ASSESSMENT OF VISUAL STATUS OF THE AETA, A HUNTER-GATHERER POPULATION OF THE PHILIPPINES (AN AOS THESIS)

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ABSTRACT

Purpose: A screening study was performed to assess levels of visual impairment and blindness among a representative sample of older members of the Aeta, an indigenous hunter-gatherer population living on the island of Luzon in the Philippines.

Methods: Unrelated older Aeta couples were randomly invited to participate in a visual screening study. All consented individuals had ocular history, medical history, complete ophthalmic examination, height, weight, and blood pressure taken.

Results: A total of 225 individuals were screened from 4 villages. Visual acuity, both uncorrected and pinhole corrected, was significantly worse among older vs younger age-groups for women, men, and when combined ($P < .001$). Visual impairment was present in 48% of uncorrected and 43% of pinhole corrected eyes in the oldest age-group. Six percent of the screened population was bilaterally blind. The major causes of blindness were readily treatable. The most common etiologies as a proportion of blind eyes were cataract (66%), refractive error (20%), and trauma (7%). No cases of primary open-angle, primary angle-closure, or exfoliation glaucoma were observed in this population.

Discussion: Visual impairment and blindness were common in the Aeta population. Primary forms of glaucoma, a major cause of blindness found in most population-based studies, were not observed. The absence of primary glaucoma in this population may reflect random sampling error. However, based on similar findings in the Australian Aborigine, this raises the possibility that these two similar populations may share genetic and/or environmental factors that are protective for glaucoma..

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INTRODUCTION

It is essential to assess a population's medical status in order to determine the need for medical services. This report describes a small-scale screening study designed to evaluate the types and relative frequency of vision-related disorders among the Aeta, an isolated population living in a remote region of the Philippines.

The Aeta (also Ayta or Agta), until recently a hunter-gatherer population, are indigenous to the main island of Luzon in the Philippine archipelago.[1-4] They are considered by anthropologists to be descendants of the original inhabitants of the Philippines. The Aeta are physically characterized by dark skin, finely curled hair, and short stature (Figure 1). They are located in isolated regions along the foothills of Mount Pinatubo in the Zambales Range in the province of Pampanga. The Aeta have traditionally lived in small mobile groups of 1 to 5 families that practice a form of slash-and-burn agriculture locally called *kaingin*. The massive eruption of Mount Pinatubo in 1991 resulted in the relocation of thousands of members of this population. Many of these families were moved to settlement villages in surrounding regions by a variety of relief organizations and governmental agencies. The establishment of these settlements has enabled greater access to this population by a variety of social agencies.[5]

FIGURE 1

Elderly Aeta couple. Zambales mountain range is seen in the background.

Recently, medical clinics have been established for some settlement villages to provide basic medical care; however, vision services are not currently available. Since screening studies have not been conducted to date, there is little information available for health agencies to utilize in planning interventions. In an effort to assess the need for vision services among the Aeta, we conducted a screening project to determine the prevalence and major causes of vision loss in older members of this population.

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METHODS

All aspects of this study adhere to the Declaration of Helsinki. The goal of this project was to perform vision screening and determine major causes of vision loss among middle-aged to older members of the Aeta population. In addition to the vision screening study, willing individuals were separately consented for inclusion in the Genographic Project sponsored by the National Geographic Society, a molecular genetic study of the origins of indigenous populations worldwide.[6] Approval for each study was obtained through the Commission for Indigenous Peoples (Philippines) and the Duke University Investigational Review Board and the University of Pennsylvania Investigational Review Board (National Geographic Genographic Project).

SUBJECT SELECTION

Population Selection

Participants were recruited from 4 small villages (*barangay*) within the Pampanga province on the island of Luzon. *Barangay* selected for this study were exclusively occupied by the Aeta population and comprised groups of smaller family subunits. These villages were chosen based on their accessibility by motorized transport. Navigable roads were essential, since most villages are located in remote areas, and large vans, or "jeepneys," were needed to transport groups of 20 to 35 individuals.

A census performed in 2001 was used to coordinate selection of participants as evenly as possible throughout the region.[7] The census data was limited, containing only population estimates for each *barangay*. Age, sex, and other demographic data were not available. In accordance with local custom, social workers contacted the leader (*kapitan*) of each *barangay* to assist with the conduct of the study. The *kapitans* were asked to discuss the nature of the study and, for willing participants, to randomly select couples from unrelated families for the screening without regard to visual status. The oldest couples within each family unit were invited to participate. Participants were informed that there would be no cost for participation in the study and that meals would be provided for the day-long process. Reading glasses were provided to all study participants at the conclusion of the screening process as a gesture of appreciation. The number of participants selected at each location was determined from the available census data, with a target of 1% of the census total (estimated 175 to 200 participants). Every effort was made to avoid bias in the subject selection process; however, it was not possible to monitor the procedure used by *kapitans* to select participating couples.

Determination of Age

An effort was made to enroll participants older than 40 years of age. The Aeta do not follow a calendar; and therefore there is no record of birthdates. In order to estimate age, a historical reference was employed as a substitute calendar. World War II (WWII) is well remembered by all older Aeta, who were displaced and in some cases attacked by Japanese troops during the occupation of the Philippines from 1941 to 1945. Using this as a calendar substitute, Aeta who were alive, or whose parents or grandparents were alive, during WWII were invited to participate. The estimated age of those alive during WWII would be greater than 60 years. The estimated age for Aeta couples to begin to have children is 12 to 15 years of age (data from the Commission for Indigenous Peoples, Manila). Therefore, the estimated age for those whose parents were alive during WWII would be approximately 40 to 60 years; those whose grandparents were alive would be less than 40 years old.

Facility and Equipment

The St James Parrish, located in the town of Guagua, was used to conduct vision screening. Electricity was available to power examination equipment. Slit lamps, goniolenses, direct ophthalmoscopes, indirect ophthalmoscopes, and Tonopens were used for examinations. Automated perimetry was not available, so in all cases where perimetry was indicated, a tangent screen was utilized.

Screening and Examination Process

After obtaining informed consent, a questionnaire was completed for each subject that included data on village of origin, assessment of approximate age, sex, past medical history, past ocular history, and visual complaints. Each individual was tested for visual acuity (uncorrected and pinhole) and intraocular pressure (IOP), and given a slit-lamp, gonioscopic, and dilated fundus examination (Figure 2). Visual acuity was assessed using tumbling E's at a distance of 20 feet. IOP was assessed in a sitting position using a calibrated Tonopen. All participants who had a vertical cup-disc ratio (VCDR) ≥ 0.6, asymmetry of VCDR ≥ 0.2, presence of focal neuroretinal rim defects, disc hemorrhages, or IOP > 21 mm Hg in either eye had tangent screen visual field testing. Tangent screen visual field testing was performed at 1 meter for each eye with a standard 3-mm white target for patients who met these criteria.

In addition to vision assessment, each patient's height, weight, and blood pressure were measured and recorded. Blood or sputum samples were obtained from all consenting study participants.

Definition of Visual Impairment and Blindness

Visual impairment was categorized using criteria commonly applied in U.S. studies that define low vision as acuity worse than 20/40 and better than 20/200 and blindness as visual acuity of 20/200 or worse.

Statistical Analysis

Descriptive statistics were computed for all variables in all patients and separately for men and women. The significance of the difference in medians among age-groups was assessed using the Kruskall-Wallis test. Pairwise comparisons of medians between age-groups used the Wilcoxon rank sum test. To assess the difference between men and women with respect to age, the chi-square test was used.

FIGURE 2

Screening slit-lamp examination of the Aeta. Because of the short stature of most Aeta, the physical methods used to perform slit-lamp examinations were modified.

RESULTS

Individuals from multiple locations were enrolled for this study. All participants originated from within the Pinatubo region. The only available census for the Aeta, performed in 2001, was used to coordinate selection of participants as evenly as possible throughout the region (Table 1).[7] Four villages were chosen based on accessibility and a population that was amenable to participation, a quality that was determined by the *kapitan* from each village. The villages that were ultimately chosen were Angeles, Floridablanca, Mabalacat, and Porac. The census populations of the *barangays* varied from 1858 to 7219. The total sampled population was 17,600. The percent of the population screened from each *barangay* varied from 0.85% in Floridablanca to 2.1% in Angeles. Approximately 1.3% of the total census populations of the selected *barangays* was enrolled and screened.

TABLE 1. TOTAL AND SCREENED POPULATIONS FROM EACH BARANGAY (VILLAGE) WITHIN THE STUDY SITE WITHIN THE PAMPANGA PROVINCE

BARANGAY	TOTAL AETA POPULATION*	AETA INDIVIDUALS SCREENED
Angeles	1,858	39 (2.1%)
Floridablanca	4,810	41 (0.85%)
Mabalacat	3,713	59 (1.5%)
Porac	7,219	86 (1.2%)

*Data derived from the 2001 census of the Aeta population within the Pinatubo region.

GENERAL BASELINE DATA

A total of 225 study participants were enrolled and examined. Height and weight by sex and combined are shown in Table 2 for each age-group. The mean height for the entire screened population was 54.6 inches, approximately 4.5 feet. The mean height for men and women as a whole was 56.8 and 53.7 inches, respectively. The mean height for women between age-groups was not significantly different. This varied from the mean heights in Aeta men, which were significantly greater in both younger groups compared with the older group ($P < .001$). The mean weight for all participants was approximately 85 lb and was 84 lb and 94 lb for women and men, respectively. The mean weight for the combined group was significantly greater in the 2 younger groups compared with the older group ($P < .002$). Weight increased from older to younger age-groups for both women ($P < .05$) and men ($P < .001$).

The past medical history was provided by each subject. The most common disorder described was systemic hypertension.

TABLE 2. COMPARISON OF STUDY PARTICIPANTS' HEIGHT AND WEIGHT BY AGE-GROUP AND SEX (n = 225)*

VARIABLE	AGE 1: YOUNG	AGE 2: MIDDLE-AGED	AGE 3: OLD	*P* VALUE†			
				OVERALL	AGE 1-AGE 2	AGE 1-AGE 3	AGE 2-AGE 3
Height, female							
N	18	73	63				
Mean (SD)	54 (2.87)	54 (2.78)	53.2 (3.24)				
Min/Median/Max	51,53.5,63	49,54,63	43,53,61	.249	.798	.348	.108
Weight, female							
N	18	73	63				
Mean (SD)	90.7 (28.5)	82.3 (18.6)	76.6 (20.6)				
Min/Median/Max	64,80,182	48,79,138	40,72,158	.052	.326	**.039**	.062
Height, male							
N	7	23	41				
Mean (SD)	59.9 (3.13)	58.8 (3.13)	55.1 (2.52)				
Min/Median/Max	55,60,64	53,60,63	49,56,61	**<.001**	.488	**.001**	**<.001**
Weight, male							
N	7	23	41				
Mean (SD)	111 (19.3)	107 (22.9)	84 (18.5)				
Min/Median/Max	78,109,139	58,100,168	60,81,152	**<.001**	.461	**.004**	**<.001**
Height, combined							
N	25	96	104				
Mean (SD)	55.6 (3.94)	55.2 (3.52)	54 (3.1)				
Min/Median/Max	51,55,64	49,55,63	43,54,61	.086	.738	.124	**.047**
Weight, combined							
N	25	96	104				
Mean (SD)	96.3 (27.4)	88.3 (22.3)	79.5 (20)				
Min/Median/Max	64,92,182	48,87,168	40,79.5,158	**.002**	.236	**.005**	**.005**

* Age is estimated. Height in inches. Weight in pounds.

†*P* values ≤.05 are in bold. Overall *P* value is based on Kruskall-Wallis test of differences among medians. *P* values for pairwise tests are based on Wilcoxon signed rank test of differences between medians.

Nineteen participants gave a history of high blood pressure. Blood pressure was measured in all participants during the course of the screen; of 199 participants who had blood pressure measured, 11 had blood pressure higher than 140/90, and 5 of these participants reported a history of systemic hypertension. Five participants reported a history of goiter, one of which had a subtotal thyroidectomy. Diabetes mellitus was reported by 2 participants. A variety of other disorders or complaints were reported, including headache, abdominal pain, joint or back pain, dizziness, and urinary tract infection. Access to medications or compliance with recommended treatment could not be determined.

VISUAL DATA

The proportion of eyes with uncorrected and pinhole corrected visual acuity of 20/40 or better, low vision (worse than 20/40 and better than 20/200), and blindness (20/200 or worse) is shown in Table 3. As expected, the vast majority of eyes in the younger age-group have visual acuity better than or equal to 20/40 both uncorrected and pinhole corrected (90% and 96%, respectively). The one exception was an individual with refractive error in one eye, correctable with pinhole to 20/50, and amblyopia in the fellow eye (counting fingers vision). In older age-groups both uncorrected and corrected visual acuity fell dramatically. Uncorrected visual acuity ≤ 20/40 dropped to 55% in the middle-aged group and 33% in the older group. Similarly, pinhole corrected visual acuity ≤ 20/40 decreased from 70% to 41%, respectively, in the older age-groups.

The prevalence of low vision in individual eyes rose from 4% of the younger age-group to 48% of those in the oldest age-group, while pinhole corrected visual acuity among these 2 groups increased from 2% to 43%, respectively. Blindness increased from 2% to 19% in uncorrected eyes and 2% to 16% of pinhole corrected eyes in the youngest to oldest age-groups. Interestingly, only 19 participants (11 female, 8 male) specifically complained about blurred or reduced vision in the screened population. Of these, only 6 had uncorrected vision worse than 20/40 in at least one eye. The majority of participants, even those who had significant visual impairment, did not report a functional deficit.

TABLE 3. UNCORRECTED AND PINHOLE (PH) CORRECTED VISUAL ACUITIES OF STUDY PARTICIPANTS, BY AGE-GROUP (EYES)

AGE-GROUP	UNCORRECTED ≤20/40	PH CORRECTED ≤20/40	UNCORRECTED >20/40 AND <20/200	PH CORRECTED >20/40 AND <20/200	UNCORRECTED ≥20/200	PH CORRECTED ≥20/200
Younger (n = 50)	45 (90%)	48 (96%)	2 (4%)	1 (2%)	1 (2%)	1 (2%)
Middle-aged (n = 192)	106 (55%)	134 (70%)	69 (36%)	47 (24%)	17 (9%)	11 (6%)
Older (n = 208)	68 (33%)	85 (41%)	100 (48%)	90 (43%)	40 (19%)	33 (16%)

Visual acuity, after conversion to LogMAR units, is analyzed for women, men, and combined by age-group in Tables 4, 5, and 6. Overall visual acuity was significantly different between age-groups, with younger groups having better vision than older groups. This pattern was consistent when analyzed by sex and combined ($P < .001$).

TABLE 4. VISUAL ACUITY (VA) IN FEMALE STUDY PARTICIPANTS ACCORDING TO AGE-GROUP, BY EACH EYE AND BOTH EYES COMBINED*

VARIABLE	AGE 1: YOUNG	AGE 2: MIDDLE-AGED	AGE 3: OLD	*P* VALUE OVERALL	AGE 1-AGE 2	AGE 1-AGE 3	AGE 2-AGE 3
VA OD							
N	18	73	63				
Mean (SD)	0.16 (0.25)	0.38 (0.48)	0.57 (0.59)				
Min/Median/Max	0,0.14,1	0,0.18,2.9	0,0.4,3.2	**<.001**	**.009**	**<.001**	**.008**
VA OS							
N	18	73	63				
Mean (SD)	0.27 (0.48)	0.37 (0.5)	0.55 (0.58)				
Min/Median/Max	0,0.18,2	0,0.18,3.2	0,0.4,3.2	**<.001**	.075	**.001**	**.003**
VA OU							
N	18	73	63				
Mean (SD)	0.21 (0.35)	0.37 (0.4)	0.56 (0.49)				
Min/Median/Max	0,0.16,1.5	0,0.29,2	0,0.4,2	**<.001**	**.016**	**<.001**	**.009**
VA OD (ph)							
N	18	73	63				
Mean (SD)	0.12 (0.13)	0.31 (0.46)	0.51 (0.56)				
Min/Median/Max	0,0.14,0.4	0,0.18,2.9	0,0.4,3.2	**<.001**	**.012**	**<.001**	**<.001**
VA OD (ph)							
N	18	73	63				
Mean (SD)	0.19 (0.46)	0.31 (0.49)	0.47 (0.56)				
Min/Median/Max	0,0.09,2	0,0.18,3.2	0,0.4,3.2	**<.001**	**.011**	**<.001**	**.002**

TABLE 4 (CONTINUED). VISUAL ACUITY (VA) IN FEMALE STUDY PARTICIPANTS ACCORDING TO AGE-GROUP, BY EACH EYE AND BOTH EYES COMBINED*

VARIABLE	AGE 1: YOUNG	AGE 2: MIDDLE-AGED	AGE 3: OLD	*P* VALUE			
				OVERALL	AGE 1-AGE 2	AGE 1-AGE 3	AGE 2-AGE 3
Visual Acuity OU (ph)							
N	18	73	63				
Mean (SD)	0.15 (0.28)	0.31 (0.38)	0.49 (0.45)				
Min/Median/Max	0,0.11,1.2	0,0.18,2	0,0.4,2	**<.001**	**.006**	**<.001**	**.001**

ph, pinhole corrected.
**P* values ≤.05 are in bold. Overall *P* value is based on Kruskall-Wallis test of differences among medians. *P* values for pairwise tests are based on Wilcoxon signed rank test of differences between medians. Visual acuity is in LogMAR units.

TABLE 5. VISUAL ACUITY (VA) IN MALE STUDY PARTICIPANTS ACCORDING TO AGE-GROUP, BY EACH EYE AND BOTH EYES COMBINED*

VARIABLE	AGE 1: YOUNG	AGE 2: MIDDLE-AGED	AGE 3: OLD	*P* VALUE			
				OVERALL	AGE 1-AGE 2	AGE 1-AGE 3	AGE 2-AGE 3
VA OD							
N	7	23	41				
Mean (SD)	0.06 (0.15)	0.36 (0.53)	0.56 (0.53)				
Min/Median/Max	0,0,0.4	0,0.18,2.6	0,0.4,2	**<.001**	**.008**	**<.001**	**.017**
VA OS							
N	7	23	41				
Mean (SD)	0.03 (0.07)	0.53 (0.85)	0.79 (0.82)				
Min/Median/Max	0,0,0.18	0,0.18,3.2	0,0.54,3.2	**<.001**	**.001**	**<.001**	**.003**
VA OU							
N	7	23	41				
Mean (SD)	0.04 (0.11)	0.45 (0.63)	0.68 (0.56)				
Min/Median/Max	0,0,0.29	0,0.29,2.9	0,0.54,2	**<.001**	**.001**	**<.001**	**.004**
VA OD (ph)							
N	0.297	23	41				
Mean (SD)	0.03 (0.07)	0.31 (0.53)	0.53 (0.54)				
Min/Median/Max	0,0,0.18	0,0.18,2.6	0,0.4,2	**<.001**	**.005**	**<.001**	**.004**
VA OS (ph)							
N	7	23	41				
Mean (SD)	0.03 (0.07)	0.52 (0.85)	0.71 (0.83)				
Min/Median/Max	0,0,0.18	0,0.18,3.2	0,0.4,3.2	**<.001**	**.001**	**<.001**	**.017**

TABLE 5 (CONTINUED). VISUAL ACUITY (VA) IN MALE STUDY PARTICIPANTS ACCORDING TO AGE-GROUP, BY EACH EYE AND BOTH EYES COMBINED*

VARIABLE	AGE 1: YOUNG	AGE 2: MIDDLE-AGED	AGE 3: OLD	*P* VALUE			
				OVERALL	AGE 1-AGE 2	AGE 1-AGE 3	AGE 2-AGE 3
VA OU (ph)							
N	7	23	41				
Mean (SD)	0.03 (0.07)	0.42 (0.62)	0.62 (0.57)				
Min/Median/Max	0,0,0.18	0,0.29,2.9	0,0.44,2	**<.001**	**.001**	**0.001**	**.010**

ph, pinhole corrected.
**P* values ≤.05 are in bold. Overall *P* value is based on Kruskall-Wallis test of differences among medians. *P* values for pairwise tests are based on Wilcoxon signed rank test of differences between medians. Visual acuity is in LogMAR units.

TABLE 6. VISUAL ACUITY IN FEMALE AND MALE STUDY PARTICIPANTS ACCORDING TO AGE-GROUP, BY EACH EYE AND BOTH EYES COMBINED*

VARIABLE	AGE 1: YOUNG	AGE 2: MIDDLE-AGED	AGE 3: OLD	*P* VALUE			
				OVERALL	AGE 1-AGE 2	AGE 1-AGE 3	AGE 2-AGE 3
VA OD							
N	25	96	104				
Mean (SD)	0.13 (0.23)	0.37 (0.49)	0.57 (0.57)				
Min/Median/Max	0,0,1	0,0.18,2.9	0,0.4,3.2	<.001	<.001	<.001	<.001
VA OS							
N	25	96	104				
Mean (SD)	0.2 (0.42)	0.41 (0.6)	0.64 (0.69)				
Min/Median/Max	0,0,2	0,0.18,3.2	0,0.4,3.2	0.001	.001	<.001	<.001
VA OU							
N	25	96	104				
Mean (SD)	0.17 (0.31)	0.39 (0.46)	0.6 (0.52)				
Min/Median/Max	0,0,1.5	0,0.29,2.9	0,0.42,2	<.001	.001	<.001	<.001
VA OD (ph)							
N	25	96	104				
Mean (SD)	0.09 (0.12)	0.31 (0.48)	0.51 (0.55)				
Min/Median/Max	0,0,0.4	0,0.18,2.9	0,0.4,3.2	<.001	<.001	<.001	<.001
Visual Acuity OS (ph)							
N	25	96	104				
Mean (SD)	0.14 (0.4)	0.36 (0.6)	0.56 (0.69)				
Min/Median/Max	0,0,2	0,0.18,3.2	0,0.4,3.2	<0.001	<.001	<.001	<.001

TABLE 6 (CONTINUED). VISUAL ACUITY IN FEMALE AND MALE STUDY PARTICIPANTS ACCORDING TO AGE-GROUP, BY EACH EYE AND BOTH EYES COMBINED*

VARIABLE	AGE 1: YOUNG	AGE 2: MIDDLE-AGED	AGE 3: OLD	*P* VALUE			
				OVERALL	AGE 1-AGE 2	AGE 1-AGE 3	AGE 2-AGE 3
VA OU (ph)							
N	25	96	104				
Mean (SD)	0.12 (0.24)	0.33 (0.45)	0.54 (0.5)				
Min/Median/Max	0,0,1.2	0,0.18,2.9	0,0.4,2	<.001	.001	<.001	0.001

ph, pinhole corrected.
**P* values ≤.05 are in bold. Overall *P* value is based on Kruskall-Wallis test of differences among medians. *P* values for pairwise tests are based on Wilcoxon signed rank test of differences between medians. Visual acuity is in LogMAR units.

Mean IOP (± SD) was 15.6 ± 3.1 for right eyes and 16.0 ± 4.6 for left eyes. Gonioscopy revealed 2 cases of narrow but nonoccludable angles, 3 cases of heavily pigmented angles (without corneal endothelial pigmentation or iris transillumination defects), 1 case of uveitis, and 5 cases of peripheral anterior synechiae related to trauma or corneal scarring. Ocular pathology found on anterior segment and fundus examination, excluding cataracts, is summarized in Table 7. In addition to these more common findings, there were 2 cases of exotropia and single cases of entropion, blepharospasm, allergic conjunctivitis, panuveitis, and optic neuropathy. Pseudophakia and aphakia were observed only in male participants.

TABLE 7. OCULAR PATHOLOGY, EXCLUDING CATARACT, IDENTIFIED IN STUDY PARTICIPANTS ON SLIT-LAMP AND FUNDUS EXAMINATIONS

FINDING	FEMALE	MALE	COMBINED
Pterygium	8	4	12
Corneal scarring	1	3	4
Phthisis or penetrating trauma	1	4	5
Pseudophakia/aphakia	0	7	7
Exfoliation syndrome	8	5	13
Retinal disease	5	2	7

Blindness was evaluated in all age-groups and is reported by eye in Table 8. Blindness *excluding* refractive error (pinhole corrected) was found in 9% of right eyes and 11% of left eyes. Bilaterally, blindness was found in 6% of participants and increased dramatically by age-group. There was no individual who was blind in both eyes in the youngest age-group, although 1 subject was 20/200 uncorrected (20/50 pinhole corrected) and counting fingers from amblyopia in the fellow eye. There were 10 nonrefractive blind eyes in the middle-aged group (5% of eyes), in which 2 individuals were blind bilaterally (2% of middle-aged group). In the older age-group there were 33 nonrefractive blind eyes (16% of eyes), of which 12 were bilaterally blind (6% of older participants). The cause of blindness in all cases is summarized in Table 9 and is presented as a percent of total eyes (n = 450) and as a percent of blind eyes (n = 59). As expected, cataract was the most common cause of blindness,it was responsible for blindness in 15% of examined eyes and caused two thirds of all blindness. This was followed in prevalence by refractive error and trauma (20% and 7% of blind eyes, respectively). Corneal scarring and amblyopia each accounted for 1 case. Three cases of blindness were caused by ocular trauma with associated glaucoma. These cases were accompanied by opacified corneas and/or flat anterior chambers. Highly elevated IOP measured by Tonopen or tactile tension was present in these cases. A history of penetrating trauma (eg, arrow injury) preceded vision loss in 2 cases. All cases were long-standing. There were no cases of blindness of any cause that had occurred recently by history.

No definite cases of primary open-angle glaucoma were identified in any study subject. There were 6 cases classified as open-angle glaucoma suspects based on optic nerve appearance alone. The VCDR was between 0.6 and 0.85 in these cases. In one case the VCDR asymmetry was greater than 0.2. Notching of the neuroretinal rim, nerve fiber layer defects, and disc hemorrhages were not observed. Tangent screen assessment did not reveal visual field loss consistent with the diagnosis of glaucoma in any case. IOP was normal in all glaucoma suspects.

Exfoliation syndrome was identified in 8 individuals. No cases of exfoliation glaucoma were observed. One female participant had

unilateral exfoliation in the middle-aged group. The remaining 7 cases were identified in the older age-group. Five cases of exfoliation syndrome were bilateral (3 females, 2 male), and 2 cases (1 female, 1 male) were unilateral. There was one suspected case of exfoliation in a pseudophakic eye of a male subject. IOP was elevated in 1 of 13 eyes with exfoliation syndrome (26 mm Hg). Optic nerve appearance and tangent screens were normal in all eyes with exfoliation syndrome.

TABLE 8. BLINDNESS IN MALE AND FEMALE STUDY PARTICIPANTS, BY EACH EYE AND BOTH EYES COMBINED *

VARIABLE	OD	OD PH	OS	OS PH	OU	OU PH
Female (n = 154)	22 (14%)	14 (9%)	17 (11%)	12 (8%)	13 (8%)	8 (5%)
Male (n = 71)	7 (10%)	7 (10%)	13 (18%)	12 (17%)	6 (8%)	6 (8%)
Total (n = 225)	29 (13%)	21 (9%)	30 (13%)	24 (11%)	19 (8%)	14 (6%)

*Blindness was defined as visual acuity ≥20/200. Vision was measured uncorrected and with pinhole correction (ph).

TABLE 9. CAUSES OF BLINDNESS IN MALE AND FEMALE STUDY PARTICIPANTS (EYES, n = 450) AND AS PERCENT OF BLIND EYES (n=59)

CAUSE OF BLINDNESS	FEMALE (n = 308)	MALE (n = 142)	TOTAL (AS % OF EYES)	AS % OF BLIND EYES (n = 59)
Cataract	25 (8%)	14 (10%)	39 (15%)	66%
Refractive error	10 (3%)	2 (1%)	12 (4%)	20%
Trauma	1 (<1%)	3 (3%)	4 (1%)	7%
Corneal scarring	1 (<1%)	1 (<1%)	2 (<1%)	3%
Amblyopia	1 (<1%)	0	1 (<1%)	2%
Optic neuropathy	0	1 (<1%)	1 (<1%)	2%

DISCUSSION

The primary intent of this study was to assess the status of visual function in a population that has not been systematically examined in the past and, as a result of their isolation, has largely been outside the purview of traditional medical care.

The Aeta population, located in a remote region of Luzon on the main island of the Philippines, provided several qualities that were ideal for this study. The Aeta are an indigenous population, believed to be the descendents of the founding population of Luzon.[1,4] They are characterized by small stature and have a distinctive sub-Saharan African appearance with dark skin and fine curly hair, in striking contrast to the majority population of the Philippines. The Aeta have lived as hunter-gatherers in the mountainous interior of Luzon until recent times. The social structure of hunter-gatherer societies comprises collections of small family units that are widely scattered. Family units migrate frequently as a function of food gathering. In the case of the Aeta, migrations often occur every 2 to 3 years when land used to grow basic food crops is depleted of nutrients. The Aeta practice of slash-and-burn farming, called *kaingin*, has been in use for millennia. Although sustainable over long periods of time, it can support only the low population densities characteristic of hunter-gatherer societies.[8]

Because of their relative isolation and social structure, traditional healthcare delivery has been problematic for the Aeta and, for the most part, nonexistent. Recently the Aeta have started living in larger villages with higher population densities, a process that was abruptly accelerated following the massive eruption of Mount Pinatubo in 1991. Mount Pinatubo was and is revered by the Aeta and is located both figuratively and geographically at the center of the Aeta homeland. The eruption caused two thirds of the Aeta land to become uninhabitable from the direct effect of pyroclastic flow or ash fall, forcing the mass evacuation of a large portion of this population.[5] Though they were accustomed to living in small numbers, the Aeta were placed in high-density resettlement camps owing to lack of time and habitable land. Measles epidemics, among others, that resulted from crowded conditions and proximity to the surrounding Filipino population were responsible for many deaths among Aeta children.[5]

Recently, more consistent efforts have been made to deliver medical care to the Aeta. Healthcare has primarily been delivered through the work of medical missions conducted intermittently. There have been no recorded ophthalmic missions for this population, which prompted this study. The data obtained from this study is being provided to the Philippines' governmental and other healthcare agencies to assist their ongoing efforts.

The primary focus of this project was to perform visual screening of a representative sample of the Aeta with an emphasis on the

older members of this population. The goal was to gauge the prevalence and major causes of visual compromise. This is not a formal population-based study, which would require resources and personnel far beyond what was available. Furthermore, because of the remoteness of this population, a large-scale study would have been problematic if not impossible. We were able to circumvent some of these challenges by working in close association with personnel from the Commission for Indigenous Peoples, a government agency that works closely with the many indigenous populations that are scattered throughout the Philippines. These government workers, who enjoy a long-standing and trusting relationship with the Aeta, explained the project goals and the methods. They worked closely with village kapitans and were integral to the successful outcome.

The available governmental census provided estimates of Aeta village populations in the Pinatubo region.[7] The census provided no data on sex, age, or maps of village locations. We arranged for the Commission for Indigenous Peoples social workers to discuss the study with *kapitans* months prior to our arrival. *Kapitans* were given instruction by social workers on how to enroll families and the need to select elder family couples randomly and not based on perceived medical need. The nature of the project, a vision screening rather than a treatment study, was explained to the *kapitans* and conveyed to study participants.

We felt that it was feasible to screen 1% of this population, which had an estimated 17,500 individuals living within the selected villages. We successfully recruited and examined 225 individuals, or 1.3% of the estimated target population, between 0.85% and 2.1% of each village (Table 1). Female participants outnumbered male by a 2 to 1 margin, 67% and 33%, respectively. This was true for all age-groups, with the lowest percent in the older age-group (61%) and the highest percent of female participants in the middle-aged and young age-groups (75% and 72%, respectively). The precise method that *kapitans* used to select older household members is not known. We requested that older couples be invited to participate in an effort to equalize gender representation and reduce familial relatedness. This differential representation by females and males may reflect a reduced willingness in men to participate. Social service collaborators stated that because of subsistence living, men were more inclined to stay home rather than forgo a day's activity of food gathering. Alternatively, there may have been more distrust regarding the objective of this study among men than women in the Aeta population, though this was not voiced or suggested by participants.

There was no way to monitor the activities of the *kapitans*, so it is not possible to assess to what degree selection bias occurred during the recruitment process. Furthermore, there was no method to record what percent of those asked to participate were ultimately screened—another potential source of bias. However, considering the time and resources that were available for a project of this type, we feel the results provide useful information for future medical interventions or studies.

It is estimated that the Aeta have lived in the central area of Luzon for millennia. These less fertile mountainous regions are capable of supporting only relatively low population densities. It is likely that the remarkably small stature and size of the Aeta is an adaptive response to the limited food supply. In our sample, the older Aeta averaged 4.5 feet and weighed less than 80 lb. These data suggest that the stature of the Aeta is similar to that of the Pygmy, a name given to several tribal groups in central and western Africa. In a study of the African Efe pygmy tribe, Cortez and coworkers[9] reported that the mean height for men and women was 56.3 inches and 53.5 inches, respectively, similar to that found among the Aeta in this study. Reduced levels of growth hormone–binding protein and insulin-like growth factor-I have been proposed as the biological mechanism for short stature among the Aeta and the Efe populations.[10,11] We found that the middle-aged and younger Aeta were significantly taller than the older age-group, an increase in height found almost exclusively among men. Along with increased height was an increase in weight among younger Aeta. Again, it was the male group that accounted for most of the change in weight. Presumably, this trend reflects changes in diet and/or activity between older and younger Aeta, which was also suggested as a contributing cause of reduced stature by Clavano-Harding and colleagues.[10] Why the increases in height and weight were observed primarily among male compared with female Aeta is unclear.

One of the primary goals of this study was to estimate the prevalence of low vision in older members of the Aeta population (Tables 3 through 6). The prevalence of low vision (visual acuity > 20/40 and < 20/200) and blindness (≥ 20/200) increased dramatically with older age. Although the younger age-group was smaller in number, a direct consequence of the study design, low vision from all causes was relatively uncommon, present in 4% of eyes without correction. The most frequent cause of low vision in the younger age-group was refractive error. Other than refractive error, there was one case of amblyopia, which accounted for the only non-refractive blind eye in the youngest-aged group. Low vision was present in 36% of eyes without correction in the middle-aged group and 48% in the older-aged group. Blind eyes accounted for 9% and 19% of uncorrected eyes in the middle-aged and older groups, respectively. Since corrective glasses were not available to the Aeta, uncorrected visual acuity is the most accurate metric of visual function for this population. However, even if treatment for refractive error were available, these data for low vision and blindness would be reduced by only 20%.

The prevalence of visual impairment and blindness in the world varies greatly between populations. Resnikoff and colleagues[12] noted, in a World Health Organization report on global rates of visual impairment, the prevalence of blindness (defined as visual acuity > 20/400 in the better-seeing eye) varied between 0.4% and 9% in populations aged 50 or more worldwide. The lowest prevalence was in developed countries, including Europe and the United States, and the highest was in several regions of Africa. The prevalence of blindness was 6.3% in the subregion that includes the Philippines, Malaysia, Indonesia, and Thailand in the population over age 50. In our study, the prevalence of blindness was estimated to be 8% in men and women. If blindness had been defined similarly between these studies, the prevalence in our study would have been lower. It is challenging to compare studies that used different methodologies and sample sizes. This study was not powered to provide a precise estimate of blindness or visual impairment, but rather, was designed to examine the common causes of vision loss in a representative sample. It is interesting, however, to find that the estimated prevalence of blindness obtained in this sample is comparable to that observed in other studies in this region.

The leading cause of blindness in developing nations is cataract; it was therefore not surprising to find that cataract was also the largest single cause of visual impairment and blindness in the Aeta population. A number of the Aeta had sought ophthalmic

treatment, mostly for cataracts. Seven individuals had had cataract surgery; 6 were pseudophakic and 1 was aphakic, all of whom were men. It is not clear whether this represents a statistical aberration or may reflect variable access to healthcare based on gender.

The major causes of blindness in this population are similar to those reported in other populations from developing nations.[12] It is important to note for the purposes of continuing healthcare that the vast majority of low vision and blindness is readily treatable. Other causes of treatable blindness, such as trachoma or other infectious diseases, were uncommon. In this population less than 3% of the observed blindness would be considered untreatable.

Interestingly, glaucoma was conspicuously absent among causes of blindness. Worldwide glaucoma is the second leading cause of blindness.[13] Only 3 cases of blindness associated with glaucoma were observed in this study, and in each case a history of major ocular trauma was present. There were no cases of blindness from primary forms of open-angle or angle-closure glaucoma. Six cases were classified as glaucoma suspects, and all of these were based on increased VCDR. One case had optic cup asymmetry greater than 0.2. None had other stigmata of glaucomatous optic neuropathy, including focal neuroretinal rim thinning, disc hemorrhages, or nerve fiber layer defects. Similarly, the tangent screen assessment of visual field lacked evidence of glaucomatous visual field loss in all cases. No glaucoma suspect had associated elevated IOP. Similarly, cases of chronic angle-closure glaucoma were not observed in this study population. Two individuals had narrow angles on gonioscopy, but neither case was occludable. There were no cases of appositional closure or posterior synechiae related to narrow angles.

It is possible that the absence of observed open-angle and angle-closure glaucoma among the Aeta is due to the limited sample size. However, it is also possible that the prevalence of these common forms of glaucoma is very low in this population compared to others. Open-angle glaucoma is a complex inherited disorder with 3 known genes and many associated chromosomal loci.[14] Likewise, angle-closure glaucoma is likely to have a strong underlying genetic component.[15]

If the Aeta do have a very low prevalence of these major forms of glaucoma, then one would anticipate that closely related populations might have similarly low rates of these inherited forms of glaucoma. DNA evidence strongly suggests that early man migrated from northeast Africa into the Arabian peninsula approximately 50 to 60 thousand years ago. It is theorized that these early migrants followed a route called the "coastal express." Living off the bounty of the sea, these early migrants followed the coastline of the Arabian peninsula, India, and Southeast Asia in a path that culminated in New Guinea and Australia.[16] It is hypothesized that branches of this original migration populated the region that now exists as many of the islands of the Southeast Asia, including the Philippines. The Aeta, phenotypically African in appearance, may be related to these historically old populations linked to this first migration out of Africa.[16] In collaboration with members of the National Geographic Society's Genographic Project, blood and sputum samples were independently obtained from consenting members of the Aeta population for DNA analysis as a separate part of this study. Analysis of DNA obtained from these samples is currently in progress and may help clarify the genetic relationship between the Aeta and other indigenous peoples in Southeast Asia. Particular attention is being placed on the relationship between the Aeta and the indigenous peoples of New Guinea and Australia, the Australian Aborigine.

If the Aeta and Australian Aborigines share a common heritage as some believe, then a comparison of the prevalence of glaucoma and other inherited disorders between these populations is relevant. Interestingly, a major population-based study of the Australian Aborigines was conducted in 1980 entitled The National Trachoma and Eye Health Programme (NTEHP).[17] Over 60,000 Australian Aborigines were examined nationwide, making this one of the largest vision surveys ever conducted on a single population. Visual acuity, slit-lamp examination, and dilated fundus examination were performed on most participants. Assessment of the role of trachoma, cataract, and other ocular diseases was recorded. The impact on vision in this population compared with the non-Aborigine was carefully tabulated.[18] Impaired vision, defined as visual acuity between 20/60 and 20/120 in the better eye, was found in 23% of the Aborigine population over age 60. Blindness was defined as acuity of 20/200 or worse in the better eye. In those aged 60 or greater, 18.9% of Aborigines were blind. The prevalence of blindness increased logarithmically after age 50. The leading causes of visual impairment were corneal and conjunctival disease (trachoma most common), cataract, and refractive error. Glaucoma was present in 1 in 1000 of the population screened, ranking 16th among visual system abnormalities in the Aborigines.[19] Of 10,601 individuals over age 40 who were screened, 11 cases of primary glaucoma (0.1%) were observed; all were of the open-angle type. There were 32 cases of secondary glaucoma associated with trauma or other ocular conditions.[19] In this report, reference is made to one of the examiners "who in spite of a substantial background in the epidemiology of glaucoma and in spite of examining more Aborigines than any other examiner, did not find one certain case of primary open or closed angle glaucoma in Aborigines."[19]

The NTEHP study reported that exfoliation syndrome was relatively common among Aborigines. In all there were 217 cases that were identified, constituting roughly 2% of the population over age 40.[19] By comparison, exfoliation syndrome was identified in 4% (8 of 200) of the Aeta over an estimated age of 40 in the current study. It is interesting to note that variants in the gene *LOXL1* have recently been shown to convey susceptibility for exfoliation syndrome and glaucoma.[20] It is equally notable that exfoliation syndrome is rare in West Africans; Herndon and colleagues[21] found no cases of exfoliation syndrome in a clinic-based study of glaucoma conducted in Ghana, West Africa.

Although far from conclusive, there is the intriguing possibility that the Aeta and the Australian Aborigine may share not only a common lineage but also a remarkably low prevalence of primary glaucoma. If this is the case, it would imply that the prevalence of genetic *susceptibility* factors for primary open- and closed-angle glaucoma, present in most other populations worldwide, is reduced. Conversely, *protective* genetic or environmental factors present in the Aeta and Aborigine would similarly reduce risk of glaucoma. Further study of these and related populations is warranted.

In summary, we were able to perform vision screening on a representative sample of older members of the Aeta, an isolated population of the Philippines. Visual impairment and blindness were relatively common among the Aeta, particularly among the older age-groups. The most common causes of vision loss in this population were cataract and refractive error, both of which are readily

amenable to treatment.

In this sample, we failed to identify any cases of primary open- and closed-angle glaucoma, a major source of visual impairment and blindness in most populations. Although this finding may be due to chance, given the results of the NTEHP study on the Australian Aborigine population, it is possible that the lack of glaucoma among the Aeta may reflect differences in genetic susceptibility or environmental factors that lower risk for primary forms of glaucoma in these populations. For these reasons, further study of this and related populations is warranted.

The results of this study will be provided to the National Commission for Indigenous People in Manila and other governmental planning agencies to assist in their ongoing efforts to provide healthcare to these and other underserved populations in the Philippines.

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