Visual Impairment, Undercorrected Refractive Errors, and Activity Limitations in Older Adults: Findings From the Three-City Alienor Study

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Purpose. As vision is required in almost all activities of daily living, visual impairment (VI) may be one of the major treatable factors for preventing activity limitations. We aimed to evaluate the attributable risk of VI associated with activity limitations and the extent to which limitations are avoidable with optimal optical correction of undercorrected refractive errors.

Methods. We analyzed 709 older adults from the Three-City–Alienor population-based study. VI was defined by presenting distance visual acuity in the better-seeing eye. Multivariate modified Poisson regressions were used to estimate the associations between vision, activity limitations, and social participation restrictions. Population attributable risk (PAR) and generalized impact fraction (GIF) were estimated. Bootstrapping was used to estimate 95% confidence intervals (CI).

Results. After adjustment for potential confounders, VI was associated with each domain of activity limitations, except basic activities of daily living (ADL) limitations. These associations were found for even minimal levels of VI. PAR was estimated at 10.1% (95% CI: 5.2–10.6) for mobility limitations, at 26.0% (95% CI: 13.5–41.2) for instrumental ADL (IADL) limitations, and at 24.9% (95% CI: 10.5–47.1) for social participation restrictions. GIF for improvement of undercorrected refractive errors was 6.1% (95% CI: 3.8–8.5) for mobility limitations, 15.8% (95% CI: 11.5–20.1) for IADL limitations and 21.4% (95% CI: 13.8–28.5) for social participation restrictions.

Conclusions. About one-sixth of IADL limitations and one-fifth of social participation restrictions could be prevented by an optimal optical correction. These results underline the importance of eye examinations in older adults to prevent disability.

Keywords: activities of daily living, refractive error, vision loss

With the population aging, the increasing number of older adults with activity limitations is a major concern for public health, with negative outcomes including reduced quality of live, higher mortality and morbidity, and increased demand for health care, mainly due to nursing home admission.[1] In that context, identification of the determinants of these limitations, especially those that may be treatable or preventable, is a concern of public health policy for the purpose of preventing or delaying their occurrence.

Vision is required in almost all activities of daily living, and visual impairment (VI), which is common in older adults,[2] may be one of the major treatable factors for preventing activity limitations. In a British study, disability-free life expectancies were 2 years lower in men and 3 years lower in women with VI.[3] VI has been associated with each domain of activity limitations: mobility, instrumental activities of daily living (IADL), and basic activities of daily living (ADL),[4–8] as well as with social participation restrictions.[9] However, the impact of VI on disability is usually evaluated for a low visual acuity as defined by the World Health Organization (WHO) classification,[10] that is, presenting distance visual acuity <20/70. Yet, an association could occur for even minimal VI. Indeed, a recent study has observed an association with activity limitations from visual acuities around 20/50 to 20/40.[4] An association with higher visual acuity levels may exist but, to our knowledge, has never been studied.

VI represents an interesting determinant of activity limitations to explore, since it is potentially treatable or preventable for a substantial number of the cases. Major causes of VI include refractive error (such as myopia, hyperopia, or astigmatism) as well as age-related eye diseases (including cataract, age-related macular degeneration [AMD], and glaucoma). VI related to

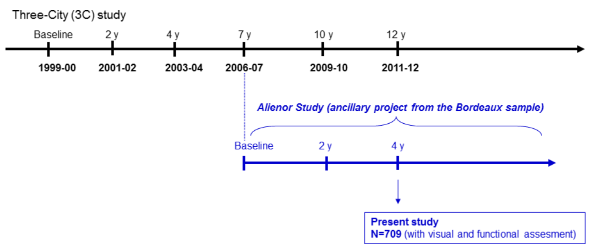

FIGURE. Study sample: the Three-City Alienor study.

refractive error can easily be avoided by using appropriate optical correction (eyeglasses, lenses), while many treatments and surgeries are available to prevent VI from the major eye diseases.[11,12] In the Pathologies Oculaires Liées à l'Age (POLA) study,[13] the proportion of undercorrected refractive errors in adults aged 63 years and older was 38.5%, with a reduction of IADL limitations resulting from changing the presenting optical correction to the optimal optical correction estimated at 20.5%. These findings underline the potential action on activity limitations that could be easily brought, just by improving optical correction.

The objective of the present study was to assess the associations of different levels of VI with activity limitations and participation restrictions. The second objectives were to assess the attributable risk of VI associated with these activity limitations by estimating population attributable risk (PAR) and to assess the fraction of limitations avoidable with optimal optical correction of undercorrected refractive errors by estimating generalized impact fraction (GIF).

METHODS

Study Population

The Three-City study (3C) is a prospective population-based cohort of 9294 community-dwelling older adults aged 65 years and older in 1999–2001. Its aim was to assess the risk of dementia and cognitive decline due to vascular risk factors. The methodology has been described elsewhere.[14] Briefly, participants were recruited from the electoral rolls of three French cities: Bordeaux, Dijon, and Montpellier, with 2104 participants recruited in Bordeaux. Participants were interviewed at baseline and 2, 4, 7, 10, and 12 years after the initial interview. Sociodemographic characteristics, lifestyle, vascular risk factors and diseases, medications, depressive symptomatology, and activity limitations were assessed at each interview with standardized questionnaires. Moreover, a systematic screening for dementia was performed, using a three-step procedure. The first step was a complete neuropsychological and functional examination. Participants who were suspected of dementia were then examined by a senior neurologist. The final diagnosis of dementia was validated by a consensus committee, based on the *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed., criteria.[15]

From 2006, eye examinations were proposed to all participants of the 3C study in Bordeaux, within the framework of the Alienor study, which aimed to assess the associations of age-related eye diseases with nutritional factors.[16] A total of 963 participants agreed to participate and underwent an eye examination in the Department of Ophthalmology of the Bordeaux University Hospital. After this baseline eye examination, following eye examinations were undertaken 2 and 4 years later (Fig.), concurrent with cognitive and functional assessment in the 3C study. At the 4-year eye examination, in addition to examinations at the hospital, at-home eye examinations were proposed for all the participants who could not move to the hospital. Thus, our study comprised 709 participants from Alienor 4-year follow-up with an Alienor eye examination (at hospital or at home) and a concurrent functional assessment in 3C.

This research followed the tenets of the Declaration of Helsinki. Participants gave written consent for participating in the study. The study protocol was approved by the Ethical Committee of Kremlin-Bicêtre University Hospital for the 3C Study and the Ethical Committee of Bordeaux for the Alienor Study.

Activity Limitations and Social Participation Restrictions

Three domains of activity limitations (mobility, IADL, and ADL) and social participation restrictions were examined. Mobility was evaluated with three items of the Rosow and Breslau scale[17]: heavy housework, walking half a mile, and using stairs. IADLs were assessed with the Lawton's scale[18]: telephone use, shopping, using transportation, managing drugs, and handling finances. Three additional activities were evaluated for women only: housework, meal preparation, and laundry. ADLs were assessed with the Katz scale[19]: bathing, dressing, toileting, transferring, and eating. For each of these three domains, participants were considered to be limited if they could not perform at least one activity of the scale without human help.

Social participation restrictions were assessed using the following question: "Do you currently feel restricted in your displacements?" This variable was dichotomized by distinguishing the participants with no restriction or neighborhood-bound from those bed-bound or homebound.

Distance Vision

The Alienor eye examination included measures of visual acuity and refraction. For examinations performed at the hospital, presenting and best-corrected monocular distance visual acuity was evaluated using the Early Treatment Diabetic Retinopathy Study (ETDRS) charts at 4 m (Low Vision; Lighthouse Guild, Low Vision, New York, NY, USA) and was scored as the total number of letters read correctly. Charts 1 and 2 were used for testing the right and left eye, respectively. Objective refraction was measured with an auto-refractometer (Speedy K; Luneau Technology, Prunay le Gillon, France) and subjective refraction with trial lenses and frames. For home visits, presenting and best-corrected distance visual acuity were evaluated with the electronic visual acuity (EVA) system, performed at 3 m (7-CEN; Jaeb Center for Health Research, Tampa, FL, USA), allowing ETDRS scores to be measured. Objective refraction was measured using a portable auto-refractometer (Retinomax; Luneau Technology) and subjective refraction with trial lenses and frames. Thus, VI refers to presenting distance visual acuity in the better-seeing eye. We created categories of at least five letters (corresponding to one line of the ETDRS chart), as follows: "1" for ETDRS > 80 letters (i.e., >20/25) as reference group; "2" for ETDRS between 76 and 80 letters (i.e., >20/32–20/25); "3" for ETDRS between 71 and 75 letters (i.e., >20/40–20/32); "4" for ETDRS between 61 and 70 letters (i.e. >20/63–20/40), and "5" for ETDRS ≤ 60 letters (i.e., ≤20/63). Categories were combined in cases of small numbers.

Best-corrected distance visual acuity was based on subjective refraction. Undercorrected refractive errors are defined as presenting distance visual acuity in the better-seeing eye that is improved for five letters or more (one line or more on the ETDRS chart) using the optimal optical correction.

TABLE 1. Characteristics of the Study Sample: The Three-City Alienor Study ($n = 709$)

Characteristics	*n*	%
Age, mean, SD	84.3	4.4
Female sex	460	64.9
Educational level		
Elementary school without diploma	67	9.5
Short secondary school	339	47.8
Higher level	303	42.7
Living alone	313	44.2
Monthly income		
<€1500	182	25.7
€1500–2300	178	25.1
>€2300	252	35.5
Refusal to answer	97	13.7
Presenting distance visual acuity*		
>20/25	280	39.5
>20/32–20/25	174	24.5
>20/40–20/32	101	14.3
>20/63–20/40	95	13.4
≤20/63	59	8.3
Undercorrected refractive errors†	274	38.8
Mobility limitations†	522	73.9
IADL limitations†	263	37.5
ADL limitations†	73	10.3
Social participation restrictions†	120	17.0
Depressive symptomatology	95	13.4
Diabetes†	112	15.8
Medication consumption (≥6 per day)†	331	47.2
Falls in the past 12 months†	230	32.6
Fear of falling†	273	39.4
Dementia	89	12.6

SD, standard deviation; IADL, instrumental activities of daily living; ADL, activities of daily living.

* The correspondence of visual impairment levels between Early Treatment Diabetic Retinopathy Study (ETDRS) and Snellen levels was as follows: >20/25, >80 letters; >20/32–20/25, 76–80 letters; >20/40–20/32, 71–75 letters; >20/63–20/40, 61–70 letters; ≤20/63, ≤60 letters.

† Missing data: diabetes ($n = 1$); medication consumption ($n = 8$); falls ($n = 4$); fear of falling ($n = 16$); undercorrected refractive errors ($n = 2$); mobility ($n = 2$); IADL ($n = 8$); ADL ($n = 2$); participation restriction ($n = 2$).

Potential Confounders

The following sociodemographic factors were considered: age, sex, educational level (elementary school without diploma, short secondary school, and higher level), living alone, and monthly income (<€1500, €1500–2300, >€2300, refusal to answer). Comorbidities were also considered: diabetes (fasting glucose ≥7.0 mmol/L, or antidiabetic medication, or self-reported diabetes); depressive symptomatology assessed using the Center for Epidemiologic Studies Depression Scale (CES-D), considering a score ≥17 for men and ≥23 for women for depressive symptomatology as previously validated[20,21]; medication consumption (≥6 per day vs. <6); self-reported hearing impairment; fear of falling; falls in the past 12 months; and dementia.

Statistical Analysis

Descriptive Analysis and Association Between VI and Activity Limitations. Participant characteristics were compared according to the participant's presenting distance visual acuity in the better-seeing eye using chi-square tests. Proportion of undercorrected refractive errors was estimated.

Despite our cross-sectional design, as activity limitations are common (10% or more, depending on the domain), relative risk (RR) rather than odds ratio (OR) were used to estimate the associations between VI and activity limitations.[22] RR and their 95% confidence interval (CI) were estimated using a modified Poisson regression with a robust error variance.[23] Separate models were performed for each domain of activity limitations. All covariates associated with activity limitations and VI at the 20% level in preliminary univariate models were included in the multivariate models as potential confounders.

Quantification of the Contribution of VI to the Burden of Activity Limitations. In case of a significant association between VI and activity limitations, the contribution of VI to activity limitations was quantified with the PAR and GIF, estimated using equations previously described.[24,25] The PAR is the proportional reduction in activity limitations that would occur if VI were eliminated.[25] For each domain of activity limitations and social participation restrictions, PAR was calculated using a binary variable for VI, considering the first level of VI associated with the activity limitations as the threshold.

The GIF here estimates the proportional reduction in activity limitations that could be obtained using the optimal optical correction instead of the presenting correction.[24] The great interest of the PAR is that it can be adjusted on all the potential confounders; however, it assumes a total removal of the cause (here, VI), which is unlikely. GIF is more specific, but cannot be adjusted for all the confounders; only stratification on the main confounders can be performed: here we stratified by age group (<85 vs. 85+ years). Moreover, as dementia is the main cause of activity limitations in older adults,[26] GIFs were calculated both for the global population and the population without dementia. The stratified GIFs were combined using a caseload weighted sum method for an overall GIF.[27] Boot-

TABLE 2. Activity Limitations According to the Presenting Distance Visual Acuity in the Better-Seeing Eye: The Three-City Alienor Study

	Presenting Distance Visual Acuity*					
Activity Limitations	**>20/25, N = 280**	**>20/32–20/25, N = 174**	**>20/40–20/32, N = 101**	**>20/63–20/40, N = 95**	**≤20/63, N = 59**	***P* Value**
Mobility limitations,† *n* (%)	169 (60.4)	134 (77.0)	80 (79.2)	81 (85.3)	58 (98.3)	**<0.0001**
IADL limitations,† *n* (%)	57 (20.4)	60 (34.5)	46 (45.6)	53 (55.8)	47 (79.7)	**<0.0001**
ADL limitations,† *n* (%)	12 (4.3)	9 (5.2)	16 (15.8)	17 (17.9)	19 (32.2)	**<0.0001**
Participation restrictions,† *n* (%)	21 (7.5)	17 (9.8)	23 (22.8)	28 (29.5)	31 (52.5)	**<0.0001**

Bolded values indicate statistical significance. IADL, instrumental activities of daily living; ADL, activities of daily living.

* The correspondence of visual impairment levels between Early Treatment Diabetic Retinopathy Study (ETDRS) and Snellen levels was as follows: >20/25, >80 letters; >20/32–20/25, 76–80 letters; >20/40–20/32, 71–75 letters; >20/63–20/40, 61–70 letters; ≤20/63, ≤60 letters.

† Missing data: mobility ($n = 2$); IADL ($n = 8$); ADL ($n = 2$); participation restrictions ($n = 2$).

Table 3. Association Between Presenting Distance Visual Acuity in the Better-Seeing Eye With Each Domain of Activity Limitations: The Three-City Alienor Study

	Mobility,* n = 703				IADL,* n = 696				ADL,* n = 703				Participation Restrictions,* n = 703			
Presenting Distance Visual Acuity	***N***	**RR†**	**95% CI**	***P* Value**	***N***	**RR†**	**95% CI**	***P* Value**	***N***	**RR†**	**95% CI**	***P* Value**	***N***	**RR†**	**95% CI**	***P* Value**
Number of events	522				263				73				120			
Visual acuity in five categories‡				**0.0058**				**0.0029**				0.2611				**0.0306**
20/25		1				1				1				1		
>20/32–20/25		1.18	1.05–1.33			1.40	1.05–1.85			0.75	0.31–1.85			0.96	0.53–1.76	
>20/40–20/32		1.13	0.99–1.29			1.44	1.08–1.93			1.35	0.67–2.69			1.53	0.90–2.58	
>20/63–20/40§		1.20	1.08–1.34			1.76	1.33–2.83			1.53	0.74–3.17			2.08	1.25–3.47	
≤20/63		-	-			1.43	1.03–1.98			0.94	0.39–2.24			1.65	0.92–2.99	

Bolded values indicated statistical significance. IADL, instrumental activities of daily living; ADL, activities of daily living; RR, relative risk; CI, confidence interval.

* Adjusted for age, sex, education, income, depressive symptomatology, diabetes, falls in the past 12 months, and dementia.

† Poisson regression models with robust error variance.

‡ The correspondence of visual impairment levels between Early Treatment Diabetic Retinopathy Study (ETDRS) and Snellen levels was as follows: >20/25, >80 letters; >20/32–20/25, 76–80 letters; >20/40–20/32, 71–75 letters; >20/63–20/40, 61–70 letters; ≤20/63, ≤60 letters.

§ For mobility, because of the small number, categories >20/63–20/40 and ≤20/63 were combined.

strapping was used to estimate the 95% CI of PAR and GIF. The analyses were performed using SAS software (version 9.3; SAS Institute Inc., Cary, NC, USA).

Results

Study Sample

The mean age of the study sample was 84.3 years (from 77.5 to 99.8 years), and 460 participants (64.9%) were women (Table 1). Regarding presenting distance acuity in the better-seeing eye, 39.5% had an acuity greater than 20/25, 24.5% between >20/32 and 20/25, 14.3% between >20/40 and 20/32, 13.4% between >20/63 and 20/40, and 8.3% below 20/63. A total of 274 participants (38.8%) had undercorrected refractive errors. A total of 73.9% had mobility limitations, 37.5% IADL limitations, 10.3% ADL limitations, and 17.0% social participation restrictions. The prevalence of dementia was 12.6%.

Association Between VI and Activity Limitations

For each domain of activity limitations and participation restrictions, the prevalence increased with decreased visual acuity ($P < 0.0001$) (Table 2). The prevalence of mobility limitations varied from 60.4% in participants with higher visual acuity (>20/25) to 98.3% in those with lower visual acuity (≤20/63). The prevalence of IADL, ADL, and participation restrictions were, respectively, 20.4%, 4.3%, and 7.5% in the highest visual acuity category and 79.7%, 32.2%, and 52.5% in the lowest one.

After adjustment for age, sex, education, income, depressive symptomatology, diabetes, falls in the past 12 months, and dementia, VI was associated with mobility limitations ($P = 0.0058$), IADL limitations ($P = 0.0029$), and social participation restrictions ($P = 0.0306$), but not with ADL limitations (Table 3). For mobility and IADL limitations, the association was shown even in the minimal category (>20/32–20/25); compared to participants with visual acuity >20/25, those with visual acuity between >20/32 and 20/25 had a 1.18 (95% CI: 1.05–1.33) RR of mobility limitations and a 1.40 (95% CI: 1.05–1.85) RR of IADL limitations. For social participation restrictions, only participants with more severe VI (>20/63–20/40) were more likely to be restricted (RR = 2.08; 95% CI: 1.25–3.47) compared to participants with visual acuity >20/25.

Contribution of VI to the Burden of Activity Limitations

PAR and GIF were calculated for mobility, IADL, and social participation, but not for ADL that was not associated to visual acuity. Adjusted PAR was estimated at 10.1% (95% CI: 5.2–10.6) for mobility limitations, at 26.0% (95% CI: 13.5–41.2) for IADL limitations, and at 24.9% (95% CI: 10.5–47.1) for social participation restrictions (Table 4).

As shown in Table 5, the GIF showing the proportion of activity limitations that could be obtained with the use of the optimal optical correction (taking age into account) was 6.1% (95% CI: 3.8–8.5) for mobility limitations, 15.8% (95% CI: 11.5–20.1) for IADL limitations, and 21.4% (95% CI: 13.8–28.5) for social participation restrictions. These percentages were nearly unchanged when the population was restricted to the nondemented: 6.0% for mobility limitations (95% CI: 3.5–8.7), 15.1% (95% CI: 9.4–21.0) for IADL limitations, and 19.1% (95% CI: 7.3–27.4) for social participation restrictions, respectively.

Table 4. Population Attributable Risk (PAR) of Visual Impairment to the Burden of Activity Limitations: The Three-City Alienor Study

	Prevalence*	RR	95% CI	PAR	95% CI
Mobility limitations†					
≤20/25 vs. >20/25‡	67.63	1.18	1.07–1.30	10.08	5.20–10.60
IADL limitations§					
≤20/25 vs. >20/25‡	78.33	1.50	1.17–1.91	25.97	13.49–41.18
Social participation restrictions‖					
≤20/32 vs. >20/32‡	68.33	1.79	1.22–2.62	24.92	10.51–47.12

RR, relative risk; CI, confidence interval; PAR, population attributable risk; IADL, instrumental activities of daily living.

* Prevalence of visual impairment among participants with activity limitations.

† Adjusted for age, sex, depressive symptomatology, medication consumption, audition, fear of falling, and dementia.

‡ The correspondence of visual impairment levels between Early Treatment Diabetic Retinopathy Study (ETDRS) and Snellen levels was as follows: 20/25, 80 letters; 20/32, 75 letters.

§ Adjusted for age, sex, living alone, depressive symptomatology, medication consumption, audition, fear of falling, and dementia.

‖ Adjusted for age, sex, income, depressive symptomatology, fear of falling, and dementia.

Discussion

This study confirmed a significant relationship between VI and activity limitations, as well as social participation restrictions, among older adults. For mobility and IADL limitations, an association was found with even minimal VI (≤20/25), whereas for social participation, only participants with more severe VI (>20/63–20/40) were more likely to be restricted. About one-fourth of prevalent cases of IADL limitations could be avoided if VI were eliminated, and almost one-sixth of these limitations could be prevented by an optimal correction of undercorrected refractive errors.

Several previous studies already found an association between VI and activity limitations, although the association with ADL limitations was controversial.[5–8,28,29] However, few publications have studied the impact of mild VI. Among them, a Finnish study found an association between mild VI on presenting binocular distance vision (acuities around 20/32–20/40) and mobility, IADL, and ADL limitations.[5] Another study in France also showed an association between mild VI on presenting distance visual acuity in the better-seeing eye (acuities around 20/40–20/50) and IADL limitations.[4] In our study, associations were found even with milder VI (around 20/25–20/32). However, we failed to find a dose-response risk association for the lowest VI category (≤20/63). Indeed, few participants have a very low visual acuity in our population (n = 59). Moreover, these participants also often had associated comorbidities, such as dementia, which explained a large part of the relationship between VI and disability after adjustment.

Table 5. Generalized Impact Fraction (GIF) of Visual Impairment to the Burden of Activity Limitations: The Three-City Alienor Study

	Presenting Vision*		Best-Corrected Vision*					Study Population		Nondemented Population	
Activity Limitations	*n*	%	*n*	%	RR	95% CI	*P* Value	GIF†	95% CI	GIF†	95% CI
Mobility limitations							**<0.0001**	6.11	3.82–8.46	6.03	3.46–8.66
>20/25‡	278	39.49	440	62.50	1						
>20/32–20/25	173	24.57	128	18.18	1.27	1.13–1.44					
>20/40–20/32	101	14.35	59	8.38	1.30	1.14–1.49					
>20/63–20/40	95	13.49	48	6.82	1.40	1.24–1.59					
≤20/63	57	8.10	29	4.12	1.62	1.46–1.79					
IADL limitations							**<0.0001**	15.82	11.45–20.12	15.10	9.37–21.00
>20/25‡	276	39.48	438	62.66	1						
>20/32–20/25	173	24.75	126	18.03	1.68	1.23–2.29					
>20/40–20/32	99	14.16	58	8.30	2.25	1.64–3.08					
>20/63–20/40	94	13.45	48	6.87	2.73	2.04–3.65					
≤20/63	57	8.15	29	4.15	3.82	2.93–4.99					
Participation restrictions							**<0.0001**	21.39	13.81–28.46	19.13	7.31–27.35
>20/25‡	279	39.57	442	62.70	1						
>20/32–20/25	174	24.68	128	18.16	1.30	0.71–2.39					
>20/40–20/32	101	14.33	59	8.37	3.03	1.75–5.22					
>20/63–20/40	95	13.48	47	6.67	3.92	2.34–6.56					
≤20/63	56	7.94	29	4.11	7.12	4.41–11.48					

Bolded values indicate statistical significance. RR, relative risk; CI, confidence interval; GIF, generalized impact fraction; ADL, instrumental activities of daily living.

* Data based on the global population.

† Estimated GIF are stratified on age (<85 y and ≥85 y).

‡ The correspondence of visual impairment levels between Early Treatment Diabetic Retinopathy Study (ETDRS) and Snellen levels was as follows: >20/25, >80 letters; >20/32–20/25, 76–80 letters; >20/40–20/32, 71–75 letters; >20/63–20/40, 61–70 letters; ≤20/63, ≤60 letters.

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In the present study, there was no association between VI and ADL limitations, although an association was found in several cross-sectional and longitudinal studies.[4–8,30–32] This lack of association could be expected as ADLs are more basic and automatic tasks and thus probably require less accurate visual abilities than do more complex activities such as the IADLs.[7,33] Moreover, the association with ADL limitations may be more pronounced for more severe VI. However, only 73 participants in our sample were ADL-disabled, with thus a limited power to accurately evaluate the association with VI.

To our knowledge, few previous studies quantified the contribution of VI to activity limitations.[8,13] In the Canadian Study of Health and Aging,[8] adjusted PAR for IADL limitations was at 2.6% (women) and 4.5% (men), thus lower than ours; however, only self-reported VI was used. In the POLA study,[13] the overall GIF for IADL limitations was 20.5%, slightly higher than our 15.8%. However, the POLA study was conducted 10 years before ours. Regarding the association between VI and social participation restrictions, few studies have been published. Two studies have found an association between VI and social participation restrictions,[9,28] whereas another study didn't find an association between VI and social disability.[34] However, none of these previous studies quantified the PAR of VI on social participation restrictions.

The major strength of our study is that activity limitations were actively screened by a trained neuropsychologist during an at-home visit using validated scales and standardized procedures. In addition, visual acuity was measured by trained orthoptists in standardized conditions, thus preventing bias due to self-reported impairment and underdiagnosis of VI and activity limitations and allowing the assessment of expected improvement using optimal optical correction. Moreover, in order to limit the selection bias of our population, examinations (both for functional abilities and VI) were performed at the participant's home when the participant could not or did not want to come to the hospital for the eye examination, thus limiting selection bias. In addition, three domains of activity limitations and social participation restrictions were examined; we could thus explore all aspects of the disablement process. Finally, we studied different levels of VI, even minimal VI, taking into account many potential confounders.

Our study has also potential limitations. First, the design is cross-sectional, thus we could not exclude a possible reverse causality. However, as most of daily living activities require visual abilities, VI probably affects directly the ability to perform these activities and thus has a nearly immediate effect. Moreover, several previous studies have found an association between VI and activity limitations, both cross-sectionally and longitudinally, with short- and long-term increased risks.[4,5,9,35–37] Second, although GIF is more realistic than PAR (total elimination of VI is highly unlikely given the presence of eye diseases such as AMD, which cannot be avoided at present), but contrary to PAR, GIF cannot be adjusted on potential confounders. However, the exclusion of participants with dementia in our population, which is the greatest contributor to activity limitations, did not affect GIF results. Third, the estimation of PAR and GIF assume that the relation between VI and daily living activities is causal, which has not been proven. However, a relationship between VI and activity limitations has been found previously in several studies,[4–8] even in some longitudinal studies.[32,36–38] Moreover, it can be considered as a plausible and coherent relationship, according to the Bradford Hill Criteria of Causality,[39] as vision is required in all daily living activities. Fourth, we focused only on distance visual acuity, whereas near visual acuity could also be important in particular activities such as reading newspaper, managing drugs, or handling finances. Fifth, among 3C participants still alive at the time of the study, only 709 (53.5%) have had an eye examination. These participants differed from the others in sociodemographic characteristics (they were younger, included more males, and had a higher educational level). However, this selection bias should have led to underestimated associations between VI and activity limitations. Finally, other parameters of vision, such as contrast sensitivity or visual field, are probably important to consider for activity limitations, but were not available in our study.

Our findings have public health implications. Indeed, low vision is currently considered to be a presenting distance binocular visual acuity less than 20/70 by the WHO[10] (according to the *International Classification of Diseases*, 10th revision) and as a presenting distance visual acuity in the better-seeing eye less than 20/40 by the U.S. classification.[40] Thus, only relatively severe VI is considered, whereas in our study, an association with mobility and IADL limitations was found with even a minimal VI, that is, a distance visual acuity $\leq$20/25. These results suggest that the current WHO and U.S. VI definitions underestimate the prevalence of VI in the population, at least when the impact on activity limitations and participation restrictions are explored. Moreover, due to the high proportion of older adults with undercorrected refractive errors in our population and due to the relationships between VI and activities of daily living, a significant proportion of IADL and mobility limitations might be avoided just by the use of an optimal optical correction, although this remains to be confirmed in interventional studies. This finding underlines the potential for optical correction to prevent or delay autonomy loss.

This study has shown an association between VI and functioning in daily life in older adults, even for a minimal VI level. These results need to be replicated, in particular in studies with larger samples and longitudinal data to explore causality. Moreover, interventional studies are needed to confirm that improvement of optical correction may prevent or reverse activity limitations. In view of the growing burden of disability, these results represent a promising possibility for disability prevention.

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