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# Accommodative Amplitude and Facility in Orang Asli Schoolchildren: A Pilot Study from a Single Sample in Petaling District, Selangor

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## Abstract:

**Objective:** Accommodation response is essential for visual performance, enabling focus adjustment for near and far objects. This study examined the distribution of the accommodative amplitude (AA) and accommodative facility (AF) of Orang Asli (indigenous) primary schoolchildren in Petaling District, Selangor, Malaysia.

**Material and Methods:** This purposive sampling study design was conducted among 28 Orang Asli schoolchildren aged 8-10 years. AA was measured using a Royal Air Force (RAF) ruler using the push-up method, while AF was assessed with ±2.00 diopters sphere (DS) flipper lenses.

**Results:** The mean monocular AA was 14.59 diopters (D) ±2.95 and binocular AA was 15.81 D ±3.14, with a statistically significant difference between the two (p-value=0.025). Compared with Hofstetter's average age-expected values, monocular AA (p-value=0.063) and binocular AA (p-value=0.484) showed no significant differences. Monocular accommodative facility (MAF) averaged 8.68 cycles per minute (cpm) ±3.05 and binocular accommodative facility (BAF) averaged 7.46 cpm ±2.89, with a significant difference between them (p-value=0.006). Both MAF and BAF values were significantly higher than established normative values (p-value=0.005).

**Conclusion:** This pilot study provides preliminary accommodative function data for Orang Asli schoolchildren; however, the purposive sampling and limited sample size restrict the generalisability of the findings. Clinicians are encouraged to integrate these results with established guidelines for improved assessment and management of visual function in underserved indigenous populations.

**Keywords:** accommodative amplitude, accommodative facility, Orang Asli schoolchildren

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## Introduction

Accommodative anomalies are one of the most common visual disorders in children, often causing blurred or double vision[1]. Accommodation is vital for clear vision at varying distances, relying on the coordinated function of the accommodation and vergence systems[2]. It is particularly important for schoolchildren engaged in near tasks such as reading, writing, and using digital devices. Two key measures of accommodative function are the accommodative amplitude (AA), which reflects maximum focusing ability, and accommodative facility (AF), which indicates the speed and flexibility of focus adjustment[3]. Deficiencies in either can lead to visual discomfort, headaches, and reduced academic performance[4].

Although the accommodative parameters are well studied in the general population, little is known about them in indigenous groups such as the Orang Asli of Peninsular Malaysia, a small minority population that numbered approximately 206,777 people in 2020 (about 0.6–0.8% of the national population), underscoring the limited population-level data available for this group[5-7]. These communities often face healthcare and socioeconomic challenges that may impact visual health[8,9]. This lack of evidence is specific to indigenous communities, whereas the limitations of the current school vision screening programmes, which typically assess only visual acuity and refractive error, represent a broader national gap that affects all schoolchildren. Together, these issues highlight the need for population-specific accommodative data for indigenous children and underscore the importance of considering accommodative assessments within standard school screenings.

In Malaysia, school vision screenings mainly assess distance and near visual acuity, which means important visual skills, such as focusing ability and eye alignment, are often not tested. As a result, many children may pass the screening but still have undetected visual problems that can affect their comfort, reading ability, and overall learning performance. Symptoms of accommodative and binocular dysfunctions include headaches, blurred vision, diplopia, and visual fatigue during near tasks[10]. Scheiman et al. reported accommodative and binocular disorders to be up to nine times more common than ocular disease in children[11], while in Puerto Rico, accommodative insufficiency (AI) (39.0%) and infacility (7.6%) were among the most frequent anomalies in pediatric patients[12]. In Malaysia, a study of 1,010 primary-school children with learning disabilities in Kota Bharu reported that although only 4.8% had uncorrected distance visual acuity worse than 6/12, 28.3% of children showed poor amplitude of accommodation and 26.0% had accommodative infacility[13]. Meanwhile, a 2024 study of Malay myopic schoolchildren in Kuala Lumpur found a mean accommodative lag of 1.14±0.35 D, with monocular and binocular AA of 15.35±2.07 D and 16.82±2.27 D, respectively[14].

AA is expressed in diopters and often measured with a Royal Air Force (RAF) ruler. AF, measured in cycles per minute (cpm) using ±2.00 DS flipper lenses, assesses the eye's ability to quickly and accurately adjust focus, with separate measures for monocular accommodative facility (MAF) and binocular accommodative facility (BAF). These tests are valuable for detecting focusing issues that affect reading efficiency, comprehension, and classroom engagement. Students are especially vulnerable due to high near-work demands, and anomalies often arise from inadequate responses to sustained visual tasks.

Visual efficiency is closely tied to learning performance because accommodative and binocular dysfunctions can disrupt reading fluency, reduce comprehension, and limit a child's ability to sustain attention during near tasks. Evidence shows that children with such visual anomalies have a 16.21% higher risk of academic difficulties than those with normal visual function[15], highlighting the significant educational impact of undetected functional vision problems. This concern is particularly relevant for underserved populations. For example, in a Malaysian screening study involving Orang Asli schoolchildren, 41% failed the initial vision screening, and follow-up assessments confirmed that nearly all had identifiable visual problems[16]. These findings emphasize the extent of unmet visual needs and the importance of assessing functional vision skills such as accommodation in populations where comprehensive eye care access may be limited. Despite Malaysia's ethnic diversity, most studies focus on majority populations, leaving groups like the Orang Asli underrepresented. Accommodation is influenced by measurement methods, refractive status, and stimulus type[17], as well as demographic variables such as age, ethnicity, and sex[18]. Variability in study findings across populations underscores the need for targeted research.

This study examined the distribution of AA and AF among Orang Asli schoolchildren in Petaling District, Selangor, providing the first pilot-baseline data for this population and supporting improved diagnosis and management of accommodation anomalies. Because a small, purposive, non-random sample was used, the findings are intended to serve as early reference values rather than normative estimates for the wider Orang Asli population.

## Material and Methods

### Study design and sampling

This study employed a purposive, non-probability sampling approach appropriate for a pilot investigation. The sample size was determined based on feasibility and to explore preliminary trends within this specific cohort. As the sample was neither random nor population-representative, the resulting values should not be interpreted as normative data for all Orang Asli children. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Conducted at Sekolah Kebangsaan (Asli) Bukit Lanjan, an application for full ethical approval was made to the Research Ethics Committee of Universiti Teknologi MARA and ethics consent was received. The ethics approval number was REC/01/2024 (ST/MR/11). Additionally, approval was obtained from the Ministry of Education [KPM 600-3/2/3-eras (18955)]. Data collection began following the completion and signing of written consent and assent forms after the participants were informed about the study's purpose. Participants were then screened through preliminary assessments, including visual acuity, stereopsis, and the cover test. The sample size calculation was made using GPower software version 3.1.9.4. Using a paired t-test (difference between two dependent means) with an alpha level of 0.05, a minimum of 24 participants was required to achieve 95% power to detect a difference of 1.15 D in AA and 1.57 cpm in AF. Accounting for an anticipated 20% dropout rate, the target sample size for this study was set at 28 participants.

### Inclusion and exclusion criteria

The study was conducted at Sekolah Kebangsaan (Asli) Bukit Lanjan, which predominantly enrolls children from the Temuan tribe. The sample comprised Orang Asli primary schoolchildren aged 8-10 years enrolled in the 2024 academic year. This age group was selected because accommodative symptoms commonly begin to appear as children increase their near-work demands, often presenting with eye strain, headaches, or intermittent blurred vision[1]. Inclusion criteria required children to have habitual distance visual acuity of at least 0.2 logMAR (Snellen 6/9) or better in each eye with the best correction, near visual acuity of N6 or better, and the ability to comprehend spoken Bahasa Melayu. Exclusion criteria encompassed children with severe cognitive or physical impairments beyond those associated with accommodation issues, as well as those with ocular conditions such as degenerative eye diseases.

Additionally, children with non-typical development, special needs, learning disabilities, or impairments in other sensory modalities were excluded from the study.

Screening procedures ensured that participants demonstrated functional visual acuity (6/9 or better) and showed no clinical signs of latent hyperopia or uncorrected refractive error. To minimise the likelihood of including latent hyperopes who could still achieve good acuity, we performed a +1.00 D blur test. Children who showed reduced clarity or a decreased accommodative response with +1.00 D were considered to have normal accommodative engagement, whereas those who did not exhibit a reduction were flagged for possible uncorrected hyperopia and were excluded. The +1.00 D blur test is commonly used as a rapid clinical screening tool for detecting latent hyperopia and evaluating accommodative behaviour in school-aged children.

### Instrument and procedure

In this study, two assessments were performed: the AA and AF measurements. The right eye was specifically chosen for monocular measurements as a previous study found a high correlation between right and left eye measurements during visual examination[19]. This high correlation indicates that the measurements from one eye are highly predictive of the other, allowing for reliable data collection while minimising the testing time and reducing participant burden. The measured AA was performed using the RAF rule. The target used was an N5 row of letters on the RAF rule target at 40 cm. The measurements were recorded in diopters (D). To ensure accuracy and reliability, three measurements were taken for each participant and the average was recorded. The calculated AA represented the age-expected normative value based on Hofstetter's formula and was used for comparison with the measured AA[20]. Participants were classified as having normal AA if their values met the minimum age-expected range, and as abnormal if their AA was at least 2 D below the predicted minimum.

For assessing AF, a lens flipper of ±2.00 DS and a near chart (N6 of Arial font type) were used to evaluate the eyes' ability to adjust accommodation rapidly and accurately. The number of cycles completed in one minute was recorded as the "accommodative facility" in cpm for both monocular and binocular measurements. The children were asked to call out the letters or numbers to indicate clarity. Participants were categorised into normal or abnormal groups based on their AF results. The cutoff points for normal and abnormal values were determined using the standards established by Scheiman and Wick[20]. For children aged 8-12, normal values are defined as 7 cpm ±2.5 for monocular AF and 5 cpm ±3 for binocular AF. All AF testing began with the +2.00 D lens, consistent with standard clinical protocols. The sequence in which AA and AF were measured was randomised to minimise order effects. A short 1-2-minute rest period was provided between tests to minimise accommodative fatigue.

### Statistical analysis

Normality and homogeneity of variances were examined to verify adherence to statistical assumptions. All inferential analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics, with the significance level set at $\alpha=0.05$. Paired t-tests were applied to compare monocular (right eye) and binocular values for both AA and AF. In addition, measured AA values were compared with the calculated average age-expected AA using paired t-tests. A one-sample t-test was also used to assess whether the distribution of AA differed significantly from established normative values.

## Results

### Demographic characteristics

A total of 31 Temuan Orang Asli participants were initially recruited for this study; however, three were excluded after failing the preliminary assessments. Twenty-eight participants were deemed eligible for selection based on the study's inclusion and exclusion criteria, making up 100% of the sample. The participants, consisting of Level 1 primary schoolchildren, had an average age of 9±0.77 years. The gender distribution was relatively balanced, with 15 females (53.6%) and 13 males (46.4%). Most households reported an income of less than RM3000 (equivalent to 700 USD) (57.1%), while only 10.7% had a household income of RM3000 or more, with 32.1% not reporting their income. Regarding maternal education, 50.0% of mothers had completed Sekolah Kebangsaan (primary school), 17.9% had attended Sekolah Menengah Kebangsaan (secondary school), and 3.6% held a bachelor's degree, while 28.6% did not report their education level. For paternal education, 42.9% had completed Sekolah Kebangsaan (primary school), 17.9% had attended Sekolah Menengah Kebangsaan (secondary school), and 39.3% did not report their education level. In terms of occupation, 25.0% of mothers were employed, 46.4% were unemployed, and 28.6% did not report their employment status. For fathers, 50.0% were employed, 10.7% were unemployed, and 39.3% did not report their employment status. These demographic characteristics highlight the socioeconomic and educational backgrounds of the parents of the participants, providing context for the study's findings.

### Normality test

Shapiro-Wilk normality tests were used to determine whether the data distribution was normal or not prior to conducting inferential data analysis, as it is more powerful and suitable for small sample sizes compared to the Kolmogorov-Smirnov test. This guided the decision to use either parametric or non-parametric tests for data analysis. The normality test results for AA and AF indicated that the data were normally distributed, as shown in Table 1.

### Distribution of AA and AF

Table 2 presents the mean and standard deviation for the monocular and binocular AA and AF measured in diopters (D) and cpm for the study. Out of the 28 participants assessed, 21 exhibited normal monocular amplitude of accommodation, while 7 participants were found to have abnormal AA levels. Binocularly, 24 participants demonstrated normal AA levels, whereas 4 participants showed abnormal levels. For the MAF, 26 participants displayed normal levels, and only 2 participants had abnormal levels. BAF, 27 participants had normal AF levels, with just 1 participant showing abnormal levels.

**Table 1** Tests of normality for AA and AF

| Accommodative variables | Shapiro wilk | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| Monocular AA (D) | 0.964 | 28 | 0.430 |
| Binocular AA (D) | 0.962 | 28 | 0.386 |
| Monocular AF (cpm) | 0.941 | 28 | 0.114 |
| Binocular AF (cpm) | 0.935 | 28 | 0.084 |

AA=accommodative amplitude, AF=accommodative facility, D=diopters, cpm=cycles per minute, df=degrees of freedom, Sig.=significance value

**Table 2** Distribution of AA and AF

| Accommodative variables | n | % | Mean±S.D. |
|---|---|---|---|
| Monocular AA (D) | | | 14.59±2.95 |
| Normal | 21 | 75 | |
| Abnormal | 7 | 25 | |
| Binocular AA (D) | | | 15.81±3.14 |
| Normal | 24 | 85.7 | |
| Abnormal | 4 | 14.3 | |
| Monocular AF (cpm) | | | 8.68±3.05 |
| Normal | 27 | 96 | |
| Abnormal | 1 | 4 | |
| Binocular AF (cpm) | | | 7.46±2.89 |
| Normal | 26 | 92.8 | |
| Abnormal | 2 | 7.2 | |

AA=accommodative amplitude, AF=accommodative facility, D=diopters, cpm=cycles per minute, S.D.=standard deviation

### Comparison between monocular and binocular AA and AF

The mean monocular AA was 14.59 D (±2.95), while binocular AA averaged 15.81 D (±3.14). A paired t-test revealed a statistically significant difference between binocular and monocular AA (t (27)=-2.046, p-value=0.025). Similarly, the mean monocular AF was 8.68 cpm (±3.05), and binocular AF was 7.46 cpm (±2.89), with a significant difference observed (t (27)=2.720, p-value=0.006) (Table 3).

### Comparison of measured and calculated AA

A paired t-test revealed a statistically insignificant mean difference between the measured and calculated AA for monocular AA (t (27)=-1.583, p-value=0.063) and binocular AA (t (27)=0.041, p-value=0.484) (Table 4).

### Comparison of AF with normative value

A one-sample t-test showed a statistically significant mean difference between the monocular and binocular AF with Scheiman and Wick's norms (p-value<0.005) (Table 5).

**Table 3** Comparison between monocular and binocular AA and AF

| Accommodative variables | Monocular | Binocular | t-stats | dF | p-value* |
|---|---|---|---|---|---|
| | Mean±S.D. | Mean±S.D. | | | |
| AA (D) | 14.59±2.95 | 15.81±3.14 | -2.046 | 27 | 0.025 |
| AF (cpm) | 8.68±3.05 | 7.46±2.89 | 2.720 | 27 | 0.006 |

*=paired t-test, AA=accommodative amplitude, AF=accommodative facility, D=diopters, S.D.=standard deviation, dF=degrees of freedom

**Table 4** Comparison between measured and calculated AA

| Accommodative amplitude | Measured AA | Calculated average age-expected AA as determined by formula: 18.5 – (0.3 x Age)[20] | t-stats | dF | p-value* |
|---|---|---|---|---|---|
| | Mean±S.D. | Mean±S.D. | | | |
| Monocular (D) | 14.59±2.95 | 15.78±0.23 | -1.583 | 27 | 0.063 |
| Binocular (D) | 15.81±3.14 | 15.78±0.23 | 0.041 | 27 | 0.484 |

*=paired t-test, AA=accommodative amplitude, S.D.=standard deviation, dF=degrees of freedom, D=diopters

**Table 5** Comparison of AF with normative values

| Accommodative facility | Total (n=27) | Scheiman & Wick's normative value[20] | t-stats | dF | p-value* |
|---|---|---|---|---|---|
| Monocular AF (cpm) | 8.68±3.05 | 7±2.5 | 3.136 | 28 | 0.002 |
| Binocular AF (cpm) | 7.46±2.89 | 5±2.5 | 4.498 | 28 | <0.001 |

*=one-sample t-test, AF=accommodative facility, cpm=cycles per minute, dF=degrees of freedom

## Discussion

The study revealed mean AA values of 14.59D ±2.95 for monocular and 15.81D ±3.14 for binocular measurements, with a statistically significant difference between them (p-value=0.025). When compared with the available Malaysian data, the AA values observed in this study (14.59 D ±2.95 monocular; 15.81 D ±3.14 binocular) appear broadly consistent with those reported in a recent study of Malay schoolchildren enrolled in a myopia-control investigation in Kuala Lumpur, which documented the monocular and binocular AA values of 15.35 D ±2.07 and 16.82 D ±2.27, respectively[14]. Malaysian data from older age groups show markedly lower AA, such as the mean push-up amplitude of approximately 11.4 D among university students, consistent with the well-established age-related decline in accommodative function and highlighting that adult-child comparisons are inherently confounded by age[21]. Earlier Malaysian research in primary schoolchildren has also demonstrated that accommodation and vergence measures vary with age, refractive status, and testing protocols, underscoring the need to interpret cross-study differences cautiously[22]. Although the similarity between our findings and those of Malay schoolchildren suggests that Orang Asli children may exhibit AA values within the expected Malaysian school-age range, the comparison is limited by the refractive profile of the reference sample, which consisted predominantly of myopic children[14]. Therefore, the present results should be regarded as preliminary baseline data rather than definitive normative values for the Orang Asli population, and future research with larger, age-matched, method-standardised samples is needed to clarify whether population-specific differences exist. However, both monocular and binocular AA did not significantly deviate from the average age-expected AA calculated using Hofstetter's formula (p-value=0.063 and p-value=0.484, respectively). Although Hofstetter's formula is derived from monocular measurements, it remains the most widely accepted reference for physiological AA in paediatric populations and is frequently used to benchmark accommodative performance in both clinical and research contexts. Previous studies have reported that in visually normal, non-presbyopic children, monocular and binocular AA values are generally comparable, with binocular AA typically slightly higher due to the contribution of convergence accommodation[23-25]. Given this near-equivalence in typical populations, comparing binocular AA to monocular normative data is considered acceptable for screening-level interpretation, provided such comparisons are made cautiously. Accordingly, in this study, Hofstetter's formula was used as a physiological reference point, with appropriate acknowledgement that binocular AA may be modestly elevated relative to monocular predictions.

This study observed a higher AA under binocular conditions compared to monocular measurements. The statistically significant difference between monocular and binocular AA observed in this study aligns with the expected physiological behaviour of the accommodative-vergence system. Binocular AA is typically slightly higher because vergence demand during binocular viewing enhances accommodative effort. This synergistic coupling of accommodation and convergence has been well documented[26,27]. Thus, although statistically significant, the difference noted here likely reflects normal physiological variation rather than clinically meaningful dysfunction. Typically, binocular AA is 1.00 to 2.00 D higher than monocular AA, as the convergence response in binocular vision stimulates additional accommodation, known as convergence accommodation. Convergence accommodation, a component of the near triad, plays a critical role in binocular accommodation. When focusing on a near object, the eyes converge, and this convergence stimulates additional accommodative effort. This phenomenon is absent during monocular testing, which might explain the difference in amplitude between monocular and binocular settings[28]. However, factors like suppression, fatigue, or vergence anomalies can affect the binocular response, potentially leading to reduced binocular AA in individuals with accommodative or binocular dysfunctions[29]. Understanding these differences is essential for accurate clinical assessments, as binocular AA provides a more functional perspective of the accommodation system in real-world tasks, where both eyes are actively engaged. The results of this study indicate that the AA in this group of Orang Asli schoolchildren aligns with established normative values. Both the monocular and binocular AA were within the normal range for their age group and showed no significant deviation from the average age-expected AA calculated using Hofstetter's formula.

MAF and BAF demonstrated a significant difference (p-value=0.006), with mean values of 8.68±3.05 cpm and 7.46±2.89 cpm, respectively. The AF recorded in this study was slightly higher than the standard norms reported by Scheiman and Wick[20], who documented 7±2.5 cpm for the MAF and 5±2.5 cpm for the BAF. In comparison, the MAF and BAF observed in this study were 8.68±3.05 cpm and 7.46±2.89 cpm, respectively. The higher-than-norm AF values observed in this study may reflect several contributing factors. First, it could be attributed to the instructional method employed, where participants were asked to read a near chart and report when the target became clear. All the reviewed studies consistently utilised lens flippers to measure AF[30-32]. However, AF testing is subjective and may pose challenges for younger children, as they might find it uncomfortable or difficult to understand. However, this approach may not be entirely reliable for primary schoolchildren. A more appropriate method for younger children would involve using targets like Accommodative Rock Cards[20]. The measurement of AF is crucial for diagnosing various accommodation anomalies, including accommodative infacility, insufficiency, and excess. Traditionally, the reduced AA has been considered the primary clinical indicator for diagnosing AI. However, it has been identified that failing the –2.00 D lens component of the MAF test was the clinical sign most strongly associated with AI[33]. Second, school-aged children frequently perform tasks that require rapid and repeated accommodative shifts, and such near-work demands have been shown to strengthen accommodative responsiveness over time[34]. Ethnic and population-related variations may also play a role, as accommodative parameters, including facility, have been reported to differ across demographic groups[35]. In addition, task elements, such as the use of a clear N6 target used during testing, may have facilitated quicker lens-flip responses, thereby elevating measured AF performance[36]. Additionally, children who regularly alternate between outdoor and indoor visual environments may develop more flexible accommodative responses due to frequent changes in viewing distance and luminance[37]. These factors collectively provide plausible explanations for the elevated AF values observed in this cohort.

## Conclusion

This study provided valuable insights into the AA and AF among Orang Asli schoolchildren, with AA values aligning with age-expected norms and AF values exceeding norms. These findings underscore the importance of assessing both parameters to better understand visual performance and detect potential accommodation anomalies. Nevertheless, the study's focus on a single Orang Asli group, the Temuan tribe, and its urban setting in Petaling, Selangor, limits the generalizability of the findings. These results provide initial reference values for accommodative function in this cohort of Orang Asli schoolchildren. However, due to the pilot design and purposive sampling, the findings should be viewed as preliminary, and broader studies are needed to establish population norms. Future research should expand to include a larger and more diverse sample of Malaysia's indigenous population, particularly from rural areas, to gain a more comprehensive understanding of their visual health needs.

This study has several limitations that should be acknowledged. A key limitation is that refractive error status was not assessed in this study. Because uncorrected hyperopia and early myopia can influence accommodative behaviour, the absence of refractive categorisation limits the interpretability of the accommodative measures obtained. Future studies should incorporate comprehensive refractive evaluations to contextualise accommodative findings more accurately. Second, ocular dominance was not assessed, which may have influenced monocular accommodative performance, particularly in tasks requiring sustained near focus. In cases where the left eye exhibited better visual acuity, the protocol, which required testing the right eye, may have resulted in measuring a slightly poorer-seeing eye. This introduces a potential source of minor downward bias in the AA and AF findings. Third, the use of a near target smaller than the inclusion threshold may have increased perceptual difficulty for some participants. This methodological issue has been acknowledged, and we recommend that future studies consider N6 or N8 print sizes to better align with the eligibility criteria and minimise unnecessary visual demand. Finally, a full subjective refraction was not performed during screening. Instead, the screening protocol focused on ensuring functional visual acuity (6/9 or better) and ruling out obvious signs of latent hyperopia or uncorrected refractive error. Although appropriate for preliminary assessment, this approach may not capture subtle refractive anomalies that could influence accommodative function.

### Ethical approval

The study received approval from the Research Ethics Committee of Universiti Teknologi MARA (REC/01/2024 (ST/MR/11)).

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## Conflict of interest

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

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