Self-reported Comorbidities and Visual Function in a Population-Based Study

The Los Angeles Latino Eye Study

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Objective: To assess the association of self-reported systemic and ocular comorbid disease and visual function in Latino subjects.

Methods: National Eye Institute 25-item Visual Function Questionnaire (NEI-VFQ-25) and eye examination data were obtained from 5380 participants in the Los Angeles Latino Eye Study, a population-based prevalence study of eye disease in Latino subjects 40 years and older. We developed and contrasted 5 comorbidity measures. One-way analysis of variance was used to assess the association between comorbidity and visual impairment and self-reported visual function. Regression analyses determined the association of sociodemographic variables, clinical variables, and the best measure of comorbidity with the NEI-VFQ-25 composite score. The main outcome measure was self-reported visual function as assessed by the NEI-VFQ-25 composite score.

Results: On average, visual function subscale scores were lowest for those participants with the most systemic comorbid conditions (P < .05). This was more evident in participants with moderate or severe visual impairment compared with those with mild or no visual impairment (P < .05).

Conclusions: Self-reported systemic comorbidities were associated with self-reported visual function. This association was greater at more severe levels of visual impairment. Of the 5 comorbidity measures assessed, the measure that summed the number of self-reported systemic comorbidities correlated most with self-reported visual function.


Comorbidity, most often measured as systemic comorbidity, is the total burden of illnesses unrelated to a patient’s principal diagnosis. Comorbidity has been shown to be important in assessing severity of disease and the risk of mortality. An additional variable of interest in assessing disease severity and outcomes is self-reported general and disease-specific function. Previous studies have demonstrated the importance of including sociodemographic factors such as sex, income, education, and insurance status in the evaluation of general and disease-specific function. The presence of systemic comorbidity has also been shown to affect self-reported general function. For example, in patients undergoing peritoneal dialysis, comorbidity was independently associated with worse scores for physical function, work, social interaction, emotional well-being, and cognitive function. Similarly, self-perceived function has been shown to decrease in the presence of diseases such as angina.

Comorbidity scores have also been useful covariates in the analysis of quality of life in certain diseases. Mozes et al illustrated that differences in quality-of-life scores between participants with and without urinary symptoms were minimized after controlling for the presence of other comorbidities in older men (≥ 70 years).

Most of the literature has focused on the use of general measures of self-reported function, such as the Medical Outcomes Study 36-Item Short-Form Health Survey. To date, one study has assessed the association of systemic comorbidity with self-reported visual function. In addition, evaluation of the association of self-reported comorbidities with self-reported function has been limited to non-Hispanic white populations. In this report, we present the relationship of 5 measures of self-reported systemic and ocular comorbidities with self-reported visual function in a Latino cohort of participants in the Los Angeles Latino Eye Study (LALES), a population-based prevalence study of eye disease in Latino subjects 40 years and older.
STUDY DESIGN

The study cohort consisted of 5380 self-identified Latino subjects 40 years and older living in La Puente, Calif. The participants were recruited as part of the LALES. The study protocol was approved by the institutional review board at the University of Southern California, Los Angeles, and followed the recommendations of the Declaration of Helsinki.

After informed consent was obtained, LALES participants completed an in-home interview, a clinic interview, and a complete ophthalmic examination at the LALES local eye examination center. Demographic information, risk factors, history of ocular and medical disease, self-reported health status, access to care, acculturation, and insurance status were collected through an in-home interview administered by a trained interviewer in English or Spanish. Self-reported health status was measured by the Medical Outcomes Study 12-Item Short-Form Health Survey.10,11 Acculturation is the process of learning behavioral adaptations when individuals are exposed to a new culture. It was measured using the short Cuellar Acculturation scale developed for the Hispanic Health and Nutrition Survey.10,11 Scale scores range from 1 to 5, with 5 representing the highest level of acculturation.

At the LALES local eye examination center, a trained interviewer administered a Visual Function Questionnaire (National Eye Institute 25-item Visual Function Questionnaire [NEI-VFQ-25]).12 In addition, an ophthalmic examination was performed to measure presenting binocular visual acuity, which was used to determine the presence and severity of visual impairment. The procedure used to measure presenting binocular visual acuity in the LALES has been described elsewhere.13 Briefly, presenting binocular visual acuity was measured with the presenting correction (if any) at 4 m using modified Early Treatment of Diabetic Retinopathy Study distance charts (Precision Vision, La Salle, Ill) transilluminated with the Early Treatment of Diabetic Retinopathy Study chart illuminator (Precision Vision). Presenting binocular visual acuity was scored as the total number of lines read correctly and converted to a logarithm of the minimum angle of resolution (logMAR) score. The degree of visual impairment was categorized in 3 mutually exclusive groups based on the presenting binocular visual acuity: no visual impairment (>20/40), moderate visual impairment (20/40 to 20/200), or severe visual impairment (<20/200).

SELF-REPORTED VISUAL FUNCTION

The NEI-VFQ-25 is composed of 12 vision-specific subcales (general health, general vision, near vision activities, distance vision activities, ocular pain, vision-specific social function, vision-specific role difficulties, driving difficulties, color vision, and peripheral vision). Each subscale contains between 1 and 4 items. The NEI-VFQ-25 was scored using standard algorithms.14 Each item was first scored on a scale from 0 to 100. Item scores within a subscale were averaged to yield the subscale score (range, 0-100). An overall composite score was calculated using the mean of the vision-targeted subscale scores but excluding the general health rating question.

COMORBIDITY MEASURES

Five different comorbidity indexes were created. These included 2 unweighted summary scores and 3 weighted summary indexes.

Unweighted Comorbidity Scores

The 2 unweighted summary scores were a measure of systemic comorbidities (systemic comorbidity summation score15) and a measure of vision-specific comorbidities (ocular comorbidity summation score). General medical conditions and ocular conditions were self-reported and collected from the health history section of the in-home interview. The systemic comorbidity summation score was the summation of a list of 12 general, self-reported medical conditions.16 The list included diabetes mellitus, arthritis, stroke or brain hemorrhage, high blood pressure, angina, heart attack, heart failure, asthma, skin cancer, other cancers, back problems, and deafness or hearing problems. The ocular comorbidity summation score was the sum of the number of ocular conditions (glaucoma, cataract, age-related macular degeneration, diabetic retinopathy, lazy eye, injury to the eye by blunt object, injury to the eye by sharp object, and chemical burn injury).

Weighted Comorbidity Indexes

The weighted indexes incorporated the degree of association between a given comorbidity (systemic or ocular) and a particular outcome (visual impairment or physical function). The odds ratio obtained from the model that regressed each comorbid disease on the outcome variable was used to weight the importance of each comorbidity.17,18 Using this method, diseases associated with higher rates of visual impairment or low physical function were given more weight in the summary systemic and ocular comorbidity indexes.

The first of the 3 weighted indexes was the systemic comorbidity visual impairment index. Logistic regression was used to model the association of the self-reported systemic comorbidities (diabetes mellitus, arthritis, stroke or brain hemorrhage, high blood pressure, angina, heart attack, heart failure, asthma, skin cancer, other cancers, back problems, and deafness or hearing problems) with the presence of visual impairment. The odds ratios for each of the comorbid conditions from this logistic regression were summed to create the systemic comorbidity visual impairment index.

The second weighted index was the ocular comorbidity visual impairment index. Logistic regression was used to model the association of the self-reported ocular comorbidities (glaucoma, cataract, age-related macular degeneration, diabetic retinopathy, lazy eye, injury to the eye by blunt object, injury to the eye by sharp object, and chemical burn injury) with visual impairment. The odds ratios were summed to create the second index.

The third weighted index used logistic regression to model the association of low physical function with self-reported systemic comorbidities (diabetes mellitus, arthritis, stroke or brain hemorrhage, high blood pressure, angina, heart attack, heart failure, asthma, skin cancer, other cancers, back problems, and deafness or hearing problems). Low physical function was defined using the physical component summary from the Medical Outcomes Study 12-Item Short-Form Health Survey.19,20 Low physical function was defined as the lowest quartile (physical component summary, <30) from the mean physical component summary in this cohort. The lowest quartile of physical function has been shown to be associated with mortality using other measures such as activities of daily living.17 The odds ratios for these comorbid diseases were summed to develop the low physical function weighted index.

STATISTICAL ANALYSIS

Descriptive statistics were generated to determine the distribution of demographic and clinical characteristics. χ² Tests
were used to assess the association between different diseases and visual impairment. One-way analysis of variance was used to assess the differences across 3 levels of visual impairment for comorbidity scores or indexes. Tukey multiple comparison test was used for pairwise comparisons within each score or index. The means of the comorbidity scores or indexes were adjusted for age and sex. Separate regression analyses were used to assess the relationship between the comorbidity scores or indexes and the NEI-VFQ-25 composite scores. A classification regression tree approach was used in which successive models were developed to assess the additional variance in visual function scores explained by independent variables. In the first model, the independent variables included sociodemographic variables such as age, sex, income, and acculturation. In the second model, presenting binocular visual acuity (logMAR score) was added to the first model. In the third model, the different comorbidity scores or indexes were added separately to the second model. The best-fit model was chosen from the third set of models as the one that explained the greatest amount of variability in the NEI-VFQ-25 composite score (the model with the highest R² value). The 5 comorbidity measures were evaluated, and the measure that explained the greatest amount of variation in the NEI-VFQ-25 composite score was selected as the best measure of comorbidity.

Finally, 2-way analysis of variance was used to assess the association of each NEI-VFQ-25 subscale score within categories of visual impairment and systemic comorbidities using the best measure of comorbidity. The subscale scores were compared for each of the 3 categories of visual impairment (none, mild, and moderate or severe) for different numbers of comorbid conditions (0, 1, and ≥2) to determine if the effect of systemic comorbidities on visual function is greater with increasing severity of visual impairment.

**RESULTS**

**SOCIODEMOGRAPHIC AND CLINICAL CHARACTERISTICS**

A total of 6357 participants (82% participation) completed an in-home questionnaire and a clinical examination.22 For purposes of these analyses, we used a sample of 5380 participants with complete data. Their ages ranged from 40 to 98 years (mean±SD age, 55.1±10.9 years). Forty-one percent of participants were male, and 43.3% had an annual income of greater than $20 000. Almost half of the participants (47.5%) were employed, and 39.0% had between 6 and 11 years of education. Most participants (93.7%) had no visual impairment (>20/40), and only 6.3% had visual impairment (≤20/40) with their current refraction.

**DISEASES AND COMORBIDITY INDEXES AND VISUAL IMPAIRMENT**

Table 1 presents the prevalence rates of comorbid systemic and ocular conditions. The self-reported systemic comorbid conditions (in descending order of frequency) were high blood pressure (30.8%), arthritis...
Table 2. Age- and Sex-Adjusted Comorbidity Measures Stratified by Visual Impairment*

Table 3. Regression Analyses of the Association of Demographic Factors, Visual Acuity, and Systemic Comorbidity Summation Measures With the National Eye Institute 25-item Visual Function Questionnaire Composite Score Among 4788 Latino Subjects*

*Analysis of covariance was used to compare mean comorbidity index scores within different severities of visual impairment. Means with different letters (a-c) across the row are statistically significantly different from one another (P<.05).

(25.9%), back problems (20.3%), diabetes mellitus (17.5%), deafness or hearing problems (11.7%), asthma (6.6%), skin cancer or other cancers (4.6%), angina (3.7%), heart attack (3.5%), stroke or brain hemorrhage (3.3%), and heart failure (3.0%).

Also shown in Table 1 for each systemic and ocular condition are the associated weights for each of the 5 comorbidity measures. For the comorbid and ocular summation scores, all weights are equal to 1. For the 3 weighted indexes, the weights are the odds ratios obtained from the logistic regression analyses. For example, the odds ratio for high blood pressure is 1.06 for the systemic comorbidity weighted index, while the odds ratio for the low physical function weighted index is 1.80.

Also in Table 1 are the summary statistics for each of the comorbidity measures. The means±SDs of the unweighted systemic comorbidity summation score and ocular comorbidity summation score were 1.3±1.4 and 0.4±0.7, respectively. The means±SDs of the weighted systemic comorbidity weighted index, low physical function weighted index, and ocular comorbidity weighted index were 1.5±1.7, 2.1±2.3, and 0.6±1.2, respectively.

The age- and sex-adjusted 5 comorbidity measures are shown in Table 2. Significant differences were found between the participants with and without visual impairment (P<.001 for all comorbidity measures).

MULTIPLE REGRESSION ANALYSIS

Multiple linear regression models were developed to determine whether the inclusion of comorbidity measures could explain some of the variation in self-reported visual function (Table 3). All regression models were adjusted for sociodemographic variables (age, sex, income, and acculturation), which explained less than 10% of the variation in the NEI-VFQ-25 visual function composite score (R²=0.06; P<.001). Regression models for comorbidity measures not dependent on visual acuity (eg, systemic comorbidity summation score, ocular comorbidity summation score, and low physical function weighted index), also adjusted for presenting binocular visual acuity (logMAR score), increased the explained variance to 17% (R²=0.17; P<.001). A significant relationship between the visual function composite score and comorbidity was apparent for all of the comorbidity scores and indexes, yielding increased R² values for all regression models, which demonstrated the robustness of the comorbidity measures. The models with the systemic comorbidity summation score or low physical function weighted index had the highest R² values (R²=0.22; P<.001). In addition, the proportion of variance in self-reported visual function did not change when the low physical function weighted index was calculated using the physical component summary as a continuous rather than a dichotomous variable. Based on R² values and simplicity of calculation, the measure of choice is the systemic comorbidity summation score.

ASSOCIATION OF NEI-VFQ-25 SUBSCALE SCORES, VISUAL IMPAIRMENT, AND COMORBIDITY

Because the systemic comorbidity summation score had the highest R² value and was the simplest to calculate, we chose this measure as the preferred covariate among the 5 comorbidity measures. We then examined the relationship of this measure across categories of visual impairment for each of the NEI-VFQ-25 subscales to assess sensitivity. As shown in Table 4, the NEI-VFQ-25 subscale scores were significantly lower in participants with any visual impairment compared with those with no visual impairment. The subscale scores decreased as the number of systemic comorbidities increased. The de-
increase in self-reported visual function was most notable in the group with the greatest visual impairment. In this group, the mean visual function scores decreased from 67.2 (no visual impairment) to 42.3 (moderate or severe visual impairment) on the NEI-VFQ-25 composite score (P < .001). All subscale scores were statistically significantly lower in participants with 2 or more systemic comorbidities compared with those with no systemic comorbidities or 1 systemic comorbidity (P < .05).

Prior studies2-4 have demonstrated the importance of including sociodemographic factors such as sex, income, education, and insurance status in evaluation of general and disease-specific function. Systemic comorbidity scores have been useful covariates in the analysis of quality of life in certain diseases. To our knowledge, this is the first study that compares different methods of measuring comorbid diseases in relation to ocular disease and self-reported visual function. It is one of 2 studies8 to assess the interaction between the number of systemic comorbidities and severity of visual impairment. The unweighted systemic comorbidity summation score was found to be the simplest measure and explained as much or more of the variance in visual function scores compared with the other methods of measuring comorbid disease in this study.

The inclusion of a measure of comorbidity becomes increasingly important in assessing self-reported visual function as the level of visual impairment increases. Because the number of participants in this study with moderate or severe impairment was small (n = 86), these results should be evaluated with caution and confirmed in a larger group of patients with moderate and severe visual impairment.

Although the inclusion of comorbidities is important for the development of epidemiologic and clinical models,23 few studies have assessed the performance of disease-specific measures compared with systemic comorbidity measures or of weighted measures compared with unweighted measures. The findings from the present study are similar to other assessments of systemic diseases and self-reported general function. For example, Schneweiss et al23 compared the performance of 6 claims-based comorbidity scores for the prediction of mortality after 1-year long-term care admission, hospitalizations, physician visits, and physician services. The cohort for this study consisted of residents of Canada, 65 years and older, who had hypertension. Similarly, Janz et al8 reported that systemic comorbidities were associated with increased reporting of problems with visual acuity, peripheral vision, and total score, as measured by the Visual Activities Questionnaire. However, our findings contrast with one of the few analyses that include disease-specific measures of health status. Brown et al24 reported that visual impairment is more strongly associated with the degree to which an individual values his or her specific state of ocular health than with the presence of comorbidities. Several methodological differences between the present study and that study may explain the differences in findings. First, Brown et al used a list of 5 systemic comorbid diseases (cardiac disease, diabetes mellitus, cancer, stroke, and renal disease). Second, they elicited visual utility values (preferences for a particular
health state) as opposed to the self-reported visual function measure (an individual’s description of his or her current health state) included in the present study. Although comorbidity is an important component in a patient’s self-reported visual function, it may be unrelated to his or her preference for a current ocular condition.

Indexes may be weighted or unweighted. Most indexes include chronic rather than acute diseases. Indexes such as that described by Charlson et al17,18 (derived from pharmacy claims data) are weighted for the association of comorbid disease with mortality25 and, therefore, may not be appropriate for ocular disease. Some authors have argued that the method used to derive the weights for the index by Charlson et al17,18 makes it poorly suited for analysis of participants with specific chronic medical conditions.3 In this study, we developed 3 weighted indexes (ocular comorbidity weighted index, systemic comorbidity weighted index, and low physical function index), which theoretically should be more closely related to visual function because they were weighted by the association of comorbid diseases with visual impairment or low physical function. However, compared with the systemic comorbidity summation score, the ocular comorbidity weighted index did not explain any additional variation in self-reported visual function. One explanation may be that most of the ocular comorbid diseases were not independently associated with visual function. The systemic comorbidity weighted index also did not explain any additional variation in visual function. An explanation for this may be that only one systemic comorbid condition, stroke or brain hemorrhage, was significantly associated with visual impairment. This association may reflect the fact that persons with stroke were likely to have visual field loss. Finally, despite the fact that most systemic comorbidities were statistically significantly associated with low physical function, the low physical function index did not explain any additional variation in self-reported visual function compared with the systemic comorbidity summation score. This observation suggests that physical function is independent of visual function and supports the need for a visual function–specific instrument. Interestingly, skin cancer was associated with a decreased risk of low physical function, perhaps because skin cancer is likely to be associated with persons who perform outdoor activities and thus have better physical conditioning.

In a study26 of patients with acute myocardial infarction, chronic heart failure, chronic obstructive pulmonary disease, hypertension, and acute coronary vascular disease, the method of comorbidity measures by Elixhauser et al27 identified a much larger proportion of patients as having comorbid illness and higher mean numbers of comorbid illnesses than the index by Charlson et al.17,18 Additional information (drawn from prior hospitalizations that occurred as long as 3 years before the index hospitalization) yielded only small improvements in the performance of both comorbidity methods. Indexes that include chronic and acute illnesses might more accurately control for variations in self-reported function.

Although the inclusion of comorbidities into the regression model increased by 5% the explained proportion of variation of self-reported visual function scores, 75% of the variation in these scores remained unexplained. One explanation may be that only chronic, self-reported comorbidities were included in all 5 comorbidity measures. Elixhauser et al27 developed a set of comorbidity measures for use with an administrative inpatient database to explain length of hospital stay and hospital charges. Increases in these outcome measures were associated with the presence of 3 or more comorbidities. The study by Elixhauser et al27 developed a comorbidity measure that allowed the inclusion of chronic (similar to the index by Charlson et al17,18) and acute illnesses as comorbidities. In the present study, an index of ocular comorbidities was included in the model. Four of the diseases included in this index—cataract, lazy eye, age-related macular degeneration, and diabetic retinopathy—were each associated with visual impairment. Although the ocular comorbidity weighted index was significantly associated with self-reported visual function, the proportion of variation in self-reported visual function increased by only 1.5% when this variable was added to the model. Including only the variables that were statistically significantly associated with visual impairment in the ocular comorbidity weighted index did not change its association with visual function. It is possible that measures of acute illnesses might have a greater effect on self-reported visual function. In addition, the use of self-reported comorbidities may have resulted in underreporting or overreporting of the conditions. Self-reported use has been shown to correlate well with medical records across varying ethnic groups,28 although a small degree of underreporting of physician visits may occur.29 Older patients demonstrated almost perfect agreement on self-reported measures of whether a contact occurred but poorer agreement on the number of visits.30 Similarly, self-reported comorbidities have been shown to be accurate across several conditions and across different ethnic groups.31-33

The present study estimated and ranked the performance of 1 published15 and 4 newly developed comorbidity measures in relation to self-reported visual function scores in a Latino cohort. It reinforces the importance of including a comorbidity measure to control for confounding in an epidemiologic study. Findings for Latino subjects in this study are similar to those in other,
non-Latino cohorts. Similarly, systemic comorbidities are an important covariate to consider when assessing self-reported visual function, as they appear to have a modifying effect of other covariates on visual function scores. In addition, the effect of the presence of comorbidities becomes greater as the level of visual impairment increases. A simple summation of self-reported systemic diseases explained more of the variation in visual function compared with the other methods assessed in this study. A further analysis of the addition of comorbid acute systemic and ocular conditions should be assessed in future studies.

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