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Overcoming barriers in anemia screening: The aspen Hb meter's role in resource-limited settings

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Abstract

Anemia is a critical global health concern affecting 1.6 billion people, with a significant burden in resource-limited settings, particularly affecting women, children, and individuals with chronic illnesses. Accurate and accessible diagnostic tools are essential for timely anemia detection and management. This study evaluated the performance of the Aspen Hb meter, spectrophotometry-based hemoglobin estimation device, compared to the Mindray BC-6000 Automated Hematology Analyzer. A total of 2,279 venous and capillary blood samples were analyzed across diverse populations, including children, women, and men. Statistical analyses revealed high sensitivity (venous: 97.78%; capillary: 96.87%), specificity (venous: 95.65%; capillary: 95.22%), and accuracy (venous: 96.77%; capillary: 96.04%) with overall 97.33% sensitivity, 95.43% specificity and 96.40% accuracy for the Aspen Hb meter. Linear regression demonstrated strong correlation coefficients ($R^2 > 0.98$) between the two methods, with minimal bias in Bland-Altman analysis (mean difference: 0.05 g/dL). Group-wise assessments highlighted consistent performance across demographic categories, with the device achieving high positive predictive value (PPV) and negative predictive value (NPV). Compared to traditional and portable methods like HemoCue, the Aspen Hb meter exhibited superior diagnostic reliability, particularly for capillary samples. Its portability, ease of use, and adaptability to low-resource settings make it a valuable tool for point-of-care anemia screening and public health interventions.

Keywords: Aspen Hb Meter; Mindray BC-6000 Autoanalyzer; Hemoglobin estimation; Anemia; Diverse cohort

1. Introduction

Anemia remains a significant global health challenge, affecting diverse populations across all age groups [1]. According to the World Health Organization (WHO), anemia affects over 1.62 billion people globally, with children under five and women of reproductive age being the most vulnerable groups [2]. In children, the global prevalence of anemia stands at approximately 42%, leading to developmental delays, reduced cognitive function, and increased susceptibility to infections [3]. Among men, although less prevalent, anemia is often indicative of underlying chronic conditions, nutritional deficiencies, or parasitic infections [4]. For women, the situation is more alarming; an estimated 29% of non-pregnant women and 38% of pregnant women globally are anemic. In India, the burden of anemia is particularly severe, with 67.1% of children aged 6–59 months, 57% of women aged 15–49 years, and 25% of men suffering from the condition as per the latest National Family Health Survey (NFHS-5) [5]. These statistics underscore the urgent need for effective diagnostic and management strategies to combat anemia and its associated health consequences.

Hemoglobin estimation serves as the cornerstone of anemia diagnosis and management. Hemoglobin, the protein responsible for oxygen transport in the blood, is a critical indicator of an individual's overall health and nutritional status [6]. Regular monitoring of hemoglobin levels is essential for early detection and timely intervention, which can prevent severe complications such as reduced productivity, impaired cognitive function, and maternal and perinatal

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mortality [7]. This is particularly critical for vulnerable groups such as children, pregnant women, and individuals with chronic illnesses. For instance, pregnant women with undiagnosed or untreated anemia are at a higher risk of preterm delivery, low birth weight, and maternal mortality [8]. Despite the importance of regular hemoglobin monitoring, access to accurate and timely diagnostic tools remains a challenge, particularly in resource-limited settings. Traditional methods of hemoglobin estimation, such as the cyanmethemoglobin method and automated hematology analyzers, are highly accurate but require well-equipped laboratory facilities and trained personnel [9]. These requirements make them less accessible in remote and rural areas where healthcare infrastructure is often inadequate. In such settings, the lack of reliable diagnostic tools can lead to delayed or missed diagnoses, exacerbating the burden of anemia. This highlights the need for portable, cost-effective, and rapid hemoglobin estimation devices that can be deployed in diverse clinical settings. Such devices not only facilitate timely decision-making by clinicians but also enhance the reach and efficiency of public health programs aimed at anemia screening and management.

The Aspen Hb Meter, spectrophotometry-based hemoglobin estimation device, evaluated in this study aims to address these challenges. This Aspen Hb Meter combines portability, accuracy, and ease of use, making it particularly suited for point-of-care applications. Unlike traditional analyzers, it can operate efficiently in low-resource environments without compromising diagnostic accuracy. This study provides a comprehensive comparison of the Aspen Hb Meter's performance against standard automated hematology analyzers, focusing on metrics such as accuracy, sensitivity, specificity, and ease of use. By evaluating the Aspen Hb Meter's potential for integration into routine clinical practice and public health programs, this research contributes to the ongoing efforts to improve anemia diagnostics, particularly in underserved regions. The findings are expected to offer valuable insights into the utility of innovative diagnostic technologies in addressing the global burden of anemia.

2. Material and methods

2.1. Sample Collection

Blood samples for hemoglobin estimation were collected at Jain Lab & X-ray Centre, Jagraon, Punjab, following standard phlebotomy procedures to ensure consistency and reliability. A total of 2,279 participants were included in the study, comprising 710 children aged 1 to 15 years, 803 women aged 16 to 90 years, and 766 men aged 16 to 95 years (Table 1). Venous blood was drawn by trained phlebotomists using aseptic techniques to minimize the risk of contamination and ensure participant safety. The procedure began with participant identification and informed consent, followed by the application of a tourniquet to the upper arm to facilitate vein visibility. After sterilizing the puncture site with 70% isopropyl alcohol, a sterile, single-use needle was used to draw 2–3 mL of blood from the median cubital vein or an accessible alternative. The blood was collected into anticoagulant-coated vacutainer tubes, ensuring proper mixing to prevent clotting. Tubes were labeled with participant details and immediately transported to the laboratory under controlled conditions. Blood samples were processed within two hours of collection to ensure sample integrity. For capillary blood analysis, capillary blood samples were collected through finger prick, with the initial drop discarded. Approximately 10 µL of blood was then drawn using a capillary transfer tube and applied to the preloaded microcuvette within the device. These standardized procedures ensured the collection of high-quality venous blood samples across all demographic groups, forming a robust foundation for subsequent hemoglobin analysis.

Table 1 Distribution of samples on the basis of age and gender

Age group	Children	Male	Female	Total
≤15	710	-	-	710
16-30	-	150	269	419
31-45	-	227	220	447
46-60	-	214	173	387
61-75	-	142	109	251
≥76	-	33	32	65
Total	710	766	803	2279

2.2. Hemoglobin Estimation

Hemoglobin levels were measured using two distinct methods: the Aspen Hb meter and the Mindray BC-6000 auto hematology analyzer. The Aspen Hb meter, a spectrophotometry-based device developed by Aspen Laboratories Pvt. Ltd., Delhi, India, measures hemoglobin and calculates hematocrit values in conjunction with its proprietary microcuvette system. The Mindray BC-6000, a hematology analyzer based on cyanide free reagent technology, is recognized for its precision and reliability, serving as the standard reference in this study.

For analysis with the Aspen Hb meter, 10 µL of well-mixed venous blood was applied to a preloaded microcuvette using a pipette or dropper. The device provided hemoglobin results within seconds, which were documented promptly. Concurrently, each sample was analyzed with the Mindray BC-6000 analyzer to obtain reference hemoglobin levels. Results from both devices were recorded and interpreted using WHO guidelines for hemoglobin concentration reference ranges specific to age and sex (Table 2). The comparative assessment of these methodologies ensured robust validation of the Aspen Hb meter's performance in diverse clinical scenarios.

Table 2 Hemoglobin reference values for severity of anemia in patients

Population Group	Normal Hb (g/dL)	Mild Anemia (g/dL)	Moderate Anemia (g/dL)	Severe Anemia (g/dL)
Children (6-59 months)	≥11.0	10.0-10.9	7.0-9.9	<7.0
Children (5-15 years)	≥11.5	11.0-11.4	8.0-10.9	<8.0
Non-pregnant Female (≥16 years)	≥12.0	11.0-11.9	8.0-10.9	<8.0
Pregnant Female	≥11.0	10.0-10.9	7.0-9.9	<7.0
Male (≥ 16 years)	≥13.0	12.0-12.9	9.0-11.9	<9.0

2.3. Statistical Analysis

Data analysis was performed using GraphPad Prism 8.0 software. Hemoglobin levels measured from 2,279 participants using the Aspen Hb Meter were compared with results obtained from the reference auto hematology analyzer. To examine the relationship between the two methods, linear regression analysis was conducted, and the Pearson correlation coefficient was calculated to determine the strength of the correlation. A Bland-Altman plot was generated to evaluate the agreement between the devices, with the mean of the two measurements plotted against their differences. Bias and limits of agreement were calculated at a 95% confidence interval to ensure statistical robustness.

Key diagnostic parameters, including accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were calculated to assess the performance of the spectrophotometry-based device. These metrics were determined using standard formulas.

Accuracy = [((True Positives + True Negatives) / (True Positives + True Negatives + False Positives + False Negatives)) × 100]

Sensitivity = [(True Positives / (True Positives + False Negatives)) × 100]

Specificity = [(True Negatives / (True Negatives + False Positives)) × 100]

Positive Predictive Value (PPV) = [(True Positives / (True Positives + False Positives)) × 100]

Negative Predictive Value (NPV) = [(True Negatives / (True Negatives + False Negatives)) × 100]

Additional indices, such as positive and negative likelihood ratios and disease prevalence, were computed to provide a comprehensive evaluation of the device's diagnostic capabilities.

Positive Likelihood Ratio (LR+) = Sesitivity / (100 – Specificity)

Negative Likelihood Ratio (LR-) = (100 – Sensitivity) / Specificity

Disease Prevalence = [((True Positive + False Negative) / Total Sample) × 100]

This approach enabled a thorough comparison of the new device's performance with the established analyzer, ensuring the reliability of its results for clinical and field applications

3. Results and discussion

This study comprehensively evaluated the diagnostic performance of the spectrophotometry-based Aspen Hb meter in comparison with the Mindray BC-6000 autoanalyzer for hemoglobin estimation across diverse populations. The density distribution of hemoglobin levels across children, men, women, and total samples highlights distinct patterns between the Mindray BC6000 Hematocytometer and Aspen Hb Meter. Both instruments show a peak at 12–13 g/dL for all groups, reflecting normal hemoglobin ranges (Fig. 1a). Men demonstrate slightly higher values, while women and children exhibit broader distributions, indicating diverse physiological and health-related variations (Fig. 1b,c,d).

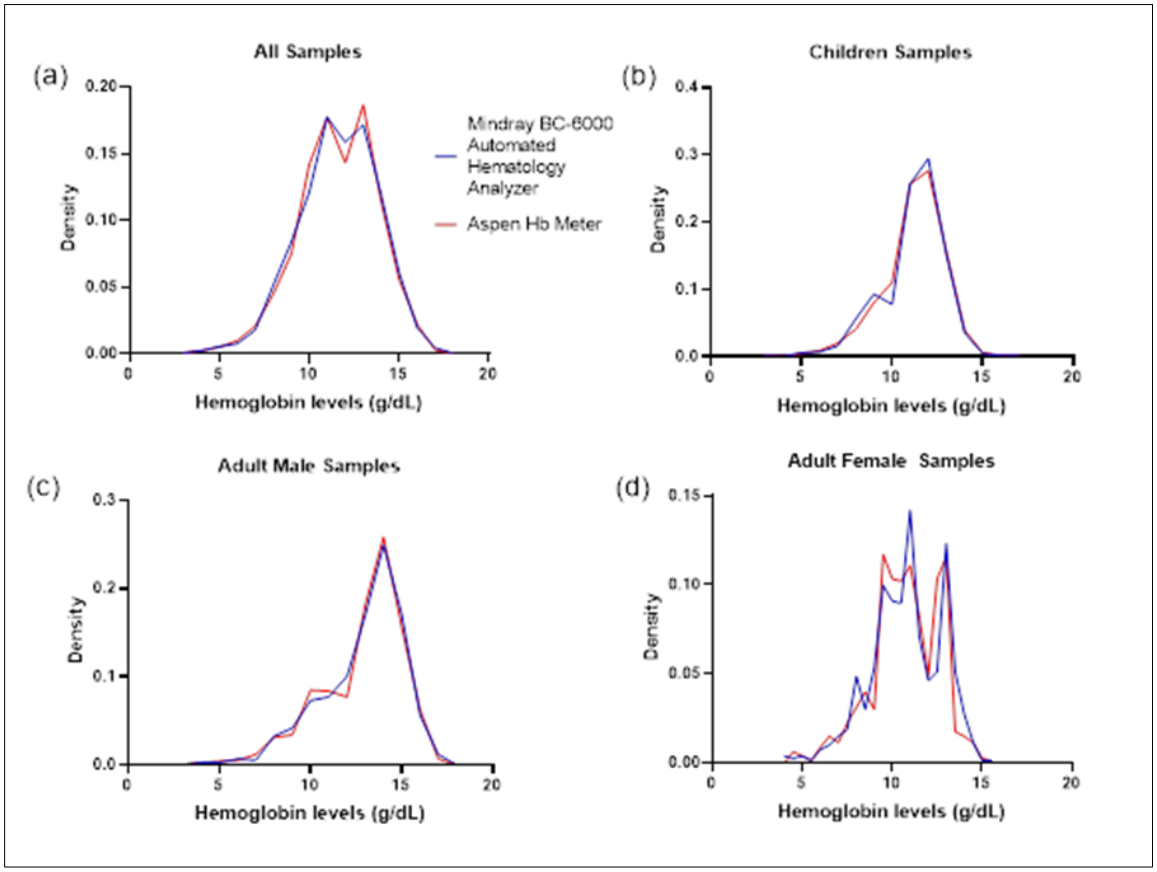

Figure 1 Density distribution of Hemoglobin levels among (a) All samples, (b) Children samples, (c) Adult male samples, (d) Adult female samples

Hemoglobin levels were estimated using venous and capillary blood samples analyzed by the Aspen Hb Meter and the Mindray BC-6000 Automated Hematology Analyzer across various populations. In the total population, Hb levels measured by the Aspen Hb Meter showed mean values of 11.41 ± 2.13 g/dL (venous) and 11.64 ± 2.18 g/dL (capillary), while the Mindray BC-6000 analyzer reported 11.58 ± 2.18 g/dL (venous) (Table 3). In table 3, among children, the Aspen Hb Meter recorded mean values of 11.05 ± 1.74 g/dL (venous) and 11.10 ± 1.62 g/dL (capillary), closely matching the Mindray results at 11.11 ± 1.71 g/dL (venous). Adult females showed similar Hb levels between venous and capillary samples, with mean values of 10.75 ± 1.97 g/dL and 10.76 ± 1.88 g/dL, respectively, using the Aspen Hb Meter, and 10.79 ± 1.95 g/dL (venous) with the Mindray analyzer (Table 3). However, adult males displayed slightly higher mean Hb values, with 12.77 ± 2.14 g/dL (venous) and 12.75 ± 2.30 g/dL (capillary) on the Aspen Hb Meter, and 12.84 ± 2.35 g/dL (venous) on the Mindray analyzer (Table 3). Statistical analysis of the Hb data demonstrated high sensitivity, specificity, and accuracy for both methods, with values for venous samples using the Aspen Hb Meter achieving 97.78% sensitivity, 95.65% specificity, and 96.77% accuracy (Table 4). Capillary samples analyzed using the Aspen Hb Meter

showed a sensitivity of 96.87%, specificity of 95.22%, and accuracy of 96.04%, closely matching the performance of the Mindray BC-6000 analyzer (Table 4). Positive predictive values (PPV) and negative predictive values (NPV) for venous and capillary samples using the Aspen Hb Meter were also comparable, demonstrating its reliability. Table 4 also confirmed that the positive likelihood ratios for venous and capillary samples were 22.49 and 20.30, respectively, while the negative likelihood ratios were 0.023 and 0.032. The Aspen Hb Meter's capability to analyze capillary blood with comparable sensitivity and specificity to venous blood makes it a practical and advantageous tool for field studies and clinical settings where venous sampling is challenging. This highlights its utility for rapid, minimally invasive hemoglobin estimation with performance metrics closely aligning with those of advanced automated analyzers like the Mindray BC-6000.

Table 3 Hemoglobin values of the study population

Population	Test	Sample Type	Hb (g/dL) (Mean ± SD)	Range (g/dL)
Total Population	Aspen Hb Meter	Venous (n=1116)	11.41 ± 2.13	3.4 – 17.2
		Capillary (n=1163)	11.64 ± 2.18	3.5 – 16.9
	Mindray BC-6000 Automated Hematology Analyzer	Venous (n=2279)	11.58 ± 2.18	3.0 – 16.8
Children Population	Aspen Hb Meter	Venous (n=357)	11.05 ± 1.74	3.4 – 16.2
		Capillary (n=353)	11.10 ± 1.62	4.8 – 16.5
	Mindray BC-6000 Automated Hematology Analyzer	Venous (n=710)	11.11 ± 1.71	3.0 – 16.8
Adult Female Population	Aspen Hb Meter	Venous (n=447)	10.75 ± 1.97	4.3 – 15.5
		Capillary (n=356)	10.76 ± 1.88	4.3 – 14.8
	Mindray BC-6000 Automated Hematology Analyzer	Venous (n=803)	10.79 ± 1.95	4.1 – 15.3
Adult Male Population	Aspen Hb Meter	Venous (n=312)	12.77 ± 2.14	4.4 – 17.2
		Capillary (n=454)	12.75 ± 2.30	3.5 – 16.9
	Mindray BC-6000 Automated Hematology Analyzer	Venous (n=766)	12.84 ± 2.35	3.6 – 16.8

Table 4 Sample-wise Statistical Parameters to evaluate the performance of Aspen Hb Meter

Statistical Parameter	Total	Venous	Capillary
Sensitivity	97.33%	97.78%	96.87%
Specificity	95.43%	95.65%	95.22%
Accuracy	96.40%	96.77%	96.04%
PPV	95.68%	96.14%	95.22%
NPV	97.17%	97.49%	96.88%
Positive likelihood ratio	21.29	22.49	20.30
Negative likelihood ratio	0.027	0.023	0.032
Disease Prevalence	51.03%	52.59%	49.52%

The group-wise evaluation of statistical parameters for hemoglobin estimation revealed notable differences across children, adult females, and adult males, providing insights into the performance of venous and capillary blood sampling for anemia diagnosis. For children, the sensitivity of the Aspen Hb Meter for venous and capillary samples was 97.53% and 97.46%, respectively, with an accuracy of 97.19% (venous) and 95.18% (capillary) based on WHO-defined

hemoglobin thresholds (<11.0 g/dL for children aged 6–59 months and <11.5 g/dL for children aged 5–11 years) (Table 5) [10]. The specificity for venous samples (96.92%) was higher than capillary samples (93.33%), indicating marginally superior performance in venous sampling for detecting anemia in pediatric populations. Positive predictive value (PPV) and negative predictive value (NPV) for children were high, demonstrating robust diagnostic reliability.

Table 5 Group-wise Statistical Parameters to evaluate the performance of Aspen Hb Meter

Statistical Parameter	Children			Adult Female			Adult Males		
	Total (n=710)	Venous (n=357)	Capillary (n=353)	Total (n=803)	Venous (n=447)	Capillary (n=356)	Total (n=766)	Venous (n=312)	Capillary (n=454)
Sensitivity	97.50%	97.53%	97.46%	97.84%	98.70%	96.77%	96.15%	95.68%	96.47%
Specificity	95.12%	96.92%	93.33%	95.12%	96.37%	93.51%	95.83%	93.87%	97.18%
Accuracy	96.19%	97.19%	95.18%	97.01%	97.98%	95.78%	95.95%	94.55%	96.91%
PPV	94.25%	96.34%	92.21%	97.84%	98.38%	97.16%	93.22%	90.24%	95.34%
NPV	97.88%	97.92%	97.84%	97.08%	97.08%	92.66%	97.66%	97.35%	97.87%
Positive Likelihood Ratio	20.01	31.69	14.62	20.05	27.24	14.93	23.07	15.62	34.24
Negative Likelihood Ratio	0.026	0.025	0.027	0.022	0.013	0.034	0.040	0.045	0.036
Disease Prevalence	45.07%	45.37%	44.75%	69.36%	69.12%	69.66%	37.33%	37.17%	37.44%

Adult females showed the highest sensitivity for venous samples at 98.70%, with capillary samples comparative at 96.77% (Table 5). Specificity remained high for both venous (96.37%) and capillary (93.51%) samples, supporting the Aspen Hb Meter's utility in addressing the high anemia prevalence among women, reported by WHO to be up to 30% globally. The NPV for both sample types exceeded 92%, ensuring reliable exclusion of non-anemic cases. In adult males, the sensitivity for capillary samples (96.47%) slightly outperformed venous samples (95.68%), while specificity was higher for capillary (97.18%) compared to venous samples (93.87%) (Table 5). Accuracy for both sample types was robust, with values of 94.55% (venous) and 96.91% (capillary). This group demonstrated the highest positive likelihood ratio for capillary samples (34.24), highlighting the utility of minimally invasive methods for effective anemia detection in men. Across all groups, the disease prevalence was consistent with WHO-reported anemia prevalence rates, with the highest prevalence observed in adult females (69.36%) and the lowest in adult males (37.33%) [11]. The Aspen Hb Meter demonstrated a positive likelihood ratio exceeding 14 across all categories, emphasizing its diagnostic effectiveness (Table 5). Negative likelihood ratios remained below 0.05, underscoring its strong ability to rule out anemia when Hb levels were within normal ranges. These results reinforce the Aspen Hb Meter's reliability for anemia diagnosis using both venous and capillary blood, particularly for resource-limited settings or field studies. While venous samples showed slightly better specificity and PPV in some groups, the close performance of capillary samples highlights their practical advantages, including minimal invasiveness and ease of collection, without significant compromise in diagnostic accuracy.

Comparative analysis with other portable hemoglobin meters, such as HemoCue and Mission Hb, revealed the Aspen Hb meter's superior diagnostic performance. While HemoCue and Mission Hb reported sensitivities and specificities ranging from 90% to 95% and accuracies close to 93% in previous studies, the Aspen Hb meter consistently achieved higher sensitivity (children: 97.5%, women: 96.10%, men: 94.12%) and specificity (children: 93.85%, women: 94.14%, men: 94.76%) with overall 97.33% sensitivity, 95.43% specificity and 96.40% accuracy [12,13]. Moreover, its low negative likelihood ratios (children: 0.0266, women: 0.0414, men: 0.0621) further underscore its reliability in excluding anemia and minimizing false negatives. These findings establish the Aspen Hb meter as a dependable tool for anemia screening, particularly in clinical and resource-limited settings.

Linear regression analysis reinforced the Aspen Hb meter's reliability by demonstrating a robust correlation with the Mindray BC-6000 autoanalyzer. For children samples, the Aspen Hb meter exhibited a high coefficient of determination

(R^2 = 0.9807), reflecting excellent agreement with the reference device (Fig. 2b). Among female samples, the analysis showed an R^2 of 0.9827, further validating the consistency of the device's measurements (Fig. 2d). Male samples exhibited the highest correlation (R^2 = 0.9872), indicating near-perfect agreement (Fig. 2c). Across the combined dataset, an R^2 of 0.9862 highlighted the Aspen Hb meter's overall reliability and accuracy in comparison with the Mindray BC-6000 autoanalyzer (Fig. 2a). This high degree of correlation ensures the device produces hemoglobin measurements comparable to laboratory analyzers, making it suitable for both clinical and field applications. Prior studies on portable hemoglobin meters, such as HemoCue and Mission Hb, reported R^2 values ranging from 0.91 to 0.95 when compared with laboratory analyzers, indicating strong correlations but slightly lower performance than the Aspen Hb meter [14].

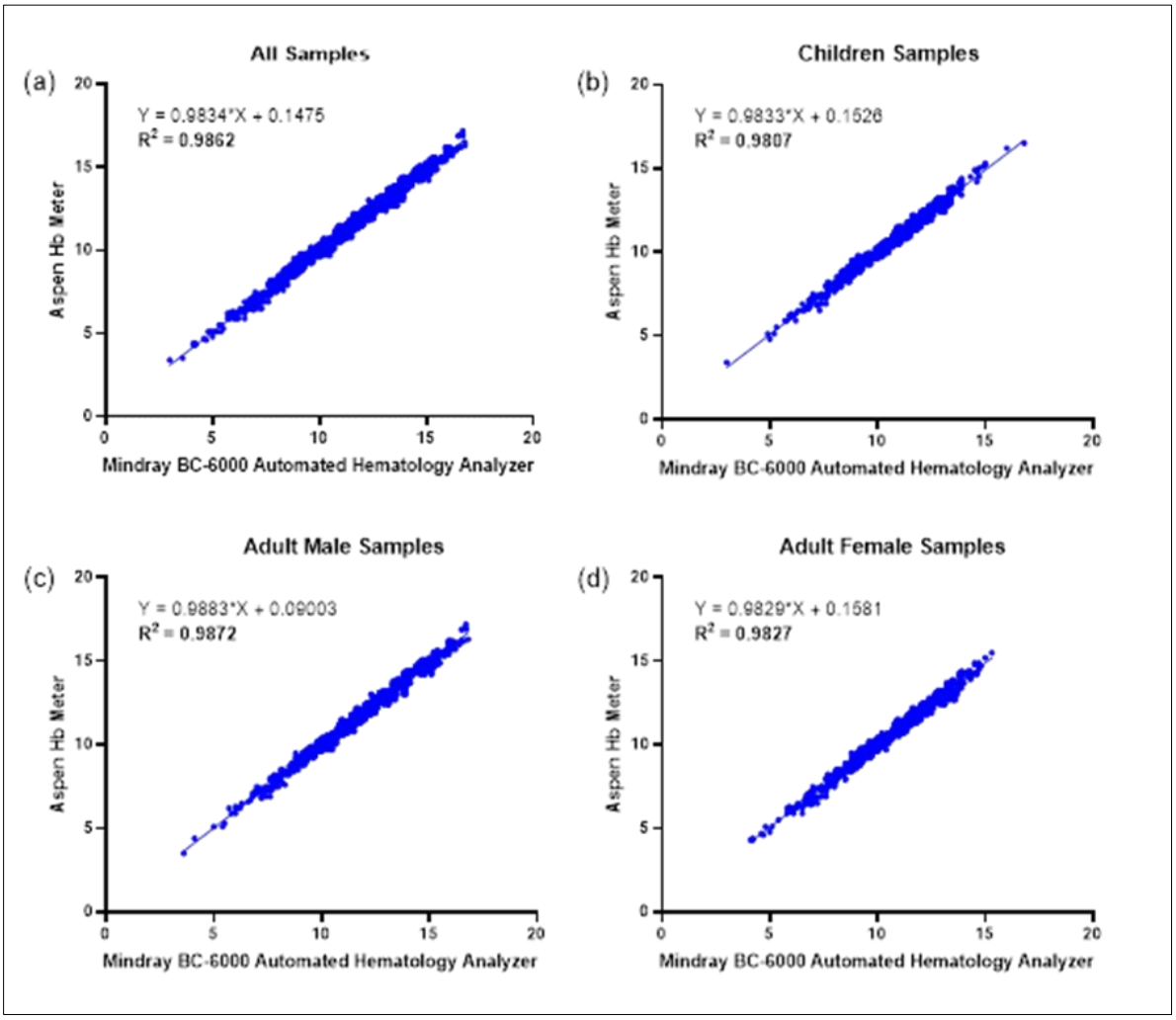

Figure 2 Linear regression analysis between Aspen® Hb meter and Mindray BC-6000 Hematocytometer for (a) All samples, (b) Children Samples, (c) Adult Male samples, (d) Adult Female samples

Bland-Altman analysis provided additional insights into the Aspen Hb meter's accuracy, revealing minimal measurement bias across all demographic groups. In children, the mean difference was 0.04 g/dL, with limits of agreement ranging from -0.41 to +0.49 g/dL (Fig. 3b). Among women, the mean difference was similarly 0.04 g/dL, with limits of agreement between -0.45 and +0.52 g/dL (Fig. 3d). Male participants showed a mean difference of 0.08 g/dL, with limits of agreement extending from -0.43 to +0.59 g/dL (Fig. 3c). For the entire dataset, the mean difference was 0.05 g/dL, with limits of agreement from -0.43 to +0.54 g/dL, underscoring the device's robust performance across diverse populations (Fig. 3a). These narrow limits of agreement and low mean differences highlight the Aspen Hb meter's minimal variability compared to the Mindray BC-6000 autoanalyzer. Previous evaluations of portable hemoglobin meters, such as HemoCue and Mission Hb, have reported limits of agreement typically within ±0.5 g/dL but often with slightly higher mean differences, emphasizing the Aspen Hb meter's superior consistency [14, 15, 16, 17].

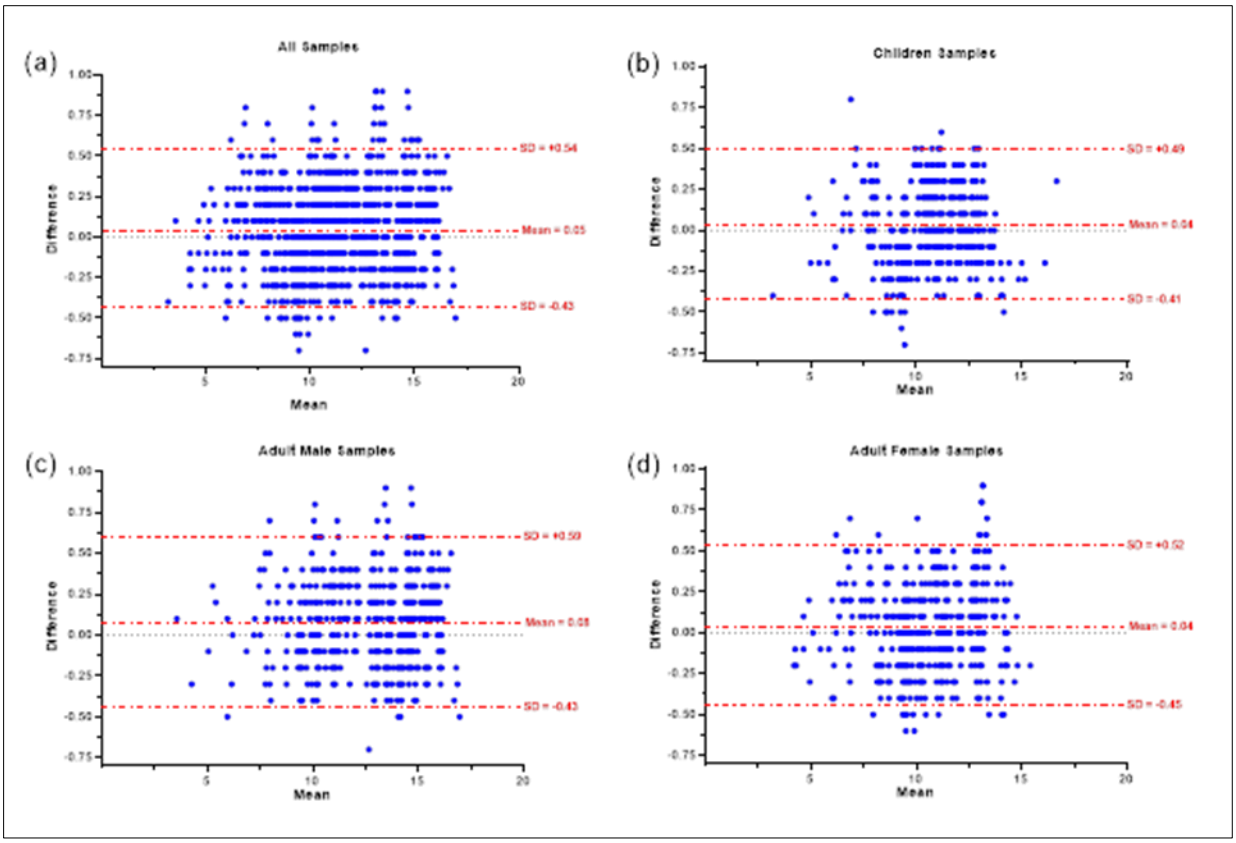

Figure 3 Bland & Altman Plot with differences in Hb level estimation obtained from Aspen® Hb meter and Mindray BC-6000 Hematocytometer plotted against mean of the values (a) All samples, (b) Children samples, (c) Adult Male samples, (d) Adult Female samples

The prevalence of anemia in women in this study was 69.36%, reflecting the significant burden of anemia among Indian women due to factors such as nutritional deficiencies, menstrual blood loss, and other socio-environmental influences [18]. The device's high sensitivity and PPV make it a valuable tool for addressing this critical public health issue. In contrast, the prevalence of anemia among men was 37.33%, aligning with global and national epidemiological trends. These findings illustrate the Aspen Hb meter's robust diagnostic performance across populations with varying anemia burdens.

Traditional methods like the cyanmethemoglobin assay, while highly accurate, are labor-intensive and reliant on advanced laboratory setups, limiting their use in resource-limited settings [9]. Automated analyzers, such as the Mindray BC-6000, offer excellent reliability but are costly and impractical for point-of-care applications. Portable devices like the HemoCue system, while effective, occasionally underperform in sensitivity or specificity. For example, Fothergill et al. (2022) reported a sensitivity of 96.5% and specificity of 92.3% for the HemoCue system, slightly lower than the values observed for the Aspen Hb meter in this study [19]. This comparison highlights the Aspen Hb meter's balanced and reliable diagnostic performance for anemia screening.

The Aspen Hb meter's adaptability for point-of-care use, accommodating both capillary and venous samples, enhances its utility. Its ability to deliver rapid, accurate results without requiring extensive technical expertise or infrastructure makes it particularly advantageous in regions with high anemia prevalence, such as rural India. False positives and false negatives were evaluated, revealing a low false positive rate and a false negative rate, minimizing diagnostic errors. A low false negative rate ensures that anemic individuals are rarely missed, while a low false positive rate reduces unnecessary treatment.

Additionally, the portability and user-friendly design of the Aspen Hb meter make it an invaluable asset for public health programs, especially those targeting maternal health. Timely anemia detection can significantly reduce maternal morbidity and mortality [20]. In comparison to non-invasive optical devices, which eliminate the need for blood collection but often fall short in sensitivity and specificity, the Aspen Hb meter strikes an optimal balance between

diagnostic accuracy and practical applicability [21]. These findings reinforce its potential as a reliable tool for anemia management and screening programs.

4. Conclusion

This study highlights the unparalleled diagnostic performance of the Aspen Hb meter, a spectrophotometry-based portable device, for hemoglobin estimation across diverse demographic groups. The device demonstrated high sensitivity, better specificity, and accuracy in detecting anemia in pediatric, female, and male populations, consistently meeting or exceeding the benchmarks set by established methods such as the Mindray BC-6000 autoanalyzer and other portable devices like HemoCue and Mission Hb. Its reliability, confirmed by high R^2 values in linear regression analyses and minimal bias in Bland-Altman assessments, underscores its comparability to laboratory-grade analyzers. These findings validate the Aspen Hb meter as a highly accurate, efficient, and practical tool for anemia screening, particularly in resource-limited or remote settings where access to laboratory infrastructure is constrained.

The device's adaptability for point-of-care use, accommodating both capillary and venous blood sampling, and its capacity to provide rapid results without extensive technical expertise or infrastructure make it particularly suited for regions with a high burden of anemia. With anemia prevalence in children, women and men recorded at 45.07%, 69.36% and 37.33%, respectively, the Aspen Hb meter's ability to accurately identify and classify anemic and non-anemic cases is of paramount importance for targeted public health interventions. Moreover, its low rates of false positives and false negatives further emphasize its diagnostic reliability, minimizing errors that could result in missed cases or unnecessary treatment. In comparison with traditional methods like the cyanmethemoglobin assay and automated analyzers, which are resource-intensive and less accessible in rural areas, the Aspen Hb meter offers a more feasible and equally reliable alternative. While non-invasive optical devices eliminate the need for blood collection, their diagnostic limitations in terms of sensitivity and specificity make the Aspen Hb meter a more balanced solution for anemia screening. Overall, the Aspen Hb meter emerges as a robust, cost-effective, and versatile diagnostic tool with the potential to strengthen anemia screening programs. Its deployment in maternal health initiatives and broader public health campaigns could significantly reduce the prevalence of anemia, contributing to improved health outcomes and reducing the burden of anemia-related morbidity and mortality.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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