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Changes in Visual Function in the Elderly Population in the United States: 1995–2010

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Abstract

Purpose—To document recent trends in visual function among the United States population aged 70+ years and investigate how the trends can be explained by inter-temporal changes in; 1) population sociodemographic characteristics, and chronic disease prevalence, including eye diseases (compositional changes); and, 2) effects of the above factors on visual function (structural changes).

Methods—Data from the 1995 Asset and Health Dynamics among the Oldest Old (AHEAD) and the 2010 Health and Retirement Study (HRS) were merged with Medicare Part B claims in the interview years and the 2 previous years. Decomposition analysis was performed. Respondents from both studies were aged 70+ years. The outcome measure was respondent self-reported visual function on a 6-point scale (from 6=blind to 1=excellent).

Results—Overall, visual function improved from slightly worse than good (3.14) in 1995 to slightly better than good (2.98) in 2010. A decline in adverse effects of aging on vision was found. Among the compositional changes were higher educational attainment leading to improved vision, and higher prevalence of such diseases as diabetes mellitus, which tended to lower visual function. However, compared to compositional changes, structural changes were far more important, including decreased adverse effects of aging, diabetes mellitus (when not controlling for eye diseases), and diagnosed glaucoma.

Conclusion—Although the US population has aged and is expected to age further, visual function improved among elderly persons, especially among persons 80+ years, likely reflecting a favorable role of structural changes identified in this study in mitigating the adverse effect of ongoing aging on vision.

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Keywords

visual function; decomposition analysis; diabetes mellitus; glaucoma; age-related macular degeneration; US elderly

Introduction

Visual impairment is associated with shorter longevity¹ and lower quality of life.² Elderly individuals with vision impairment are at increased risk of injuries, mobility impairment, being disabled, and depression.^{3–7} The aggregate economic impact of visual impairment and blindness in the United States accounted for \$5.5 billion in added expenditures on personal health care services (2004 value) and a loss of more than 209,000 quality-adjusted life years annually.⁸ Evidence regarding trends in visual impairment among US elderly persons is mixed, with studies based on data before 2000 documenting no change^{9, 10} or reductions^{11, 12} in visual impairment over time, and some studies based on data from the early 2000s showing a minor deterioration^{13, 14} or improvement in vision.¹⁵

Existing studies are largely silent about explaining visual impairment trends in the US elderly population. Disparities in visual function among persons of different race/ethnicity, socioeconomic status, and health behaviors or their effects, such as smoking and body mass index, have been well documented.¹⁶ Age-related macular degeneration (AMD), glaucoma, cataract, and diabetic retinopathy are the most common eye diseases causing visual impairment,¹⁷ and rates of diagnosis of these eye diseases have increased. Yet these trends have not been studied systematically with regard to their effects on vision on a population basis. Investigating how changes in the above factors over time affect visual impairment trends can shed light on interventions likely to be effective in reducing visual impairment prevalence.

This study documents most recent trends in visual impairment among US Medicare beneficiaries aged 70 years and older, and investigates how the trends can be explained by changes in: 1) composition of the US population aged 70+ years measured in terms of demographic characteristics, socioeconomic status, prevalence of chronic diseases (diabetes mellitus, DM, and stroke), and prevalence of the most common chronic eye diseases (compositional changes); and, 2) effects of these compositional characteristics on vision (structural changes). Rather than identifying individuals' eye diseases from patient self-report as most previous studies have done, we ascertained beneficiaries' chronic eye conditions from Medicare claims data.¹⁷ We measured visual function based on patient self-report rather than from claims, since visual acuity is likely to be underreported in claims data, particularly since patient visual acuity is not a basis for payment.

Materials and Methods

This is a cross-sectional study. Data came from the 1995 Asset and Health Dynamics among the Oldest Old (AHEAD), 2010 Health and Retirement Study (HRS), and 1993–5 and 2008–10 Medicare Part B (carrier) claims files merged with the interview data from AHEAD (1993–5 claims) and HRS (2008–10 claims). Both AHEAD and HRS are large, nationally-

representative longitudinal surveys of older adults in the US, and are conducted biannually with new cohorts added periodically. AHEAD and HRS are the same survey but AHEAD surveyed only the older population: AHEAD sampled persons aged 70+ years at study initiation (1993). HRS surveyed individuals aged 51–61 years from 1992. Starting in 1998, AHEAD was incorporated into HRS. AHEAD/HRS data have been used previously to document relationships between self-reported vision and functional status and well-being of persons aged 70+ years,^{6, 18} and in analysis of longitudinal rates of cataract surgery.¹⁹ Medicare carrier claims files were used to obtain information on respondents' diagnosed eye diseases based on diagnosis codes from the International Classification of Diseases Ninth Revision, Clinical Modification (ICD-9-CM), using a diagnosis ascertainment period of 3 years, 1993–5 claims for 1995 and 2008–10 claims for 2010. 23% of subjects from AHEAD/HRS were excluded from this analysis because they did not have Medicare claims data due to being enrolled in Medicare Advantage plans (in which healthcare benefits are managed by private insurers) in 1993–1995 or 2008–2010, or not resident in the US. However, the trend in visual function for the restricted sample used in our analysis is similar to the trend for the whole sample including all subjects from AHEAD/HRS (Supplementary Table S1). We also conducted a sensitivity analysis using all respondents from AHEAD/HRS to confirm that results are robust (Table 3, column 4). The merge between AHEAD/HRS and Medicare claims was performed by prior arrangement between the US National Institute on Aging and the US Centers for Medicare and Medicaid Services; the data were made available for our study on a restricted use basis to protect confidentiality of the information. Duke University Institutional Review Board approved the study protocol and use of the restricted data prospectively.

The study population consisted of persons aged 70+ years at the time of their interviews. The dependent variable was a measure of an individual's self-reported visual function. At each interview in AHEAD and HRS, respondents were asked to rate their vision on a 6-point scale, indicating legally blind (6), poor (5), fair (4), good (3), very good (2), and excellent (1). The numbers in parentheses are assigned values in constructing the person's visual function score, this study's dependent variable. The visual function score was systematically and plausibly related to the hypothesized determinants of visual function, including diagnosed eye diseases common among the elderly (Supplementary Table S4).

We specified that visual function depends on demographic characteristics and socioeconomic status: Age, sex, ethnicity, marital status, total number of school years completed, and household income (in 2011 dollars); cognitive status; chronic diseases other than of the eye; physician diagnosis of DM or stroke as reported to AHEAD or HRS; and diagnoses of chronic diseases of the eye identified in Medicare claims.

Cognitive status directly affects activities (eg, reading) that are likely to affect self-assessed visual function. Moreover, visual function has been associated with changes in cognitive status.^{20, 21} AHEAD and HRS measured cognitive status as the sum of total recall and mental status measures ranging from 0 to 35 with higher values indicating better cognition. The total recall index summarized the immediate and delayed word recall tasks that contained a list of 10 words. The mental status index summed scores from naming, counting

and vocabulary tasks. This measure of cognitive status has been widely used and its properties have been assessed.²²

Explanatory variables for the presence of diagnosed chronic eye diseases were based on ICD-9-CM diagnosis codes appearing in Medicare claims during 1993–5 for the base year and 2008–10 for the terminal year. We included covariates for beneficiaries with diagnosed cataract, glaucoma, dry AMD, wet AMD, and non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR; Table 1). Since diagnosis codes were based on data from 3-year periods, persons could have legitimately been diagnosed with more than 1 type of diabetic retinopathy or AMD. To deal with this, individuals diagnosed with both NPDR and PDR were considered to only have a PDR diagnosis. Similarly, when there was a diagnosis of both dry and wet AMD, we considered the beneficiary to only have had wet AMD. Like the chronic eye diagnosis covariates, the binary variable for cataract surgery was based on a report of such surgery on a claim during a 3-year ascertainment period.

We first examined whether there were statistically significant changes in mean visual function for the entire sample and for the subsample for each age group between 1995 and 2010 and similarly for each explanatory variable. Second, we investigated reasons for observed changes in visual function. To do this, we used decomposition analysis to analyze the relative importance of various causes of change in visual function. In this step, we included all explanatory variables except those for eye diseases. Third, we performed decomposition analysis with covariates for eye diseases added. We conducted sensitivity analyses by limiting the sample to beneficiaries with 1 Medicare claims submitted by an ophthalmologist or an optometrist in the 3-year diagnosis ascertainment period to mitigate concerns about under-ascertainment of chronic eye conditions (Table 3, column 3).

Decomposition analysis was first developed to study sex differences in wages, dividing the difference into a part explained by differentials in characteristics of females and males, eg, such characteristics as educational attainment and work experience, and a residual part not explained by these characteristics and hence attributed to discrimination, eg, lower incremental effects of 1 additional year of education on wages of females than males.²³ This decomposition of analysis has been extended to partition inter-temporal changes in disability.^{24, 25} Our decomposition analysis was conducted using Stata release 11 (StataCorp, College Station, TX, USA) Blinder-Oaxaca 2-fold decomposition for linear regression models.²⁶

We used decomposition analysis to partition effects of 2 types of changes on observed changes in visual function that occurred between 1995 and 2010; 1) effects of changes in composition of persons aged 70+ years on visual function (compositional changes), eg, higher levels of educational attainment of persons aged 70+ years in 2010 than 15 years earlier; and, 2) changes in the effects of each explanatory variable on visual function (structural changes). Compositional changes may have occurred because of adverse or favorable changes to visual function in the mix of the elderly population, eg, aging, growing prevalence of DM, or AMD. Structural changes may have occurred because of changes in disease ascertainment rates, changes in disease management practices, and/or technological

change. Improvements in the latter may have offset or more than offset compositional changes unfavorable to visual function, eg, population aging.

Decomposition analysis separates combined structural and compositional changes ($\hat{Y}$) into two component parts; 1) the part attributable to changes in the parameter estimates ($\hat{\beta}$) between baseline and terminal periods, here 1995 and 2010; structural changes; and, 2) the part attributable to changes in population mix; compositional changes, ie, changes in the values of X between baseline and terminal periods.²³ As applied to our analysis of changes in vision, the analysis starts with visual function equations for 2010 and 1995.

$$\hat{Y}^{2010} = \hat{\beta}_{0,2010} + \sum_{k=1}^K X_{k,2010} \hat{\beta}_{k,2010} \quad (1a)$$

$$\hat{Y}^{1995} = \hat{\beta}_{0,1995} + \sum_{k=1}^K X_{k,1995} \hat{\beta}_{k,1995} \quad (1b)$$

Equation 1a shows the relationship between visual function in 2010 ($\hat{Y}^{2010}$) and the explanatory variables. Equation 1b is the counterpart for 1995. This specification allows for different effects of explanatory variables on vision in 2010 versus 1995. Taking the difference between equations 1a and 1b and collecting terms yields equation 2:

$$\hat{\Delta}_o^u = \underbrace{(\hat{\beta}_{0,2010} - \hat{\beta}_{0,1995}) + \sum_{k=1}^K \bar{X}_{k,2010} (\hat{\beta}_{k,2010} - \hat{\beta}_{k,1995})}_{\hat{\Delta}_s^u \text{ (structural effect)}} + \underbrace{\sum_{k=1}^K (\bar{X}_{k,2010} - \bar{X}_{k,1995}) \hat{\beta}_{k,1995}}_{\hat{\Delta}_X^u \text{ (compositional effect)}} \quad (2)$$

The first term on the right of equation 2 represents the change in the intercepts between 2010 and 1995. These are temporal changes not associated with any particular explanatory variable. The second term, the summation over explanatory variables 1 to K, represents the sum of the products of the values of the K explanatory variables for X in 2010 and the corresponding changes in parameter estimates between terminal (2010) and baseline periods (1995). The sum of the products represents the total change (less the intercepts) due to changes in effects of each explanatory variable on vision, assuming the structure of the terminal period (structural change). The third term is the sum of products of changes in levels of explanatory variables and the effects of these variables on vision that prevailed at baseline (compositional change).

One potential limitation of applying decomposition analysis in this study is focusing on 2 single waves, 1995 and 2010. The estimated visual function trends may be sensitive to the choice of the specific waves. However, as Supplementary Figure S1 shows, the pattern of estimates of mean visual function score for each wave from 1995 to 2010 indicates that the choice of 1995 and 2010 is representative of visual function trends over 1995–2010.

Results

Overall, visual function of persons aged 70+ years improved between 1995 and 2010 from 3.14 to 2.98 ($P<0.05$; predicted visual function score was based on equation 1a for 2010 and 1b for 1995), or from slightly worse than good on average to slightly better than good (Table 2). More detailed changes in visual function can be found in Supplementary Table S2. Visual function declined monotonically with increasing age, but less so in 2010 than in 1995. Improvements in vision between baseline and follow-up were mainly realized by the older age groups (75–79, 80–84 and 85+ years). For the sample as a whole, household income adjusted for inflation increased from \$40,820 to \$47,500. Educational attainment increased by 1.3 years on average; increases in educational attainment occurred in all 4 age groups. Overall, the proportion of persons who said that a physician had told them that they had had a stroke rose from 0.12 to 0.15. This overall increase reflected a substantial increase in the proportion of persons over 85 years with a prior stroke. The proportion of respondents who said that they had been told they had DM nearly doubled in just a decade and a half, from 0.14 to 0.26 overall, the largest increase occurred among persons aged 75–79 years. The proportion of persons with diagnosed common eye diseases generally rose, particularly for wet AMD, which more than doubled. The proportion of persons with a NPDR diagnosis rose, but at a smaller rate than growth in DM prevalence. The proportion of persons with cataract decreased; the proportion of beneficiaries receiving cataract surgery increased from 0.217 in 1995 to 0.246 in 2010. Prevalence of diagnosed glaucoma increased.

Our first decomposition analysis excluded explanatory variables for diagnosed eye diseases (Table 3, column 1). Parameter estimates based on data for the baseline year predicted a mean visual function score of 3.076 relative to a scale from 1 to 6 (Table 3, Panel A). The corresponding prediction for the follow-up period was 2.927. Comparing the 2 predictions, there was an improvement in visual function (-0.149). The improvement of 0.15 compares to an improvement of 0.4 from receipt of cataract surgery in a study using the same visual function index and AHEAD data.¹⁹

The largest single compositional change leading to improved vision stemmed from increased educational attainment. This increase alone was responsible for an improvement in vision of -0.043 . Better cognition also improved vision (-0.005). An increased rate of cataract surgery in the 3-year ascertainment period resulted in improved visual function (-0.006). An increase in the share of the elderly population with a prior stroke led to minor deterioration in visual function (0.008). The growth in prevalence of DM had a much larger adverse effect on vision (0.032) than did stroke.

Among structural changes, aging had a much smaller adverse impact on visual function in 2010 than in 1995, especially for the 2 oldest age groups. Being 80–84 years and 85+ years, relative to being 70–74 years had 0.036 and 0.043 less adverse effects, respectively, on vision in 2010 than in 1995. The other statistically significant structural changes were for Hispanic ethnicity and DM. The adverse effect of being Hispanic increased by 0.017 between 1995 and 2010, but the adverse effect of a DM diagnosis decreased by 0.030.

The differences in predicted values of visual function were much larger for persons at older ages (Supplementary Table S3), ie, 80+ years (Table S3, Panel A). For persons aged 85+ years, the large total structural change could not be well explained by the included covariates. This is reflected by the large value of the intercept term, -0.542 , which represents changes not attributable to any of the model's covariates. Increased educational attainment was a compositional change leading to better vision in all age groups (except the 85+ years age group). Increased prevalence of DM contributed to a worsening of visual function at nearly all ages.

Adding covariates for chronic eye diseases had no effect on predicted levels of visual function changes (Table 3, column 2, Panel A). However, a diagnosis of glaucoma, or dry or wet AMD tended to lower self-reported vision (Table 3, Panel B).

Visual function of elderly persons with a glaucoma diagnosis improved between baseline and follow-up as implied by the structural change of -0.035 (Table 3, column 2b). The relatively favorable change in the effects of age on visual function remained after including the covariates for eye diseases, to a slightly higher extent.

Results were robust when the sample was limited to respondents who had at least 1 ophthalmologist/optometrist visit in the 3-year ascertainment period and could be identified in both Medicare claims and AHEAD/HRS (Table 3, column 3). Results were also robust when the sample was expanded to all subjects in 1995 AHEAD and 2010 HRS (Table 3, column 4), ie, without applying the restriction to Medicare claims or ophthalmologist/optometrist visits

To validate our measure of self-reported vision, we ascertained whether or not the visual function score was systematically and plausibly related to the hypothesized determinants of visual function, including diagnosed eye diseases common among the elderly (Supplementary Table S4). Results suggest that beneficiaries diagnosed (as evidenced from Medicare claims) with DM, glaucoma, PDR, and dry and particularly wet AMD had statistically significantly higher scores on the visual function scores, ie, had poorer self-reported vision. This result held irrespective of whether we used ordinary least squares treating the dependent variable as continuous as in the decomposition analysis or ordered logit analysis with the dependent variable consisting of a set of ordered mutually-exclusive categories from 1 (excellent vision) to 6 (blind). This result provides assurance that there is consistency between patient self-report to AHEAD and HRS and ophthalmologist or optometrist reports in claims.

Discussion

Using survey data merged with Medicare claims data, this study documented trends in visual function among persons aged 70+ years which occurred within a 15-year time frame and, more importantly, investigated explanations for the observed trends, where little work has been done by earlier studies. This study found visual function improved overall among persons aged 70+ years from slightly worse than to slightly better than good. The improvement was larger for persons aged 80+ years than for younger elderly persons. These

results are consistent with earlier reports on vision trends among the US elderly population. Our results also show that, although visual function continued to decline with age, the age gradient in loss of visual function decreased over time. Thus, even though aging of the US population will result in an increased burden from visual problems,²⁷ this increased burden may be diminished by favorable changes in visual function among persons 70+ years.

Our results suggest that increased educational attainment and cognition improved elderly individuals' visual function, but increased prevalence of DM, and rates of diagnosed glaucoma and dry and wet AMD were factors tending to decrease visual function over time.

The visual function improvements largely reflected the favorable structural changes that occurred between 1995 and 2010. Noting compression in morbidity by age for the population in general, Fries²⁸ attributed this phenomenon to improvements in treatment. Conceptually, observed improvements may arise from a combination of technological advances in clinical care, more effective and widespread application of existing technologies, and probably from higher rates of ascertainment of less severe conditions. We documented declines in adverse effects of glaucoma on visual function. We lacked data to distinguish among possible factors that would explain these favorable structural changes. The glaucoma field has benefited from pharmaceutical innovation, but drug delivery, ie, subpar patient adherence to drug therapy,²⁹ remains a challenge. One study of persons diagnosed with primary open-angle glaucoma in the elderly reported an increase in the proportion of persons with untreated primary open-angle glaucoma.³⁰ Another study based on analysis of Medicare claims data for 1997–2006 documented a decrease in use of surgery for glaucoma between 1997 and 2001 but an increase in such rates thereafter.³¹

Until a decade ago, there were no effective therapies for AMD. New pharmaceuticals based on suppression of vascular endothelial growth factor (VEGF) have substantially improved outcomes of wet AMD.³² Our analysis did not reveal favorable structural changes for wet AMD. One reason may be that although anti-VEGF therapy has improved the visual prognosis of wet AMD at the individual level, 2010 may have been too early to detect an improvement in vision at the population level given the residual proportion of patients with irreversible vision loss that had occurred prior to anti-VEGF development. Another reason may be a substantially higher rate of diagnosis of wet AMD accompanying technological advances in treatment of this condition. When therapy offered little or no promise, many elderly persons with this condition may have not sought treatment or may not have been coded with a diagnosis for which no reimbursable treatment was available. Rather than appear as a favorable structural change for diagnosed wet AMD, these changes may be reflected in our result that vision of the oldest old improved relative to younger Medicare beneficiaries and to a lesser extent as a structural change in the intercepts. The structural improvement for DM and the lack of structural change for diabetic retinopathy may have occurred for the same reason.

A strength of our study is the use of recently available national data to examine recent visual function trends in the US elderly population. More importantly, this study bridges the gap in earlier literature by examining explanations for vision trends, not only roles of trends in

prevalence of examined factors but also structural changes in vision worsening/improving effects of the analyzed factors.

We acknowledge the limitation that our measure for visual function was based on patient self-report. However, as discussed above, the associations between self-reported visual function and sociodemographic characteristics and eye diseases identified from Medicare claims by ICD-9-CM codes (Table S4) suggested self-reported visual function is valid.

In summary, even with population aging, which should have led to increased visual impairments, there were offsetting factors leading to improved vision, eg, DM and glaucoma tended to have less adverse effects on vision in 2010 than they did in 1995. Population aging does not have the same adverse effect on vision it once had. To the extent that these trends continue, vision at the population level will be much better by mid-century than it would have been in the absence of these structural changes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Diagnosis codes for chronic eye diseases from the International Classification of Diseases 9th revision, Clinical Modification (ICD-9-CM)

Disease	ICD-9-CM code	CPT code
Cataract	366.xx, 379.31	
Cataract surgery	V43.1, V45.61	66984, 66982
Glaucoma	365.xx, 360.42	
AMD		
Dry AMD	362.51, 362.57	
Wet AMD	362.52	
Diabetic retinopathy		
Non-proliferative diabetic retinopathy	362.01, 362.03, 362.04, 362.05, 362.06	
Proliferative diabetic retinopathy	362.02	

CPT, Current Procedural Terminology; AMD, age-related macular degeneration

Summary statistics of dependent and explanatory variables (only subjects linked to Medicare claims), 1995 Asset and Health Dynamics among the Oldest Old (AHEAD) and 2010 Health and Retirement Study (HRS), United States

Age group, years															
Variables	All			70–74			75–79			80–84			85+		
	1995	2010	P	1995	2010	P	1995	2010	P	1995	2010	P	1995	2010	P
Dependent															
Visual function, mean score	3.138	2.981	**	2.890	2.857		3.064	2.939	*	3.248	2.960	**	3.519	3.243	**
Explanatory, mean coefficient															
Age 70–74 years (1 70–74 years, 0 otherwise)	0.274	0.322	**												
Age 75–79 years (1 75–79 years, 0 otherwise)	0.320	0.272	**												
Age 80–84 years (1 80–84 years, 0 otherwise)	0.231	0.195	**												
Age 85+ years (1 85+ years, 0 otherwise)	0.174	0.211	**												
Female (1 female, 0 otherwise)	0.625	0.592	**	0.608	0.566	*	0.606	0.587		0.636	0.581	**	0.675	0.650	
Black ethnicity (1 black, 0 otherwise)	0.123	0.126		0.117	0.142	*	0.117	0.141	*	0.129	0.090	**	0.135	0.116	
Hispanic ethnicity (1 Hispanic, 0 otherwise)	0.053	0.072	**	0.056	0.099	**	0.052	0.066		0.054	0.052		0.049	0.057	
Married (1 married, 0 otherwise)	0.482	0.499		0.641	0.616		0.513	0.536		0.410	0.511	**	0.267	0.261	
Income (unit \$10,000, 2010)	4.082	4.750	**	4.783	5.527	**	4.244	5.071	*	3.587	4.413	**	3.339	3.456	
Education (years)	10.902	12.217	**	11.464	12.416	**	11.171	12.285	**	10.541	12.310	**	10.005	11.740	**
Cognition (scale 0–35)	20.071	20.397	**	22.040	21.885		20.793	20.911		18.900	19.846	**	16.464	17.218	*
Stroke (1 stroke, 0 otherwise)	0.122	0.153	**	0.094	0.112		0.113	0.131		0.147	0.166		0.149	0.233	**
Diabetes (1 diabetes, 0 otherwise)	0.143	0.263	**	0.173	0.275	**	0.140	0.291	**	0.135	0.259	**	0.110	0.212	**
Glaucoma (1 glaucoma, 0 otherwise)	0.155	0.190	**	0.126	0.150	*	0.152	0.201	**	0.166	0.212	**	0.188	0.215	**
Cataract (1 cataract, 0 otherwise)	0.600	0.549	**	0.533	0.497	*	0.593	0.595		0.655	0.585	**	0.650	0.537	**
Cataract surgery (1 cataract surgery, 0 otherwise)	0.217	0.246	**	0.133	0.168	**	0.212	0.242	*	0.270	0.317	*	0.286	0.307	
NPDR (1 NPDR, 0 otherwise)	0.020	0.034	**	0.023	0.035	*	0.021	0.038	**	0.017	0.035	**	0.015	0.027	
PDR (1 PDR, 0 otherwise)	0.007	0.010		0.010	0.011		0.009	0.013		0.005	0.005		0.001	0.006	*
Dry AMD (1 dry AMD, 0 otherwise)	0.056	0.108	**	0.028	0.051	**	0.048	0.096	**	0.074	0.145	**	0.089	0.174	**
Wet AMD (1 wet AMD, 0 otherwise)	0.015	0.036	**	0.008	0.016	*	0.015	0.028	**	0.012	0.035	**	0.029	0.078	**
Total, n	5,618	6,055		1,542	1,950		1,798	1,648		1,299	1,182		979	1,275	

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* significant at 5%,
** significant at 1%

6, legally blind; 5, poor; 4, fair; 3, good; 2, very good; 1, excellent

NPDR, non-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy; AMD, age-related macular degeneration.

Table 3

Visual function trends in the United States elderly population since the mid-1990s, 1995 Asset and Health Dynamics among the Oldest Old (AHEAD) and 2010 Health and Retirement Study (HRS)

Panel A: Differences in predicted visual function, 2010 and 1995, vision level *** (SE)								
	column 1		column 2		column 3		column 4	
Predicted 2010	2.927**	(0.014)	2.927**	(0.014)	2.935**	(0.017)	2.927**	(0.012)
Predicted 1995	3.076**	(0.015)	3.076**	(0.015)	3.100**	(0.018)	3.069**	(0.014)
Difference	-0.149**	(0.021)	-0.149**	(0.021)	-0.165**	(0.025)	-0.142**	(0.018)
n	11,673		11,673		7,354		13,924	
Panel B: Detailed decomposition analysis results, mean coefficient (SE)								
	1a	1b	2a	2b	3a	3b	4a	4b
	Compositional	Structural	Compositional	Structural	Compositional	Structural	Compositional	Structural
Age 75–79 years (1 75–79 years, 0 otherwise)	-0.007** (0.002)	-0.027 (0.014)	-0.007** (0.002)	-0.032* (0.014)	-0.006* (0.002)	-0.038* (0.018)	-0.007** (0.002)	-0.017 (0.013)
Age 80–84 years (1 80–84 years, 0 otherwise)	-0.007** (0.002)	-0.036** (0.011)	-0.006** (0.002)	-0.039** (0.011)	-0.009** (0.003)	-0.056** (0.014)	-0.009** (0.002)	-0.028 (0.009)
Age 85+ years (1 85+ years, 0 otherwise)	0.010** (0.003)	-0.043** (0.012)	0.009** (0.003)	-0.053** (0.012)	0.011** (0.004)	-0.049** (0.015)	0.005 (0.003)	-0.039** (0.009)
Female (1 female, 0 otherwise)	-0.002 (0.002)	0.010 (0.025)	-0.001 (0.002)	0.005 (0.025)	-0.000 (0.002)	0.011 (0.032)	-0.003 (0.002)	0.004 (0.022)
Black ethnicity (1 black, 0 otherwise)	0.001 (0.001)	0.014 (0.008)	0.001 (0.001)	0.019* (0.008)	0.001 (0.001)	0.021* (0.009)	0.001 (0.001)	0.018* (0.008)
Hispanic ethnicity (1 Hispanic, 0 otherwise)	0.001 (0.001)	0.017** (0.006)	0.001 (0.001)	0.018** (0.006)	0.001 (0.001)	0.016** (0.006)	-0.000 (0.002)	0.022** (0.007)
Married (1 married, 0 otherwise)	-0.000 (0.001)	-0.029 (0.023)	-0.001 (0.001)	-0.024 (0.023)	-0.001 (0.001)	-0.026 (0.027)	0.000 (0.001)	-0.026 (0.021)
Income (unit \$10,000)	-0.001 (0.001)	-0.011 (0.016)	-0.002 (0.001)	-0.011 (0.016)	-0.003 (0.002)	0.007 (0.018)	-0.002 (0.001)	0.005 (0.014)
Education (years)	-0.043** (0.007)	-0.027 (0.089)	-0.045** (0.007)	0.002 (0.087)	-0.039** (0.008)	-0.031 (0.107)	-0.041** (0.006)	-0.036 (0.077)
Cognition (scale: 0–35)	-0.005** (0.002)	-0.011 (0.090)	-0.005** (0.002)	-0.042 (0.088)	-0.006* (0.003)	-0.084 (0.107)	-0.007** (0.002)	-0.030 (0.080)

	All subjects linked to Medicare claims not enrolled in Medicare Advantage			ophthalmologist/optometrist visit in last 3 years ¹		All subjects 70+ years in AHE/AD/HRS
Stroke (1 stroke, 0 otherwise)	0.008** (0.002)	-0.009 (0.008)	0.007** (0.002)	-0.009 (0.008)	0.006** (0.002)	-0.008** (0.010)
Diabetes (1 diabetes, 0 otherwise)	0.032** (0.006)	-0.030* (0.014)	0.027** (0.006)	-0.028 (0.015)	0.023** (0.007)	-0.030** (0.018)
Glaucoma (1 glaucoma, 0 otherwise)			0.010** (0.002)	-0.035** (0.010)	0.016** (0.004)	-0.051** (0.015)
Cataract (1 cataract, 0 otherwise)			-0.002 (0.002)	-0.012 (0.026)	-0.001 (0.002)	0.019 (0.052)
Cataract surgery (1 cataract surgery, 0 otherwise)			-0.006** (0.002)	0.020 (0.013)	-0.011** (0.003)	0.028 (0.019)
NPDR (1 NPDR, 0 otherwise)			0.001 (0.002)	-0.002 (0.005)	0.002 (0.003)	-0.003 (0.007)
PDR (1 PDR, 0 otherwise)			0.001 (0.001)	0.001 (0.002)	0.002 (0.001)	0.002 (0.003)
Dry AMD (1 dry AMD, 0 otherwise)			0.018** (0.004)	-0.009 (0.008)	0.027** (0.006)	-0.012 (0.012)
Wet AMD (1 wet AMD, 0 otherwise)			0.021** (0.004)	0.001 (0.005)	0.031** (0.006)	0.002 (0.007)
Constant ([AU: clarify?])		0.049 (0.121)		0.061 (0.120)		0.071 (0.155)
						0.053 (0.106)

* statistically significant at 5%,

** statistically significant at 1%

Scale for vision: 6, legally blind; 5, poor; 4, fair; 3, good; 2, very good; 1, excellent.

SE, standard error; NPDR, non-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy; AMD, age-related macular degeneration