86), having at least 1 IADL limitation (OR=0.72; 95% CI: 0.55–0.95) and living 20+ miles from the nearest ophthalmologist (OR=0.67; 95% CI: 0.45–0.99) were factors associated with fewer periods with eye exams during follow-up.

In terms of magnitude, being married, male gender, being limited in an IADL at baseline, and distance to the nearest ophthalmologist were most important. The odds ratio for educational attainment implies that 5 years of extra schooling led to a 15 percent increase in the odds of eye exam receipt. The odds ratio for men implies a 28 percent reduction in the probabilities of having an exam during follow-up. For distance, beneficiaries who lived in zip codes that were over 20 miles from the nearest ophthalmologist were 33 percent less likely to have eye exams than were those who lived closer to the nearest ophthalmologist. The effect of the Charlson Index was substantially smaller than for the above covariates. An increase of about a third in the Charlson Index, which implies diminished health, would increase the probability of receipt of exams by about 3 percent. Being limited in at least 1 IADL was a much more important barrier to eye exam receipt.

Adding covariates for the eye disease diagnoses eliminated statistically significant results for age, marital status, educational attainment, and the Charlson Index because of multi-

collinearity between beneficiary attributes and the eye disease diagnoses (Table 4, col. 2). However, the odds ratios on covariates for males, IADL limitations, and distance to the nearest ophthalmologist remained statistically significant. The odds ratio for men in the second specification implied a 17 percent reduction in the odds of receipt versus a 28 percent reduction when the eye disease covariates were excluded. By contrast, having an IADL limitation at baseline was even a greater impediment to receipt of an exam in the second specification (38% versus 28% previously). For distance, living 20+ away from the nearest ophthalmologist was even a greater impediment, but the difference between the first and second specifications was smaller than for IADL limitations.

Persons with a diagnosis of glaucoma had the highest probabilities of having exams during follow-up (OR=3.31; 95% CI: 2.78–3.93). This was a 231 percent increase over persons with diabetes mellitus alone, the omitted reference group. Beneficiaries with a diagnosis of background diabetic retinopathy at baseline were 159 percent more likely to have exams during follow-up than were beneficiaries with only a DM diagnosis. The corresponding difference between proliferative diabetic retinopathy and diabetes mellitus was not statistically significant. Beneficiaries diagnosed with dry AMD at baseline were 60 percent more likely to receive eye exams while other persons with an “other” AMD diagnosis at baseline were 34 percent more likely. Two other eye disease covariates associated with increased number of exams were cataracts (OR=2.78; 95% CI: 2.23–3.47) and other eye diseases (OR=1.59; 95% CI: 1.35–1.88). Beneficiaries with 1+ Activities of Daily Living limitations were 38 percent less likely to have eye exams during follow-up.

Only a few results depended on how the dependent variable was defined in sensitivity analysis (Table 5). In particular, cognitive function was only statistically significant in 2 specifications with binary dependent variables: 1 if the beneficiary had 1+ periods with an eye exam and the other when 2+ periods with exams was set to 1. In both cases, a one-unit increase in the cognitive index (out of a maximum of 35) led to a 4 percent increase in the probability of having 1+ or 2+ exams during follow-up. Being male was only statistically when the dependent variable was 1 for persons with 1+ periods with exams and 0 for those with no periods with exams during follow-up. Men were 29 percent less likely to receive eye exams during the follow-up period. The odds ratio for educational attainment was only statistically significant in the regression with the binary dependent variable defined as 2+ periods with exams. However, the results implied that a year increase in years of schooling would increase the likelihood of exam receipt by 2 to 4 percent.

By contrast, having 1 or more Instrumental Activities of Daily Living limitations at baseline made it less likely that the beneficiary would have eye exams during follow-up: for 1+ exams (OR=0.53; 95% CI: 0.33–0.84); 2+ (OR=0.67; 95% CI: 0.46–0.98); and for 4 periods with exams during follow-up (OR=0.57; 95% CI: 0.39–0.83). Results for 3+ periods with exams were similar in magnitude, but statistically insignificant.

Greater distance to the nearest ophthalmologist, which was not statistically significant when the dependent variables were binary variables for 1+ and 2+ periods with exams, was an impediment to regular receipt of exams when the dependent variables were binary variables

for 3+ and 4 periods with exams. The estimated decreases in the probability of having 3+ or 4 periods with exams were 43 and 58 percent, respectively.

With some exceptions (for AMD), results for eye disease diagnosis covariates were consistent across the 4 specifications, which supports the proportionality assumption of the ordered logit analysis. When results on these covariates were not statistically significant, the magnitudes of effect tended to be similar in magnitude to their statistically significant counterparts. Odds ratios for wet AMD were not statistically significant in any of the 4 specifications. Diagnoses of glaucoma, background diabetic retinopathy, cataracts, and other eye diseases implied much larger odds of eye exams than for the reference group, even though the amount of excess varied somewhat by how the dependent variable was specified.

DISCUSSION

Individuals with frequently-occurring chronic eye diseases and diabetes mellitus obtained routine eye exams at far below recommended rates.[26] Roughly one third of beneficiaries included in our analysis were examined by an ophthalmologist or an optometrist in all 4 follow-up periods. About a quarter of the sample only obtained an eye exam at most during 1 of the 4 15-month follow-up periods. All the Medicare beneficiaries in this study had been diagnosed with a disease for which monitoring on a continuous basis is clinically important. Even more noteworthy is that all of sample persons had insurance coverage for vision care, at least through Medicare. Since the beneficiaries were diagnosed with an eye disease at baseline, any limitations on coverage for preventive care would not have applied to these patients. Having supplemental insurance coverage did not affect the number of periods with eye exams in our study.

Greater distance to the nearest ophthalmologist but not to the nearest optometrist was a barrier to regular surveillance. However, this barrier only applied to beneficiaries who had several periods with exams during follow-up. Distance to the nearest ophthalmologist did not explain why some beneficiaries never had exams or only had an exam during 1 of the 4 follow-up periods. One reason for the difference in results between ophthalmologists and optometrists is that the fraction of beneficiaries living more than 20 miles from the nearest optometrist was far lower than for ophthalmologists. Most of the Medicare beneficiaries did not live far from an optometrist or an ophthalmologist.

The low rates of exams during the follow-up period for beneficiaries diagnosed with diabetes mellitus is particularly troublesome. Rates of follow-up for glaucoma were considerably higher than for beneficiaries diagnosed with DM alone. Our observational period largely preceded the introduction of anti-VEGF therapies which occurred in 2006.[27] It is possible that given the introduction of an effective therapy, rates of eye exams would have been higher for beneficiaries diagnosed with wet AMD if our observational period had included more years following 2006.

A unique aspect of the Health and Retirement Study is the inclusion of measures largely missing from other surveys. Such measures include the individual’s cognitive function, subjective probability of living another 10 years, and the financial planning horizon.

However, only cognitive function demonstrated a relationship with the number of periods with exams during follow-up.

While other studies have shown disparities in use by race and socioeconomic status,[8, 28, 29] many of the same covariates provided little explanatory power in our longitudinal analysis of periods with eye exams. In particular, differences in use between blacks and whites were not statistically significant. This result, although unexpected, is not out of line with the current literature as several studies have shown that black race is a statistically significant predictor of eye care use among persons aged 40 – 64 but not 65 or older.[30, 31] Educational attainment primarily made a difference to receipt of eye exams during follow-up in our univariate analysis.

That follow-up care was more likely for beneficiaries with eye diagnoses at baseline is somewhat reassuring. The barrier for beneficiaries with a DM diagnosis but no eye complications at baseline may reflect a lack of awareness that monitoring by an eye care professional is important even before a diabetes-related eye complication is diagnosed.[32] Some beneficiaries in the DM non-eye complication group may have not been diagnosed with a complication because they did not visit an eye care provider prior to baseline.

The growth in Medicare expenditures, both past and projected, has led to substantial pressures for cost containment. Yet if there is overutilization of some forms of care, there is also underutilization, as our findings demonstrate. Previous research has documented that individuals with greater visual impairment are more likely to receive regular eye care.[13, 33] In our study, all beneficiaries with a previous diagnosis of an eye disease were much more likely to receive regular eye exams than were beneficiaries diagnosed with DM only. However, from a policy standpoint, increased adherence to guidelines in the form of regular eye care earlier in the disease progression process is much more potentially cost-effective than adherence among individuals already suffering from visual impairment.[15, 34]

Puent and coauthors[35] documented a link between recent visits to a healthcare professional and receipt of eye care, while others[14, 36] have shown an association between previously diagnosed ocular comorbidities and receipt of eye care. We expanded on these results by identifying an association between individuals receiving preventive care such as habitual cholesterol tests, mammograms, and prostate exams, and receipt of eye exams, but we did not find a statistical relationship. This result suggests that general interventions designed to increase use of preventive care may not encourage persons with chronic eye diseases to receive regular eye exams.

In contrast to earlier studies,[14, 31, 37, 38] we found little positive effect of educational attainment and income on regular receipt of eye exams. The reasons could be that educational attainment and income work through other channels, including higher cognitive function, better health, better awareness of signs and symptoms of poor health, and more comprehensive health insurance coverage, all of which were explicitly measured in this study.

We acknowledge these study limitations. First, we used Medicare claims data, which were designed for payment rather than research purposes. There is a large and growing body of

research in ophthalmology that uses Medicare data.[39, 40] One study showed that administrative coding correctly identified 99%+ of cataract surgeries,[40] which is a reassuring finding. Second, we only considered whether or not a beneficiary had 1+ eye exams in a 15 month period, not how many exams s/he had. A beneficiary could have had 5 exams in 1 period and none in the other 3 periods; such a person would have been coded as having 1 period with an exam. Yet even if an individual were to have had multiple eye visits in a given 15-month period, not having an eye visit for a period of 15 months is a serious gap in care that cannot be explained by scheduling patterns alone. Third, while the case for annual exams reflects an evidence base, exams per se do not guarantee proper receipt of care for individuals with major eye diseases.[41]

In sum, rates of eye exams for individuals diagnosed with diabetes mellitus, age-related macular degeneration, or glaucoma remain below recommended levels in a nationally representative sample of U.S. elderly persons with universal health insurance. Greater distance to an ophthalmologist is a deterrent to regular receipt of eye exams. As treatment becomes more effective for previously untreatable conditions, such as it has for wet age-related macular degeneration, one can expect that older persons with more chronic eye conditions will demand more regular exams, thus placing additional demands on the existing pool of providers.

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Table 1

Summary of Sample Generation Process

	Change in Sample	Sample Size
1. Query HRS-linked claims for beneficiaries with qualifying[a] diagnosis	+10826	10826
2. Drop beneficiaries with first occurrence of qualifying diagnosis after 1998	−5229	5597
3. Drop beneficiaries with no qualifying survey waves	−1188	4409
4. Drop beneficiaries who joined MA plan before end of 5 year follow-up	−803	3606
5. Drop beneficiaries who died before end of 5 year follow-up	−1081	2525
6. Drop beneficiaries younger than 68 at baseline to allow at least 3 years of look-back	−303	2222
7. Drop beneficiaries with missing data	−71	2151
Final Sample Size		2151

[a]Diabetes Mellitus, Glaucoma, Age Related Macular Degeneration

Table 2

List of Condition Codes

Condition	ICD-9CM/CPT-4/HCPCS Code
Diabetes Mellitus	ICD-9: 250.xx
Glaucoma	ICD-9: 365.xx 364.73
Age-related Macular Degeneration, Dry	ICD-9: 362.51
Age-related Macular Degeneration, Wet	ICD-9: 362.52
Age-related Macular Degeneration, Other	ICD-9: 362.5 362.50 362.53 362.57
Background Diabetic Retinopathy	ICD-9: 362.01
Proliferative Diabetic Retinopathy	ICD-9: 362.02
Cataract	ICD-9: 366.xx 379.31 V43.1 V45.6
Low Vision/Blindness	ICD-9: 369.xx or CPT-4/HCPCS: 92392 V26.00 V26.10 V26.15
Other Eye Disease	ICD-9: 360.xx 361.xx 363.xx 368.xx 370.xx-378.xx
Visit with Eye Exam	ICD-9: 16.21 95.02 95.11 95.12 or CPT-4: 65850 65855 65865 65870 65880 65900 65930 66150 66155 66160 66165 66170 66172 66180 66184 66185 66500 66505 66600 66625 66630 66700 66710 66720 66740 66761 66762 67036 67038 67039 67040 67101 67105 67107–67110 67112 67208 67210 67218 67227 67228 67220 67221 76511–76513 76516 92002 92004 92012 92014 92018 92019 92020 92081–92083 92100 92120 92130 92140 92225 92226 92230 92235 92240 92250 92260 92275 92283 92284 92287 or CPT-4: 99024 99025 99201–99205 99211–99215 99241–99245 99251–99255 99261–99263 99271–99275 99281–99285 with either optometrist (HCFA specialty code 41)/ophthalmologist (HCFA specialty code 18) or ICD-9:360.xx-379.xx

Table 3

Summary Statistics

	Full Sample	No Visits	One Visit	Two Visits	Three Visits	Four Visits
Sample Size						
Number of Observations	2,151	257	292	365	447	790
% of Full Sample in Group		11.95	13.58	16.97	20.78	36.73
Binary Explanatory Variables[a]						
Male	36.36	44.75	36.99	**35.89**	**34.00**	**34.94**
Black	11.58	17.12	15.41	**10.41**	**10.29**	**9.62**
Other	2.93	4.67	3.08	3.01	3.13	**2.15**
Married	55.00	52.53	50.68	55.07	54.14	57.85
Widowed	35.29	34.24	38.70	35.34	36.91	33.42
Income > $50k	18.13	12.06	13.36	**18.08**	**21.25**	**20.13**
IADL >0	11.39	18.29	15.07	**12.60**	**12.08**	**6.84**
ADL>0	21.29	24.90	27.05	23.01	21.92	**16.84**
Has Medicaid	12.92	17.12	15.41	13.70	**12.08**	**10.76**
Has Private Insurance Coverage	61.88	52.14	56.85	**65.48**	**61.52**	**65.44**
Distance to Ophthalmologist > 20 miles	3.95	4.67	5.48	5.75	4.25	**2.15**
Distance to Optometrist > 20 miles	0.51	0.78	1.37	0.27	0.45	0.25
Diabetes Mellitus	53.51	73.15	**59.93**	**55.34**	**51.01**	**45.32**
Glaucoma	39.47	14.79	**22.26**	**33.97**	**42.51**	**54.68**
Age-related Macular Degeneration, Dry	15.53	6.23	**17.81**	**12.60**	**15.21**	**19.24**
Age-related Macular Degeneration, Wet	5.39	2.72	4.11	4.93	**6.04**	**6.58**
Age-related Macular Degeneration, Other	27.10	17.51	**24.66**	**29.04**	**29.75**	**28.73**
Background Diabetic Retinopathy	6.83	3.11	3.08	**6.03**	6.49	**10.00**
Proliferative Diabetic Retinopathy	1.72	1.17	0.68	1.10	2.01	2.41
Cataract	82.24	56.03	**73.29**	**84.93**	**87.02**	**90.13**
Low Vision/Blindness	3.67	2.72	4.11	4.93	3.36	3.42
Other Eye Disease	57.23	34.63	**47.60**	**58.36**	**59.96**	**66.08**
Continuous Explanatory Variables[b]						

	Full Sample	No Visits	One Visit	Two Visits	Three Visits	Four Visits
Age at Baseline	77.19 (6.23)	76.56 (6.45)	**77.82 (6.50)**	77.58 (6.45)	**77.55 (6.21)**	76.79 (5.94)
Years of Education	11.29 (3.72)	10.16 (3.73)	10.57 (3.69)	**11.46 (3.59)**	**11.50 (3.68)**	**11.73 (3.71)**
Charlson Index	3.22 (3.01)	3.10 (3.13)	3.27 (3.20)	3.15 (2.91)	3.40 (3.05)	3.17 (2.94)
Preventive Behavior Index	0.64 (1.15)	0.63 (1.10)	0.57 (1.10)	0.63 (1.16)	0.57 (1.13)	0.72 (1.21)
Unhealthy Behavior Index	1.23 (0.74)	1.23 (0.72)	1.30 (0.72)	1.22 (0.74)	1.26 (0.77)	1.19 (0.74)
Cognitive Function Index	21.14 (5.34)	19.61 (5.66)	20.14 (5.83)	**21.56 (5.58)**	**21.34 (5.19)**	**21.64 (4.91)**
Financial Horizon Index	3.44 (3.55)	3.33 (3.59)	3.09 (3.19)	3.81 (3.68)	3.45 (3.55)	3.43 (3.59)
Subjective probability of living 10 more years	42.29 (32.54)	44.20 (34.86)	39.74 (32.54)	40.35 (32.14)	42.96 (32.59)	42.98 (32.03)

[a] % of sample;

[b] Mean (standard deviation)

Note: Summary statistics in bold are significantly different from the “no visits” group at conventional levels.

Table 4

Factors Affecting Receipt of Eye Examinations: Basic Results[a]

	(1) Partial Specification OR [95% CI]	(2) Full Specification OR [95% CI]
Age at Baseline	1.02* [1.002,1.04]	0.99 [0.98,1.01]
Male	0.72** [0.60,0.86]	0.83* [0.68,0.999]
Black	0.85 [0.66,1.10]	0.89 [0.68,1.15]
Other	0.84 [0.52,1.36]	0.87 [0.53,1.42]
Married	1.34* [1.01,1.79]	1.31 [0.98,1.75]
Widowed	1.13 [0.85,1.51]	1.09 [0.82,1.47]
Income > $50k	1.17 [0.94,1.45]	1.17 [0.94,1.47]
Years of Education	1.03* [1.004,1.06]	1.03 [1.00,1.06]
IADL >0	0.72* [0.55,0.95]	0.62** [0.47,0.82]
ADL>0	0.86 [0.70,1.06]	0.87 [0.71,1.08]
Charlson Index	1.03* [1.01,1.06]	1.02 [0.99,1.04]
Cognitive Function Index[b]	1.01 [0.99,1.03]	1.02 [1.00,1.04]
Preventive Behavior Index[b]	1.07 [0.99,1.16]	1.04 [0.96,1.13]
Unhealthy Behavior Index[b]	0.95 [0.85,1.05]	0.95 [0.85,1.05]
Financial Horizon Index[b]	0.99 [0.97,1.02]	0.99 [0.97,1.02]
Subjective probability of living 10 more years[b]	1.00 [1.00,1.00]	1.00 [1.00,1.00]
Has Medicaid	1.15 [0.96,1.39]	1.12 [0.93,1.36]
Has Private Insurance Coverage	1.16 [0.88,1.54]	1.09 [0.82,1.45]
Distance to Ophthalmologist > 20 miles	0.67* [0.45,0.99]	0.63* [0.43,0.95]
Distance to Optometrist > 20 miles	0.78 [0.26,2.33]	1.15 [0.36,3.71]
Glaucoma		3.31** [2.78,3.93]
Age-related Macular Degeneration, Dry		1.60** [1.26,2.02]
Age-related Macular Degeneration, Wet		1.33 [0.93,1.92]
Age-related Macular Degeneration, Other		1.34** [1.11,1.62]
Background Diabetic Retinopathy		2.59** [1.81,3.70]
Proliferative Diabetic Retinopathy		1.25 [0.63,2.47]
Cataract		2.78** [2.23,3.47]
Low Vision/Blindness		0.88 [0.58,1.34]
Other Eye Disease		1.59** [1.35,1.88]

Abbreviations: OR, odds ratio; CI, confidence interval

** p<0.01,

* p<0.05

[a] Ordered logit analysis was used to generate these results

[b] We have controlled for missing values in the index variables

Table 5

Factors Affecting Receipt of Eye Examinations: Sensitivity Analysis[a]

	(1) At Least One Visit OR [95% CI]	(2) More Than One Visit OR [95% CI]	(3) More Than Two Visits OR [95% CI]	(4) Exactly Four Visits OR [95% CI]
Age at Baseline	1.01 [0.98,1.04]	1.00 [0.98,1.03]	0.99 [0.97,1.01]	0.98 [0.96,1.01]
Male	0.71 [0.51,1.00]	0.79 [0.61,1.02]	0.83 [0.66,1.04]	0.91 [0.73,1.14]
Black	1.01 [0.66,1.57]	0.81 [0.57,1.15]	0.82 [0.60,1.13]	0.87 [0.62,1.22]
Other	1.00 [0.46,2.21]	1.06 [0.55,2.03]	0.84 [0.47,1.50]	0.68 [0.36,1.28]
Married	1.49 [0.91,2.43]	1.36 [0.92,2.00]	1.20 [0.85,1.69]	1.16 [0.82,1.66]
Widowed	1.22 [0.74,2.00]	1.09 [0.73,1.61]	1.06 [0.75,1.50]	1.01 [0.70,1.45]
Income > $50k	1.34 [0.85,2.11]	1.33 [0.95,1.84]	1.27 [0.97,1.66]	1.03 [0.80,1.34]
Years of Education	1.03 [0.98,1.09]	1.04* [1.003,1.08]	1.02 [0.99,1.05]	1.02 [0.98,1.05]
IADL >0	0.53** [0.33,0.84]	0.67* [0.84,1.80]	0.71 [0.51,1.01]	0.57** [0.39,0.83]
ADL>0	1.03 [0.70,1.52]	0.90 [0.67,1.19]	0.87 [0.67,1.12]	0.83 [0.63,1.08]
Charlson Index	1.03 [0.98,1.09]	1.03 [0.99,1.07]	1.03 [0.99,1.06]	1.00 [0.97,1.04]
Cognitive Function Index[b]	1.04* [1.01,1.08]	1.04** [1.01,1.06]	1.01 [0.99,1.03]	1.00 [0.98,1.02]
Preventive Behavior Index[b]	1.05 [0.91,1.22]	1.02 [0.91,1.14]	1.01 [0.91,1.11]	1.05 [0.95,1.16]
Unhealthy Behavior Index[b]	1.09 [0.88,1.34]	0.95 [0.81,1.11]	0.96 [0.84,1.09]	0.90 [0.79,1.02]
Financial Horizon Index[b]	1.00 [0.95,1.06]	1.02 [0.97,1.06]	0.99 [0.95,1.02]	0.98 [0.95,1.02]
Subjective probability of living 10 more years[b]	1.00 [0.99,1.00]	1.00 [1.00,1.00]	1.00 [1.00,1.01]	1.00 [1.00,1.01]
Has Medicaid	1.25 [0.89,1.75]	1.18 [0.91,1.53]	1.03 [0.82,1.29]	1.16 [0.92,1.45]
Has Private Insurance Coverage	1.24 [0.77,2.00]	1.23 [0.84,1.80]	0.96 [0.68,1.35]	1.03 [0.72,1.48]
Distance to Ophthalmologist > 20 miles	1.00 [0.46,2.16]	0.92 [0.51,1.64]	0.57* [0.34,0.95]	0.42** [0.23,0.77]
Distance to Optometrist > 20 miles	1.48 [0.24,9.09]	0.63 [0.15,2.66]	1.20 [0.29,5.00]	1.38 [0.25,7.53]
Glaucoma	4.40** [3.01,6.43]	4.00** [3.09,5.17]	3.33** [2.71,4.09]	2.98** [2.44,3.64]
Age-related Macular Degeneration, Dry	2.79** [1.59,4.88]	1.31 [0.94,1.81]	1.58** [1.20,2.09]	1.74** [1.33,2.29]
Age-related Macular Degeneration, Wet	1.36 [0.58,3.14]	1.50 [0.86,2.62]	1.48 [0.94,2.32]	1.33 [0.87,2.05]
Age-related Macular Degeneration, Other	1.56* [1.07,2.29]	1.45** [1.11,1.89]	1.31* [1.05,1.65]	1.21 [0.97,1.52]

	(1) At Least One Visit OR [95% CI]	(2) More Than One Visit OR [95% CI]	(3) More Than Two Visits OR [95% CI]	(4) Exactly Four Visits OR [95% CI]
Background Diabetic Retinopathy	2.91** [1.30,6.49]	3.20** [1.81,5.68]	2.35** [1.53,3.60]	2.45** [1.66,3.62]
Proliferative Diabetic Retinopathy	0.87 [0.23,3.38]	1.39 [0.47,4.12]	1.78 [0.75,4.23]	1.32 [0.61,2.87]
Cataract	3.18** [2.30,4.41]	3.14** [2.39,4.12]	2.42** [1.87,3.15]	2.18** [1.62,2.92]
Low Vision/Blindness	1.06 [0.45,2.50]	0.92 [0.51,1.66]	0.74 [0.45,1.22]	0.90 [0.54,1.52]
Other Eye Disease	1.84** [1.35,2.51]	1.77** [1.41,2.22]	1.50** [1.23,1.83]	1.51** [1.23,1.84]

Abbreviations: OR, odds ratio; CI, confidence interval

** p<0.01,

* p<0.05

[a] Ordered logit analysis was used to generate these results

[b] We have controlled for missing values in the index variables