Prevalence Rates of Refractive Errors in Sumatra, Indonesia

Seang-Mei Saw,1 Gus Gazzard,2,3,4 David Kob,1 Mohamed Farook,2 Daniel Widjaja,5 Jeanette Lee,1 and Donald T. H. Tan2,5,6

PURPOSE. To determine the prevalence rates of myopia, hyperopia, astigmatism, and anisometropia in a prevalence survey of adults in Sumatra, Indonesia.

METHODS. A population-based prevalence survey of 1043 adults 21 or more years of age was conducted in five rural villages and one provincial town of the Riau Province, Sumatra, Indonesia. A one-stage household cluster sampling procedure was used wherein 100 households were selected from each village or town. Refractive error measurements were obtained with one of two handheld autorefractors. Household interviews were conducted to obtain information on relevant lifestyle risk factors.

RESULTS. The age-adjusted overall prevalence rates of myopia (SE [spherical equivalent] at least −1.0 D), hyperopia (SE of at least +1.0 D), astigmatism (cylinder of at least −1.0 D), and anisometropia (SE difference of +1.0 D) were 26.1% (95% confidence interval [CI]: 23.4–28.8), 9.2% (95% CI: 7.4–11.0), 18.5% (95% CI: 16.2–20.8), and 15.1% (95% CI: 12.9–17.4), respectively. The age-adjusted overall prevalence rate of high myopia (SE at least −6.0 D) was 0.8% (95% CI: 0.2–1.5). In a multiple logistic regression model, myopia rates varied with age and increased with income. Hyperopia, astigmatism, and anisometropia rates were independently higher in older adults.

CONCLUSIONS. The prevalence rates of myopia in provincial Sumatra are higher than the rates in white populations, but lower than the rates in other urbanized Asian countries such as Singapore. The prevalence rate of high myopia is lower than in most other populations, and other refractive errors are common. (Invest Ophthalmol Vis Sci. 2002;43:3174–3180)

Refractive errors are one of the most common eye disorders and the correction of refractive errors by spectacles or contact lenses may pose a large economic burden.1 In the United States, the prevalence rates of myopia (SE at least −0.5 D) were 28.1% in white adults aged 40 or more years in the Baltimore Eye Survey,2 and 26.2% in adults aged 43 to 84 years the Beaver Dam Study.3 In a study of 15,068 Singapore military recruits aged 16 to 25 years, the prevalence rates of myopia (SE at least −0.5 D) were much higher with some racial variation: 82.2% in Chinese, 68.8% in Indians, and 65.0% in Malays.4 Similar high rates of myopia (SE at least −0.25 D; 84%) were present in 16- to 18-year-old Chinese children in Taiwan.5 In other parts of Asia such as the Andhra Pradesh Eye Disease Study in India (one-fourth urban and three-fourths rural), the prevalence rate of myopia (SE at least −1.0 D) was 15.2%.6 The prevalence rates of hyperopia defined as SE at least +0.5 D were 0.6% and 1.0%, respectively, in young Singapore Chinese and Malay recruits, compared with rates ranging from 11.8% in black men 40 to 49 years to 68.1% in white men more than 80 years of age in the older U.S. population (Baltimore Eye Survey).2 Comparisons of refractive error rates across studies may be limited by differences in definitions of myopia, measurement techniques, and study population.

The relative influence of “nature” versus “nurture” on myopia has intrigued researchers for decades. Evidence for nearwork as a risk factor for myopia from previous epidemiologic studies has produced mixed results.8–11 One hypothesis is that the high prevalence rates of myopia in urban areas of Asia (Singapore and Taiwan) could be attributable to both a hereditary predisposition of the Asian population and an intensely competitive schooling system.4,5 However, the exact nature of the environmental and genetic factors that contribute to myopia are unknown.

There is little known about the prevalence rates of refractive errors in developing countries in Southeast Asia. We sought to examine the prevalence rates and risk factors for refractive errors (myopia, hyperopia, astigmatism, and anisometropia) in provincial Indonesians who are similar in ethnic origin to Singapore Malays, but are subject to different environmental influences. This survey was conducted in a provincial area of Riau Province, Sumatra (3.9 million inhabitants), one of the largest islands in the Western part of Indonesia (total population, 195 million), 240 km from Singapore and on the same latitude.

METHODS

A population-based prevalence survey of refractive errors in five rural villages and one provincial town of the Riau Province, Sumatra, Indonesia, was conducted from April 2001 to June 2001. This survey was part of a large, general village health survey of respiratory symptoms. The region of study is District Pelalawan, a tropical area with secondary forests near the Kampar river, and the nearest large city is the capital of the Riau Province, Pekan Baru. A random sample of adults 21 or more years of age living in five villages (Kuala Terusan Baru, Pelalawan, Delik, SP 7, and Segati) and in the nearby town, Pangkalan Kerinci, were selected for the study. All houses in each village were individually mapped and assigned a number by an enumeration team. A one-stage cluster sampling procedure was conducted wherein 100 households (because there were only a total of 60 households in Delik, all 60 were assessed) were randomly selected from a sampling frame of 2170 households in Kerinci, 238 in Kuala Terusan Baru, 215 in Pelalawan, 60 in Delik, 500 in SP 7, and 204 in Segati. The sampling fractions...
for Kerinci, Kuala Terusan Baru, Pelalawan, Delik, SP7, and Segati were 4.6%, 42.0%, 46.5%, 100%, 20.0%, and 49.0%, respectively. There were 194 subjects recruited from Kerinci, 205 from Kuala Terusan Baru, 196 from Pelalawan, 107 from Delik, 180 from SP7, and 161 from Segati. The overall participation rate was 83.4%. Nonparticipants included noncontactables and refusals. Noncontactables were defined as individuals who could not be reached on three separate occasions and refusals as individuals who declined to participate in the study. The mean age of the participants (36.8 years) and nonparticipants (35.5 years) was not different (P = 0.19). Training of team members and a pilot study of 16 subjects in SP7 were conducted in April 2001, 2 weeks before the survey proper. Before the examinations, meetings were held with the village leaders to explain the purpose of the study and obtain cooperation from the community. Informed verbal consent was obtained from the subjects, and all subjects were treated in accordance with the tenets of the Declaration of Helsinki. Approval for the study was obtained from the Ethics Committee, Singapore Eye Research Institute.

Eye Examinations

The eye examinations were performed in the village houses by a trained team of nurses and technicians. An ophthalmologist (GG) and optometrist (MF) from Singapore supervised and trained the Indonesian team on several occasions in the measurement of visual acuity and refraction. Repeated review and testing of the quality of all technicians’ performances were conducted. Corrected and uncorrected distance visual acuity was measured in good lighting conditions (outside the village hut) using tumbling “E” log minimum angle of resolution (MAR) charts for each eye separately, according to a standard protocol.12 Autorefractive measurements in the right and left eye were performed using one of two handheld autorefracters (Retinomax K-plus; Nikon, Tokyo, Japan), and the average of eight refractive error readings was taken.13,14 No cycloplegia was instilled. The team members performing the eye examinations were masked to lifestyle information from the questionnaire.

Household Interview

Trained interviewers conducted household interviews using the same questionnaire. The questionnaire was translated to Bahasa Indonesian and back-translated into English. Demographic data included age, gender, and total household income per month. Information was also obtained on possible surrogates of nearwork activity, specifically completed educational level, whether the individual was literate, and the number of books and number of pages read per week in the past year.

### Table 1. Distribution of Refractive Errors by Age

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>All Ages</th>
<th>21–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50+</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1043</td>
<td>541</td>
<td>344</td>
<td>184</td>
<td>174</td>
</tr>
<tr>
<td>Refractive error (SE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>−0.48 ± 1.57</td>
<td>−0.68 ± 1.00</td>
<td>−0.51 ± 0.77</td>
<td>−0.05 ± 0.98</td>
<td>−0.47 ± 3.23</td>
</tr>
<tr>
<td>Median (range)</td>
<td>−0.38 (−4.50 to −15.75)</td>
<td>−0.63 (−3.00 to −12.00)</td>
<td>−0.50 (−2.75 to −4.88)</td>
<td>0.00 (−4.00 to −2.75)</td>
<td>−0.13 (−14.63 to −15.75)</td>
</tr>
<tr>
<td>Spherical equivalents (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>−6.0 D or less</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>−3.0 D to −5.9 D or less</td>
<td>23.3</td>
<td>38.7</td>
<td>13.0</td>
<td>19.0</td>
<td></td>
</tr>
<tr>
<td>−1.0 D to −2.9 D or less</td>
<td>22.5</td>
<td>28.7</td>
<td>23.3</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td>More than −1.0 D to +1.0 D</td>
<td>67.4</td>
<td>69.5</td>
<td>75.3</td>
<td>75.0</td>
<td></td>
</tr>
<tr>
<td>More than +1.0 D</td>
<td>7.2</td>
<td>0.6</td>
<td>0.6</td>
<td>10.9</td>
<td></td>
</tr>
<tr>
<td>Cylinder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>−0.51 ± 0.71</td>
<td>−0.37 ± 0.47</td>
<td>−0.38 ± 0.40</td>
<td>−0.46 ± 0.55</td>
<td>−1.12 ± 1.24</td>
</tr>
<tr>
<td>Median (range)</td>
<td>−0.25 (−3.50 to −0.00)</td>
<td>−0.25 (−2.50 to −0.00)</td>
<td>−0.25 (−1.75 to −0.00)</td>
<td>−0.25 (−3.50 to −0.00)</td>
<td>−0.75 (−7.50 to −0.00)</td>
</tr>
</tbody>
</table>

### Definitions and Data Analysis

SE was defined as refractive error +0.5 negative cylinder. Myopia was categorized as follows: SE at least −0.5, −0.75, and −1.0 D. Hyperopia was defined as follows: SE at least +0.5, +0.75, and +1.0. Astigmatism was defined as at least −0.5, −0.75, and −1.0 cylinder, and anisometropia was defined as the difference in SE between the right and left eyes of 0.5, 0.75, and 1.0 D. There was a high correlation between right and left eye refractive error data (Spearman correlation coefficient = 0.75). Results from analyzing right and left eyes separately were found to be similar; thus, only results of the right eye are presented. The prevalence rates and 95% confidence intervals (CIs) of myopia, hyperopia, astigmatism, and anisometropia in subjects with different characteristics were calculated, allowing for clustering by village and household. Age-adjusted prevalence rates were derived with the 1990 Indonesian census population used as the reference standard. The crude and multivariate odds ratios with 95% CIs denoting the associations between the various risk factors and myopia (SE at least −1.0 D), hyperopia (SE at least +1.0 D), astigmatism (cylinder at least +1.0 D), and anisometropia (SE difference of at least 1.0 D) were calculated. Multivariate adjusted odds ratios were obtained from multiple logistic regression models, allowing for clustering by village and household. All statistical analyses were performed using commercially available software (Stata, ver 7.0; Stata Corp., College Station, TX).15

### Results

Among the 1099 villagers randomly selected, refractive error examinations were performed on 1043 adults aged 21 or more years. The average age was 36.7 ± 12.7 (SD) years, and there were 498 men and 545 women. The overall literacy rate was 93.7% and was lower in older adults (98.8% in adults aged 21–29 years versus 81.0% in adults aged 50 or more years; P < 0.001). Similarly, the proportion of adults with education at least beyond 16 years was lower in more elderly individuals (31.6% in adults 21–29 years of age versus 6.3% in adults 50 or more years of age; P < 0.001). The proportion of villagers who owned a radio was 56.6% and a television set, 59.4%. Electricity was present in 82.3% of the dwelling. Eighty-six percent were married, 8.4% single, and 5.6% widowed or divorced.

The overall mean refractive error was −0.48 D (Table 1). The mean refractive error in adults aged 21 to 29 years was −0.68 D compared with −0.47 D in adults aged 50 or more years. The mean cylinder was higher in older adults (P < 0.001). The majority of myopic adults (defined as SE at least
1.0 D) had lower myopia (SE at least -1.0 D to -2.9 D or less; 88.6%); while a smaller proportion had higher myopia (SE at least -3.0 D to -5.9 D or less; 9.1%) and high myopia (SE at least -6.0 D; 2.4%). The rates of hyperopia (SE at least +1.0 D) were higher in older adults, whereas the rates of myopia (SE at least -1.0 D) were lowest in adults aged 30 to 49 years. (Fig. 1).

Table 2 shows the prevalence rates of myopia using three definitions (SE at least -0.5, -0.75, and -1.0 D). The age-adjusted (using the 1990 Indonesian census population as the standard) prevalence rate of myopia (SE at least -1.0 D) was 26.1% (95% CI: 23.4–28.8). The prevalence rates of myopia were lower in older middle-aged men (30.6% in 21–29-year-olds, 23.7% in 30–39-year-olds, 16.3% in 40–49-year-olds), but higher (32.6%) in men older than 50 years. Similar trends were seen in women: 29.5% in 21- to 29-year-olds, 24.6% in 30- to 39-year-olds, 12.0% for 40- to 49-year-olds, and a high rate of 29.1% in adults older than 50 years. The myopia rates increased with total family income (P = 0.001). No gender differences in myopia prevalence rates were observed (P = 0.65). The age-adjusted prevalence rate of high myopia (SE at least -6.0 D) was 0.8% (95% CI: 0.2–1.5).

The prevalence rates of hyperopia (SE at least +0.5, +0.75, and +1.0 D) are presented in Table 3. The age-adjusted prevalence rate of hyperopia (SE at least +1.0 D) was 9.2% (95% CI: 7.4–11.0). The prevalence rates of hyperopia were highest in adult males aged 40 to 49 years (6.5%) and adults older than 50 years (26.3%) compared with 0.7% in men aged 20 to 29 years. In women, a similar pattern was noted: 0.5% in 21- to 29-year-olds, 1.2% in 30- to 39-year-olds, 15.2% in 40- to 49-year-olds, and 32.9% in those older than 50 years. The prevalence rates of hyperopia were lower with higher income (P = 0.08) or educational attainment (P = 0.007) but were not different in men and women (P = 0.54).

The age-adjusted prevalence rate of astigmatism (cylinder at least -1.0 D) was 18.5% (95% CI: 16.2–20.8). Other definitions of astigmatism (cylinder at least -0.5 D and cylinder at least -0.75 D) are presented in Table 4. The prevalence rates of astigmatism (cylinder at least -1.0 D) were higher in older adults (P = 0.001) and men (P = 0.02), were highest in adults with higher myopia (SE at least -3.0 D), and were higher in individuals with less education (P = 0.007), but did not vary with income (P = 0.09).

The prevalence rates of anisometropia (defined as SE difference of at least +0.5, +0.75, and +1.0 D) are shown in Table 5. The age-adjusted prevalence rate of anisometropia (SE difference of at least +1.0 D) was 15.1% (95% CI: 12.9–17.4). The prevalence rates of anisometropia were higher in older adults (P = 0.001), were highest in adults with higher myopia (SE at least -3.0 D; P < 0.001), and were higher in individuals with less education (P = 0.04), but did not vary with gender (P = 0.64) or income (P = 0.86).

Four multivariate logistic regression models depicting the risk factors for myopia (SE at least -1.0 D), hyperopia (SE at least +1.0 D), astigmatism (cylinder at least -1.0), and anisometropia (SE difference at least +1.0 D) are shown in Table 6.

**Table 2. Prevalence Rates of Myopia in Six Villages in Sumatra, Indonesia**

<table>
<thead>
<tr>
<th>Myopia (SE of at least -0.5D)</th>
<th>Prevalence Rate (95% CI)</th>
<th>P for Trend</th>
<th>Myopia (SE of at least -0.75D)</th>
<th>Prevalence Rate (95% CI)</th>
<th>P for Trend</th>
<th>Myopia (SE of at least -1.0D)</th>
<th>Prevalence Rate (95% CI)</th>
<th>P for Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total crude rate</td>
<td>1043</td>
<td>48.5 (41.6–55.5)</td>
<td>0.001</td>
<td>36.8 (31.5–42.2)</td>
<td>0.02</td>
<td>25.4 (21.0–29.8)</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>498</td>
<td>48.0 (41.4–54.6)</td>
<td>0.63</td>
<td>35.7 (28.5–42.9)</td>
<td>0.45</td>
<td>25.9 (20.1–31.7)</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>545</td>
<td>49.0 (41.0–57.0)</td>
<td>0.006</td>
<td>37.8 (32.6–43.0)</td>
<td>0.05</td>
<td>25.0 (20.6–29.3)</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21–29</td>
<td>341</td>
<td>61.6 (55.1–68.0)</td>
<td>0.006</td>
<td>46.3 (38.0–54.7)</td>
<td>0.05</td>
<td>29.9 (17.8–42.0)</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>30–39</td>
<td>344</td>
<td>50.6 (39.7–61.4)</td>
<td>0.28</td>
<td>37.5 (28.8–46.2)</td>
<td>0.24</td>
<td>14.1 (9.5–18.8)</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>40–49</td>
<td>184</td>
<td>28.8 (20.2–37.4)</td>
<td>0.51</td>
<td>20.1 (13.2–27.1)</td>
<td>0.14</td>
<td>14.1 (9.5–18.8)</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>174</td>
<td>39.7 (32.5–46.8)</td>
<td>0.36</td>
<td>34.5 (25.7–43.3)</td>
<td>0.05</td>
<td>31.0 (22.8–39.3)</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Income (rupiah per month;</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10,000 rupiah = 1 US$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;500,000</td>
<td>487</td>
<td>42.9 (38.0–47.9)</td>
<td>0.005</td>
<td>32.2 (30.4–34.1)</td>
<td>0.008</td>
<td>20.9 (17.7–24.2)</td>
<td>0.001</td>
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</tr>
<tr>
<td>500,000–999,999</td>
<td>386</td>
<td>53.1 (41.1–65.1)</td>
<td>0.001</td>
<td>40.2 (31.3–49.0)</td>
<td>0.01</td>
<td>28.0 (22.5–33.4)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>1,000,000 or more</td>
<td>170</td>
<td>54.1 (47.5–60.7)</td>
<td>0.001</td>
<td>42.4 (34.9–49.8)</td>
<td>0.001</td>
<td>32.4 (26.6–38.1)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Completed educational level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No education</td>
<td>56</td>
<td>48.2 (44.6–51.8)</td>
<td>0.14</td>
<td>37.5 (24.0–51.0)</td>
<td>0.30</td>
<td>32.1 (25.8–38.5)</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Elementary school</td>
<td>509</td>
<td>40.9 (34.2–47.6)</td>
<td>0.001</td>
<td>32.2 (25.1–39.4)</td>
<td>0.02</td>
<td>22.6 (15.0–30.2)</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Junior High</td>
<td>172</td>
<td>58.7 (45.1–72.4)</td>
<td>0.001</td>
<td>43.6 (33.8–53.4)</td>
<td>0.02</td>
<td>29.1 (25.6–32.6)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Senior High</td>
<td>220</td>
<td>56.8 (47.1–66.5)</td>
<td>0.001</td>
<td>40.5 (29.5–51.4)</td>
<td>0.02</td>
<td>27.7 (18.1–37.4)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>College or polytechnic</td>
<td>86</td>
<td>52.3 (21.1–83.6)</td>
<td>0.001</td>
<td>40.7 (13.3–68.1)</td>
<td>0.001</td>
<td>24.4 (9.3–39.6)</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>

*Age-adjusted to the Indonesian 1990 census population.*
After adjustment for gender and income, adults aged 30 to 39 years had a 0.7-fold risk of myopia and adults aged 40 to 49 years had a 0.4-fold risk of myopia compared with adults aged 21 to 29 years. In the same multivariate model, the adjusted odds ratios of myopia were greater with higher income. There were no significant associations between myopia and educational level, literacy, books read per week, or pages read per week in multivariate analyses. Older adults aged 40 to 49 years and 50 years or more had 22-fold and 78-fold higher risks of hyperopia, respectively, than young adults aged 21 to 29 years, when controlling for gender. Adults aged 50 years or more had an 11-fold higher risk of astigmatism than young adults (aged 21–29 years), when controlling for gender. After adjustment for gender, adults aged 50 years or more had a sixfold higher risk of anisometropia than did younger adults aged 21 to 29 years. There were no significant relationships between educa-

### Table 3. Prevalence Rates of Hyperopia in Six Villages in Sumatra, Indonesia

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Total crude rate</th>
<th>Male</th>
<th>Female</th>
<th>Income (rupiah per month; 10,000 rupiah = 1US$)</th>
<th>Completed educational level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Prevalence Rate</td>
<td>P for Trend</td>
<td>n</td>
<td>Prevalence Rate</td>
</tr>
<tr>
<td></td>
<td>(SE of at least +0.5D)</td>
<td>(95% CI)</td>
<td></td>
<td>(SE of at least +0.75D)</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>21–29</td>
<td>498</td>
<td>13.1 (9.5–16.6)</td>
<td>0.63</td>
<td>487</td>
<td>17.9 (14.9–20.8)</td>
</tr>
<tr>
<td>30–39</td>
<td>10.5 (6.7–14.9)</td>
<td>0.57</td>
<td>13.4 (11.1–15.6)</td>
<td>0.07</td>
<td>13.4 (11.1–15.6)</td>
</tr>
<tr>
<td>40–49</td>
<td>184</td>
<td>28.8 (21.5–36.1)</td>
<td>19.0 (10.7–27.4)</td>
<td>11.7 (9.2–14.2)</td>
<td>0.07</td>
</tr>
<tr>
<td>50+</td>
<td>174</td>
<td>35.6 (24.5–46.8)</td>
<td>30.5 (23.3–37.4)</td>
<td>11.7 (9.2–14.2)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

* Age-adjusted to the Indonesian 1990 census population.

### Table 4. Prevalence Rates of Astigmatism in Six Villages in Sumatra, Indonesia

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Total crude rate</th>
<th>Male</th>
<th>Female</th>
<th>Income (rupiah per month; 10,000 rupiah = 1US$)</th>
<th>Completed educational level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Prevalence Rate</td>
<td>P for Trend</td>
<td>n</td>
<td>Prevalence Rate</td>
</tr>
<tr>
<td></td>
<td>(cylinder of at least +0.5D)</td>
<td>(95% CI)</td>
<td></td>
<td>(cylinder of at least +0.75D)</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>21–29</td>
<td>498</td>
<td>43.8 (35.5–52.1)</td>
<td>0.63</td>
<td>44.3 (24.4–50.0)</td>
<td>0.55</td>
</tr>
<tr>
<td>30–39</td>
<td>10.4 (5.4–15.4)</td>
<td>0.57</td>
<td>18.5 (17.2–19.8)</td>
<td>0.07</td>
<td>18.5 (17.2–19.8)</td>
</tr>
<tr>
<td>40–49</td>
<td>220</td>
<td>10.0 (5.5–14.5)</td>
<td>0.57</td>
<td>8.7 (3.1–14.5)</td>
<td>0.005</td>
</tr>
<tr>
<td>50+</td>
<td>86</td>
<td>4.7 (3.0–6.3)</td>
<td>0.57</td>
<td>4.7 (3.0–6.3)</td>
<td>—</td>
</tr>
</tbody>
</table>

* Age-adjusted to the Indonesian 1990 census population.
The prevalence rates of myopia are apparently higher in Asians. The age-adjusted rates of myopia (SE at least 6.0 D), hyperopia (SE at least 1.0 D), and anisometropia (cylinder at least 1.0 D) were 26.1%, 9.2%, 18.5%, and 15.1% respectively. The prevalence rates of myopia were highest in young adults aged 21 to 29 years and 9.2%, 18.5%, and 15.1% respectively. The prevalence rates of myopia were 82.2% in Singapore Chinese, 31.9%, and rates in 21- to 29-year-olds in Sumatra was 61.6%, whereas the myopia rate in Sumatra in adults older than 40 years was 22.3%.

### DISCUSSION

This study involved a large population-based prevalence survey of refractive errors in provincial Sumatra, Indonesia. There are few data on the rates of refractive errors in developing countries in Southeast Asia. The age-adjusted rates of myopia (SE at least −1.0 D), high myopia (SE at least −6.0 D), hyperopia (SE at least +1.0 D), astigmatism (cylinder at least +1.0 D), and anisometropia (SE difference at least +1.0 D) were 26.1%, 9.2%, 18.5%, and 15.1% respectively. The prevalence rates of myopia were highest in young adults aged 21 to 29 years and lowest in middle-aged adults, whereas the prevalence rates of hyperopia, astigmatism, and anisometropia were higher in older subjects of all ages. The sociodemographic associations of the various refractive errors were similar to those in other Asian and white populations.

In any comparison of prevalence rates between surveys, we must note differences in the definitions of myopia, varying age compositions of the study population, refractive error measurement techniques and study methodology. Using the more conservative definition of myopia of SE of at least −1.0 D, the myopia rate in Sumatra in adults older than 40 years was 22.3%, whereas rates in Singapore Chinese were 31.9%, and rates in Australians were 13%.16,17 If a marginal but more commonly used definition of myopia is applied (SE at least −0.5 D), the prevalence rate of myopia (SE at least −0.5 D) in 21- to 29-year-olds in Sumatra was 61.6%, whereas the myopia rate in 16- to 25-year-old Singapore Malay military conscripts was 65.0%.4 The rates of myopia were 82.2% in Singapore Chinese military conscripts (using the same definition) and 84% in 16- to 18-year-old Chinese in Taiwan (defined as SE at least −0.25 D).4,5 The prevalence rates of myopia were 34.1% in adults aged 40 years and more, and 17% to 28.0% in adults aged 40 or more years in the United States and Australia, respectively.2,16 The prevalence rates of myopia are apparently higher in Asians (Singapore Chinese, Singapore Malays, and Indonesians), who may have a genetic predisposition to myopia.4 Income is positively associated with myopia after adjustment for other factors, such as age and gender. Total family income may be a surrogate for nearwork activity, because adults with higher income may read more. An alternative explanation is that refractive errors (especially if uncorrected) may affect vision and functional ability, thus lowering work performance and income earned.

The prevalence rates of myopia are higher in younger adults and lower in more elderly adults, similar to the pattern in other populations (Baltimore Eye Survey, Beaver Dam Eye Study, Andhra Pradesh Eye Disease Study, Visual Impairment Project, Tanjong Pagar Survey).2,3,6,16,17 Although an increasing prevalence rate of myopia in Asia over time, possibly due to increasing nearwork activity,9,10,18 has been widely inferred from cross-sectional studies, a review of Western data suggests that differences in prevalence rates at different ages could be due to intrinsic age-related decreases in the amount of an individual’s myopia.19 Longitudinal data from cohort studies are needed to further evaluate possible age or cohort effects. A noteworthy finding is that the prevalence rate of high myopia (SE at least −6.0 D) in provincial Sumatra was 0.8%. In contrast, when similar definitions were used, the rates in young Singapore military recruits were 5.0% in Malays and 14.8% in Chinese, 9.1% in Singapore Chinese aged 40 or more years (SE at least −5.0 D), and 12.6% in adults older than 40 years in Australia (SE at least −5.0 D).4,10,17 Myopia may not be a large public health problem in Sumatra, because potentially blinding complications, such as myopic macular degeneration, cataract, glaucoma, and retinal tears are associated with high myopia, which is uncommon in Sumatra.20,21 The rates of hyperopia in different countries should be compared with caution, because the measurement methods, study subgroups, and sampling strategies differ. When the more marginal definition of hyperopia of SE at least +0.5 D was used, the prevalence rate of hyperopia in Sumatra was 2.6% in 21- to 29-year-olds, compared with 1.0% in young Singapore.

### TABLE 5. Prevalence Rates of Anisometropia in Six Villages in Sumatra, Indonesia

<table>
<thead>
<tr>
<th>Anisometropia (SE difference of at least +0.5D)</th>
<th>Anisometropia (SE difference of at least +0.75D)</th>
<th>Anisometropia (SE difference of at least +1.0D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence Rate (95% CI)</td>
<td>Prevalence Rate (95% CI)</td>
<td>Prevalence Rate (95% CI)</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td><strong>P for Trend</strong></td>
<td><strong>P for Trend</strong></td>
</tr>
<tr>
<td>Total crude rate 1043</td>
<td>37.7 (32.3–43.0)</td>
<td>20.8 (15.3–26.4)</td>
</tr>
<tr>
<td>Age-adjusted rate*</td>
<td>39.3 (36.4–42.5)</td>
<td>22.0 (20.0–25.2)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>53.2 (29.4–75.7)</td>
<td>19.6 (14.6–24.5)</td>
</tr>
<tr>
<td>Female</td>
<td>41.8 (33.4–49.9)</td>
<td>22.0 (15.1–28.9)</td>
</tr>
<tr>
<td>Age (y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21–29</td>
<td>31.6 (24.8–38.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>30–39</td>
<td>31.1 (27.9–34.3)</td>
<td>14.0 (9.1–18.8)</td>
</tr>
<tr>
<td>40–49</td>
<td>38.8 (28.1–49.5)</td>
<td>24.0 (16.8–31.3)</td>
</tr>
<tr>
<td>50+</td>
<td>62.7 (57.2–68.1)</td>
<td>43.2 (37.4–51.8)</td>
</tr>
<tr>
<td>Income (rupiah per month;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;500,000</td>
<td>37.5 (32.3–42.7)</td>
<td>22.3 (15.5–29.1)</td>
</tr>
<tr>
<td>500,000–999,999</td>
<td>38.2 (32.7–43.8)</td>
<td>19.6 (15.1–24.2)</td>
</tr>
<tr>
<td>1,000,000 or more</td>
<td>37.1 (24.7–49.4)</td>
<td>19.4 (11.3–27.6)</td>
</tr>
<tr>
<td>Completed educational level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No education</td>
<td>55.6 (42.5–68.6)</td>
<td>38.9 (8.1–69.6)</td>
</tr>
<tr>
<td>Elementary school</td>
<td>40.0 (33.8–46.2)</td>
<td>23.8 (17.3–30.3)</td>
</tr>
<tr>
<td>Junior High</td>
<td>36.0 (25.6–46.5)</td>
<td>19.2 (11.5–26.8)</td>
</tr>
<tr>
<td>Senior High</td>
<td>31.4 (25.1–37.7)</td>
<td>13.2 (8.3–18.0)</td>
</tr>
<tr>
<td>College or polytechnic</td>
<td>32.6 (18.7–46.4)</td>
<td>15.1 (4.5–25.7)</td>
</tr>
</tbody>
</table>

* Age-adjusted to the Indonesian 1990 census population.

The prevalence rates of myopia are apparently higher in Asians (Singapore Chinese, Singapore Malays, and Indonesians), who may have a genetic predisposition to myopia.4 Income is positively associated with myopia after adjustment for other factors, such as age and gender. Total family income may be a surrogate for nearwork activity, because adults with higher income may read more. An alternative explanation is that refractive errors (especially if uncorrected) may affect vision and functional ability, thus lowering work performance and income earned.

The prevalence rates of myopia are higher in younger adults and lower in more elderly adults, similar to the pattern in other populations (Baltimore Eye Survey, Beaver Dam Eye Study, Andhra Pradesh Eye Disease Study, Visual Impairment Project, Tanjong Pagar Survey).2,3,6,16,17 Although an increasing prevalence rate of myopia in Asia over time, possibly due to increasing nearwork activity,9,10,18 has been widely inferred from cross-sectional studies, a review of Western data suggests that differences in prevalence rates at different ages could be due to intrinsic age-related decreases in the amount of an individual’s myopia.19 Longitudinal data from cohort studies are needed to further evaluate possible age or cohort effects. A noteworthy finding is that the prevalence rate of high myopia (SE at least −6.0 D) in provincial Sumatra was 0.8%. In contrast, when similar definitions were used, the rates in young Singapore military recruits were 5.0% in Malays and 14.8% in Chinese, 9.1% in Singapore Chinese aged 40 or more years (SE at least −5.0 D), and 12.6% in adults older than 40 years in Australia (SE at least −5.0 D).4,10,17 Myopia may not be a large public health problem in Sumatra, because potentially blinding complications, such as myopic macular degeneration, cataract, glaucoma, and retinal tears are associated with high myopia, which is uncommon in Sumatra.20,21 The rates of hyperopia in different countries should be compared with caution, because the measurement methods, study subgroups, and sampling strategies differ. When the more marginal definition of hyperopia of SE at least +0.5 D was used, the prevalence rate of hyperopia in Sumatra was 2.6% in 21- to 29-year-olds, compared with 1.0% in young Singapore.
Malay conscripts and 0.7% in young Singapore Chinese conscripts. For adults 40 years of age and older, the prevalence rates of hyperopia in Sumatra were 35.8% compared with 27.8% and 44.2% in young Singapore Malay and Chinese conscripts, respectively. However, this comparison is limited by differences in methodology, year of conduct of survey and age groups studied. Similar to other studies, patterns of higher rates of astigmatism in older adults were seen in Sumatra. A cause could be higher rates of astigmatism associated with increasing levels of lens opacities with age. 

Alternatively, there may be a cohort effect with lower rates of astigmatism in the younger compared with the older generation. As expected, astigmatism rates did not vary with income, gender, or educational level in multivariate regression models. When the same definitions are used, the prevalence rate of anisometropia (SE difference at least +1.0 D) in 21- to 29-year-old Sumatrans was 8.8%, whereas the rate in young Singapore Malay military conscripts was 7.3%.

One strength of the current study is that the participation rate in the eye survey was high (83.4%). A potential criticism is that nonoptimal refractive error measurements were noncycloplegic in nature, and there may be an overestimation of myopia rates in younger adults who may have excessive residual accommodation. Thus, more conservative definitions of myopia (SE at least −1.0 D), hyperopia (SE at least +1.0 D), astigmatism (cylinder at least −0.4 D), and anisometropia (SE difference at least +1.0 D) were used in the multivariate regression models. A validation study of noncycloplegic and cycloplegic autorefraction was performed on 670 young Singapore military conscripts (average age 19.5 years), and the intraclass correlation coefficient for refractive error (SE) was very high at 0.99, suggesting that even in young Asian subjects, this was not a major source of error. If there is any error in noncycloplegic refraction measures, this may result in an overestimation of the prevalence rates of myopia and anisometropia, especially in younger adults. For example, we could project that the expected prevalence rate of myopia (SE at least −0.5 D) in adults aged 21 to 29 years in Sumatra may be lower than the observed 61.6%, when compared with rates of 65.0% in Singapore Malay conscripts and 0.7% in young Singapore Chinese conscripts. For adults 40 years of age and older, the prevalence rates of hyperopia in Sumatra were 35.8% compared with 27.8% and 44.2% in young Singapore Malay and Chinese conscripts, respectively. The patterns with age, income, and education are in the reverse direction of the trends of myopia, the converse of the case with hyperopia. Variations with age, income, and education are similar to those found in other eye surveys, although in our study, income and education were not associated with hyperopia, after controlling for age and gender.

Using the marginal definition of astigmatism (cylinder at least −0.5 D), the prevalence rates of astigmatism in Sumatra were 35.8% compared with 27.8% and 44.2% in young Singapore Malay and Chinese conscripts, respectively. However, this comparison is limited by differences in methodology, year of conduct of survey and age groups studied. Similar to other studies, patterns of higher rates of astigmatism in older adults were seen in Sumatra. A cause could be higher rates of astigmatism associated with increasing levels of lens opacities with age. Alternatively, there may be a cohort effect with lower rates of astigmatism in the younger compared with the older generation. As expected, astigmatism rates did not vary with income, gender, or educational level in multivariate regression models. When the same definitions are used, the prevalence rate of anisometropia (SE difference at least +1.0 D) in 21- to 29-year-old Sumatrans was 8.8%, whereas the rate in young Singapore Malay military conscripts was 7.3%.

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The accuracy of the handheld autorefractor was determined previously in a validation study, and the average refractive error was 0.28 D more “plus” on average compared with subjective refraction. In a validation study of the handheld Retinomax K-plus (Nikon, Tokyo, Japan) in 67 Singapore adults aged 21 to 40 years, the Spearman correlation coefficient of the handheld autorefractor (SE) and stand-alone Topcon (Topcon Optical, Tokyo, Japan) autorefractor (SE) was 0.97, whereas the Spearman correlation coefficient of the handheld autorefractor (SE) and subjective refraction (SE) was 0.96 (personal communication, Mohamed Farook, 2001). In a further validation study of the handheld Retinomax K-plus (Nikon, Tokyo, Japan), the Spearman correlation coefficient of the handheld autorefractor and subjective refraction of 676 Singapore Chi-
inese adults 40 years and older in the Tanjong Pagar study was 0.95 (personal communication, Paul Foster, 2001). An unavoidable limitation of this study is that ocular axial lengths are not available, and therefore a correlation of function with anatomy is not possible.

Refractive error is a significant public health problem in Indonesia that may have an impact on visual function and activities of daily living. If refractive errors are undercorrected or remain uncorrected, optimal visual function may be compromised in a large proportion of individuals. This may arise in a rural population from inadequate access to both testing facilities and spectacles. Measures should be taken to improve the training of ophthalmologists, optometrists, and nurses in rural settings and to increase the awareness of the general public of the availability and affordability of corrective lenses. Because refractive error can be easily treated, increased attention to the detection and correction of this eye disorder is indicated in rural Indonesian populations.

In summary, the myopia (SE at least 1.0 D) prevalence rates in our survey in provincial Sumatra (26.1%) were apparently higher than the rates in white populations but lower than the rates in other Asian countries such as Singapore. Of the myopes in this provincial Asian population, the majority (97.6%) had low myopia and a very small proportion (2.4%) had high myopia. Other refractive errors (hyperopia, astigmatism, and anisometropia) were common and variations with age, education, and income were similar to that of other Asian and white populations.

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**References**