Prevalence and factors associated with uncorrected presbyopia in a rural population of Japan: the Locomotive Syndrome and Health Outcome in Aizu Cohort Study

Running title: Uncorrected presbyopia in rural areas

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Abstract

Purpose To investigate the prevalence and factors associated with uncorrected presbyopia among rural community dwellers in Japan.

Study design: A population-based cross-sectional study was conducted in 2011 among community dwellers aged 40 to 74 years who received specific health checkups in Minamiaizu and Tadami, Fukushima Prefecture, Japan.

Methods Uncorrected presbyopia was considered as when the distance-corrected visual acuity in the better eye was ≥0.5 and the near-presenting visual acuity in the better eye was <0.4, regardless of distance refractive status. Multiple logistic regression analysis was employed to calculate the odds ratios (ORs) for uncorrected presbyopia and to adjust for possible confounders.

Results A total of 2054 individuals participated in the specific health checkups. In the 1156 individuals (response rate: 56.28%) analyzed in the study, the mean (SD) age was 63.0 (8.68) years, the percentage of women was higher (57.87%), and the prevalence of uncorrected presbyopia was 26.38% (95% CI: 23.86%–29.03%). Multivariate analysis revealed that the factors associated with uncorrected presbyopia were older age (adjusted OR: 1.054 [95% CI: 1.034–1.075]), female sex (adjusted OR: 1.388 [95% CI: 1.006–1.915]), and distance-presenting vision impairment (adjusted OR: 2.651 [95% CI: 1.697–4.143]).

Conclusion Approximately one-quarter of the participants in this study from a rural population of Japan did not have adequate near vision. It is recommended that a public health intervention should be enacted to correct presbyopia, especially in the older age group, women, and those with uncorrected refractive errors.

Keywords Presbyopia, Near-sightedness, Presenting visual acuity, Epidemiology

Introduction

The definition of visual impairment changes with time. The World Health Organization (WHO) traditionally used the best-corrected visual acuity (BCVA) to define visual impairments. Since the above definition overlooked uncorrected refractive errors, the major contributor to visual impairment, the WHO decided to employ presenting visual acuity (PVA), with usual optical correction, instead of BCVA in October 2006 [1]. In 2018, the International Classification of Diseases 11 included near PVA impairment in the category of vision impairment, as well as distance PVA impairment [2].

Near vision impairment, commonly caused by presbyopia, which is the age-related loss of near focusing ability, increases with age. It was estimated to affect more than 1 billion people globally in 2005, with more than half of those unable to access the necessary refractive correction to overcome the associated vision impairment [3]. Presbyopia can be easily corrected using glasses, contact lenses, or surgical approaches. However, the prevalence of uncorrected presbyopia in those aged over 50 years is reportedly as high as 34% in developed countries and as high as 50% in developing countries [4].

Many studies have reported on blindness or visual impairment surveys. However, most have focused on distance vision impairment, with limited focus on near vision impairment. Populations in developed countries are rapidly aging, and the Japanese population is aging the fastest. Therefore, the need for presbyopia correction is increasing and becoming an important public health issue. The objective of this

study was to investigate the prevalence and factors associated with uncorrected presbyopia among rural community dwellers in Japan.

Participants and methods

The Locomotive Syndrome and Health Outcome in Aizu Cohort Study (LOHAS) is an ongoing population-based cohort study of locomotive disorders, health outcomes, and life-related diseases among Japanese individuals in Minamiaizu and Tadami, Fukushima Prefecture, Japan [5–7]. This study is linked with annual specific health checkups by the local government.

All national health-insured persons aged 40 to 74 years are obliged to receive specific health checkups every year. The objective of these specific health checkups in Japan is to prevent life-related diseases (eg, cardiovascular diseases, cancer, diabetes, and hypertension). An eye examination is not included for the general population but only for individuals who had hyperglycemia, dyslipidemia, hypertension, or obesity in a previous year. To investigate the eye health status of the population in rural communities, an eye survey team has been involved since 2009 [8–10].

The detailed protocol of the LOHAS has been described elsewhere [5–10]. In 2012, distance and near vision tests were conducted as an option of specific eye health checkups for community dwellers. All participants

were requested through the public relations department of the local government to bring their corrective spectacles currently being used for near and distance vision. The study was conducted from April 11through June 8, 2012.

The participants received a standard set of health checkups items, such as a physical examination, laboratory tests, and a questionnaire. The physical examination included measurements of abdominal circumference, body weight, height, and blood pressure. The laboratory tests investigated serum triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), aspartate aminotransferase (AST), alanine transaminase (ALT), ɤ-glutamyl transferase (ɤ-GT), glucose or bN1-deoxyfructosylhemoglobin (HbA1c), urinary protein, and glucose. The questionnaire included current smoking status, alcohol consumption habit, and treatment history for systematic diseases, including diabetes, hypertension, cardiovascular disease, cerebrovascular disease, and any eye disease. All the participants were requested to answer a self-reported quality of vision assessment using the Japanese 11-item National Eye Institute Visual Function Questionnaire (VFQ-J11), previously reported to be reliable and to provide valid data on visual functioning in patients with eye diseases [11, 12].

After completion of the standard set of health checkup items, the participants proceeded to the vision screening site. Distance PVA was measured in all the participants by use of the Landolt ring chart (Handaya Co., Ltd.) at a distance of 5 m. For eyes with distance PVA <0.7, distance BCVA was also measured using

117 trial lenses, on the basis of data of noncyclopedic objective refraction using an auto ref/keratometer
118 (TONOREF II; Nidek Co., Ltd.). Near PVA in each eye was also measured unilaterally using the Landolt
119 ring chart (T.M.I. Co., Ltd.) at a fixed distance of 30 cm maintained from the chart using a string attached to
120 it. If a participant forgot to bring near vision spectacles, then the visual acuity without spectacles was
121 assessed. All visual acuity tests were performed by registered Japanese orthoptists.
122
123 *Data management and statistical analysis*
124 With reference to a systematic review and meta-analysis of the literature on the prevalence of distance and
125 near vision impairment [13], a participant was defined as having presbyopia when the distance-corrected
126 visual acuity in the better eye was ≥0.5 and the near PVA in the better eye was <0.4, regardless of distance
127 refractive status. In descriptive statistics, a continuous variable was expressed as the mean ± standard
128 deviation (SD), whilst categorical variables were expressed as the number and percentage (%). We assumed
129 that age; sex; distance PVA (≥0.5 vs <0.5); treatment history for diabetes (none/cured, under treatment vs
130 untreated), hypertension, cardiovascular disease, cerebrovascular disease, or any eye disease; current
131 smoking status (yes vs no); and alcohol consumption (frequent/occasional drinker vs moderate
132 drinker/abstainer) were associated with uncorrected presbyopia. We excluded from the analysis participants
133 who did not bring their currently used optical correction for near vision.
134 We estimated the prevalence of uncorrected presbyopia, and the probability value for trend was calculated
135 using the Cochrane-Armitage test to examine the linear pattern of the association of prevalence of

uncorrected presbyopia with age groups. Age-standardized prevalence estimates with 95% CIs were calculated using publicly available demographic data in Japan and worldwide [14]. Finally, crude and adjusted odds ratios (ORs) with 95% CIs were calculated using simple and multivariate logistic regression models to examine the measure of association between uncorrected presbyopia and the described variables. Data were analyzed using Stata/SE 15.1 for Windows (StataCorp).

Ethical considerations

All participants received an explanation of this study, provided their agreement to participate in it, and submitted written informed consent. The study complied with the principles set forth in the Declaration of Helsinki and was approved by the institutional review boards of Fukushima Medical University and Juntendo University School of Medicine.

Results

A total of 2054 Japanese individuals aged 40 to 74 years living in Minamiaizu and Tadami participated in specific health checkups. Of them, 1998 individuals proceeded to the vision screening test and 1971 individuals had BCVA ≥0.5 in the better eye, whilst 27 individuals (1.35% [95% CI: 0.89%–1.96%]) met the visual impairment criteria of the United States. Sixty individuals who rejected the near vision test, 747 individuals who did not bring reading glasses, and 8 individuals with missing variables were excluded,

leaving a total of 1156 participants who were included in the analysis. A flow diagram of the study population is shown in Figure 1.

The mean (SD) age of the study population was 63.0 (8.68) years, and 57.87% were women. Among 1156 participants with a distance BCVA ≥0.5, 92 participants had distance visual impairment due to uncorrected refractive errors. The overall demography of the analyzed population is shown in Table 1.

The prevalence of uncorrected presbyopia among participants with a distance BCVA ≥0.5 by age category is shown in Figure 2. The overall prevalence was 26.38% (95% CI: 23.86%–29.03%). Prevalence by age category was 5.56% (95% CI: 2.26%–11.11%), 24.02% (95% CI: 17.96%–30.96%), 28.55% (95% CI: 24.83%–32.49%], and 32.65% (95% CI: 27.32%–38.34%) for the groups aged 40 to 49 years, 50 to 59 years, 60 to 69 years, and 70 to 74 years, respectively (*P* for trend: <.001). The age-standardized prevalence estimates among individuals aged 40 to 74 years were 18.15% (95% CI: 13.76%–23.80%) and 21.15% (95% CI: 16.70%–26.61%) using the global and Japanese populations, respectively.

Table 2 shows the measure of association between uncorrected presbyopia and possible risk factors. Age (crude OR: 1.049 [95% CI: 1.031–1.067]) and poor distance PVA (crude OR: 2.961 [95% CI: 1.922–4.561]) were directly associated with uncorrected presbyopia in a simple logistic regression model. However, in a multivariate model, older age (adjusted OR: 1.054 [95% CI: 1.034–1.075]), female sex (adjusted OR: 1.388

[95% CI: 1.006–1.915]), and poor PVA (adjusted OR: 2.651 [95% CI: 1.697–4.143]) were significantly associated with uncorrected presbyopia.

Discussion

To the best of our knowledge, this is the first population-based epidemiologic study about near vision impairment conducted among a part of the Japanese population. The estimated prevalence of uncorrected presbyopia in our study population was 26.38%, and factors associated with uncontrolled presbyopia were older age, female sex, and distance visual impairment due to uncorrected refractive errors.

The definition of presbyopia has been inconsistent. Variations in font type, font size, and test distances have been the main causes of comparability issues [3]. The majority of near-vision research has used Times New Roman font, with the ability to see either N6 or N8 (N = Times New Roman font and the number denotes the point size in print) at either 40 cm or a preferred distance as the threshold for impairment, corresponding to 20/40 or 20/50 [3]. However, we defined uncorrected presbyopia as near PVA <0.4 at 30 cm. This is rational because, in Japan, near vision is usually measured at 30 cm, and a near visual acuity of 0.4 to 0.5 is required to read Japanese newspapers [15].

The WHO had recommended measurements for near vision in a population-based survey [16], but

193 epidemiologic surveys of near vision have been very limited worldwide. In Asia, several studies have been
194 published, most of which were performed in developing countries, such as China [17–19], Fiji [20], India
195 [21–24], Iran [25], Nepal [26], and Timor-Leste [27]. Since the socioeconomic aspect had been associated
196 with the prevalence of visual impairment, it would not be sensible to compare our results with those from
197 developing countries. Among high-income countries in the Asia-Pacific region, the prevalences of
198 uncorrected presbyopia are reported to be 16.0% and 33.9% in Australia [28] and Singapore [29],
199 respectively. Our result of 26.38% is in-between these results. Given that our study was conducted in a
200 remote area whilst others focused on urban areas, the prevalence of uncorrected presbyopia in Japan as a
201 whole would probably be closer to that in Australia.
202
203 The relationship between uncorrected presbyopia and predictors is not well known. In this study, the choice
204 of covariates was made with reference to previous population-based studies [17, 20, 24, 27, 30, 31]. It would
205 be plausible that older age and distance PVA impairment were associated with higher OR of uncorrected
206 presbyopia. However, sex difference is controversial. A large epidemiologic study in Japan found that women
207 were less likely than men to go out, work, engage in hobby activities, attend meetings, or socialize with
208 friends [32]. As compared with men, women may have fewer situations where they feel the need to correct
209 presbyopia.
210
211 Current smoking [30] and alcohol consumption status [17, 24, 31] were also reported to be associated with

near vision impairment. In this study, we found no association between smoking or alcohol consumption and uncorrected presbyopia. Treatment history was divided into 3 categories—none or cured, under treatment, and untreated—because untreated individuals were expected to have low eye health literacy. Uncorrected presbyopia was not high even among untreated participants who were assumed to have low eye health literacy. Apart from the medical history for systematic diseases, it is surprising that the ORs did not differ significantly between individuals undergoing ophthalmic treatment and those not undergoing it. This may be due to the lesser interest among ophthalmologists in correcting refractive errors and presbyopia. To support this theory, only 18.40% (95% CI: 16.31%–20.65%) of the 1266 participants were prescribed reading glasses under the supervision of ophthalmologists [result not shown].

A strength of our study is that this is the first population-based study in Japan focusing on near and distance PVA using a standardized protocol. As compared with BCVA, PVA represents the visual quality in daily life. At the same time, surveys on PVA can indirectly represent the screening status of visual impairment in a region, the resident awareness of the importance of daily vision, and the level of comprehensive medical ophthalmic services. We assumed that community dwellers would be more interested in their PVA than in their BCVA. In rural areas, public transportation is more limited than that in urban areas, making driving a car for those in rural areas and getting around by themselves an extremely important daily activity.

Several limitations of this study should be acknowledged. First, the study raises concerns about

231 generalizability. The survey site was located in the most remote and rural area of Fukushima Prefecture,
232 Japan. Geographic access is the most important rural health care barrier. Remote and rural communities lack
233 adequate public transportation, making access to eye health providers very difficult. The prevalence of
234 uncorrected presbyopia would have been lower if this survey had been conducted in an urban setting, where
235 access to eye health care is easier.
236
237 Second, the participation rate in the near vision test was low. Long waiting times for participants contributed
238 to lower participant rates for health checkups. In addition, the local health sectors announced that participants
239 should bring reading glasses currently in use, but many did not bring them. The mean (SD) scores of near
240 vision in VFQ-J11 (score between 0 and 100, with higher scores indicating better vision-specific quality of
241 life) were 80.82 (0.60) and 74.63 (0.85) for analyzed individuals and excluded individuals, respectively
242 [results not shown]. However, the mean difference between the 2 groups was relatively small. Considering
243 that 25 points are required to raise the inconvenience in near work by 1 level, the influence of this selection
244 bias might be smaller than expected.
245
246 Third, near PVA was measured at a fixed distance of 30 cm. But this measurement might overestimate the
247 prevalence of uncorrected presbyopia because an individual's correction for near work (eg, reading) might
248 not match his or her preferred distance. In support of this notion, 84.41% (95% CI: 82.18%–86.46%) of the
249 participants answered "no difficulty at all" or "a little difficulty" in reading newspapers on the VFQ-J11

(result not shown).

Fourth, our study did not include other risk factors previously reported, such as educational level and income. Thanks to the nationwide compulsory education and universal health insurance systems, we could probably ignore these biases.

Uncontrolled presbyopia negatively impacts quality of life, especially for the older population. However, nearly a quarter of the tested rural population in Fukushima Prefecture, Japan, did not have an adequate optical correction for near vision. The findings in this study have important implications from clinical and public health perspectives. Public health interventions to increase health literacy about near vision, especially among the older population, women, and those with distance vision impairment due to refractive errors, should be a priority in public health ophthalmology.

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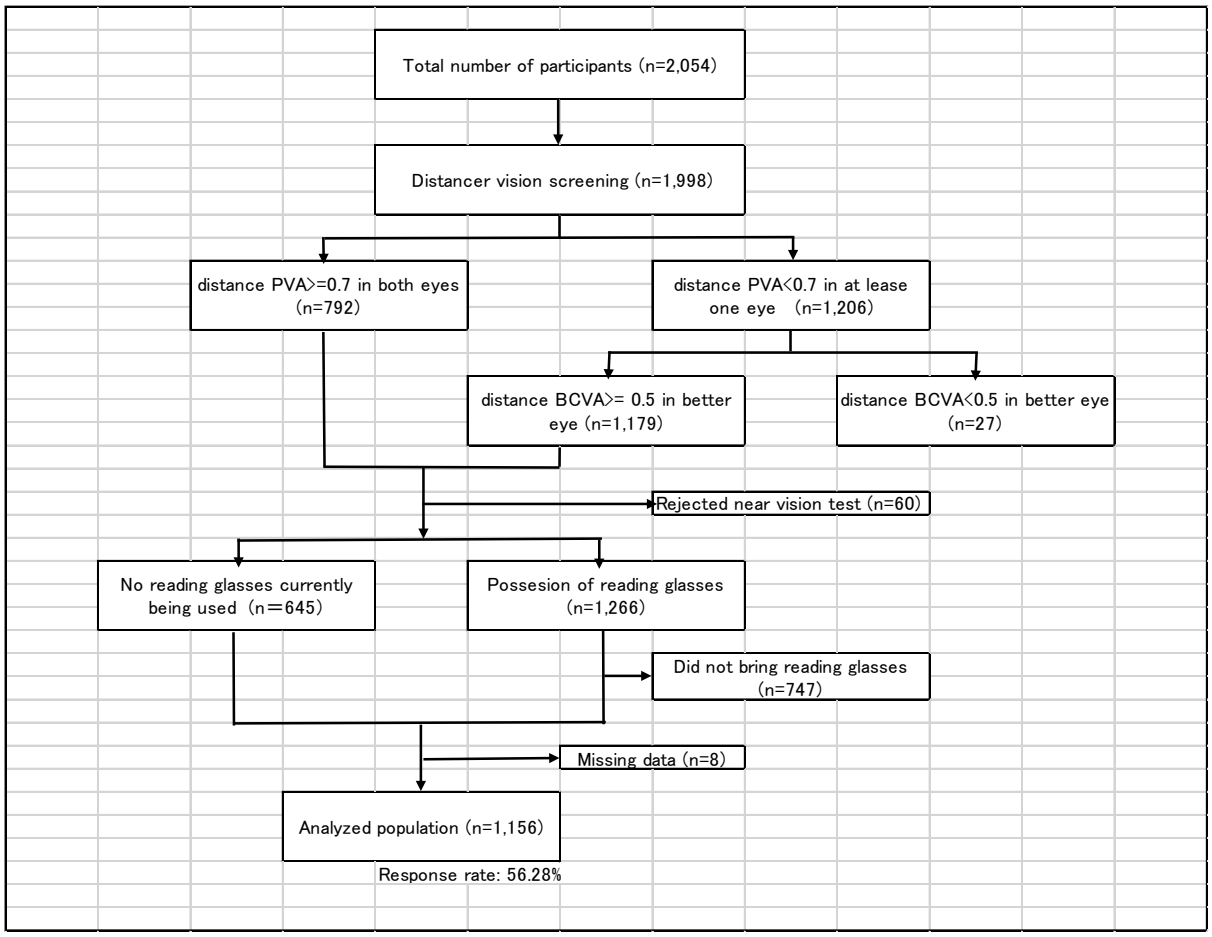
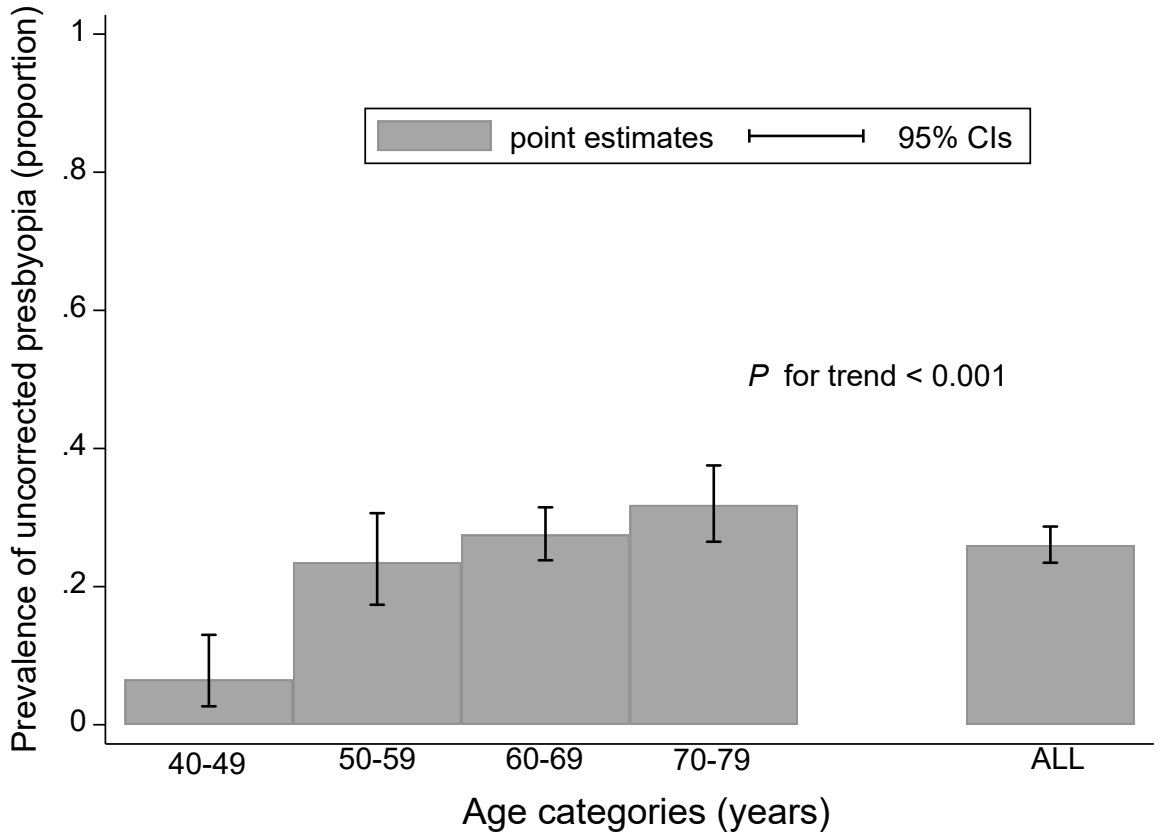
354

355 **Figure legends**



356

357 **Fig. 1** Flow diagram of studied population. *PVA* presenting visual acuity, *BCVA* best-corrected visual acuity



358

359 **Fig. 2** Prevalence of uncorrected presbyopia by age category

360

Table1: Demography of studied population (n=1,156)

		No.	*%*
Age category	40-49	126	10.90%
	50-59	179	15.48%
	60-69	557	48.18%
	70-74	294	25.43%
Sex	Males	487	42.13%
	Females	669	57.87%
Distance PVA	>=0.5	1,064	92.04%
	<0.5	92	7.96%
Eye Diseases	No/Cured	970	83.91%
	Under treatment	160	13.84%
	Untreated	26	2.25%
Hypertention	No/Cured	704	60.90%
	Under treatment	416	35.99%
	Untreated	36	3.11%
Diabetes	No/Cured	1,072	92.73%
	Under treatment	73	6.31%
	Untreated	11	0.95%
Heart diseases	No/Cured	1,098	94.98%
	Under treatment	56	4.84%
	Untreated	2	0.17%
Cerevascular diseases	No/Cured	1,130	97.75%
	Under treatment	26	2.25%
	Untreated	0	0.00%
Alcohol consumption	No	594	51.38%
	Yes	562	48.62%
Current smoking	No	987	85.38%
	Yes	169	14.62%

361 *PVA* Presenting visual acuity

Table2: Measure of association between uncorrected presbyopia and variables

		SLR model				MLR model			
		Crude ORs	95% Confidence Intervals		*P*-values	Adjusted ORs	95% Confidence Intervals		*P*-values
Age		1.049	1.031	to 1.067	0.000	1.054	1.034	to 1.075	0.000
Sex	Males	*1*	–	–	–	*1*	–	–	–
	Females	1.259	0.963	to 1.646	0.092	1.388	1.006	to 1.915	0.046
Distance PVA	>=0.5	*1*	–	–	–	*1*	–	–	–
	<0.5	2.961	1.922	to 4.561	0.000	2.651	1.697	to 4.143	0.000
Eye Diseases	No/Cured	*1*	–	–	–	*1*	–	–	–
	Under treatment	1.331	0.924	to 1.915	0.124	1.003	0.679	to 1.481	0.988
	Untreated	1.301	0.559	to 3.029	0.542	1.084	0.445	to 2.640	0.858
Hypertention	No/Cured	*1*	–	–	–	*1*	–	–	–
	Under treatment	1.096	0.834	to 1.440	0.512	0.886	0.655	to 1.198	0.432
	Untreated	0.819	0.367	to 1.830	0.627	1.046	0.454	to 2.407	0.916
Diabetes	No/Cured	*1*	–	–	–	*1*	–	–	–
	Under treatment	1.131	0.669	to 1.912	0.645	1.101	0.630	to 1.926	0.735
	Untreated	0.623	0.134	to 2.899	0.546	0.638	0.130	to 3.118	0.578
Heart diseases	No/Cured	*1*	–	–	–	*1*	–	–	–
	Under treatment	0.753	0.392	to 1.445	0.393	0.633	0.319	to 1.257	0.191
	Untreated	2.760	0.172	to 44.273	0.473	1.678	0.096	to 29.436	0.723
Cerevascular diseases	No/Cured	*1*	–	–	–	*1*	–	–	–
	Under treatment	2.085	0.947	to 4.591	0.068	1.731	0.747	to 4.007	0.200
	Untreated	–	–	–	–	–	–	–	–
Alcohol consumption	No	*1*	–	–	–	*1*	–	–	–
	Yes	0.995	0.766	to 1.293	0.970	1.171	0.872	to 1.572	0.293
Current smoking	No	*1*	–	–	–	*1*	–	–	–
	Yes	1.015	0.701	to 1.468	0.938	1.383	0.913	to 2.093	0.126

362 *SLR* Simple logistic regression, *MLR* Multivariate logistic regression, *OR* Odds ratio, *PVA* Presenting visual acuity

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