Original Article

Accuracy and agreement of vision screening by secondary school students in Dass, Nigeria

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ABSTRACT

Background: Training school students to screen vision and communicate eye-health messages may expand the reach of community eye-care initiatives. This study assessed screening accuracy and agreement of trained senior secondary school students relative to ophthalmologist classifications among adults.

Methods: A community-based study was conducted in Dass, northeastern Nigeria, between July and September 2021. Ninety students were randomly selected from three schools and received three hours of training from two qualified ophthalmologists. Each student approached four eligible adults from their household or adjacent households through non-probability recruitment. Adults were eligible if they were aged 18 years or older and had resided locally for at least six months. Screening procedures were adapted from the World Health Organization Primary Eye Care Training Manual and comprised visual acuity testing at the 6/12 threshold and assessment of conjunctival appearance, cornea/lens appearance, eye size, and ocular alignment. Ophthalmologist classifications served as the reference standard. Sensitivity, specificity, positive and negative predictive values, overall agreement, and Cohen's κ were calculated from five aggregate participant-level 2 × 2 tables.

Results: All 90 students participated and 358 of 360 recruited adults were assessed (99.4%), including 234 women (65.4%). Students classified 143 adults (39.9%) as having impaired visual acuity, compared with 88 (24.6%) classified by the ophthalmologists. Visual acuity screening had 71.6% sensitivity, 70.4% specificity, 44.1% positive predictive value, and 88.4% negative predictive value, with Cohen's κ = 0.347. Sensitivity, specificity, and κ were 91.0%, 85.3%, and 0.701 for conjunctival assessment; 80.2%, 67.0%, and 0.377 for cornea/lens assessment; and 70.0%, 94.0%, and 0.640 for eye-size assessment, respectively. Ocular alignment assessment had 25.0% sensitivity, 93.4% specificity, and κ = 0.171, detecting six of 24 reference-positive classifications. Conjunctival assessment had the highest sensitivity and κ, whereas eye-size assessment had the highest overall agreement (89.9%).

Conclusions: Screening accuracy and agreement varied substantially by task. Conjunctival assessment showed the highest sensitivity and agreement beyond chance, whereas ocular alignment assessment missed most reference-positive findings. These findings warrant caution before wider implementation of student-led screening. Future studies should evaluate standardized training and screening procedures, retained competence, referral completion, and clinical outcomes.

KEYWORDS

vision screening, health education, students, sensitivity and specificity, Nigeria.

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INTRODUCTION

Avoidable vision loss remains a substantial challenge for health systems seeking to provide equitable access to care. Global analyses estimated that 43.3 million people were blind and 295 million had moderate or severe distance vision impairment in 2020; cataracts and uncorrected refractive error accounted for a large share of this burden [1, 2]. In 2020, an estimated 157 million people had moderate or severe vision impairment attributable to uncorrected refractive error, which illustrates the ongoing need for accessible detection, refraction, and spectacle services [3]. The Lancet Global Health Commission on Global Eye Health has therefore emphasized integrating eye care into broader health systems and connecting community access with effective treatment [4]. Community screening can contribute to this pathway, provided that screening procedures and referral arrangements are evaluated in the population they are intended to serve [4].

The need for accessible services is particularly relevant in sub-Saharan Africa, where regional analyses have documented a substantial burden of vision loss and persistent differences in its distribution [5]. In Nigeria, the national blindness and visual impairment survey examined 13,599 adults aged 40 years or older and estimated a blindness prevalence of 4.2%, with the greatest regional burden in the northeast [6]. A companion analysis identified cataracts as a major cause of blindness and uncorrected refractive error as the principal cause of moderate visual impairment [7]. These historical, older-adult estimates establish a regional rationale for improving access, although they do not specify the prevalence among all adults in the Dass Local Government Area (LGA).

Service availability depends on the distribution and capabilities of the workforce as well as its size. Nigerian studies have described concentration of eye-care personnel in state capitals and reluctance among many optometry students to begin practice in rural areas [8, 9]. Assessments of primary health care facilities in Anambra State identified interconnected gaps in staffing and governance, eye-health promotion, equipment, and information systems [10–12]. These findings support investigating complementary ways to connect households with existing services. Such approaches should define community screeners' responsibilities and provide appropriate professional support [13].

School students may offer a practical link between eye-care services and households through both screening and communication. In southwestern Nigeria, trained primary-school pupils assessed community members and encouraged attendance at eye-care activities [14]; in Nepal, trained students screened fellow pupils for reduced visual acuity [15]. Research on child-mediated health promotion in Kenya [16] and Zambia [17] also suggests that children can communicate health information within families, although the adoption of practices depends on opportunities, resources, and guidance [16, 17]. Recent reviews of teacher-administered vision screenings report encouraging average accuracy alongside substantial methodological variation [18, 19]. However, screening children in schools, detecting visible abnormalities in adults, and communicating messages that influence adult decisions are distinct tasks. Evidence for one task cannot establish competence in the others.

The use of school students in household vision screening warrants evaluation of their accuracy and agreement with eye-care professionals. This study aimed to assess the screening accuracy and agreement of trained senior secondary school students' visual acuity and external-eye classifications relative to ophthalmologist classifications among adult residents of Dass LGA, Bauchi State, northeastern Nigeria.

METHODS

This community-based study evaluated the screening accuracy and agreement of trained senior secondary school students relative to ophthalmologist classifications among adults in Dass LGA, Bauchi State, northeastern Nigeria. The study was conducted between July and September 2021. All three secondary schools in the LGA offering senior secondary education were included. Students were recruited through these schools, and adults were recruited from the students' households and adjacent households. Ethical approval was obtained from the Human and Research Ethical Committee of the National Eye Centre, Kaduna. Administrative permission was obtained from the Bauchi State Ministry of Education and participating school management. Informed consent was obtained from all adult community participants and students aged ≥ 18 years. For students younger than 18 years, parental or guardian informed consent and student assent were obtained.

The study records reported a minimum adult recruitment target of 282 based on a sample-size calculation. However, as the calculation parameters and the source of the assumed 18.8% prevalence could not be verified, the original sample-size justification remained uncertain. The recruitment plan involved 90 students, each asked to examine four adults, yielding a target of 360 adults. Adequacy of this target for estimating screening accuracy with a prespecified level of precision could not be established from the available records.

Eligible adults were aged ≥ 18 years and had resided in Dass LGA for at least six months. Eligible students were willing participants in senior secondary classes 1 or 2 (SS1 or SS2). No additional exclusion criteria were documented. Thirty students were selected from each school by simple random sampling through balloting, with 15 drawn from each senior secondary class, yielding 45 SS1 and 45 SS2 students. Each student was instructed to examine the first four eligible adults in their household. Where fewer than four eligible adults were available, adults from adjacent households were approached. Adult recruitment therefore constituted household-based non-probability sampling. The ordering of adults within households, selection of adjacent households, and any procedures to prevent duplicate recruitment were not specified in the study records. Demographic characteristics and ocular examination findings were recorded on the study forms.

Two qualified ophthalmologists delivered three hours of training in basic vision screening and dissemination of eye-health messages. Pictures and charts presented using PowerPoint supported instruction, and students subsequently practiced with adults in their homes. Pamphlets in Hausa and English supported dissemination of messages on facial cleanliness, nutritious foods, prevention of ocular injury, reduced vision, and the importance of prompt care. The messages were adapted from the World Health Organization (WHO) Primary Eye Care Training Manual [20]. The extent of adaptation and translation verification was not documented. The present analysis focused on screening accuracy and agreement.

Screening procedures were adapted from the WHO Primary Eye Care Training Manual [20]. Each adult was examined while seated in an adequately illuminated space, with the procedure explained beforehand. Distance visual acuity was screened monocularly using a Tumbling E chart at a distance of 3 m, measured with a prepared cord. The fellow eye was occluded, and habitual distance spectacles were worn when normally used. Before testing, the examiner confirmed that the participant understood the task by asking them to indicate the orientation of the limbs in a demonstration E chart. Correct identification of at least four of the five 6/12 optotypes constituted a pass for the tested eye [20].

External ocular screening comprised four appearance criteria adapted from the WHO manual: whether the white of the eye appeared white, with only a few visible vessels; whether the black of the eye appeared black; whether the two eyes were of equal size; and whether both eyes appeared to look straight ahead [20]. These criteria were analyzed as conjunctival findings, cornea/lens findings, eye size, and ocular alignment, respectively. Each finding was classified as normal or abnormal. These assessments represented screening observations made without slit-lamp examination or refraction and were not treated as confirmed disease diagnoses. For each of the five assessments—visual acuity, conjunctival findings, cornea/lens findings, eye size, and ocular alignment—the analysis contained one binary classification (normal or abnormal) per participant from student screening and one from ophthalmologist examination.

The two qualified ophthalmologists who provided the students' training performed the reference-standard examinations. Their classifications served as the reference standard for the screening accuracy and agreement analyses. Masking, examination order, and interval between student and ophthalmologist assessments were not documented in the available records.

The original data were entered into Microsoft Excel and analyzed using Stata version 14. For the present report, categorical findings were summarized as counts and percentages; screening accuracy and agreement estimates were recalculated from five aggregate participant-level 2 × 2 tables, each containing 358 paired student and ophthalmologist classifications. Positive classifications denoted impaired visual acuity or an abnormal external finding. True-positive (TP), false-positive (FP), false-negative (FN) and true-negative (TN) classifications were defined relative to the ophthalmologist reference standard. Sensitivity was calculated as TP/(TP + FN), specificity as TN/(TN + FP), positive predictive value as TP/(TP + FP), and negative predictive value as TN/(TN + FN) [21]. Overall agreement was calculated as (TP + TN)/(TP + FP + FN + TN), and Cohen's κ quantified agreement beyond chance [22]. Estimates described pooled participant classifications and did not assess repeatability or variation in performance between individual students. Separate eye-specific results, individual records, and student or household identifiers were unavailable, precluding eye-specific analyses, adjustment for clustering, and estimation of cluster-adjusted confidence intervals [23]. Analyses were descriptive; no inferential comparisons between student classes were undertaken.

RESULTS

All 90 selected students participated, 43 (47.8%) men and 47 (52.2%) women. Their mean age was 17.4 years (range 16–19), calculated from the recorded age frequencies, and 45 students (50.0%) were enrolled in each senior secondary class. Of the 360 adults recruited, 358 were assessed—124 men (34.6%) and 234 women (65.4%)—giving an assessment completion proportion of 99.4%. Reasons for non-assessment of the remaining two adults were unavailable. Overall, 277 adults (77.4%) had some formal education, including 150 (41.9%) with secondary education and 59 (16.5%) with tertiary education (Table 1).

Each of the five screening comparisons included 358 paired student and ophthalmologist classifications. For visual acuity, students classified 143 adults (39.9%) as impaired, compared with 88 (24.6%) classified by the ophthalmologists. There were 63 TP, 80 FP, 25 FN, and 190 TN classifications (Table 2). Sensitivity was 71.6%, specificity 70.4%, positive predictive value 44.1%, and negative predictive value 88.4%. Overall agreement was 70.7%, with Cohen's κ = 0.347.

For conjunctival assessment, students classified 129 adults (36.0%) as abnormal, compared with 100 (27.9%) classified by the ophthalmologists (Table 3). Sensitivity was 91.0%, specificity 85.3%, positive predictive value 70.5%, and negative predictive value 96.1%. Overall agreement was 86.9%, with κ = 0.701.

For cornea/lens assessment, students classified 161 adults (45.0%) as abnormal, compared with 91 (25.4%) classified by the ophthalmologists (Table 4). Sensitivity was 80.2%, specificity 67.0%, positive predictive value 45.3%, and negative predictive value 90.9%. Overall agreement was 70.4%, with κ = 0.377.

For eye-size assessment, students and ophthalmologists each classified 60 adults (16.8%) as abnormal, although these were not identical groups. There were 42 TP, 18 FP, 18 FN, and 280 TN classifications (Table 5). Sensitivity and positive predictive value were both 70.0%, while specificity and negative predictive value were both 94.0%. Overall agreement was 89.9%, with κ = 0.640.

For ocular alignment assessment, students classified 28 adults (7.8%) as abnormal, compared with 24 (6.7%) classified by the ophthalmologists. There were six TP, 22 FP, 18 FN, and 312 TN classifications (Table 6). Sensitivity was 25.0%, specificity 93.4%, positive predictive value 21.4%, and negative predictive value 94.5%. Overall agreement was 88.8%, with $\kappa = 0.171$.

Ranges across the five assessments were 25.0–91.0% for sensitivity, 67.0–94.0% for specificity, 70.4–89.9% for overall agreement, and 0.171–0.701 for κ. Conjunctival assessment had the highest sensitivity and κ, while eye-size assessment had the highest specificity and overall agreement. Ocular alignment assessment had the lowest sensitivity and κ.

Positive values denote impaired visual acuity (Table 2) or an abnormal external finding (Tables 3–6). Each table contains 358 participant records screened by 90 students.

Table 1. Characteristics of participating students and adults

Group	Characteristic	Category	n (%)
Students	Sex	Male	43 (47.8)
		Female	47 (52.2)
	Age	16 years	10 (11.1)
		17 years	38 (42.2)
		18 years	34 (37.8)
		19 years	8 (8.9)
	Class	SS1	45 (50.0)
		SS2	45 (50.0)
	Religion	Islam	85 (94.4)
		Christianity	5 (5.6)
Adults	Sex	Male	124 (34.6)
		Female	234 (65.4)
	Age-group	18–24 years	67 (18.7)
		25–34 years	65 (18.2)
		35–44 years	82 (22.9)
		45–54 years	87 (24.3)
		55–64 years	30 (8.4)
		65–74 years	24 (6.7)
		≥75 years	3 (0.8)
	Education	No formal education	81 (22.6)
		Primary education	68 (19.0)
		Secondary education	150 (41.9)
		Tertiary education	59 (16.5)
	Occupation	Civil servant	58 (16.2)
		Farmer	112 (31.3)
		Self-employed	115 (32.1)
		Unemployed	73 (20.4)

Abbreviations: n, number; %, percentage. Note: Student denominator: 90; adult denominator: 358. SS1 and SS2 denote senior secondary classes 1 and 2. Each characteristic is summarized separately within its participant group.

Table 2. Student and ophthalmologist classifications of visual acuity

Student classification	Reference positive	Reference negative	Total
Positive	63 (TP)	80 (FP)	143
Negative	25 (FN)	190 (TN)	215
Total	88	270	358

Abbreviations: TP, true positive; FP, false positive; FN, false negative; TN, true negative. Note: Sensitivity 71.6%, specificity 70.4%, positive predictive value 44.1%, negative predictive value 88.4%, overall agreement 70.7%, Cohen's κ 0.347. Reference standard, ophthalmologist classification.

Table 3. Student and ophthalmologist classifications of conjunctival findings

Student classification	Reference positive	Reference negative	Total
Positive	91 (TP)	38 (FP)	129
Negative	9 (FN)	220 (TN)	229
Total	100	258	358

Abbreviations: TP, true positive; FP, false positive; FN, false negative; TN, true negative. Note: Sensitivity 91.0%, specificity 85.3%, positive predictive value 70.5%, negative predictive value 96.1%, overall agreement 86.9%, Cohen's κ 0.701. Reference standard, ophthalmologist classification.

Table 4. Student and ophthalmologist classifications of cornea/lens findings

Student classification	Reference positive	Reference negative	Total
Positive	73 (TP)	88 (FP)	161
Negative	18 (FN)	179 (TN)	197
Total	91	267	358

Abbreviations: TP, true positive; FP, false positive; FN, false negative; TN, true negative. Note: Sensitivity 80.2%, specificity 67.0%, positive predictive value 45.3%, negative predictive value 90.9%, overall agreement 70.4%, Cohen's κ 0.377. Reference standard, ophthalmologist classification.

Table 5. Student and ophthalmologist classifications of eye size

Student classification	Reference positive	Reference negative	Total
Positive	42 (TP)	18 (FP)	60
Negative	18 (FN)	280 (TN)	298
Total	60	298	358

Abbreviations: TP, true positive, FP, false positive, FN, false negative, TN, true negative. Note: Sensitivity 70.0%, specificity 94.0%, positive predictive value 70.0%, negative predictive value 94.0%, overall agreement 89.9%, Cohen's κ 0.640. Reference standard, ophthalmologist classification.

Table 6. Student and ophthalmologist classifications of ocular alignment

Student classification	Reference positive	Reference negative	Total
Positive	6 (TP)	22 (FP)	28
Negative	18 (FN)	312 (TN)	330
Total	24	334	358

Abbreviations: TP, true positive, FP, false positive, FN, false negative, TN, true negative. Note: Sensitivity 25.0%, specificity 93.4%, positive predictive value 21.4%, negative predictive value 94.5%, overall agreement 88.8%, Cohen's κ 0.171. Reference standard, ophthalmologist classification.

DISCUSSION

This study assessed screening accuracy and agreement between trained senior secondary school students and ophthalmologists among adults in Dass, northeastern Nigeria. All 90 selected students participated, assessing 358 of 360 recruited adults. Performance differed substantially between screening tasks. Conjunctival assessment had the highest sensitivity and Cohen's κ, whereas ocular alignment assessment detected only six of 24 reference-positive classifications. Visual acuity screening identified approximately seven in ten reference-positive adults, but fewer than half of student-positive classifications were confirmed by the ophthalmologists. These findings support task-specific evaluation of student screening and caution against treating performance in one assessment as evidence of competence across all five categories.

The rationale for reaching households is consistent with the wider burden of avoidable vision loss. Global trend, cause-specific and uncorrected-refractive-error analyses describe continuing unmet need despite improvements in some age-standardized estimates [1–3]. These related analyses draw on overlapping bodies of population-survey evidence and provide complementary perspectives on burden rather than independent evaluations of community screening. Regional estimates for sub-Saharan Africa similarly support improving access but cannot predict the accuracy of a particular screening method [5]. In this context, the contribution of the Dass study is its assessment of a specific delivery approach; it does not demonstrate a reduction in blindness or vision impairment. Such a claim would require evidence that detected problems led to effective care and improved visual outcomes, consistent with the service pathway emphasized by the Lancet Commission [4].

The Nigerian evidence also requires careful separation of population burden from screening classifications. The national survey documented substantial blindness among adults aged at least 40 years, including a high burden in the northeast, while its cause-specific analysis identified opportunities for cataract and refractive services [6, 7]. Its analysis of poverty showed socioeconomic inequalities in blindness and cataract surgical coverage [24]. More recently, the Kogi rapid assessment described persistent unmet needs and inequalities in access to cataract surgery among older adults [25]. These studies establish the relevance of improving access, but their age restrictions, sampling frames, and visual impairment definitions differ from those in Dass. The proportion of adults classified by the ophthalmologists as having impaired visual acuity in this household sample (24.6%) should therefore not be interpreted as an LGA prevalence estimate or compared directly with national blindness prevalence.

The high completion proportion describes follow-through among recruited adults rather than community coverage. Selection began with students' households and expanded to adjacent households, so participation depended on the students' social and geographical reach. Women comprised 65.4% of the assessed adults, but the available information does not establish why they were more frequently recruited or whether the sample resembled the adult population of Dass. These limitations matter because age, spectacle use, disease severity, and other case-mix characteristics can affect the performance observed in a screening study. Methodological research shows that sensitivity and specificity can vary across populations as disease spectrum and related characteristics change [26].

For visual acuity, the most immediately relevant findings are the balance of missed and additional positive classifications. Students identified 63 of the 88 adults classified as impaired by the ophthalmologists, leaving 25 FN classifications. Of the 143 student-positive classifications, 80 were reference-negative. Thus, 55.9% of positive student classifications were not confirmed by the ophthalmologists, while 28.4% of reference-positive classifications were missed. If the student result alone triggered referral, this pattern could generate substantial assessment demand while failing to identify some people requiring further evaluation. These are potential consequences of the classification pattern; referral volume, attendance, and clinical consequences were not measured in this study. Interpretation of screening performance should therefore consider both sensitivity, which describes detection among reference-positive individuals, and positive predictive value, which describes the proportion of positive screening results confirmed by the reference assessment [21].

The closest Nigerian child-to-community comparison is the study by Ayorinde et al., in which 90 primary-school pupils received three days of training and used a 6/60 illiterate E chart to assess community members: reported right- and left-eye sensitivities were 84.8% and 86.1%, with specificities of 44.4% and 50.0%, respectively [14]. The Dass 71.6% sensitivity and 70.4% specificity reflected a different balance of classifications, but one program could not be established as superior: the studies differed in acuity threshold, training duration, screener age, eye-level versus participant-level reporting, and verification of those screened. In particular, Ayorinde et al.'s 6/60 task addressed substantially poorer acuity [14] than the 6/12 task used in Dass.

Bhattarai et al. reported 81.7% sensitivity, 97.6% specificity, 77.3% positive predictive value, and 98.2% negative predictive value for student-led screening in Nepal; their screeners were selected with input from school principals, received two days of training, and assessed other schoolchildren [15]. Those circumstances differ from random selection of senior secondary students, three hours of initial instruction, and household assessment of adults. Nepalese protocols classify 6/12 or worse acuity in either eye as abnormal [15], whereas the Dass records identify 6/12 optotypes as a pass. Such differences at the decision boundary can alter classification. The comparison supports the feasibility of training students for a defined acuity task, but does not establish why accuracy was lower in Dass or whether longer training alone would improve it.

Teacher-led studies further illustrate the importance of using the correct threshold in numerical comparisons. In Delhi, Saxena et al. reported 77.0% sensitivity and 97.1% specificity at 6/12; the often-quoted values of 79.2% and 93.3% applied to the 6/9.5 threshold [27]. Marmamula et al. found 72.3% teacher sensitivity at a 6/12 threshold, with considerable variation between teachers, while community eye-health workers had numerically higher sensitivity in that setting [28]. Rewri et al. reported 69.2% sensitivity and 95.3% specificity among younger children [29]. The similarity of some sensitivity estimates to the Dass result should not obscure the lower specificity in Dass or the differences between screening children and adults.

Other studies evidence why favorable results should not be selected in isolation. In South India, Muralidhar et al. reported teacher-screening sensitivity of only 24.8%, despite 98.65% specificity [30]. In Iran, comparison of teacher records with optometrist examinations yielded 37.5% sensitivity and 92.0% specificity, using an acuity definition different than that in Dass [31]. Conversely, Vietnamese teachers achieved 86.7% sensitivity and 95.7% specificity for uncorrected acuity, with less accurate assessment of presenting acuity [32]. Sharma et al. also found that spectacle-related factors affected teacher measurements in rural Chinese secondary schools [33]. These findings suggest that task specification, spectacle status, implementation, and examinee characteristics require attention before attributing performance to the screener's occupational or educational category.

Recent evidence syntheses offer a useful benchmark but do not provide a transferable performance guarantee. Cunha et al. included 19 articles and reported pooled sensitivity of 76.8% and specificity of 93.6%, with substantial variation and differences according to risk of bias [18]. Umesh et al. reported pooled sensitivity of 70% and specificity of 96% after excluding two studies from their reanalysis because of poor sensitivity and wider confidence intervals [19]. That exclusion warrants caution when interpreting the pooled result as representative of routine practice. These reviews also include overlapping

primary studies [18, 19], so they should not be counted as independent replications of those studies. Neither directly validates secondary-school students examining adults in households.

Verification procedures are another important source of incomparability. Shukla et al. reported 92.3% sensitivity and 72.6% specificity in primary-school screening, but professional assessment included referred children and a sample of those classified as normal [34]. Sudhan et al. likewise combined review of referrals with examination of a small sample of screen-negative children [35]. The Dass aggregate tables contain paired student and ophthalmologist classifications for all 358 assessed adults, allowing reconstruction of the five comparisons. However, undocumented masking, examination order, timing, and handling of uncertain findings limit appraisal of potential bias. A systematic review identified verification procedures, reference standards, and observer-related features as important sources of bias and variation in diagnostic accuracy studies [36].

Positive predictive value also has practical consequences that sensitivity alone does not capture. Latorre-Arteaga et al. reported positive predictive values of 59.1% and 47.8% in two groups of Peruvian children screened by teachers, alongside difficulties ensuring hospital attendance [37]. In Kaur et al.'s large Indian program, many teacher-identified problems were not confirmed during subsequent examination [38]. These experiences are relevant to the 44.1% visual acuity positive predictive value in Dass, although the underlying populations and referral criteria differ. Predictive values depend on the frequency of the target finding in the screened population and should not be transferred directly between settings [21]. Reducing avoidable positive classifications may conserve clinical capacity, but any revised threshold must also be evaluated for missed cases.

The external-eye results indicate that screening tasks should be assessed separately. Conjunctival classification had 91.0% sensitivity, 85.3% specificity, and 0.701 κ, whereas the cornea/lens category had 80.2% sensitivity, 67.0% specificity, and 0.377 κ. The latter category produced 88 FP classifications, indicating limited specificity for the appearance-based task used in this study. The assessments were adapted from the WHO primary eye care manual [20] and should be interpreted as screening observations rather than confirmed diagnoses of conjunctivitis, corneal disease, or cataracts. Inspection of the visible dark portion of the eye does not establish anatomical source or clinical significance of abnormal appearance. Further evaluation should therefore use clearly specified observational criteria and an explicit scope of practice before expanding students' screening responsibilities [13, 39].

Related studies support this task-specific interpretation. Gammoh and Moore found that teachers' performance differed between distance-acuity screening and detection of ocular abnormalities in Jordanian schoolchildren, with substantially lower sensitivity for the latter [40]. The Vision in Preschoolers study showed that trained lay and nurse screeners could achieve similar sensitivity at fixed specificity, but performance depended on the instrument and test format used [41]. In Rwanda, Mathenge et al. evaluated a WHO-based protocol implemented by allied health trainees, combining 6/60 and 6/12 acuity testing with a flashlight examination and a checklist for ocular abnormalities [39]. Children who failed screening underwent same-day reassessment, and 1,187 children who passed screening, comprising two per class, were also reexamined; no FNs were identified in this subgroup. The authors reported 100% sensitivity and 97.2% specificity after extrapolating the subgroup findings to all screen-negative children. These estimates require cautious interpretation because verification covered only a subset of screen-negative children, and the absence of observed FNs in that subset does not establish perfect detection throughout the screened population. The study illustrates a structured screening and referral pathway [39], but its screener population and documented procedures differ from those in Dass.

Ocular alignment was the clearest area of concern. A 25.0% sensitivity means that students missed 18 of the 24 reference-positive classifications, despite 88.8% overall agreement. Most concordance came from the 312 jointly negative classifications, and κ was only 0.171. Adhikari and Shrestha reported 50% sensitivity and 100% specificity for ocular misalignment screening by certified medical assistants in Nepal; however, inconsistencies between the source's narrative case counts and contingency table limit this comparison [42]. Their examination methods cannot be assumed as equivalent to the appearance-based assessment of straightness in primary gaze used in Dass. In the Dass study, a negative student screening results did not reliably rule out abnormal ocular alignment as assessed by the ophthalmologists.

More structured training may improve performance, although this remains to be demonstrated in the Dass setting. In Bangladesh, Mezbah et al. found better overall screening validity with a translated KieVision™ Preschool Vision Screening Kit than with the comparison training module; the program included a specified ocular alignment assessment [43]. A Malaysian randomized study found higher sensitivity after recertification training than after a briefing session among previously trained preschool teachers [44]. These studies support testing standardized materials, observed practice, and reassessment of competence [43, 44]. They do not justify assuming that a particular kit, duration of training, or pediatric protocol would produce the same improvement when secondary-school students screen adults.

Eye-size assessment illustrates a different interpretive issue: students and ophthalmologists each classified 60 adults as abnormal, but their positive groups weren't identical. The 18 FP and 18 FN classifications would disappear from view if only the two marginal totals were compared. Likewise, the comparatively high overall agreement for eye size and alignment should be considered alongside the complete contingency tables. Kappa provides information beyond raw concordance, but its

interpretation is influenced by the distribution of classifications and should remain tied to the clinical task [22]. The numerical estimates are therefore more informative here than a single label declaring students generally reliable across examinations.

Training outcomes and clinical screening performance should be evaluated separately. Krumholtz found that educational sessions could improve teachers' recognition of pupils with vision problems, although recognition and formal diagnostic accuracy are different outcomes [45]. Shukla et al. documented improved knowledge and screening skills among accredited social health activists, followed by some decline in skill retention over one year [46]. In Abuja, Garba et al. evaluated structured glaucoma-related training with portable devices, revealing training-related proficiency rather than an independent estimate of clinical diagnostic accuracy [47]. These studies support assessing procedural competence, accuracy, and retained skills separately when evaluating future student screening programs.

Evidence from primary eye care reinforces the importance of assessing retained competence. Kalua et al. found low competence in several basic eye-care tasks among primary health care workers in Kenya, Malawi, and Tanzania [48]. In a related randomized trial, enhanced supervision produced modest improvements over two years while substantial staff turnover and equipment limitations persisted [49]. Mafwiri et al. observed immediate gains after training in Tanzania, but later qualitative assessment identified diagnostic difficulties and demand for more practical instruction [50]. These workers had different roles and training backgrounds than school students. Their experience nevertheless indicates why the adequacy of a three-hour training session should be evaluated through observed performance and subsequent reassessment rather than assumed from training completion.

Detection must be connected to accessible care if screening is to provide clinical benefit. Onwubiko et al. documented multiple initial pathways to eye care in a rural Nigerian community, including medicine vendors and self-medication [51]; Arinze et al. identified awareness, cost, and fatalistic attitudes as barriers [52]; Olawoye et al. described knowledge and follow-up challenges among glaucoma cases or suspects identified through outreach [53]; and a systematic review of Nigerian eye-care utilization likewise identified financial, geographical, informational, and sociocultural constraints [54]. These findings indicate that screening accuracy alone cannot establish successful access to treatment. Future evaluation of student screening should include support for referral completion and documentation of subsequent care.

Structured referral support is therefore an important component to test. Rono et al. iteratively developed a smartphone-guided algorithm for Kenyan community volunteers, achieving 91.0% sensitivity and 78.1% specificity for referral need in the final validation stage [55]. That result concerns a composite decision under a defined algorithm, rather than the five individual screening categories used in Dass. Surveys of American student-led programs found an association between direct appointment scheduling and higher reported follow-up attendance, describing institutional partnerships, supervision, and follow-up infrastructure as operational priorities [56, 57]. These two reports draw on the same program network and involve medical students in a different health system. Their relevance lies in the need to design and evaluate a complete referral process, not in transferring their attendance estimates to Dass.

Program expansion would also depend on the receiving health system. The Anambra studies identified linked constraints in personnel and governance, delivery of eye-health promotion, equipment, medication, and information systems [10–12]. Because these publications report on different aspects of the same facility assessment, they should be interpreted together. Historical workforce surveys in Enugu Urban and Kwara further show that aggregate staffing levels can obscure geographical maldistribution and inappropriate staff mix [8, 58]. Findings from Enugu Urban suggest that eye-care workforce shortages should not be assumed to be uniform across Nigerian settings [58]. Contemporary local information would be needed to establish whether services around Dass could accommodate additional referrals generated by student screening.

The workforce implications extend beyond availability of volunteers. Atuanya et al.'s survey concerns optometry students' intentions for rural practice rather than observed deployment, but highlights the importance of conditions that support rural careers [9]. Palmer et al. documented shortfalls against suggested workforce indicators across surveyed sub-Saharan African countries using 2011 data; those findings should not be presented as a direct assessment of Nigeria's workforce in late 2020 [59]. Somerville et al.'s review linked task sharing with recruitment, retention, and context-specific incentives [60]. For a school-based program, the corresponding questions include protected time, teacher coordination, professional supervision, and continuity when students leave school. These arrangements require resources even when screening itself is unpaid.

Integration studies provide both encouraging examples and evidence of implementation difficulties. Ademola-Popoola et al. analyzed the use of trained community health workers and specified examination tools within Nigerian infant immunization services, a substantially different setting from adult household screening [61]. Yip et al. described Rwanda's national primary eye-care program, in which training is accompanied by changes to policy, medicines, insurance, and information systems [62]. Conversely, Jolley et al. found that trained Tanzanian workers remained constrained by limited resources and supervision [63], while an earlier Rwandan program reported that initial increases in attendance were not sustained and many cataract referrals did not result in surgery [64]. These findings suggest that durable access requires organizational support beyond training screeners.

Defining the scope of the student role is especially important. Courtright et al.'s review questioned the evidence base and clarity of expectations for primary eye care in sub-Saharan Africa [13]. A later Delphi study by Aghaji et al. specified technical capacities needed to implement the WHO African primary eye-care package, including health promotion and facility

management of cases [65]. Those capacities represent expert consensus about implementation requirements, rather than validation of the Dass procedures. Bright et al.'s national Rwandan survey also showed that need for primary eye care spans refractive, near-vision, and minor-eye-condition needs [66]. A single distance-acuity pass or normal external appearance cannot capture that broader need. Students' role should consequently be defined around a small set of validated observations, understandable messages, and supported referral.

Cost effectiveness remains an empirical question. Priya et al. compared an all-class-teacher model with a selected-teacher model in Southern India and reported lower screening cost per child with confirmed ocular pathology in the former program [67]. That comparison provides evidence that organization can affect costs and referral completion, but does not establish the cost effectiveness of senior secondary students screening Nigerian adults. The Dass study did not measure training and supervision costs, household time, transport, FP assessment costs, completed treatment, or visual benefit. A future economic evaluation should compare program costs and health outcomes with those of a relevant alternative, specify the analytical perspective, and account for downstream resource use and health consequences. A low cost per person screened alone would not establish cost effectiveness or demonstrate value from either a healthcare-sector or societal perspective [68].

Transparent reporting is necessary before stronger implementation conclusions can be drawn. Standards for Reporting Diagnostic Accuracy Studies (STARD) 2015 and its explanation and elaboration identify test procedures, target conditions, reference standards, masking, participant flow, and uncertainty as essential information for interpreting accuracy studies [69, 70]. The aggregate tables make the numerical comparisons transparent, and two qualified ophthalmologists performed the reference examinations. However, undocumented masking, examination order, and timing limit appraisal of potential observer bias. Ophthalmologist classifications constituted the study reference standard; agreement with them should not be interpreted as independent confirmation of specific disease diagnoses. Potential observer and reference-standard effects should remain part of the interpretation, consistent with methodological evidence on diagnostic bias [36].

Strengths of this study are participation from all three senior secondary schools in Dass LGA, random selection of students within classes, and paired student-ophthalmologist classifications for each of the five screening categories. The study provides original, locally generated evidence on household vision screening in northeastern Nigeria—where the national survey documented a substantial burden of blindness [6]—and identifies both the capabilities and task-specific limitations of a locally relevant approach. Limitations of this study include nonprobability adult recruitment, uncertain prevention of duplicate recruitment, and an unverifiable original sample-size justification. Although two qualified ophthalmologists performed the reference examinations, incomplete methodological documentation limits reproducibility and assessment of potential bias. The absence of individual records and cluster identifiers prevents estimation of cluster-adjusted uncertainty and assessment of variation between students. Separate eye-specific results were also unavailable, and the findings do not establish disease diagnoses, retained screening competence, referral completion, or clinical benefit. To address these limitations, future studies should prospectively specify screening and reference procedures, retain participant and cluster identifiers, assess screening competence over time, and evaluate strategies to improve performance. Referral completion, clinical and visual outcomes, and costs should also be evaluated before wider implementation.

CONCLUSIONS

Screening accuracy and agreement between trained senior secondary school students and ophthalmologists varied substantially by task. Conjunctival assessment had the highest sensitivity and agreement beyond chance, whereas ocular alignment assessment missed most reference-positive findings. Visual acuity screening also produced substantial false-positive and false-negative classifications. These findings warrant caution before wider implementation, and support further evaluation of students' performance on clearly defined screening tasks within a professionally supported referral pathway. Future studies should evaluate standardized training and screening procedures, retained competence, referral completion, and clinical outcomes.

ETHICAL DECLARATIONS

Ethical approval: Ethical approval was obtained from the Human and Research Ethical Committee of the National Eye Centre, Kaduna. Administrative permission was obtained from the Bauchi State Ministry of Education and participating school management. Informed consent was obtained from all adult community participants and students aged ≥ 18 years. For students younger than 18 years, parental or guardian informed consent and student assent were obtained.

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