Association between Socio-Demographic Factors and Global Left Ventricular Function in Children with Sickle Cell Anemia at Usmanu Danfodiyo University Teaching Hospital, Sokoto

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Abstract

Background: Sickle cell anaemia (SCA) causes progressive cardiac dysfunction, with socioeconomic factors potentially influencing disease progression. This study examined the relationship between sociodemographic variables and left ventricular function using myocardial performance index (MPI) in children with SCA from Sokoto, Nigeria - a high-burden, resource-limited region.

Methods: In this cross-sectional study at Usmanu Danfodiyo University Teaching Hospital, 340 SCA children (2-15 years) in steady state underwent echocardiographic MPI assessment. Sociodemographic data including age, gender, and socioeconomic status (SES) were collected. Statistical analyses included ANOVA and χ^2 tests to evaluate MPI variations across groups.

Results: The study revealed significant age-related MPI deterioration ($p<0.05$), with mean MPI increasing from 0.49±0.09 (≤5 years) to 0.51±0.14 (>10-15 years). A striking socioeconomic gradient emerged, with lower SES children showing highest MPI values (0.53±0.18 vs upper SES 0.48±0.11; $p<0.001$) and highest prevalence of abnormal MPI (65.5% vs 31.1%; $\chi^2=25.17$, $p<0.001$). No gender differences were observed ($p=0.08$).

Conclusion: This study demonstrates significant socioeconomic disparities in cardiac function among Nigerian children with SCA, independent of gender. The findings underscore the need for targeted cardiac monitoring in high-risk populations and socioeconomic interventions to mitigate cardiovascular complications in resource-limited settings.

Keywords: Sickle cell anaemia, myocardial performance index, socioeconomic status, cardiac dysfunction, paediatric cardiology, health disparities, Nigeria

Introduction

Sickle cell anemia (SCA) is a homozygous autosomal recessive disorder caused by a single nucleotide mutation in the *HBB* gene, resulting in the substitution of valine for glutamic acid at the sixth position of the β-globin chain of adult hemoglobin (HbA)[1]. This genetic alteration leads to the formation of hemoglobin S (HbS), which under deoxygenated conditions polymerizes, distorting erythrocytes into a characteristic sickle shape. Clinically significant sickle cell

syndromes include hemoglobin SS disease (SCA), hemoglobin SC disease, hemoglobin S-β°-thalassemia, and hemoglobin S-β+-thalassemia.

Globally, SCA affects an estimated 20–25 million individuals,[2,3] with a disproportionate burden in sub-Saharan Africa, where approximately 80% of affected infants die before the age of five[4]. Nigeria bears the highest prevalence, accounting for over 40% of SCA cases in the region[5]. Epidemiological studies report varying prevalence rates across Nigeria's geopolitical zones: North West (1.0%), North East (0.9%), North Central (0.9%), South West (2.4%), South East (1.1%), and South South (0.3%)[6]. Notably, a recent hospital-based study in Sokoto, Northwestern Nigeria, documented an alarming prevalence of 11%[7]. The State is noted as among those whose inhabitants have limited resources for purchasing health as most of its inhabitants are peasant farmers. A characteristic that often exacerbate disease burden and complicate management[8].

Cardiac dysfunction is a well-documented complication of SCA, with subclinical abnormalities often preceding overt symptoms. The Myocardial Performance Index (MPI), a Doppler-derived measure, provides a comprehensive assessment of global ventricular function by integrating systolic and diastolic performance while remaining independent of loading conditions and heart rate. Prior studies[9,10] have demonstrated significant correlations between left ventricular (LV) function parameters and sociodemographic variables, such as age, weight, height, and body surface area, in pediatric SCA populations. However, the influence of these factors on cardiac function remains understudied in high-burden, low-resource regions like Sokoto. This study aims to evaluate the relationship between sociodemographic factors and global left ventricular function, as assessed by MPI, in children with SCA at Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto.

Methodology

Study Location

This hospital-based cross-sectional study was conducted at the Sickle Cell Clinic of the Department of Paediatrics, Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto, Nigeria. Sokoto, the capital of Sokoto State, is situated at latitude 13.0533°N and longitude 5.3223°E[11]. The state is predominantly inhabited by the Hausa

and Fulani ethnic groups, with minority populations including the Yoruba, Igbo, Nupe, Idoma, and Tiv. According to the 2006 national census, Sokoto had a population of 3.7 million, with an annual growth rate of 3%, projecting to approximately 5.27 million by 2018[12]. The region's economy is primarily agrarian, dominated by subsistence farming, with a minority engaged in civil service[8]. Socioeconomic stratification places most residents in the lower social class, which may influence healthcare access and disease outcomes.

Study Population

The study population comprised children aged 2-15 years with confirmed sickle cell anemia (SCA) in a steady state, defined as the absence of vaso-occlusive crisis, recent blood transfusion, acute illness, or febrile episodes requiring hospitalization within the preceding three months[13,14].

Study Design

A descriptive cross-sectional design was employed to evaluate the relationship between sociodemographic factors and left ventricular function.

Sample Size Determination

The sample size was calculated using the formula for prevalence studies[15,16]

$$n=Z^2 \cdot p \cdot q/d^2$$

where:

- n = desired sample size (for populations >10,000),
- Z = standard normal deviate (1.96 at 95% confidence level),
- p = estimated proportion of SCA children with abnormal MPI (50% [0.5], due to absence of prior studies),
- q = 1−p,
- d = precision (5% margin of error).

The calculated sample size was 340 participants, rounded to account for potential attrition.

Sampling Technique

Participants were selected via simple random sampling using a random number table applied to the outpatient clinic register.

Eligibility Criteria

- Inclusion Criteria:
    - Confirmed SCA (HbSS) in steady state.
    - Parent/guardian-provided written informed consent.
    - Assent obtained from children aged ≥7 years.

- Exclusion Criteria:
    - Use of cardioactive medications (e.g., inotropes [digoxin, amiodarone], anthracyclines [doxorubicin]).
    - Acute illness or hemodynamic instability.

Data Collection

1. Sociodemographic and Clinical Assessment

A structured questionnaire captured biodata (age, sex), anthropometrics (weight [nearest 0.01 kg], height [nearest 0.01 cm]), socioeconomic status (SES): Classified using Oyedeji's method, incorporating parental occupation and education.

2. Echocardiographic Evaluation

Myocardial Performance Index (MPI) was obtained via apical five-chamber view using pulsed-wave Doppler. The Cursor on the scene was made to lie mid-way between the mitral valve and the aortic valve and the width was adjusted to 2mm. Pulse wave was applied to produce a waveform of the mitral inflow and the left ventricular outflow tract velocities, and MPI was measured as:

MPI= IVCT + IVRT/ ET

where:

- IVCT = isovolumetric contraction time,
- IVRT = isovolumetric relaxation time,
- ET = ejection time.

Ethical Considerations

Ethical approval was obtained from the UDUTH Ethics Committee. Written informed consent was secured from parents/guardians, with assent from children aged ≥7 years.

Statistical Analysis

Data were analyzed using SPSS v22.0 (IBM, 2016). Continuous variables, such as age and MPI, were summarized as mean ± standard deviation. Categorical variables, including sex and socioeconomic status (SES), were reported as proportions (%) and compared using Chi-square or Fisher's exact tests. Pearson's correlation test was used to assess the relationship between MPI and age. One-way ANOVA was employed to compare the mean MPI across different SES strata. Statistical significance was set at $p < 0.05$, two-tailed.

Results

A total of 340 children with sickle cell anemia (SCA) were recruited, comprising 170 males and 170 females, resulting in a male-to-female ratio of 1:1. Table 1 shows that majority of the SCA children, 165 (48.5%), belonged to the age category of 5-10 years, with a mean age of 8.6 ± 3.6 years. The difference in the age distribution among these children was not statistically significant. Most of the SCA children belonged to the middle socioeconomic status (SES) (39.4%), followed by the upper SES (35%), with 25.6% in the lower SES. Statistically significant difference was observed across the different SES groups.

A significant association was observed between left ventricular (LV) Myocardial Performance Index (MPI) and the age of SCA children, indicating that LV MPI increased with increasing age. The mean LV MPI was highest in the lower socioeconomic status (SES) group, followed by the middle SES and upper SES groups, and this difference was statistically significant across the different socioeconomic classes ($p<0.001$).

The distribution of myocardial performance index (MPI) abnormalities varied significantly across socioeconomic strata ($\chi^2 = 22.94$, $p < 0.001$). Children from the lower class exhibited the highest prevalence of abnormal MPI (65.5%), followed by the middle class (40.3%) and upper class

Table 1: Distribution of the SCA children by age, gender and socioeconomic status (N=340)

Variables	Frequency (%)	Test statistic (χ^2)	P-values
Age categories (years)			
≤ 5	62(18.3%)		
>5 -10	165(48.5%)	7.035	0.060
>10 -15	113(33.2%)		
Mean	8.62±3.4		
Gender			
Male	170(50%)	0.540	0.462
Female	170(50%)		
Socioeconomic Status (SES)			
Lower class	87(25.6%)		
Middle class	134(39.4%)	51.820	<0.001
Upper class	119(35%)		

SCA = sickle cell anaemia

Table 2: Relationship between left ventricular MPI and socio-demographic factors (N=340)

Variables	LV MPI (Mean±SD)	Test of significance
Age (years)	0.49±0.09	F=0.889,
≤5	0.50±0.14	p=0.40
>5-10	0.51±0.14	
>10-15		r=0.055,
2-15		p=0.341
Gender		
Male	0.52±0.03	t=1.73, p=0.08
Female	0.49±0.09	
SES		
Upper	0.48±0.11	F=2.92,
Middle	0.51±0.12	p<0.001
Lower	0.53±0.18	

(31.1%). Conversely, normal MPI was most prevalent among the upper class (68.9%) and declined progressively across lower socioeconomic groups (middle class: 59.7%; lower class: 34.5%). These findings suggest a graded inverse relationship between socioeconomic status and left ventricular dysfunction in children with sickle cell anemia.

Table 3: Distribution of Myocardial Performance Index (MPI) by Socioeconomic Status (SES) (N=340)

Socioeconomic Status (SES)	Normal MPI n (%)	Abnormal MPI n (%)	Test of Significance
Lower class	30 (34.5%)	57 (65.5%)	χ^2=25.17
Middle class	80 (59.7%)	54 (40.3%)	P<0.001
Upper class	82 (68.9%)	37 (31.1%)	
Total	192 (56.3%)	148 (43.7%)	

Discussion

This study demonstrates a progressive age-related deterioration in left ventricular (LV) function among children with sickle cell anaemia (SCA), as evidenced by increasing Myocardial Performance Index (MPI) values with advancing age. These findings align with prior reports documenting cumulative cardiac dysfunction in SCA due to chronic anaemia, volume overload, and sustained myocardial stress[10]. The gradual rise in MPI underscores the necessity for early and regular cardiac surveillance in this population to pre-empt irreversible cardiovascular sequelae.

A striking socioeconomic gradient in LV dysfunction was observed, with children from lower socioeconomic strata exhibiting significantly higher MPI values than their middle- and upper-class counterparts. This disparity likely reflects multifactorial determinants, including limited healthcare access, suboptimal disease-modifying therapies (e.g., hydroxyurea), and nutritional deficiencies prevalent in resource-constrained settings[9,17]. Chronic hypoxia, recurrent vaso-occlusive crises, and untreated infections, more common in disadvantaged groups, may exacerbate myocardial remodeling, compounding functional decline. Our results corroborate global evidence linking poverty to poorer cardiac outcomes in SCA,[9,17] emphasizing the urgent need for targeted interventions in high-risk populations.

Notably, no gender-based differences in MPI were detected, consistent with studies

suggesting that sex does not independently modulate LV function in paediatric SCA[18,19]. This uniformity implies that biological factors may be overshadowed by disease-specific pathophysiology and environmental determinants in driving cardiac impairment. The findings underscore several critical implications for clinical practice and public health policy. First, implementing routine echocardiographic monitoring, particularly for older children with SCA and those from lower socioeconomic backgrounds, could enable early detection of cardiac dysfunction and prompt intervention. Second, targeted socioeconomic interventions, including improved healthcare access, nutritional support programs, and caregiver education initiatives, may help reduce disparities in cardiac outcomes among this vulnerable population. Finally, integrating comprehensive cardiac assessments into standard SCA management protocols, especially in resource-limited settings, could optimize long-term cardiovascular health in paediatric patients.

Several limitations should be considered when interpreting these results. The single-centre study design may affect the generalizability of findings to broader SCA populations. Additionally, the cross-sectional nature of the data limits our ability to establish causal relationships; longitudinal studies would be valuable to track MPI progression over time. Unmeasured confounders, such as hydroxyurea utilization and transfusion history, may also influence cardiac function parameters but were not accounted for in this analysis.

Future research should prioritize prospective studies examining how social determinants of health, including healthcare accessibility, parental education levels, and community support systems, impact myocardial performance in children with SCA. Concurrently, intervention trials evaluating the efficacy of community-based programs (e.g., nutritional supplementation, caregiver education workshops, and decentralized cardiac screening) could provide actionable insights for improving outcomes in high-risk populations. Such investigations would strengthen the evidence base for developing targeted, multilevel management strategies.

Conclusion

This study demonstrates that socioeconomic status significantly impacts cardiac function in children with SCA, as evidenced by a graded inverse relationship between SES and MPI values, with disadvantaged children

showing markedly worse myocardial performance. The findings reveal both age-related progression of cardiac dysfunction and the predominant influence of environmental over biological factors, as no gender differences were observed. These results highlight critical public health implications, advocating for enhanced cardiac monitoring in disadvantaged populations, integrated socioeconomic-nutritional support programs, and policy interventions to address healthcare disparities in low-resource settings. While the study's cross-sectional, single-center design necessitates further multicenter longitudinal research, the findings strongly support incorporating socioeconomic factors into SCA cardiac risk assessment and management protocols, particularly in high-burden regions like sub-Saharan Africa, to mitigate progressive cardiac complications.

References

1. Gladwin M, Sachdev V. Cardiovascular Abnormalities in Sickle Cell Disease. J Am Coll Cardiol. 2012 59(13):1123-1133.
2. World Health Organization. Sickle Cell Anaemia Report by secretariat: WHO; 2006 [cited march 2018 24]. Fifty ninth World Health Assembly]. Available from: :http://apps.who.int/gb/who.
3. World Health Organization. Geneva2006 [cited march 2018 20]. Available from: http:www.who.int/genomics/public/maphaemoglobin.pdf.
4. Adekile AD, Adeodu OO. Haemoglobinopathies. In: Azubuke JC, Nkanginieme KE, editors. Paediatrics and Child Health in A Tropical Region. 2nd edition. ed. Owerri: African Educational Services; 2007.
5. World Health Organization. Sickle cell disease prevention and control [cited 2017 20th June]. Available from: http://www.afro.who.int/pt/sickle-cell-disease-prevention-and-control.html
6. World Health Organization. World Health Organization. Sickle-Cell Anaemia. In: Report by the Secretariat, editor. 2018 March 15.
7. Jiya NM, Umar A, Ibrahim KK, Mohammed K, Erhabor O, Ndakosu MA, et al. Sickle Cell Anaemia : A Prevalence Study among the Children Attending Usmanu Danfodiyo University Teaching Hospital,Sokoto,North-Western Nigeria. Asian J Med Health. 2017;2:1-8.
8. National Bureau of Statistics. Sokoto state information. 2014.
9. Animasahun BA, Njokanma OF, Nwodo UP, Omokhodion SI. Relationship of age, anthropometry and haemoglobin concentration with echocardiographic findings in Nigerian children with sickle cell anaemia. NigerJPaediatr. 2013;40(1):24-25.
10. Chinawa JM, Chinawa AT, Ossai EN, Chukwu BF, Ndu IK, Asinobi IN. Left ventricular function and cardiac valvar annular dimensions among children with sickle cell anemia compared to those with hemoglobin AA type in Enugu, Nigeria. Malawi MedJ. 2021;33(2):41-44.
11. Nigeria Business Directory. Sokoto State Nigeria, 2017 [cited 2018 24 july]. Available from: http://www.sokotostate.gov.ng.
12. National Population Commission. National Census. Federal Republic of Nigeria Official Gazette. 2007;24:196.
13. Awogu AU. Leucocyte counts in children with sickle cell anaemia.Usefulness of steady state value during infections. West Afr J Med. 2000;19:55-58.
14. Bookchin RM, Lew VL. Pathophysiology of sickle cell anaemia. Hematol Oncol Clin North Am. 1996;10:1241-1253.
15. Jaykaran C, Tamoghna B. How To Calculate Sample Size For Different Study Designs In Medical Research. Indian J Psychol Med. 2013;35(2):121-126.
16. Araoye M.O. Research methodology with statistics for health and social sciences. ilorin,nigeria: university of ilorin; 2003. 115-121 p.
17. Animasahun BA, Omokhodion SI, Okoromah CA, Njokanma OF, Ekure EN. Echocardiographic findings among children with sickle cell anaemia at the Lagos University Teaching Hospital. Niger Postgrad Med J. 2010;17(2):107-112.
18. Eidem BW, Tei C, Leary PW, Cetta F, Seward D. Nongeometric quantitative assessment of right and left ventricular function: myocardial performance index in normal children and patients with Ebstein anomaly. JBJ Am Soc Echocardiogr. 1998;11:849-855.
19. Tei C, Nishimura RA, Seward JB, Tajik AJ. Non-invasive Doppler derived myocardial performance index: correlation with simultaneous measurements of cardiac catheterization measurements. J Am Soc Echocardiogr. 1997;10:169-178.

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