

Association of socioeconomic factors and body mass index on visual acuity in 7–10-year-old children

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Background: Visual acuity (VA) in children aged 7–10 is a significant concern that can impact academic performance, yet 45%–68% of parents do not seek comprehensive eye examinations. Low physical activity is linked to higher body mass index (BMI), affecting children's VA. In addition, lower socioeconomic status (SES) restricts access to adequate eye care, contributing to poor eye health in children. **Aim:** This study aims to conduct preliminary eye exams on 7–10-year-old children within 6 months, to measure BMI using the Center for Disease control and prevention (CDC) calculator, estimate guardians' SES via a standardized tool, to analyze associations between BMI, VA, SES, and VA using statistical methods, and to record the number of guardians who take their children to an ophthalmologist within 28 days for further eye examinations. **Setting and Design:** The study design involves longitudinal observational study. **Materials and Methods:** A Longitudinal study with 304 subjects was carried out. Demographic details, BMI, SES, and vision of 7–10-year-old children were assessed. After 28 days, a follow-up for an ophthalmologist visit for an eye examination was done. **Statistical Analysis:** Spearman's correlation was used for BMI, VA, and SES, and Chi-square was used for demographical variables. **Results:** Out of 304 subjects, most subjects had a healthy weight. VA difficulties affected 47.32% of girls, higher than in boys. The BMI-VA correlation was 0.13, whereas the SES-VA correlation was 0.008. 103 out of 128 subjects with VA referrals were provided. The Chi-square *P* value for BMI category and gender is 0.001. **Conclusions:** Our study identified a positive correlation between BMI and VA, but the correlation between SES and VA was found to be very weakly positive.

Key words: Body mass index, children, ophthalmology, Snellen, socioeconomic factors, visual acuity

Visual impairment (VI) is an essential observation in children aged 7–9.^[1] Early comprehensive eye examinations enhance children's visual motor function^[2] and academic performance,^[3] which are an effective treatment and intervention for any visual impairments in young children. According to research, 45% and 68% of parents never take their children for a complete eye examination.^[4–6] The World Health Organization reports that, as of 2022, over 1 billion people worldwide are overweight or obese, and 2.2 billion experience far- or near-vision impairment – both rapidly increasing in many countries.

According to the National Blindness and Visual Impairment Survey India 2015–2019, there are 4.95 million people who are blind, 35 million have VI, and 0.24 million children are blind in India.^[7] VI is one of the five priority areas identified by the World Health Organization (WHO) in VISION 2020.^[8] Obesity for children is defined as “having a Body Mass Index (BMI) greater than or equal to 95th percentile for age and gender in children aged 2 years or older.”^[9] Among school-age students, overweight and obesity are significant health problems.^[10] Obesity has been demonstrated to be negatively associated with visual acuity (VA).^[11]

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In school-going children, VI is mainly associated with excessive use of TV and watching computers and insufficient outdoor physical activity.^[12] Low socioeconomic level and vision impairment are significantly correlated in adult populations across gender and ethnic groups.^[13] Socioeconomic status (SES) also affects food habits, and a bad diet can negatively affect eye health and possibly VA. Lower SES-related environmental issues, such as cramped or dimly lit living quarters, may exacerbate eye strain and visual problems.^[14] According to study, myopia was more prevalent among children from families with low socioeconomic status and their VA was also worse than that of children from higher socioeconomic status families.^[15]

Although several research studies have examined VI in preschool children in Malaysia,^[14,16,17] research on the association between VI and SES in these age groups remains unestablished. A study by Kalamkar *et al.* discovered refractive error as a major cause for ocular morbidity, followed by strabismus.^[18] This study aims to establish an association between BMI and VA, SES, and VA in school-going children aged 7–10.

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Objectives

- To assess VA in 7–10-year-old school-going children using a prevalidated Snellen chart within a study duration of 6 months
- To determine the relationship between socioeconomic status and VA in 7–10-year-old school-going children, using a standardized questionnaire and statistical analysis within 6 months
- To analyze the association between BMI and VA in 7–10-year-old school-going children by calculating BMI percentiles using the BMI calculator for children and teens developed by CDC and correlating them with VA
- To record the percentage of guardians who took their children for a follow-up ophthalmologist visit after initial VA screening within 28 days of the initial assessment
- To evaluate the proportion of guardians who responded to follow-up communication regarding their child's eye examination results.

Materials and Methods

Researchers of a study conducted discussion sessions with parents of subjects at school and provided information regarding the study. Data were collected from four selected sites within community settings. To facilitate interpretation, the schools have been labeled as Sites 1 through 4. Site 1 was S.V. English medium school, site 2 was S.G. English medium school, Site 3 was R.N. Patel primary school and Site 4 was J.B. Patel primary school- all located in Gandhinagar, Gujarat. Parents were given an Informed Consent Form and Participant Information Sheet. Sufficient time was given to parents to think about the study, and researchers discussed questions regarding the survey at the time of the meeting. For queries arising later on, a telephone conversation was also provided as an option to contact the researcher at any time. According to the Guidelines for Biomedical Research on Human Subjects verbal assent was obtained from each participant. Subjects whose parents agreed to give consent on behalf of subjects for participation in the study were enrolled. Boys and girls 7–10 years old, children with VA, and children whose parents provided consent on behalf of their children to participate in the study were included. The sample size was calculated by considering a 5% margin of error and a 95% confidence interval. A total of 304 subjects were examined and selected for data analysis. Children whose guardians refuse to provide written informed consent for data collection or follow-up, children with a prior diagnosis of VI (e.g. conjunctivitis) as reported by guardians that could influence VA, and children with recent acute eye infections or reported history of eye trauma.

In this study, demographic data such as name, age, gender, address, and date of birth were collected along with the subject's height, weight, BMI, gadget usage time, dietary habits, and physical activity frequency in the week. Data were recorded using a paper-based Data collection Form and face-to-face interviews. The study was conducted for a duration of 6 months.

The subjects' height and weight were measured using standard procedures, such as a calibrated height scale (MCP, India) and weighing balance (Doctor Beli Ram and Sons, India). The BMI of the subject was calculated using the BMI calculator for children and teens, developed by the CDC^[19] by entering data of height in meters and weight in kilograms along with the child's age and gender. BMI percentiles were categorized according to CDC growth charts for pediatric populations. Children with a BMI below the 5th percentile were classified as underweight, those between the 5th and 85th percentile as demonstrating a healthy weight, those between the 85th and 95th percentile as overweight, and those at or above the 95th percentile as obese. Severe obesity is characterized by a BMI at or exceeding 120% of the 95th percentile or a BMI of 35 kg/m² or higher. Researchers opted out of training to perform eye examinations using the Snellen chart by registered ophthalmologists. After completing training, the researcher conducted a VA screening of all eligible subjects. An ophthalmologist also validated Snellen's chart. A distance of 6 meters (20 feet) from the Snellen chart was marked using prevalidated meter tape. The subject was asked to stand at a marked distance, 6 m from the Snellen chart. Subjects were asked to read the chart from top (larger size alphabet) to bottom (smaller size alphabet). VA was classified based on standard WHO criteria. Normal vision was defined as 20/20, while mild VA included VA ranging from 20/25–20/50. Moderate VA was categorized as VA > 20/50 up to 20/200. Face-to-face interviews with the subject assessed dietary habits, and the subject was asked specific questions that yielded information about diet, including the type of food consumed in breakfast, lunch, and dinner, along with the inclusion of fruits, dry fruits, dairy products, and tea/coffee/flavored milk.

In the gadget usage details section of the form, data collection involved assessing the usage of mobile phones, TVs, laptops, and other electronic devices used by subjects. Data regarding diverse physical activities such as muscle strengthening, bone strengthening, and aerobic exercises, were collected. Subjects' engagement in these activities was recorded, detailing the weekly frequency for each category. The socioeconomic status of guardians was assessed using the Aggarwal Socioeconomic Scale.^[20] Scores were categorized as follows: upper high (≥ 76), high (61–75), upper middle (46–60), Lower middle (31–45), poor (16–30), and very poor or below the poverty line (≤ 15). Guardians of subjects were provided with 22 structured questionnaires, which helped assess the guardian's socioeconomic status. The scale considers factors such as education, occupation, and income. According to a selection of predetermined options and summing up, the total score of individual socioeconomic status was determined.

Follow-up

Follow-up assessment was done after 28 ± 2 days of preliminary examination. This part of the follow-up form consisted of the date and time of the guardian's response, along with answers to three questions – is the child wearing glasses? information on the doctor's note, and change in gadget usage

time. This follow-up was taken up to three attempts in case the follow-up call was not answered previously.

Ethical statement

The study protocol was reviewed and approved by the institutional ethics committee, ensuring compliance with ethical standards. The study was conducted as per the Indian Council of Medical Research Guidelines for Biomedical Research on Human subjects, schedule Y (Amended Version 2013) and International Conference on Harmonization's-Good Clinical Practice guidelines E6 (R1) and by the ethical principles that have their origin in the Declaration of Helsinki (Fortaleza, Brazil, October 2013), and other applicable regulatory requirements, as well as in compliance with the approved protocol.

Statistical method

In the analysis, the data values are conveyed through frequency and percentage. Spearman's correlation coefficient method was employed to assess the association between BMI and VA, as well as socioeconomic status and VA. Chi-square tests were used to calculate associations between demographic variables, such as gender and BMI, and between BMI and socioeconomic factors. In addition, Chi-square tests were utilized to assess the relationships between VA findings and visits to an ophthalmologist. The statistical analysis was conducted using SPSS Inc. Released 2020. IBM SPSS Statistics for Windows, Version 27.1. Armonk, NY: IBM Corp. The $P < 0.05$ was considered statistically significant.

Results

Age and body mass index

A total of 304 school-going children participated in the study, with a mean age of 9.04 ± 0.84 years. Figure 1 illustrates the population distribution of subjects. 59 out of 304 subjects were underweight, 196 subjects had normal weight, 38 were overweight and 11 were obese. The BMI of a total of 304 subjects was assessed. The mean BMI with the standard deviation of subjects is represented in Table 1.

Visual acuity

Out of a total of 304 subjects who were screened for VA, 107 boys (60.79%) had normal vision, 66 (51.96%) boys had

mild VA, while 69 (39.2%) girls had normal vision and 61 girls (48.03%) had mild vision. The Chi-square value of 2.237 with a $P = 0.134$ shows no statistically significant association between gender and VA categories in the sample. Figure 2 shows VA results across the four approved sites. Site 2 had the highest proportion, with 48.27% of individuals showing VA, followed by Site 3 at 45.36% and Site 1 at 44.76%. Site 4 had the lowest percentage, with 22.72% of participants showing VA.

Body mass index and visual acuity

In the normal category, most are in the healthy weight range (114), followed by underweight (34), overweight (23), and obese (5). In the mild category, healthy weight leads (81), followed by underweight (25), overweight (15), and obese (6). Moderate issues are seen in 1 healthy-weight individual. Table 2 shows the distribution of individuals in different BMI categories at four sites, with corresponding VA percentages. The Spearman correlation coefficient (r_s) between BMI and VA is determined to be 0.1314. This coefficient suggests a weak positive correlation between these two variables.

Socioeconomic status

The socioeconomic status results are divided into five distinct categories: high, upper middle, lower middle, middle, poor, and very poor. The sample includes 51 respondents (16.77%) in the high socioeconomic status group, 170 (55.92%) in the upper middle, 71 (25.35%) in the lower middle, 11 (3.61%) in poor, and 1 (0.32%) in very poor.

Socioeconomic status and body mass index

Three study parameters – BMI category, gender, and socioeconomic status are summarized in Table 3. Most participants had a healthy weight (boys: 50.51%, girls: 49.48%), with underweight more common in girls (23.72%) than boys (76.27%). When examining socioeconomic status, individuals in the upper middle class show the highest percentages in the healthy weight category (59.69%). In contrast, those in the Poor socioeconomic status category have the highest percentage of individuals classified as underweight (3.57%). Notably, the obese category has the highest percentage among boys in the upper

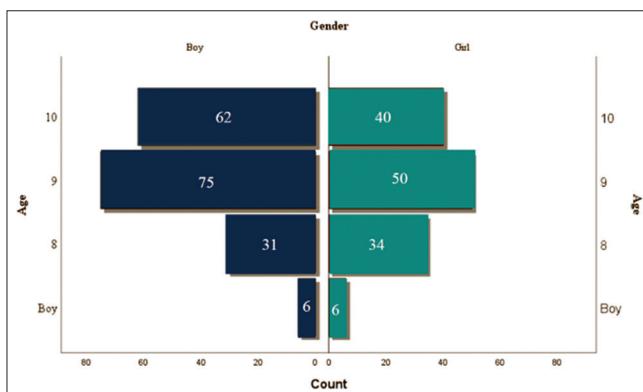


Figure 1: Population pyramid

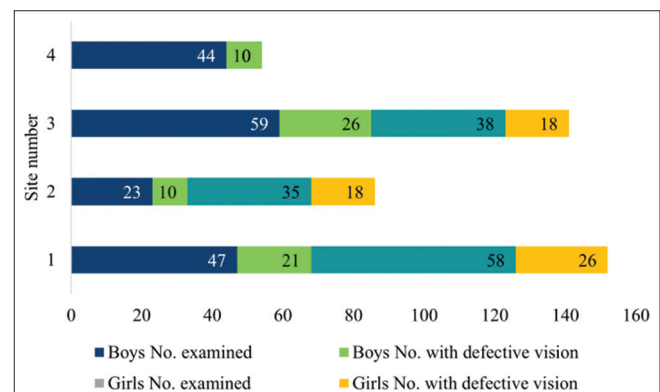


Figure 2: Visual acuity distribution across sites

middle class (54.54%) and girls in the poor socioeconomic status (9.09%). The P value for BMI category and gender is 0.001, indicating a relation between BMI and gender. The P value of approximately 0.0002 suggests a statistically significant association between the subjects' socioeconomic status and weight categories.

Socioeconomic status and visual acuity

A statistically significant correlation between SES and VA is supported by a Chi-square value of 10.446 and a $P = 0.033$. The SES and VA correlation coefficient (r_s) of 0.008 indicate a very modest positive link between these two factors. The fact that the positive correlation coefficient in this instance is nearly 0 suggests that the relationship between socioeconomic position and VA is, at most, minimally linear.

Referral details

A total of 304 subjects were screened during the project period. Of those, 106 had vision problems and were referred to visit an ophthalmologist for further eye examination. Figure 3 provides details of the referral rate according to age.

Table 1: Mean body mass index with standard deviation of subjects

Age	Mean $\pm$ SD BMI (kg/m ²)	
	Boy	Girl
7	16.55 $\pm$ 2.78	15.9 $\pm$ 2.77
8	16.45 $\pm$ 2.97	16 $\pm$ 2.75
9	15.79 $\pm$ 2.97	16.53 $\pm$ 2.73
10	17.09 $\pm$ 3.03	17.91 $\pm$ 2.72

Table 2: Body mass index distribution and visual acuity across different weight categories at multiple sites

BMI Categories	BMI (VA count)	Visual acuity (%)
Site 1		
Underweight	19 (9)	47.36
Healthy weight	68 (30)	44.11
Overweight	16 (6)	37.50
Obese	2 (2)	100
Site 2		
Underweight	7 (5)	71.42
Healthy weight	37 (17)	45.94
Overweight	13 (6)	46.15
Obese	1 (1)	100
Site 3		
Underweight	29 (11)	37.93
Healthy weight	63 (30)	47.61
Overweight	4 (2)	50
Obese	1 (1)	100
Site 4		
Underweight	4 (0)	0
Healthy weight	28 (7)	25
Overweight	5 (1)	20
Obese	7 (2)	28.57

Follow up

Table 4 describes the subjects' follow-up details. Subjects with 20/50 and 20/100 Snellen chart readings had the highest number of visits to an ophthalmologist for further eye examination. Subjects with 20/30 also ranked second for visits to ophthalmologists. 48.57% of subjects with 20/25 VA reading did not visit an ophthalmologist, which was the highest rate for not visiting an ophthalmologist. A $P = 0.029$ suggests evidence supporting a statistically significant association between visiting an ophthalmologist for eye examination and VA reading in school-going children.

Discussion

Children's vision can have a significant impact on their health and well-being. The visual experience of a child plays a substantial role in his physical, psychological, and intellectual development. Many of the causes of VI in childhood are avoidable, either preventable or treatable. This study revealed that 57.89% of students were with 20/20 reading, which indicates good VA.^[20] In addition, mild impairment cases were overweight and obese, consistent with other studies.^[21,22] Showing a significant link between higher BMI and VA issues. Understanding this relationship is essential, as BMI and VA can significantly impact a child's overall well-being and academic performance, which determines that a higher BMI correlates with an increased likelihood of VA.^[23] Understanding these differences is critical, as they may provide insight into how a child's physical health influences their vision, which impacts academic performance. A study by Rajput *et al.*^[24] pointed out that the majority of children with refractive error present with nonvisual complaints, and the involvement of parents could help to reduce morbidity from uncorrected refractive error. There was reference number error due to oversight. Updated sentence will be: The case series by Lobo *et al.*^[25] elucidates how preliminary screenings conducted at school camps can facilitate the diagnosis of vision impairments in children. As an initiative of early VA detection in children, our study explored the association between BMI and VA, uncovering a potential link between a child's physical health and visual capabilities.

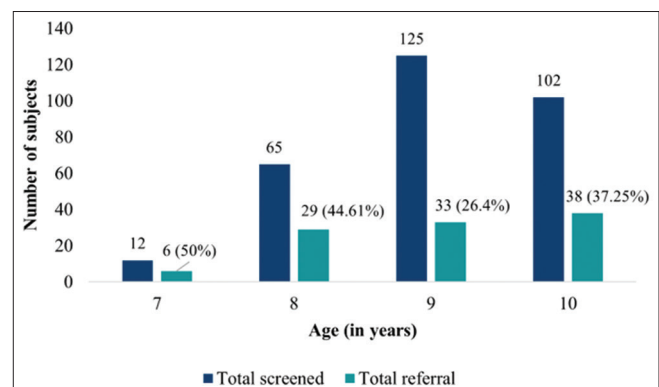


Figure 3: Referral rate details age wise

Table 3: Body mass index by gender and socioeconomic status

	BMI Category				Test of significance
	Underweight (n=59)	Healthy weight (n=196)	Overweight (n=38)	Obese (n=11)	
Gender					$\chi^2=17.979$ $P=0.001$
Boy	45 (76.27%)	99 (50.51%)	21 (55.26%)	9 (81.81%)	
Girl	14 (23.72%)	97 (49.48%)	17 (44.73%)	2 (18.18%)	
Socioeconomic status					$\chi^2=40.056$ $P=0.0002$
High	9 (15.25%)	24 (12.24%)	6 (15.78%)	3 (27.27%)	
Upper middle	30 (50.84%)	117 (59.69%)	21 (55.28%)	6 (54.54%)	
Lower middle	17 (28.81%)	48 (24.48%)	11 (28.94%)	1 (9.09%)	
Poor	2 (3.38%)	7 (3.57%)	0	1 (9.09%)	
Very poor	1 (1.69%)	0	0	0	

Table 4: Follow up details

Visual acuity reading	Visited ophthalmologist for eye examination		Test of significance
	Yes (n=62)	No (n=41)	
20/25 (n=35)	18 (51.42%)	17 (48.57%)	$\chi^2=3.868$ $P=0.029$
20/30 (n=46)	27 (58.69%)	19 (41.3%)	
20/40 (n=18)	13 (72.22%)	5 (27.77%)	
20/50 (n=3)	3 (100%)	0	
20/100 (n=1)	1 (100%)	0	

SES was a crucial variable, as it includes factors such as family income, parental education, and occupational status, significantly affecting a child's access to resources and opportunities, influencing educational outcomes and health, including VA. Considering SES, we aimed to understand better its role in shaping the relationship between a child's physical health, particularly BMI, and academic performance. This research also compared SES with VA to explore how economic and social factors might influence children's vision. Our analysis aimed to determine whether disparities in SES are linked to differences in VA, potentially impacting educational outcomes and overall well-being. Of those with normal vision, 176 subjects were distributed across these socioeconomic categories. Socioeconomic scores averaged 49 for normal vision, 51 for mild vision, and 48 for moderate vision. The study found a weak positive correlation between socioeconomic status and VA, indicating no significant association. However, the prospective nature of the current study provides evidence that 57.89% had 20/20 vision, indicating good VA. Clear distance vision is also crucial for children's learning, especially since blackboards were the primary instructional tool in all the classrooms of the schools that participated in our study, where a significant portion exhibited impaired vision.

Among this objective, there is another important one, which was to evaluate the number of guardians who responded to follow-up after eye examinations, which is essential as regular visits to an ophthalmologist for eye examinations

are crucial for school-aged children, as early detection of visual impairments can significantly affect their academic performance and overall development. VA screenings are vital in this age group, as many children may not realize they have vision issues that could hinder their ability to learn effectively in the classroom. Routine eye examinations ensure that any vision problems are found and addressed promptly, supporting children's educational success and long-term eye health, which is evidence to support a statistically significant association between visiting an ophthalmologist for eye examination and VA reading in school-going children. There are some limitations of our study. First, given the longitudinal design, we could not draw any firm conclusions about the cause and effect of this association. Second, the study duration was insufficient to yield significant results, as more time was needed to assess VA risk factors, such as dietary habits contribute to eye health. Still, the data collected on meals were vague, leading to a lack of statistical significance; another factor was the gadget use, where broad data were collected from only one family member, limiting the accuracy.

Conclusions

This study found a weak positive association between VA and BMI, suggesting that those with impaired vision are more prone to having a high BMI. Participants with excess weight exhibited a greater incidence of VA issues. Children from upper-middle socioeconomic backgrounds exhibited a higher likelihood of experiencing visual impairments. A notable correlation was identified between VA and consultations with ophthalmologists, indicating that children with impaired vision are more likely to seek eye examinations. These findings underscore the necessity for routine vision assessments and parental attentiveness.

Data availability statement

The data supporting the findings of this study will be made available upon reasonable request.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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