

Do Routine Eye Exams Improve Vision?

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I. Introduction

Routine examinations serve several potential purposes. During some encounters, patient health may be ascertained to be normal, but patients may receive advice about self-protective activities, which they may implement on their own. In public health terminology, this is often primary prevention, activities that reduce the occurrence or incidence of disease (advice about diet and exercise, protection of eyes from ultraviolet light).¹ For persons with preexisting disease, examinations provide secondary prevention, actions that reduce or mitigate the consequences of existing disease. Screening for existing diseases (e.g., for cancer, diabetes, glaucoma) can lead to earlier and more timely treatment and hence better outcomes than would occur without a therapeutic intervention. Tertiary prevention involves actions that reduce harm from existing chronic disease (e.g., laser therapy for visual complications of diabetes). Examinations allow for monitoring the course of the disease and permits proper choice and timing of therapeutic interventions.

Although regular exams are recommended under a variety of circumstances, the supporting empirical evidence documenting the productivity of exams in terms of

¹ See Kenkel (2000) for further discussion of types of prevention and for economic evidence on determinants of preventive activity.

particular health outcomes is meager.² Further, if such exams are productive at the margin, for a variety of conditions, it is a stylized fact that persons fail to visit their physicians regularly (Lee et al. 2002).

There are many possible reasons why persons do not demand such care. First, because therapeutic care is covered by health insurance, persons with such insurance may demand too little preventive care. Although a theoretical possibility, there is little direct empirical evidence on this (Kenkel 2000). A related reason is that preventive care may not be as well covered as is therapeutic care. For example, Medicare does not cover regular eye exams unless justified by a diagnosis. Yet many of the therapeutic interventions are covered.

Second, there is controversy among professionals about the scientific basis for particular guidelines. Because professional guidelines are recommended by professional organizations, either with financial or professional interests in a high frequency of visits, these guidelines may be stronger than medically necessary.³ Third, optimal care as reflected in professional guidelines does not typically reflect the private cost of obtaining such care. Thus, even if such care is productive at the margin, the guidelines may recommend more care than is socially optimal. Fourth, individual patients and providers may be ignorant of the benefits of such care and hence it is not demanded in optimal amounts.

² A larger question is whether medical care overall is productive. This question has typically be addressed by assessing the impact of variations in insurance coverage on health outcomes. In view of its importance, it is regrettable that there has not been more analysis of this issue. See, e.g.: Newhouse and the Insurance Experiment Group (1993), Cutler and Berndt (2001); Lichtenberg (2002).

³ This problem is not unique to professional guidelines and it applies to most service industries. For example, car dealers recommend maintenance visits for cars that are more frequent than those recommended by the manufacturers.

Fifth, care may be productive for some and not for others, and the guidelines cannot adequately account for patient heterogeneity.⁴ There is plausibly heterogeneity in both cost and benefit, only some of which is observed by the researcher. One source of heterogeneity is in competing risks of various threats to health (Dow et al. 1999). For example, many elderly men with prostate cancer die from a disease other than this cancer. Having a terminal disease affects the probability that a person will develop diabetic retinopathy or suffer harm to vision from glaucoma.

In principle, the productivity of preventive care, of which regular routine eye examinations are only one type, could be ascertained by a randomized controlled trial (RCT). However, RCTs are expensive, are difficult to run for lengthy time periods, are subject to ethical constraints, such as concerning denial of potentially beneficial care, are subject to various biases such as from sample selection (although randomly assigned to treatments, subjects in RCTs are volunteers) and attrition (Philipson and Hedges 1998), and often are typically conducted on a population limited geographically, by race, gender, or in some other respect. Finally, conditions in an RCT may not be replicated in the general population and for this reason, findings from RCTs may not generalize. However, in observational studies, the amount of preventive care demanded is potentially endogenous to health status.

In this study we analyzed empirically if routine eye exams lead to better vision. Specifically, using a longitudinal national sample of claims submitted on a nationally representative sample of Medicare beneficiaries drawn for purposes of the National Long Term Care Survey (NLTC) and data from the NLTC, we investigated whether annual eye exams during a five-year period (1994-98) have a significant effect on the ability to

⁴ This list does not exhaust the possibilities. People may be myopic or time inconsistent.

read newsprint with or without eyeglasses and on the probability of being diagnosed with low vision or becoming legally blind over about the same period (1994-99). Not being able to read newsprint may lead to other adverse consequences (Lee et al. 1999), but is not as disabling as low vision or blindness. Persons with low vision require devices to substantially magnify nearby objects (Harvard Medical School 2001).

The difficulty of using observational data to measure productivity of care is that such care is likely to be endogenous to the person's underlying health in ways not observed by the researcher. Our econometric strategy accounts for the endogeneity of eye doctor visits.

The rest of this study is organized as follows: Section II provides some background on practice guidelines for diabetes and major eye diseases. Section III presents a conceptual framework to guide our empirical specification. Section IV discusses our econometric strategy, Section V, data and empirical specification, and Section VI, our results. Section VII presents our conclusions.

II. Practice Guidelines

Practice guidelines for elderly persons vary depending on risk factors, current eye diseases, and the issuing source. On one hand, the American Academy of Ophthalmology recommends that all individuals age 65 and older have an eye exam every one to two years. On the other hand, the American Optometric Association recommends annual eye exams for persons age 61 and older. Both recommend more frequent exams for persons with specific risk factors, such as a family history of eye disease. For persons with specific diagnoses, such as diabetes, glaucoma, and age-related macular degeneration (ARMD), multiple professional organizations recommend annual exams. Visual complications from these diseases occur after a long latency period during

which affected persons experience no symptoms. For this reason, and because some early and effective treatments exist, it would appear that regular examinations may be productive. Some evidence from RCTs supports the view that certain therapies are effective (Johnson and Kurtz 2002), but there is no direct evidence from RCTs on effects of screening intervals on visual health (Vijan et al. 2000 for diabetes). However, as already noted, in spite of the evidence, there are several reasons for concluding that regular exams may not be optimal. Also, some professional organizations have financial and other incentives to recommend that people demand their services.⁵

Several diseases of the eye, common among elderly individuals, such as diabetic retinopathy or glaucoma, are characterized by a long latency period. Thus, for these illnesses timely eye exams may be productive and professional guidelines recommend visits to an ophthalmologist or an optometrist annually (American Academy of Ophthalmology 1998, 2000, 2001; American Diabetes Association 2002). However, as with many other professional guidelines, there is controversy surrounding the recommended frequency of exams (Vijan et al. 2000).

III. Conceptual Framework

Assume that the individual lives for two periods. In the first, she decides to visit an eye doctor regularly, occasionally, or never. Unlike health care use, following an acute health shock, such as admission to a hospital for a heart attack, for which the individual and the researcher observe the health shock, eye doctor visits often precede an observable health shock. However, by allowing for a timely therapeutic intervention, a timely eye doctor visit may prevent future health shocks. In the second period, the health shock is

⁵ But in addition, the National Committee for Quality Assurance, through HEDIS measures uses regular eye exams as a measure of quality in all patients with diabetes. See National Committee for Quality Assurance (1997).

revealed and the individual gains utility from her vision. Individuals who visit an eye doctor regularly should be less likely to suffer a vision shock leading to visual impairment than those with occasional visits or those who never visit.

Formally, assume that in period 1, an individual is endowed with a stock of vision V_1 , which depreciates to $\rho(M_1)V_1$ in period 2. M_1 is a discrete variable indicating the degree of compliance with professional guidelines by the individual, in this context measured by the regularity of visits.⁶ In logarithms, the level of vision in period 2 is $\ln V_2 = \ln \rho(M_1) + \ln V_1$

and

$$\ln \rho(M_1) = X' \beta + u + \gamma(u)M_1 + \varepsilon_1,$$

where X is a vector of observable characteristics affecting depreciation of vision, u is an unobservable shock to vision ($u \leq 0$), ε_1 is a normally distributed random term independent of X and u . The marginal product of visits in terms of vision stock is a function of the unobservable shock. In particular, we assume that $\gamma(0) = 0$, $((\partial \gamma(u)) / (\partial |u|)) > 0$, and $|u| > \gamma(u) \max M_1$ for all u .

The change in vision stock is given by

$$\ln V_2 - \ln V_1 = X' \beta + u + \gamma(u)M_1 + \varepsilon_1 \quad (1)$$

Because $\gamma(u)$ is a function of u , we can only identify $\gamma^* = E_u[\gamma(u)]$. We call this coefficient the average partial effect.

⁶ In our empirical analysis, M_1 equals five if the individual visits an eye doctor at least once each year during a five-year period. M_1 equals four if the individual has four yearly visits during a five-year period and so on.

Individuals are not randomly assigned to different levels of M_1 , but they rationally choose the level of M_1 . The individual maximizes the following utility function

$$U(C_1, V_2, M_1) = \alpha_1 \ln C_1 + \alpha_2 \ln V_2 + \alpha_3 M_1$$

subject to the budget constraint

$$P_c C_1 + P_m M_1 = W,$$

where C_1 represents consumption of other goods, W represents wealth, α_1 , preferences for consumption, α_2 , preferences for vision, α_3 , non-monetary costs associated with a doctor visit. P_c and P_m are the money prices of consumption and visits.

To find the optimal level of M_1 , assume that u is observed by the individual but not the researcher.⁷ Let $P_c = 1$ and substitute C_1 and V_2 from the budget constraint and health production function into the utility function:

$$U(M_1) = \alpha_1 \ln(W - P_m M_1) + \alpha_2 \ln \rho(M_1) + \alpha_3 M_1.$$

The individual increases the number of visits until the marginal cost of the last visit equals marginal benefit of that visit. The marginal cost of a visit is given by:

$$MC(M_1) = \alpha_1 [\ln(W - P_m M_1) - \ln(W - P_c(M_1 - 1))] + \alpha_3$$

and the marginal benefit by

$$MB(M_1) = \alpha_2 [\ln \rho(M_1) - \ln \rho(M_1 - 1)] = \alpha_2 \gamma(u)$$

Thus, marginal benefit depends on the unobservable health shock u . Individuals with a higher subjective probability of a vision shock are more likely to visit an eye doctor regularly. This will create a negative bias in equation (1) if one does not control for the endogeneity of visits and we may erroneously conclude that visits are not productive.

⁷ Although the individual may not observe u perfectly, she is likely to know much more than the researcher about the distribution function of u .

The previous discussion suggests potential instruments for estimating equation (1): monetary prices of visits; variables correlated with preferences for vision (e.g. expected longevity); and variables correlated with the non-monetary cost of visits (e.g. distance to eye doctor).

Let Z be a vector of variables correlated with α_2 and α_3 , but uncorrelated with u . The linear projection of eye doctor visits M_l on P_m and Z is

$$L(M_l|I, P_m, Z) = \delta_0 + \delta_1 P_m + \delta_2 Z \quad (2)$$

IV. Econometric Strategy

Our goal was to estimate equation (1) using a random sample $\{Y_i, X_i, M_{li} : i=1, \dots, n\}$ and accounting for potential endogeneity of M_{li} . We did not observe the dependent variable in equation (1), but rather a binary variable, Y_i , that equaled one if the individual has worse vision than in the base period and was zero otherwise. If ε_i follows a normal distribution, then our problem was to estimate a probit model with a potential endogenous explanatory variable.

We estimated equation (1) using Amemiya's generalized least squares (AGLS) estimator discussed in Newey (1987). This estimator is the AGLS counterpart to the two-step estimator proposed by Rivers and Vuong (1988). If M_{li} is normally distributed, the AGLS estimator is consistent and asymptotically efficient (Newey 1987). The AGLS estimator is obtained by applying probit estimation to the following reduced form equation

$$y_i^* = \pi_1 X_i + \pi_2 Z_i^* + \lambda \hat{v}_i + \eta_i$$

where Z^* includes the variables included in equation (2), but not X , and then solving back via a generalized least square estimator.

We performed several specification tests. First, we tested for the endogeneity of M_{1i} using the exogeneity test proposed by Rivers and Vuong (1988) and Smith and Blundell (1986). We implemented this test by estimating equation (1) using probit models and adding a consistent estimate of the disturbance from equation (2) as an additional explanatory variable. If the coefficient associated with the predicted disturbance was different from zero, we concluded that M_{1i} is endogenous. We estimated the joint significance of our instruments using an F-test from the first-stage regression.

V. Data and Empirical Specification

Data

Data for this study came from three principal sources: (1) Medicare claims, which provided information on eye exams, (2) a Medicare vital statistics file, which provided exact dates of birth and death, and a non-survey source of gender and race data; and (3) 1994 and 1999 waves of the National Long-Term Care Survey (NLTC). The Medicare claims and vital statistics files were on a nationally representative sample of Medicare beneficiaries. A subset of persons from this file was also interviewed by the NLTC.

The NLTC, sponsored by the National Institute of Aging and conducted by the Duke University Center for Demographic Studies, is a longitudinal study conducted in 1982, 1984, 1989, 1994, and 1999. The NLTC data files include 41,947 elderly individuals randomly sampled from Medicare enrollment records. Until 1994, the selection criterion for a full NLTC interview was that the respondent have at least one limitation in activities of daily living (ADL) or in instrumental activities of daily living (IADL). ADL limitations involve needing help with such basic personal tasks as eating and bathing. IADL limitations include needing help with such tasks as balancing a checkbook and with shopping. In 1994 and 1999, some elderly persons without ADLs or

IADLs were also interviewed. Presence of ADLs and IADL limitations were determined during a screener interview, which also collected some basic demographic information on the individual.

Over 25,000 individuals were first screened in 1982 or 1984. These individuals were followed at five-year intervals through 1999 or time of death. To maintain a consistent sample size for purposes of screening more than 20,000 at each wave, new beneficiaries were drawn from the Medicare population at each of the 1989, 1994, and 1999 follow-up waves. Persons in the refreshment sample were aged 65-69 to keep the sample representative of the 65-and-older population.

The Medicare claims data, available on beneficiaries who were not screened, those screened but who did not receive a full interview, and on those who received full interviews, were merged with NLTCs data for persons on whom screeners or full interviews were obtained. For purposes of this study, the relevant claims files were physician Part B (carrier), outpatient, and durable medical equipment (DME) files. The claims included detailed information on diagnoses, services and procedures, and amounts billed and paid by Medicare.

We excluded observations on persons who died before 1994, the beginning of our observational period for this analysis, individuals less than age 65 at the beginning of 1994, and persons who died between 1994 and 1999 for whom we could not observe eye exams and visual status for the entire period, yielding a total eligible sample consisting of 15,480 individuals.

For the analysis of low vision or blindness, we also removed individuals who had low vision or were legally blind at the beginning of 1994, yielding an analysis sample of

15,425.⁸ Only non-institutionalized individuals (NLTCs respondents not in nursing homes) were administered the full NLTCs community survey, which asked about ability to read newsprint. For this analysis, we required that individuals have received the full interview in both years and were able to read newsprint with or without glasses in 1994, yielding a sample of 2,053 observations.

Empirical Specification

Dependent Variables: The dependent variables were: (1) a binary variable for the ability to read newsprint in 1999 conditional on being able to read newsprint in 1994; and (2) a binary variable for low vision and/or blindness during 1994-99, conditional on not having these conditions at the start of 1994. The two measures capture the full spectrum of visual decline, from lesser impairment (inability to read newsprint) to severe impairment (blindness).

Our measure of reading came from an NLTCs community survey question: "Do you normally see well enough to read ordinary newsprint, with or without glasses or contact lenses?" Although the data were only available on a subsample of the Medicare beneficiaries sampled, this variable had two important advantages. First, this measure was not based on diagnosis codes from Medicare claims, but rather from self-reports of the individuals themselves. Measures of disease prevalence based on claims are subject to ascertainment bias. Persons who do not visit a physician do not obtain Medicare diagnoses. Second, the ability to read newsprint measures a much more common but less serious degree of visual impairment than does low vision or blindness.

Analysis of low vision and legal blindness was based on codes in Medicare claims between 1994 and 1999. These measures capture a much more severe degree of

⁸ For a description of clinical criteria for legal blindness, see Lennie and Van Hemel (2002).

impairment than inability to read newsprint. We obtained information on low vision and legal blindness for both Part A and B claims, although visits were only measured from physician Part B and outpatient records. The probability of onset of these conditions is low—0.015 over 1994-99 for the sample as a whole and the measures are subject to ascertainment bias.⁹ We have reduced such bias by observing claims over a five-year period, looking for diagnostic information on all Medicare claims, and treating visits as endogenous; 29.5 percent of our sample did not have an exam during the five-year period, 1994-98.¹⁰ The percentages were much lower in samples of persons diagnosed with glaucoma (7.1%), cataract (11.6%), ARMD (9.1%), and diabetes (19.2%) by the beginning of 1994.¹¹ Blindness was defined by ICD-9-CM diagnosis codes indicating legal blindness, a functional definition indicating 20/200 vision or worse in the better eye. Low vision, or uncorrectable visual impairment, was defined by procedure codes indicating the supply of low vision aids, large magnifying devices that enable individuals with low vision to read or view certain materials.

Eye Exams: Our main explanatory variable was a count of the number of years in which the person obtained an eye exam in five 12-month periods between 1994 and 1998. By treating each year separately, we measured routine eye care and avoid confounding the variable with follow-up visits for treatment of eye disease, which may have involved many visits within a year. We did not include visits in 1999 because the year was only partially observed by NLTCs and to allow for a lag between visits and outcomes.

⁹ In total, the proportion of Medicare beneficiaries who had low vision or were blind in 1999 was 1.5%.

¹⁰ Medicare did not cover dilated eye exams, part of a full checkup on the state of an individual's eyes, unless the claim contained a diagnosis of an eye condition of some sort or a diagnosis implying a higher propensity to have an eye disease, such as diabetes.

¹¹ 19 persons who had no visits during 1994-98 had an onset of low vision or blindness during 1994-99. Of the 19, 9 were identified from Part A claims only. One person was identified from Part B only. The others were identified from both Part A and B claims, but the visit code did not match the codes for eye exams.

Other Explanatory Variables: Several variables are likely to be associated with depreciation of vision. We controlled for demographic characteristics, age, gender, and race, and educational attainment, general health, measured by the DxCG score, and cognitive status, measured by a diagnosis of dementia. Various eye diseases occur at higher frequency at higher age, and vary by gender, and race (Klein et al. 1984; Klein et al. 1988; Klein et al. 1992; Mason et al. 1989). We included binary variables for males, blacks, Hispanics and persons of other race, with white non-Hispanics the omitted reference group, and binary variables for diabetes and for each of the three major eye diseases, cataract, glaucoma, and ARMD, measured as of the beginning of 1994.

Education was measured as the number of years of schooling completed. There is a large literature documenting a positive relationship between health and education (see e.g., Kenkel 2000). The mechanisms underlying the link between education and health are not well understood. More educated persons may be more efficient in producing health (Grossman 1972) or may be less impatient (Fuchs and Farrell 1982; Becker and Mulligan 1997). There are many channels through which education may affect efficiency in health production, the relative importance of which is unknown. More educated persons may be more knowledgeable of the objective probabilities of disease onset and the health production function parameters (even though here, learning about them is the object of our study). They may be better able to project utility in a bad state of health—in our context, what it is like not being able to read or to be blind or nearly so. In addition, more educated persons may place a higher valuation on having good near vision to the extent that they place gain higher utility from reading. Persons with severe cognitive impairment are also likely to value near vision and perhaps vision in general less highly. We included a binary variable for persons who had been diagnosed with dementia by the

beginning of 1994. Both education and dementia are more clearly determinants of visits than of visual status, but because of the complexity of the underlying relationships, we included these variables as determinants of change in visual status as well.

A general measure of health, the DxCG score, accounted for variation in general health at baseline. This score was based on all diagnosis and procedure codes in Part A and B claims data and is designed to predict a person's health care resource use (Ellis et al. 1996). To compute the DxCG score for sample persons in our study, we excluded all vision-related diagnoses and procedures. We measured the score at the beginning of 1994, based on diagnostic and procedure codes on claims for 1993. We included binary variables for persons diagnosed with diabetes, cataract, glaucoma, and ARMD as of this date as well.

We included a variable for the number of months during the the five-year period that the person was enrolled in a Medicare HMO. This variable served two purposes. First, Medicare claims data do not measure utilization for beneficiaries enrolled in HMOs. Thus, while the person was in an HMO, we could not observe either visits or onset of low vision or blindness. Second, healthier beneficiaries are more likely to enroll in HMOs.¹² During the whole study period, 5.5 percent of sample persons were enrolled in a Medicare HMO.

Instruments: In previous sections, we argued that potential instruments for eye doctor visits were variables that affected the monetary price of eye doctor visits, variables associated with the disutility of an eye doctor visit (e.g. transportation costs), and variables associated with preferences for vision and/or time preference (e.g. expected

¹² See Cutler and Zeckhauser (2000) for a review of this literature.

longevity). Such variables affect demand for care but do not appear in the health production function.

Although we could not measure the money price that the patient paid, this amount is plausibly correlated with health insurance coverage. First, many beneficiaries have supplemental insurance policies (“Medigap” insurance) to cover out-of-pocket cost that remains after Medicare pays its share. We included a binary variable for persons who had such insurance in 1994. This variable came from the NLTCs. When the variable was missing, we set Medigap to zero and set a variable for “Medigap missing” equal to one. This was our general procedure when we had missing values from the NLTCs. Second, we included a variable for the number of months during the year that the person was enrolled in Medicaid, information available from the claims. Medicaid covers much of the expense that Medicare does not cover. In contrast to Medigap, the Medicaid variable measured Medicaid coverage for each month of the entire observational period (values ranged from zero to 60).

We included two proxies for transportation cost. First, we measured density (1) of optometrists and (2) of ophthalmologists in 1994 in the Primary Sampling Unit (PSU) in which the person resided (number per 100,000 population). A PSU (N=173) was a Standard Metropolitan Statistical Area (SMSA) for persons who lived in metropolitan areas and a small group of neighboring counties for residents of non-metropolitan areas. We matched PSU counties to the U.S. Census's County Business Patterns to measure the number of optometrists by county. Ophthalmologists and an urban-rural dummy were obtained by matching PSU counties to the Bureau of Health Professions' Area Resource File.

For the probability of two-year mortality, we used data from the Medicare vital statistics file for dates of death, merged with data from claims and from the NLTCs interviews. The dependent variable was one if the person died within a two-year time interval and was zero otherwise. Explanatory variables (with signs on parameter estimates in parentheses) were: age (+); male gender (+); years of education (-); dementia (+); number of ADL limitations (+); DxCG score (+); black (-); Hispanic, other race (-); self-reported health fair or poor (+); and hospitalized in last two years (+). The R-squared was 0.17 with all parameter estimates significant at the better than the one percent level. Dropping ADL limitations and self-reported health had little effect on the parameter estimates on the other variables and no effect on the signs.

In addition to the instruments, the visits equations contained all of the explanatory variables in the main equations.

VI. Results

Loss of reading ability is a common outcome among the elderly (Table 1). Frequencies ranged from a low of 14.2 percent for the full sample to a high of 25.9 percent for persons diagnosed with macular degeneration (ARMD) before 1994. In view of the ages of persons in the sample, these findings are not surprising.¹³

Including those using low vision aids, blindness/low vision incidence over the five years ranged from a low of 1.5 percent for the entire sample to 4.5 percent for the ARMD sub-sample. Macular degeneration is a progressive disease, with no generally effective treatment during the observational period.

¹³ See Lennie and Van Hemel (2002) for a review of epidemiological evidence on prevalence of low vision and blindness as a function of age.

Characteristics were similar for both samples (Table 2). The mean age was 76. On average, persons received exams in slightly more than two of the five years.

In the probit analysis for the ability to read newsprint, which does not account for endogeneity of number of years with visits, the coefficient on the variable for number of visits with eye exam visits is positive and insignificant (Table 3). But with AGLS (instrumental variables probit), the coefficient on years with eye exams is positive and statistically significant at better than the ten percent level ($p=0.052$) with a marginal effect at the observational means of 0.12, which is a large effect.

For low vision/blindness for the entire sample, with probit, the coefficient on the number of years with eye exams is negative and statistically different from zero, again implying that eye doctor visits are not productive. With AGLS, the coefficient is positive and statistically significant at better than the ten percent level ($p=0.097$) with an associated marginal effect of 0.0098.

With TSLS, coefficients for both reading and low vision/blindness are statistically significant at conventional levels ($p=0.020$ and $p=0.021$, respectively; see Table 4). The implied TSLS marginal effects are somewhat greater than with AGLS.

Most of the results for the other explanatory variables are plausible (Table 3). Older persons were more likely to experience visual decline as were women, those in poor health (high DxCG score), and persons with each of the eye diagnoses. Educational attainment had a positive and insignificant effect for reading and negative and significant for low vision/blindness, but economically unimportant in terms of the associated marginal effect. The parameter estimate for blacks was positive and significant in the reading analysis, but positive and insignificant for low vision/blindness. Visual decline for Hispanics did not differ from whites. The number of months in an HMO was positive

and significant in both analyses, possibly suggesting that HMO enrollees had better visual health in dimensions we could not observe.¹⁴ The marginal effect of being a month in an HMO was essentially zero for low vision/blindness, but larger for ability to read.

Using TSLS, we reject the null hypothesis of exogeneity. Also, our first-stage exclusion restrictions (instruments) are statistically significant in both samples (Table 4).

Table 5 repeats the analysis of blindness and low vision for four disease sub-samples. We only report the coefficients for years with eye exams. With AGLS, the only statistically significant coefficient is for diabetes. The marginal effect on the probability of not having low vision or being blind in 1999 is 0.028 as compared to 0.0098 for the whole sample, suggesting that, for persons diagnosed with diabetes, having regular exams is even more productive than for elderly persons in general. For cataract, ARMD, and glaucoma, the coefficients are insignificant and implied marginal effects are smaller than for diabetes, and for ARMD, larger than for elderly persons overall.

In Table 6, we assess the sensitivity of our findings to the functional form assumption underlying probit. Although probit analysis on the whole sample imposes a restriction that the marginal product declines in the years with exams, we find the opposite. Splitting the samples into persons with 0-2 and 3-5 years with exams, we find that the marginal effect of visits is negative and insignificant in the 0-2 range but positive and insignificant in the 3-5 range. This indicates that regular exams are productive if they occur fairly regularly.

¹⁴ The exposure period was shorter for persons in HMOs, which should have made it harder to observe transitions to low vision or blindness, but this should have had no effect on our ability to observe changes in ability to read since the dependent variable for reading came from the NLTCs.

VII. Discussion and Conclusions

We have examined the productivity of a technology that is at least 200 years old, although the nature of the product, and presumably its effectiveness, has changed appreciably over this period.¹⁵ Although the technology has been around for a long time, there has been no empirical assessment of its effectiveness in a general population.

After accounting for endogeneity, regular eye exams are productive in reducing depreciation of vision. In particular we found that individuals that visit an eye doctor regularly have a lower probability of reading ability depreciation and of developing blindness and low vision. Elderly persons who have no eye exams over a five-year period or visit occasionally realize little or no benefit from such exams. Productivity of exams is realized by persons who obtain exams regularly. We found a statistically significant effect of exams on visual status for persons diagnosed with diabetes, providing empirical evidence for the guidelines specifying regular eye exams for persons with this diagnosis.

The observed productivity of exams suggests that such visits have high marginal benefit. Suppose, for example, that the full cost of an exam to patients is \$50 per unit and having regular visits reduces the probability of low vision or blindness by 0.04, the marginal effect for no blindness and/or low vision in the 3-5 years with exam range. Thus, a \$250 expenditure would be worthwhile if willingness to pay to avoid blindness is at least \$62,500, even neglecting the other potential benefits, such as averting automobile accidents, being able to read the newspaper, watch television, avoid grandchildren's toys on the floor, and so on.

¹⁵ One of the authors (Sloan) comes from a family that has examined eyes since at least 1808. An advertisement in a German newspaper by his great-great grandfather from 1813 advertises eye exams.

We used data from an experimental module of the Health and Retirement Study to measure the value of good vision based on a time-tradeoff question. The HRS asked respondents to describe their vision on a six-point scale from excellent to blind. Holding other factors constant with the dependent variable being whether the person would be willing to trade life years for better health, probit coefficients increased monotonically as vision worsened with most coefficients being statistically significant at conventional levels. For those persons willing to trade off life years for better health, blind persons were willing to give up 1.31 years for better vision, but the coefficient was not statistically significant ($p=0.30$). The coefficients on the other vision variables were smaller in magnitude and even less significant. Nevertheless, overall, this evidence suggests that good vision matters to people.

This raises a question why the sample mean was only two to three years with exams out of five. One possibility is that the Medicare claims data did not include some exams that the Medicare beneficiaries had. In fact, to be covered, the Medicare beneficiary had to have an eye diagnosis or diabetes. But this explanation seems incomplete in that many sample persons with these diagnoses did not have regular exams. Another possibility is that the elderly have a low willingness to pay to avoid low vision and/or the full cost of exams to many elderly is higher than our example implied. On willingness to pay, there is no empirical evidence, although the elderly's willingness to pay to avoid a limitation of activity of daily living is about at the level in our example (Perreira and Sloan 2002). A third possibility is that the elderly are not forward-looking and/or do not know that eye exams are productive. Physician ignorance or other reasons for physician noncompliance with guidelines is still another possibility (see, e.g., Ackermann and Cheal 1994, Drass et al. 1998; and Marrero et al.2000). Given current

evidence, this is a speculation. Certainly, the evidence underlying the professional guidelines appears to leave something to be desired. Whatever reason, lack of compliance with professional guidelines is widespread, including among the elderly (Jencks et al. 2000).

Overall, the study shows the potential of using national data on insurance claims for assessing the productivity of specific medical interventions. Yet, claims data are subject to limitations. First, measures of health status are limited. In our context, the only measure of visual status to be derived from claims is for low vision, measured by Medicare subsidy for visual aids, and blindness. People suffer visual impairments, but do not need expensive magnifiers. Nor are most persons with visual impairments classified as being legally blind. Diagnoses on claims such as for cataract, diabetic retinopathy, glaucoma, or age-related macular degeneration identify persons with major eye diseases, but there is considerable heterogeneity in visual status within these categories (and even the subcategories for each). Data on vision from household surveys are also extremely limited. We used the responses to the only question on vision in the National Long-Term Care Survey. Second, even if a large sample size, we were limited in statistical power to detect effects of exams, especially for persons with any of the major eye conditions.

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