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Variables on the Proportion of Children with Sickle Cell Hemoglobin

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Abstract

Variables on the Proportion of Children with Sickle Cell Hemoglobin in Nigeria

by

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MSc, University of Pretoria, 2018

MBChB, Olabisi Onabanjo University, 1995

Dissertation Submitted in Partial Fulfillment

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Abstract

The case fatality rate among children living with sickle cell disease was approximately 50% to 90% in Sub-Saharan Africa. Though researchers have contributed social determinants of health more broadly, they have not provided adequate screening information on children living with sickle cell disease aged 6 months to 59 months. The purpose of this cross-sectional study was to examine the association between sickle cell disease status, infection prevention, pain and anemia management, demography, socioeconomic status, and healthcare use. This study included approximately 11,536 genotype results of children under 5-years-old in Nigeria. Bronfenbrenner's systems theory and Krieger's ecological theory formed the theoretical frameworks in this study. The 2018 Nigeria Demographic and Health Survey data were analyzed using binary logistic regression. Statistically significant positive associations were found between sickle cell disease status and variables such as a child's age ($p = .022$); children's hemoglobin ($p = .034$); mother's uptake of children's genotype testing ($p < .001$); living in Northcentral Nigeria ($p = .047$); Southeast Nigeria ($p = .008$); or South Nigeria ($p = .011$); and having Yoruba ethnicity ($p = .036$). These findings enable evidence-based approaches in the clinical management of sickle cell disorders in Nigeria. For example, the Federal Ministry of Health may prioritize early screening of sickle cell hemoglobin in all six geopolitical zones of Nigeria with heightend focus in the areas that were found to be statistically significant. The positive social implication includes improved community knowledge on prevention and control of childhood sickle cell disease. Future research is needed in the field of vaccine hesitancy and childhood sickle cell disorders in Nigeria.

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Dedication

I will dedicate this Ph.D. dissertation to my immediate and extended family.

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Chapter 1: Introduction to the Study

Childhood sickle cell disorders or sickle cell hemoglobin are associated with high death rates in developing countries. Disorders related to the presence of sickle cell hemoglobin are the most common inherited disorders in Sub-Saharan Africa (Islam et al., 2021). Westnedge et al. (2018) and Karna et al. (2021) classified sickle cell hemoglobin into various groups such as sickle cell trait (AS), sickle cell anemia (SS), hemoglobin SC disease (SC), and hemoglobin C trait (AC). Normal hemoglobin (AA) is due to inheritance of hemoglobin that does not possess SS, AS, SC or AC (Manafa et al., 2018; Tetteh et al., 2021). Researchers have alluded to various clinical manifestations of sickle cell disorders such as anemia, vaso-occlussive pain, infections, dactylitis, and growth failure (Du et al., 2020; Paintsil et al., 2022; Ramsay et al., 2021; Sagi et al., 2020; Victoria et al., 2020). Children living with sickle cell disease could present with life-threatening medical complications, leading to reduced health outcomes in the society.

Universal healthcare is a nonnegotiable issue in the developing countries, raising an argument to embrace the recommended public health prevention strategies. Social determinants of health are the prevailing situations in our lives due to where we are born, live, learn, work, and age (Booysen et al., 2021; Ford et al., 2021). Researchers suggested various health determinants in childhood sickle cell disorders such as poor healthcare access, inequity, low socioeconomic status, stigma, and low education (Nnodu et al., 2021; see also Caldwell, 2020; Famuyiwa, 2020; Lee et al., 2019; Omotoso & Koch, 2018; Takeuchi et al., 2021). Equally, Brandow and DeBaum (2018) found that childhood sickle cell disorders were susceptible to the adverse effects of an austere

environment, leading to reduced survival in the society. Therefore, social determinants of health could influence health and well being in childhood sickle cell disorders.

This study utilized a quantitative cross-sectional design to examine the association between healthcare use, health literacy, socioeconomic status, demography, medical complications, infection prevention, and the presence of sickle cell hemoglobin. In addition, the measures of healthcare used in this study include selected variables such as antenatal care use, mother's use of genotype testing, mother's place of delivery, mother's reading of newspapers, and mother's age. The 2018 Nigeria Demographic and Health Survey (Nigeria DHS) data were obtained from the United States and National Population Commission (NPC).

From the above, this study's selected variables were from the 2018 Nigeria DHS dataset. This study could allow health policy formulation in developing countries, leading to improved health outcomes and well being. Again, this study examined the association between healthcare use, health literacy, infection prevention, pain and anemia management, demography, socioeconomic status, and the presence of sickle cell hemoglobin. Overall, the interaction between presence of hemoglobin and selected variables were provided in this study (See Table 1).

Table 1

Variables Derived From the 2018 Nigeria Demographic and Health Survey

Factors to be considered in this study	Selected variables determining each factor (using the 2018 Nigeria Demographic and Health survey dataset)
Infection prevention	Childhood vaccination, household use of mosquitoes' net, children's African diet supplement, children's treatment of diarrhea, and children's weight-for-height.
Pain and anemia management	Children's transfusion status, mother's treatment of fever, children's antibiotic prophylaxis, children's hemoglobin, children's rehydration status, and a child's age.
Healthcare use and health literacy	Use of antenatal care, mother's reading of newspapers, mother's uptake of children genotype testing, mother's use of health insurance, mother's place of delivery, and mother's age.
Demography	Residence, ethnicity, Nigeria geopolitical zone, child's gender, religion, and child's age.
Socioeconomic status	Mother's educational level, mother's employment status, household presence of water, household wealth index, and household toilet facility location.
Proportion of children with sickle cell hemoglobin in Nigeria	Presence of sickle cell hemoglobin in children under 5-years-old.

Furthermore, Westnedge et al.'s study (2018) indicated the need for more research in the field of childhood sickle cell disorders. Lee et al. (2019) suggested the need for health policy formulation in sickle cell disorders, leading to improved health status in the society. Tambor et al. (2021) argued that multistakeholders' approaches were needed for policy formulation in sickle cell disorders. In Sub-Saharan Africa, there was a lack of information on the relationship between sickle cell hemoglobin, health equity, infections, nutrition, healthcare access, and geography (Alradie-Mohamed et al., 2020; Eleonare et al., 2020; Inusa et al., 2019; Islam, 2021; Kanter, 2021; Nnodu et al., 2021;

Rocha et al., 2021). In short, with this study, I hoped to cover the existing gaps in the literature and enhance improved health equity in every child.

In Chapter 1, this study addresses items such as the background, problem statement, purpose of the study, theoretical and conceptual framework, nature of the study, definitions, scope and delimitations, assumptions, limitations, and significance. In brief, this study explores the relationship between infection prevention, pain and anemia management, healthcare use, demography, socioeconomic status, and the presence of sickle cell hemoglobin.

Background

Globally, approximately 5.3 million deaths were documented in children under 5-years-old in 2018 (United Nations Children's Fund [UNICEF], 2019a). The prevalence of sickle cell hemoglobin in Nigeria was 2% in 2018 (NPC, 2019). Based on the above statistics, the high mortality rate in children under 5-years-old could result from the medical complications of sickle cell hemoglobin. Researchers found that hemoglobin mutation in the beta globin chain was associated with abnormal hemoglobin production in sickle cell disorders (Arishi et al., 2021; Bhatt, 2021; Karna et al., 2021; Renoux et al., 2018). Similarly, Ochocinski et al. (2020), Galadanci et al. (2019), and Niss et al. (2020) alluded to acute and chronic medical complications childhood sickle cell disorders such as vaso-occlusive pain, anemia, infection, and cognitive impairment. Childhood sickle cell disorders were susceptible to life-threatening infections, leading to reduced life expectancy (Belay et al., 2021; Eleonare et al., 2020; Kambale-Kombi et al., 2021; Ochocinski et al., 2020; Ramsay et al., 2021; Tan et al., 2020). Therefore, children living

with sickle cell disorders could be susceptible to medical complications compromising their quality of life in adulthood.

As previously mentioned, researchers have described sickle cell disorders as indicating presence of abnormal sickle cell hemoglobin such as SS, AS, AC, and SC (Ashorobi et al., 2021; Esoh et al., 2021; Inusa et al., 2019; NPC, 2019, Saramba et al., 2020; Sundd et al., 2019). Du et al. (2019) and Sagi et al. (2020) focused on the medical complications of sickle cell disorders such as vaso-occlusive pain and community-acquired infections. Tossea et al. (2018) found that the mutation of beta globin chain was the cause of abnormal hemoglobin SS or SC. Inusa et al. (2019) and Sundd et al. (2019) underscored the pathophysiological changes in sickle cell disorders such as decreased nitric oxide, hemoglobin polymerization, Gardos channel dehydration, and endothelial dysfunction. These pathophysiologic changes resulted in the clinical symptoms of childhood sickle cell disorders.

Adherence to public health prevention strategies could lead to improved survival in the society. Researchers have focused on the various infection prevention measures such as childhood vaccination, antibiotic prophylaxis, nutrition, fever management, and anemia treatment (Abdullahi et al., 2021; Burroway & Hargrove, 2018; Efunshile et al., 2018; Kapoor et al., 2018; Nowakowski et al., 2021; Opoka et al., 2019; Prout et al., 2018; Tsitsikas et al., 2021; Wise et al., 2021). According to Eleonare et al. (2021) and Heng et al. (2021), malaria infection was a cause of low birth weight and malnutrition in children under 5-years-old, leading to the need for government policy formulation.

Improved survival in childhood sickle cell disorders could be ensured by adherence to public health prevention strategies and health policies implementation by government.

Researchers have focused on infection prevention as a modality to reduce morbidity and mortality in the community (Apanga & Kumbeni, 2020; Bertozzi-Villa et al., 2021; Green et al., 2021; Muhammad et al., 2021; Prout et al., 2018). Awosolu et al. (2021) found that insecticide-treated mosquitoes' net was a significant infection prevention strategy in malarial infection. According to Ugboko et al. (2021), childhood diarrhea was a cause of increased morbidity and mortality in Nigeria, leading to the need for health policy formulation. Government interventions are needed to reduce the burden of infections in children under 5-years old. Thus, this study examined neglected tropical disease in the setting of childhood sickle cell hemoglobin.

Health education in the community could influence health-related behavior in the community. Parent's health literacy level could impact decision-making behavior on health issues (Kanter et al., 2020; 2021; Power-Hays et al., 2020). In addition, authors have suggested various determinants of healthcare use in the community such as geographical location, education attainment, socioeconomic status, disability, and health literacy (Brandow & DeBaun, 2018; Dormandy et al., 2018; Islam et al., 2021; Marks et al., 2018; Oron et al., 2019; Prout et al., 2018). Abreha et al. (2021) and Alabi and Ramsden (2021) found that women's health-related behavior was a significant factor in healthcare facilities utilization and innovation uptake. Taken together, healthcare use in the community could be determined by various factors such as health literacy, socioeconomic status, and gender equality.

A child's development could be affected by prevailing disparity and health inequalities in the society. Researchers found that adverse experiences in childhood sickle resulted from the deleterious effects of social determinants of health (Agorastus et al., 2018; Adegoke et al., 2018; Akinyemi et al., 2021; Bartlett et al., 2020; Booysen et al., 2018; Caldwell, 2020; Koce et al., 2021; Kruk et al., 2018). Adeyinka et al. (2020) and Rashid et al. (2021) addressed the need for health equity in every child, leading to improved health outcomes. To summarize, absence of health inequality and disparity could allow improved healthcare access in children living with sickle cell hemoglobin.

Screening for social determinants of health could allow improved health outcomes in children. In addition, researchers suggested the need for screening for social determinants to allow improved control and prevention of sickle cell disorders (Nnodu et al., 2019; 2021; Raphael, 2020; Shook & Ware, 2018). Oldfield et al. (2020), Ngandu et al. (2019), and Adeyinka et al. (2020) showed the importance of screening for social determinants of health in the community, leading to improved health outcomes and life expectancy. According to Olatunya et al. (2021) and Oron et al. (2020), inaccessible healthcare in Sub-Saharan Africa has led to poor genotype screening uptake. Screening for social determinants of health must be incorporated into health practitioners' treatment of sickle cell disorders.

Community screening for sickle cell hemoglobin could ensure improved health outcomes in the society. According to Ezenwosu et al. (2021), community-based education was a significant factor in the uptake of early genotype screening. Similarly, researchers found that genotype screening was an effective strategy of achieving

improved surveillance for sickle cell hemoglobin (McClintock et al., 2020; see also Kuyinu et al., 2020; Mor-Anavy et al., 2021; Segbefia et al., 2021). As mentioned, screening for childhood sickle cell hemoglobin limit mortality and morbidity.

Policy formulation on sickle cell hemoglobin is defective due to inaccurate national data in Nigeria (Nnodu et al., 2021). Also, health policies monitoring need to embody various procedures, such as assessing stakeholders' input and implementing cost analysis by Debie et al. (2022). Researchers have suggested the various reasons for failure of health policy including lack of decentralization, financial constraints, and logistic problems. Thus, policy implementation in developing countries must entail various characteristics such as sustainability, equitable participation, monitoring, and evaluation (Crane et al., 2022; Walugembe et al., 2019).

The manifestations of sickle cell disorders could vary based on geography. Researchers suggested that the clinical presentation of sickle cell hemoglobin were affected by various factors such as geography, ethnicity, race, and residence (Faremi et al., 2021; Hahn et al., 2018; Isa et al., 2020; 2021; Kuersten et al., 2020; Nnodu et al., 2019). Geographical variation in the allocation of scarce resources led to reduced survival of children living with sickle cell hemoglobin (Hahn, 2021; Nnodu et al., 2019). Gebregziabher et al. (2018), Serjeant and Vinchisky, 2018, Gage et al. (2021), and Loo et al. (2021) focused on interaction between the environment factors (such as demography) and a child's health outcomes. Similarly, disparity and health inequalities in sickle cell disorders affected severity of medical complications by Cortright et al. (2020) and Hardy et al. (2021). Hence, childhood sickle cell disorders could present with variation in

medical complications due to geographical locations. Assessing the social determinants of health related to sickle cell disorder outcomes could lead to a better understanding of variation in childhood adverse experiences in the society.

According to Shelton and Lee (2019), little research has focused on evidence-based policy implementation within the health system. Also, researchers suggested the need for more information on the association between sickle cell disorders, healthcare use, health insurance use, infection prevention, nutrition supplement, malnutrition, socioeconomic status, and geography (Donald et al., 2019; Eleonare et al., 2020; Lu et al., 2021; Ochocinski et al., 2020; Takeuchi et al., 2019). Evidence-based management in sickle cell hemoglobin must be embraced by professionals in Sub-Saharan Africa (Ajisegiri et al., 2021; Byrnes et al., 2022; NPC, 2019). As mentioned, future research must consider the field of childhood sickle cell disorders.

This study presents evidence for health policy formulation and a sustainable health system. This study can allow evidence-based guidelines to be promulgated in such as neglected tropical infections (such as childhood diarrhea), malaria infection, geographic variation, and healthcare access. Reduction in mortality and morbidity could be initiated through screening for social risk factors in childhood sickle cell disorders. Briefly, my study's findings are aimed to achieve improved clinical management of sickle cell disorders.

Women's decision making in the community could be a determinant of well being and health outcomes. Women's civil rights were affected by the culture or religion in the society by Abreha et al. (2021) and Alabi and Ramsden (2021). In a similar manner,

community campaign on the reduction of stigma (e.g., internalized, perceived, and negative stereotypes) led to improved health outcomes in childhood sickle cell disorders (Blake et al., 2018; Bulgin et al., 2018; Buser et al., 2018; Leger et al., 2018). Researchers have suggested it is important to view civil rights as a social determinant of health in the vulnerable or marginalized groups in the society (Hahn et al., 2018; Taylor, 2020). Based on the above, parent's health-related behavior could be affected by culture, law, and religion in the society.

At the community level, clinical manifestations of childhood sickle cell disorders were also provided in this study. This study suggests using findings on the various subjects assessed, such as socioeconomic status, infection prevention, medical complications, healthcare use, and demography. Overall, children living with sickle cell disorders in Nigeria could benefit from health policy targeting social determinants of health and medical complications.

Problem Statement

Children living with sickle cell hemoglobin are susceptible to increased mortality and morbidity due to social risk factors and medical complications (Alradie-Mohamed et al., 2020; Cortright et al., 2020; Ojelabi et al., 2019; Pittet & Posfay-Barber, 2021). At community level, societal health inequalities predisposed to low healthcare access, stigma, structural violence, and infections (Leger et al., 2018; Nnodu et al., 2019). Similarly, Saramba et al. (2020) and Buser et al. (2021) argued that care giver's decision making may determine the health status in sickle cell hemoglobin. Therefore, a child's well being and survival may be threatened by degrading effects of health determinants.

As mentioned above, social risk factors have been linked to mortality and morbidity rate in sickle cell disorders (Braveman et al., 2021; Ibemere et al., 2021; Lee et al., 2019; Smith & Brownell, 2018; Williams et al., 2018). Equally, Salih et al. (2019) focused on the acute and chronic medical complications in pediatric sickle cell disease such as cognitive impairment, emotional disturbance, and family's dysfunction. As such, childhood sickle cell disorders could lead to negative psychological consequences in the society. A child's experience may be shaped by the environment and medical complications.

Minority groups could present with recurrent exacerbations of medical complications and deterioration of health outcomes (Victoria et al., 2020). Blake et al. (2019) reported that sickle cell disorders could predispose to various complications such as isolation, stigma, loneliness, loss of independence, and social isolation. Similarly, Hood et al. (2022) focused on the interaction between sickle cell disorders, stigma, and healthcare access. Researchers found that stigma was responsible for inaccessible healthcare children living with sickle cell disorders (Bulgin et al., 2018). Briefly, structural violence could predispose to reduced health and well being in childhood sickle cell disorders.

Social determinants may influence health-related behavior and well being in children living with sickle cell disorders. Ibemere et al. (2021) and Middleton et al. (2018) found that culture was a significant predictor of health-related behavior in the community. Also, Babalola et al. (2021) suggested that health literacy was a significant

factor in innovation uptake (e.g., genotype screening). Mother's health-related behavior could alter the prognosis in childhood sickle cell disorders.

In Nigeria, unreliable national data was associated with reduced evidence-based policy formulation in childhood sickle cell disorders (Ezenwosu et al., 2021; Islam et al., 2021; Nnodu et al., 2021). Researchers suggested a mixture of power centralization and devolution to achieve timely policy implementation (Abimbola et al., 2020; Masuku & Macheka, 2020; Murphy & Moosa, 2021). Equally, policy implementation that embodied decentralization or power devolution led to health equity in the society (Abubakar et al., 2022). Royal et al. (2020), Elsey et al. (2019), and Agyemang-Duah (2018) suggested that decentralization of power could enhance a functioning health system and equities in the society. Based on the above studies, health policy must target health equity in childhood sickle cell disorders. Delegation of power from national government to a subnational level could improve policy making in childhood sickle cell disorders.

First, researchers have alluded to the need for more research using a national dataset in childhood sickle cell disorders (NPC, 2019). Second, Ibemere et al. (2021) suggested the need for more research on health-seeking behavior in sickle cell disorders. Third, researchers found that more research was needed on the relationship between childhood sickle cell disorders, healthcare access, infections, malnutrition, gender inequality, disparity, and health equity (Abreha et al. 2020; Alradie-Mohamed, 2020; Cortright, 2020; Eleonare et al., 2020; Van tonder et al., 2019). Fourth, authors found that more research was needed on the interaction between pediatric sickle cell disorders, geography, race, ethnicity, religion, equity, and cultural norms (Australian Institute of

Health and Welfare, 2021; Deshpande et al., 2020; Inusa et al., 2020; Serjeant & Vinchisky, 2018; Sun et al., 2020). Finally, the information on the advantages of healthcare use (e.g., antenatal visit and delivery place) was contentious in the literature (Ezenwosu et al., 2021; Gage et al., 2021; Nimako et al., 2021; Roder-DeWan et al., 2020).

Purpose of the Study

The purpose of this quantitative cross-sectional study was to examine the relationship between presence of sickle cell hemoglobin and selected independent variables. This study examined the influence of social determinants of health on health and well being. Similarly, this secondary dataset analysis used the 2018 Nigeria DHS dataset to examine the relationship between the independent variables and the outcome. The dependent variable (i.e., outcome) was sickle cell disease status. The independent factors included various factors such as infection prevention, demography, anemia and pain management, socioeconomic status, and healthcare access.

First, socioeconomic status was represented by the selected variables such as household wealth index, mother's employment status, household toilet facility location, mother’s education level, and household presence of water. Second, demography was represented by the selected variables such as residence, ethnicity, Nigeria’s geopolitical zones, male child, female child, religion, and a child’s age. Third, infection prevention was represented by selected variables such as childhood vaccination, household use of mosquitoes’ net, children’s African protein diet supplement, children’s diarrhea treatment, children’s weight-for-height, and a child’s breastfeeding status. Fourth, pain

and anemia management were represented by selected variables such as children's blood transfusion status, mother's treatment of fever, children's rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, and child's age. Fifth, healthcare use was represented by selected variables such as antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children genotype testing, mother's place of delivery, and a mother's age. Sixth, the covariates considered in this study were the mother's age, a child's age, the children's weight-for-height, and the mother's education level.

Research Questions and Hypotheses

Research Question 1: Is there any association between socioeconomic status (as determined by household wealth index, household toilet facility location, household presence of water, mother's employment status, mother's education level), and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$1: There is no association between socioeconomic status (as determined by household wealth index, household toilet facility location, household presence of water, mother's employment status, mother's education level), and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a1: There is an association between socioeconomic status (as determined by household wealth index, household toilet facility location, household presence of water, mother's employment status, mother's education level), and the proportion of children with sickle cell hemoglobin in Nigeria.

Research Question 2: Is there an association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$2: There is no association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a2: There is an association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria.

Research Question 3: Is there an association between infection prevention (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$3: There is no association between infection treatment (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a3: There is an association between infection treatment (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-

height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria.

Research Question 4: Is there an association between pain and anemia management (as determined by children's blood transfusion status, mother's treatment of fever, children's rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$4: There is no association between pain and anemia management (as determined by children's blood transfusion status, mother's treatment of fever, children's fluid rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a4: There is an association between pain anemia management (as determined by children's blood transfusion status, mother's treatment fever, children's fluid rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

Research Question 5: Is there an association between healthcare use (as determined by antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria?

H_05: There is no association between healthcare use (as determined by antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

Ha5: There is an association between healthcare use (as determined by mother's antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

The Study Theoretical Foundation

Socioecological Theory of Bronfenbrenner

Bronfenbrenner's socioecological theory allows the alignment of each element in this study. Urie Bronfenbrenner first conceptualized the socioecological theoretical framework (Erickson et al., 2018; Haleemunnissa et al., 2021). Since, researchers have used Bronfenbrenner's theory to examine the interaction between health outcomes, infection prevention, biology, and psychosocial aspects (Chigangaidze et al., 2020). Walker et al.'s (2019) study focused on the use of Bronfenbrenner's conceptual framework to explain the relationship between various factors such as institutional violence, culture, power, health outcomes, socioeconomic status, and education attainment. As mentioned, Bronfenbrenner's socioecological theory considers the interplay between various factors such as individual, social, legal, cultural, health

outcomes, and politics. Therefore, Bronfenbrenner's bioecological theory could allow the examination of the interaction between social determinants of health and health outcomes.

A child's growth could be affected by social determinants of health and historical events. Bronfenbrenner's ecological systems theory allowed the examination of the interconnection between chrono-, micro-, macro-, meso-, and exosystems (Axelsson et al., 2020; Haleemunnissa et al., 2021; Sinvani et al., 2021). Similarly, researchers provided Bronfenbrenner's theory to examine the interaction between time (i.e., history), human existence (i.e., a child's development), and immediate environment (Guy-Evans, 2020). At the macrosystem level, childhood adverse health outcomes were associated with culture and beliefs in the society (Halsall et al., 2018). The chronosystem takes into cognizant the effect of time (i.e., history) on a child's development (Erickson et al., 2018). Above all, Bronfenbrenner's ecological systems theory could be used to examine the impact of social risk factors on a child's health outcome.

At the exosystem level, a child's health status can be indirectly affected by events linked to their parents' environment (Guy-Evans, 2020). According to Gunnarsdottir et al. (2021), the mesosystem reveals the relationship between two or more microsystems. Bronfenbrenner's systems consider the relationship between parents' actions, culture, time (i.e., history and temporal), and the environment. Also, the microsystem is comprised of the child's environment such as home, family, neighborhood, workplaces, schools, and hospital (Fitzsimons & Clark, 2021). Using Bronfenbrenner's ecological systems theory, researchers have determined the interplay between age, gender,

socioeconomic status, peers' group, health status, and traits (Alghzawi & Ghanem, 2021; Bailey & Im-Bolter, 2018; John et al., 2020; Michaelson et al., 2021; Trude et al., 2020). Thus, a child's adversity in an early stage in life could influence their health status in adulthood.

Ecosocial Theory of Disease Distribution

In 1994, Nancy Krieger first described the ecological theory of disease distribution (Krieger, 2020, 2021). Also, Vineis et al. (2020) found that health inequalities and disparity were associated with poor survival early stage in life. Using Krieger's ecosocial theory of disease distribution, a child's early development was divided into proximal and distal pathways (McLinden et al., 2018). Again, Krieger's ecological model was used to evaluate the social determinants of health (up-, mid-, and down-stream) and health outcomes (Mkhize et al., 2019; National Academies of Sciences, Engineering, and Medicine, 2021; Taylor et al., 2019). Similarly, researchers argued on the interplay between health outcomes, sickle cell disorders, biology, environment, and behaviors (Bills et al., 2020). Equally, Serjeant and Vinchinsky (2018) focused on the impact of environment factors (e.g., climate, race, infection, education, gene, psychological state, and social support) on childhood sickle cell disorders. In sum, Krieger's ecological theory is a rigorous approach to explain the association between up-, mid-, and down-stream social determinants of health in this study.

A child's health may be shaped by the experiences in the community (e.g., history, age, and family). The prognosis of childhood genetic diseases is affected by environment, policy, and structural violence (Berhe et al., 2019; Centers for Disease

Control and Prevention [CDC], 2018a; Farooq et al., 2020; Gebreyesus et al., 2019; Office of Disease Prevention and Health Promotion [ODPHP], n.d.). Researchers suggested Krieger's ecological model to understand the association between social justice, disease risk, treatment population, and survival (Krieger, 2019). According to Conway et al. (2021), Pearce et al. (2019) and Feletto and Sharkey (2019), a child's predisposition to the effects of inequalities was influenced by various factors such as life course analysis, socioeconomic analysis, and ecological systems. As such, the ecological theory of disease distribution could enable robust examination of variables contributing to adverse health outcomes in the community. Overall, the Krieger's ecological theoretical framework served as a well-grounded approach to show the relationship between the selected variables in this study.

Using Krieger's ecological theory, this study examined the relationship between social determinants of health (up-, mid-, and down-stream), health outcomes, and childhood sickle cell disorders. Bolte et al. (2021), Perry et al. (2021), and McCuster et al. (2019) described the interaction between health outcomes, genes, environment, phenotypic presentation, and sickle cell disease. Similarly, the ecosocial theory of disease distribution hinges on the interaction between the environment, healthcare, neighborhood, infection prevention treatment, and traits (Ismainar et al., 2020). As mentioned, my study determined the relationship between the selected variables using an embodiment pathway.

Nature of the Study

This study used a cross-sectional quantitative study to examine the relationship between a demography, infection prevention, pain and anemia management, healthcare use, socioeconomic status, and the presence of sickle cell hemoglobin. Also, the 2018 Nigeria DHS data were used to demonstrate the relationship between dependent and independent variables. The dataset population contained information on the sickle cell hemoglobin genotypes. The dependent variable was recoded into a binary variable (i.e., 1 = *presence of sickle cell hemoglobin* and 0 = *absence of sickle cell hemoglobin*). The objective of this study was to determine the interaction between healthcare use, socioeconomic status, demography, pain and anemia management, infection prevention, and sickle cell hemoglobin.

First, Research Question 1 was answered using selected variables such as household presence of water, mother's education level, mother's employment status, household wealth index, household presence of water, and household toilet facility location. Second, Research Question 2 was answered with selected variables such as Nigeria geopolitical zone, a child's age and gender, religion, residence, and ethnicity. Third, Research Question 3 was answered with selected variables such as childhood vaccination, household use of mosquitoes' net, African protein diet supplement, children's treatment of diarrhea, children's weight-for-height, and a child's breastfeeding status. Fourth, Research Question 4 was answered using selected variables such as antenatal care, mother's place of delivery, mother's uptake of children genotype testing, mother's use of health insurance, mother's reading of the newspaper, and mother's age.

Last, Research Question 5 was answered using selected variables such as children's blood transfusion status, mother's treatment of fever, children's rehydration status, children's hemoglobin, and child's age.

This study addressed items such as research design, population, research setting, sampling procedures, sample size and power calculation, instruments, and operationalization of constructs. For instance, this study provided information on the 2018 Nigeria DHS dataset cleaning and manipulation. This secondary study included information on various items such as the data dictionary, data analysis, data table, missing data handling, threats to validity, and ethical considerations. Thus, the binomial logistic regression analysis was used to determine the association between the independent and dependent variables.

The data analysis ensured power (80%), Type II error (20%), and *p*- value less than .05 using Statistical Package for the Social Sciences version 27 (SPSS). The binomial logistic regression analysis considered statistical information such as *OR*, effect sizes, *B* coefficients, the *Nagelkerke* R^2, the *Cox and Snell's* R^2, null hypothesis, and 95% CI. Finally, the statistical analysis determined the association between the selected explanatory variables and the presence of sickle cell hemoglobin.

Definitions

Sickle cell hemoglobin: Is defined as the mutation arising from the beta globin gene, leading to the production of an abnormal sickle cell hemoglobin (Arishi et al., 2021).

Variable: A quantity representing a set of values in research (Merriam-Webster, n.d.).

Sickle cell disorders: Indicates the presence or availability of sickle cell hemoglobin such as SS, SC, AS, AC, and others. On the other hand, AA denotes the absence of sickle cell hemoglobin in this study. Also, the terms sickle cell hemoglobin and sickle cell disorders were interchanged in this study (Ashorobi et al., 2021; Esoh et al., 2021; Inusa et al., 2019; Karna et al., 2021; NPC, 2019, Saramba et al., 2020; Sundd et al., 2019).

African children's protein diet supplementation: Diet supplement such as edible insect, snails, winged termite, cricket, periwinkle, and palm weevil larva. This variable indicates the mother's health-related behavior (NPC, 2021).

Health equity: Is a term that determines the absence of disparity and health inequities in the community (Ochiai et al., 2021).

The Nigeria geopolitical zones: There are six geopolitical zones in Nigeria (NPC, 2019).

Presence of sickle cell hemoglobin: The proportion of hemoglobin SS, SC, AC, and AS in children aged 6-59 months (NPC, 2019).

Hemoglobin AA: Is the regular or normal hemoglobin (i.e., not associated with sickle cell disorders; NPC, 2019).

The increased proportion sickle cell hemoglobin: This indicates a positive step in the control and prevention of sickle cell disorders in the community. Also, it refers to the presence of sickle cell hemoglobin in this study.

Sickle Cell Crises: Acute and chronic medical complications in childhood sickle cell hemoglobin such as vaso-occlusive bone pain, hemolytic anemia, organ dysfunction, sequestration crises, renal failure, and abdominal pain (Gaartman et al., 2021; Pace et al., 2021; Sundd et al., 2019).

Sickle cell trait: Indicates the inheritance of one mutated allele from the parent, leading to hemoglobin AS (Arishi et al., 2021; Esoh et al., 2021: NPC, 2019).

Hemoglobin SC: Indicates the inheritance of two mutated alleles from both parents, leading to hemoglobin SC (Ashorobi et al., 2021; Esoh et al., 2021; Inusa et al., 2019; Karna et al., 2021; NPC, 2019; Saramba et al., 2020; Sundd et al., 2019).

Hemoglobin SS: Indicates the presence of two homozygous sickle cell hemoglobin (Ashorobi et al., 2021; Esoh et al., 2021; Inusa et al., 2019; Karna et al., 2021; NPC, 2019; Saramba et al., 2020; Sundd et al., 2019).

Hemoglobin AC: Indicates the inheritance of two mutated alleles from both parents, leading to hemoglobin AC (Ashorobi et al., 2021; Esoh et al., 2021; Inusa et al., 2019; Karna et al., 2021; NPC, 2019; Saramba et al., 2020; Sundd et al., 2019).

Assumptions

This study considered the following assumptions during statistical analysis: (a) representative sample size and (b) absence of selection bias, and (c) absence of recall bias. The data were obtained from a reputable organization the United States. This study considered handling of missing information during statistical analysis that allowed improved internal and external validity. Also, the representative sample allowed improved external validity of the findings. The data were sufficient to answer Research

Questions 1 through 5. Trinah (2018) and Wickham (2019) alluded to the inability of a secondary dataset to meet all the requirements in research. In short, this study used a rigorous statistical approach to determine the strength of the association between the independent and outcome variables.

Scope and Delimitations

This study examined the impact of explanatory variables (i.e., demography, healthcare use, health literacy, pain and anemia treatment, infection prevention, and socioeconomic status) on the outcome (i.e., sickle cell disease status). Using binomial logistic regression, this study determined the strength of association between the selected variables. In addition, this study employed a list of inclusion and exclusion criteria, described in Chapter 3. The independent variables consisted of various selected factors such as infection treatment, pain and anemia management, socioeconomic status, demography, and healthcare use. The 2018 Nigeria DHS secondary dataset provided the information needed to answer Research Questions 1 through 5. Nevertheless, the father's information was involved in the statistical analysis. Data were downloaded from the 2018 Nigeria DHS program website in this study. Statistical analysis involved various processes such as file downloading, data merging, and handling of missing values.

Because the variables were not weighted in the 2018 Nigeria DHS dataset, the statistical analysis involved weighting of the selected variables. Also, the primary study provided measurements that were used to answer the research questions in this study. The sampling procedures showed a two-staged stratified sampling method. The primary survey data collection eliminated the following biases: (a) interview, (b) selection, (c)

information, and (d) recall. Overall, this study showed the efforts to achieve improved internal and external validity.

This study considered a power (80%), 95% CI, (α) level (0.05), and Type II error (20%). The rigorous statistical analysis allowed improved internal validity in this study. Because of the large sample size, the effect size and power was high. This study illustrated a large sample size of children's genotype result. The 2018 Nigeria DHS data were not only within the last 5 years, but also met the anticipated time and cost. By and large, this study presented an opportunity to use a secondary dataset from a reputable organization in the United States, leading to improved external and internal validity.

Limitations

Because the design of this study was cross-sectional design, the causal inference could not be determined. Also, threat to the internal validity could occur based on errors in various procedures such as data collection, data analysis, and data interpretation. Threat to external validity could occur due to biases (e.g., information, selection, and measurement). Because all the children in the target population were not available for selection, population validity could be absent in this study. There were significant missing values in the data that could have affected the internal and external validity.

Significance

This study examines the relationship between infection prevention treatment, pain and anemia management, socioeconomic status, healthcare use, demography, and the presence of sickle cell hemoglobin. For that reason, this study may stimulate health policy formulation at the national, state, and local level. Again, this study enhances

collaboration between the Nigerian government and international organizations, leading to improved control and prevention of sickle cell hemoglobin. This study enables the rights of vulnerable or marginalized groups in the society to be preserved. The application of the evidence-based findings may lead to improved health outcomes in childhood sickle cell disorders.

This study may indicate the need to screen for social determinants in childhood sickle cell disorders. In addition, health equity for every child must be embraced by each level of government. A comprehensive program that influences health-related behavior (e.g., vaccines uptake) and genotype screening in the communities may be initiated. In Sub-Saharan Africa, clinical guidelines on neglected tropical diseases (e.g., childhood diarrhea) may be stimulated. Policy on primary prevention of malaria infection in sickle cell disorders may be invigorated. SickleCellNigeria initiative may allow the attainment of universal health in Sub-Saharan Africa.

Summary and Transition

Sickle cell hemoglobin is a common genetic disorder in Nigeria (Famuyiwa, 2020; Nnodu et al., 2021). Children living with sickle cell disorders are susceptible to the deleterious effects of social determinants of health (Cortright et al., 2020; see also Alradie-Mohamed et al., 2020; Eleonare et al., 2020; Ochocinski, 2020; Saramba et al., 2020; Serjeant & Vinchinsky, 2018). Because of the rising mortality in childhood sickle cell disease, there is a need for early diagnosis and screening for social determinants of health (Krause et al., 2021; Oldfield et al., 2021; Omotoso & Koch, 2018). Bronfenbrenner's socioecological systems theory and Krieger's ecosocial theory were

used to align the different elements of this study. This study examined the relationship between selected factors such as healthcare use, pain and anemia management, infection prevention, demography, and the presence of sickle cell hemoglobin.

In Chapter 2, I focus on items such as introduction, literature review, research problem, nature of the study, and literature search strategies. Furthermore, the conceptual or theoretical frameworks will be discussed in detail. To summarize, the next chapter will include items such as literature review, gaps in the literature, theoretical frameworks, research questions, hypotheses, and definitions.

Chapter 2: Literature Review

Usually, childhood sickle cell disorders are genetic blood abnormalities inherited from a parent. Researchers have found that sickle cell disorders were common inherited genetic anomalies worldwide due to the presence of abnormal hemoglobin (Cisneros & Thein, 2021; Cruz et al., 2019; Kanter et al., 2020; Poku et al., 2018; Stewart et al., 2021). The common hemoglobin abnormalities in human history were hemoglobin AS, SS, SC, and AC (Saramba et al., 2020; Westnedge et al., 2018). Islam et al. (2021), Ochocinski et al. (2020), and Steele et al. (2019) found that hemoglobin SS was the most common variant of sickle cell disorders occurring with the homogenous inheritance of abnormal hemoglobin from the parent. Similarly, Tossea et al. (2018) found that hemoglobin SC was due to the inheritance of aberrant hemoglobin from the parent. Arishi et al. (2021) found that hemoglobin AS was due to the inheritance of one mutated allele from the parent. As mentioned above, inheritance of sickle cell hemoglobin could culminate in various abnormalities such as SS, AS, AC, SC, and thalassemia.

The genetic abnormalities in sickle cell disorders are some of the prominent features. De Villaverde Cortabarria et al. (2021) and Inusa et al. (2021) argued on the monogenetic characteristic of sickle cell disorders due to the replacement of valine by glutamic acid on the beta globin gene. Also, authors found that sickle cell hemoglobin denoted various abnormalities found in human beta globin chain such as thalassemia, SS, AC, AS, and SC (Ashorobi et al., 2021; Farrell et al., 2018; Esoh et al., 2021; NPC, 2019; Saramba et al., 2020). According to Royal et al. (2021), sickle cell hemoglobin was a

Mendelian disorder associated with different clinical manifestations. The aberration predisposes to medical complications in sickle cell disorders.

Medical complications are found in children living with sickle cell hemoglobin in the communities. Researchers have documented that the increased in neonatal death rate in Sub-Saharan Africa was associated with high prevalence of sickle cell hemoglobin (Burstein et al., 2019; see also Hsu et al., 2018; Islam et al., 2021; Nnodu et al., 2019; World Health Organization [WHO], n.d.). Esoh et al. (2021) emphasized that the prevalence of hemoglobin AS and AC dictated the prevalence of hemoglobin SS and SC in the community. Equally, children living with hemoglobin SS were susceptible to a lower survival rate in comparison to their counterpart living with hemoglobin AS (Uyoga et al., 2019). Gbotosho et al. (2021) found that intravascular and extravascular hemolysis were accentuated in children living with sickle cell hemoglobin. In short, sickle cell hemoglobin could lead to susceptibility to life-threatening complications and to reduced health outcomes and life expectancy.

The number of individuals with sickle cell disorders is rising in Sub-Saharan Africa. In 2022, researchers documented a total population of 218 million in Nigeria (World Population Review, n.d.). Also, Nigeria has a high global prevalence of sickle cell disorders in the six geopolitical zones (Nnodu et al., 2021; Oluwole et al., 2020). Again, Nnodu et al. (2021) found that childhood sickle cell-related death in Nigeria was found before the fifth birthday. Researchers presented approximately 5.3 million under-5 mortality worldwide in 2018, which accounted for 85% of deaths among children (UNICEF, 2019a). In 2018, the birth rate was approximately 7 million in Nigeria

(National Bureau of Statistics, 2020). In 2019, the birth rate was still approximately 7 million in Nigeria (UNFPA, n.d.). These statistics above indicated high mortality rate in children under 5-years-old despite high birth in Nigeria. Despite the rising population density in Nigeria, the mortality rate in children under 5-years-old is still high.

The clinical manifestations of sickle cell hemoglobin vary across geographical locations. Phenotypic presentation of sickle cell disorders in children could be affected by factors such as ethnicity, geography, demography, socioeconomic status, education, and healthcare access (Berghs et al., 2020; Claeys et al., 2021; Dwivedi et al., 2018; Kang & Kim, 2019; Serjeant & Vinchinsky, 2018). Children living with sickle cell disorders could experience adverse health outcomes due to factors such as racism, gender inequality, inaccessible healthcare, stigma, and illiteracy (Houwing et al., 2021; Lee et al., 2019; Major et al., 2018, Omotoso & Koch, 2018). Thus, the phenotypic presentation in genetic disorders could be linked to environment, socioeconomic status, biology, and trait.

The rights of a child in the society are nonnegotiable and need to be respected. The United Nations (UN) convention proposed the following tenets of operation on the rights of a child: (a) nondiscrimination, (b) the right to life, and (c) acting in a child's interest (UNICEF, 2019b). Also, Kindblom et al. (2020) considered the need for more studies on a child's rights, leading to evidence-based management by professional. On the contrary, authors found that a child's right in developing countries did not receive the deserved attention due to inadequate knowledge or education (WHO, 2018a). The reduction of mortality rates in childhood sickle cell disease is correlated with improved

management of medical complications in chronic diseases (Westnedge et al., 2018). The rights of a child must be protected in the constitution of every country to allow achievement of the UN global development goals.

In Africa, childhood sickle cell disorders predisposed to high morbidity and mortality, leading to health policy formulation at the different government levels (Oron et al., 2020). Similarly, researchers provided the need for current guidelines on the prevention and control of sickle cell disorders in Sub-Saharan Africa and improved data sharing, harmonization, and collaboration (Isa et al., 2020; 2021; Nembhard, 2020). Evidence-based policies on sickle cell disorders were absent in Nigeria due lack of a national representative data (NPC, 2019). Management of childhood sickle cell disorders must embrace policy implementation at the national, state, or local level.

Health equity a play crucial role in the health and well being in childhood sickle cell disorders. Van Malderen et al. (2019) found that equitable health care delivery was associated with improved health and well being in the society. The proposed target for the global reduction of mortality in children under 5-years-old was 25/1,000 in childhood sickle cell disorders (Jin et al., 2018). Adeyinka et al. (2020) provided that developing countries were burdened with communicable and infectious diseases, leading to inability to attain universal health. Despite the need to reduce mortality and morbidity in developing countries, the lack of health equity in developing countries could pose a major challenge.

Kindzeka (2018) found that children living with sickle cell hemoglobin were affected by negative experiences in the community (e.g., unfulfilled dreams and

discrimination). Hardy et al. (2021) found that determinants of health was associated with morbidity and mortality rate in the society. Booysen et al. (2021) and Oldfield et al. (2020) suggested the need to screen for social determinants of health, especially for elements predisposing to health inequalities and inequity. According to Power-Hays et al. (2020), children affected by sickle cell disorders were easily susceptible to the adverse effects of low socioeconomic status. As mentioned, screening for social determinants of health in children may lead to a reduction of morbidity and mortality rate in low- and middle-income countries.

A stronger society is built in the presence of equity and equality. According to Bambra (2021), the determinants of social inequalities included factors such as age, gender, race, education, and income. Hahn (2021) and Nnodu et al. (2019) found that race and geography affected the distribution of scarce resources in the communities. In addition, Loo et al. (2021) emphasized that a child's health and well being were affected by the influence of social determinants. Similarly, researchers found that children living with sickle cell disorders were affected by health inequalities and disparity, leading to reduced life expectancy (Meier et al., 2020; Power-Hays et al., 2020). A resilient and equitable health system in Sub-Saharan Africa must be embraced by decision makers.

Community health literacy could lead to health-related behavior in the developing countries. Liu et al. (2020) and Faremi et al. (2018) alluded to parent’s decision making as an influential factor of health outcomes in sickle cell disorders. Also, authors found that nutrition therapy and infection prevention treatment were beneficial in children living with sickle cell disorders (Islam et al., 2021; Royal et al., 2021; Suryawan et al.,

2021; Torlesse & Aguayo, 2018). Researchers suggested the need for caregivers' health literacy on the benefits of screening (e.g., genotype screening) and blood transfusion (Darshana et al., 2021; De Haan et al., 2020; Forte et al., 2018; Nnodu et al., 2019; Wilson et al., 2021). Akrimi and Simiyu (2018) and Pertet et al. (2018) found that antibiotic prophylaxis and vaccination were effective methods of infection prevention in children. Parent's health literacy level could play a role in the provision of quality healthcare in the society.

This quantitative study addressed the relationship between demography, socioeconomic status, genotype screening, pain and anemia management, infection prevention treatment, healthcare access, and presence of sickle cell hemoglobin. The 2018 Nigeria DHS were analyzed to determine the relationship between independent and dependent variables using a cross-sectional design (NPC, 2019). Researchers pointed to the need for health policies formulation in field such as hemoglobinopathies, neglected tropical diseases, and genetic screening (Ashorobi et al., 2021; Darshana et al., 2021; Forte et al., 2018; Ochocinski et al., 2020; Ugboko et al., 2021). This study answered the Research Questions 1 through 5 and covered the identified gaps in the literature.

This chapter includes information on items such as search strategies, literature review, literature gaps, problem statement, theoretical frameworks, and study's purpose. The literature search section provides information on the databases, search strategy, and search terms. Overall, the selected variables are discussed in detail in Chapter 2.

Literature Search Strategies

The databases used include Embase, SAGE Journals, Science Direct, ProQuest, Nursing, Cumulative Index to Health, Allied Nursing, Cochrane, PubMed, EBSCOHost, Walden University library, Goggle Scholar, MEDLINE with Full test, Dissertation & Thesis at Walden University, and EndNote. The Boolean phrases used include the following: *Sickle cell anemia, sickle cell disease, Hemoglobin SS, Hemoglobin AC, Hemoglobin AS, sickle trait, hemoglobin SS variant, thalassemia, homozygous HbSS, heterozygotes AC* in the first search box. Again, the year is narrowed into the last 3 years and limiting the age to less than 5-years-old or 6-59 months.

The search terms used in the second box of the databases are *gender, bias, female genital mutilation, female genital cutting, behavior, knowledge, belief, attitude, decision making, household decision making, health literacy, internalized stigma, stigma, negative attitude prejudice, inequalities, disparity, race, ethnicity, health facilities, immunization, antenatal care, antenatal care use, low birth weight , failure to thrive, stunting, wasting, body mass index, equality, quality of health, morbidity, mortality, anthropometric measurement, genetic, wealth index, precipitating factors, risk factors, micronutrient intake, edible African insect, African protein supplementation, nutrition therapy, sociodemographic, socioeconomic status, demography, women underrepresentation, geographical variation, variability, genetic factors, communication, literacy, behavioral factors, healthcare disparity, disparity, place of delivery, WHO, UNICEF, United Nations Children's Fund, World Health Organization, employment status, neglected African disease, healthcare utilization, environmental, Latin America, United Kingdom,*

Asia, delivery facility, North America, West Africa, Sub-Saharan Africa, Africa, Nigeria, access to healthcare, women's decision making, women disempowerment, women empowerment, healthcare facility, diarrhea, intestinal infection, malaria, neglected tropical disease, insecticide-treated nets, mosquitoes net, pain, anemia, vaso-occlusive crises, hemolytic crisis, opioid, nonsteroidal antiinflammatory agent, abdominal crisis, stroke, renal dysfunction, Jehovah witness, religion, culture, opioid, aspirin, ibuprofen, Panadol, analgesia, poverty, health insurance, socioecological theory, Bronfenbrenner's, socioecological theory, Krieger's ecosociological theory of disease distribution, and *disability.*

The Study Theoretical Foundation

Socioecological Theory of Bronfenbrenner

Bronfenbrenner's theory could allow the examination of the interconnection between a child's characteristic, life course, and adverse health outcomes. Urie Bronfenbrenner developed the socioecological theory in 1979 (Erikson et al., 2018). Bronfenbrenner's socioecological theory showed the interaction between environmental factors and a child's well being (Buser et al., 2020). Also, Chigangaidze et al. (2020) focused on the use of the socioecological model to delineate the relationship between health outcomes, infections, biology, psychology, and socioeconomic status. Bronfenbrenner's ecological systems suggested the various pathways affecting childhood health status such as micro-, meso-, micro-, exo-, and macro-systems (Fitzsimons & Clark, 2021).

Bronfenbrenner socioecological model could illustrate the interplay between different ecological factors in the society. Walker et al. (2019) have emphasized on the impact of social determinants on health outcomes and well being. Individual traits played a role in modifying health-related behavior in the community. (Ahinkorah et al., 2019). According to Ungar (2021), a child's well being was affected by adversity, stress, psychopathology, structural violence, and biology. Thus, a child's development may be examined based on screening for social determinants.

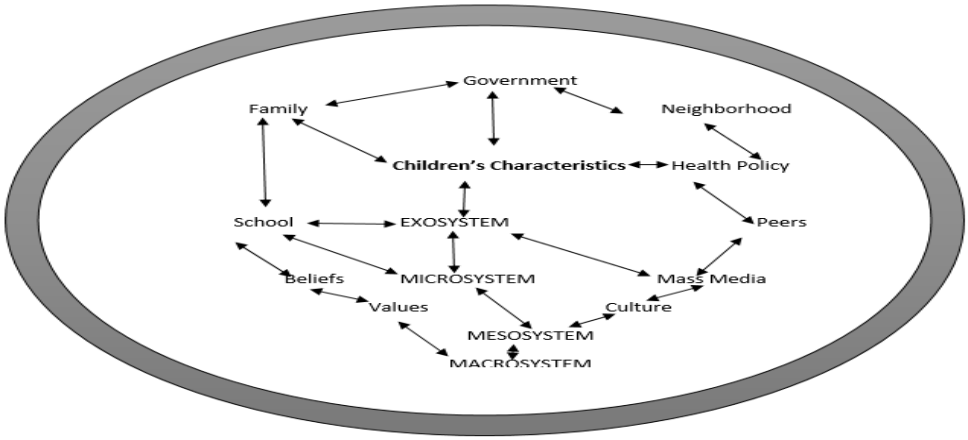
Bronfenbrenner's systems theory could provide information on the proximal and distal social determinants of health. According to Ericksson et al. (2018), the determinants of illness in children included the interaction between social, environment, and power. Based on Bronfenbrenner's assertion, the socioecological framework allows the examination of the interaction between the environment, a child's growth, culture, and family (Guy-Evans, 2020). Domoff et al. (2020) have argued that socioecological framework consisted of the distal and proximal determinants of health. Finally, Bronfenbrenner's theory conceptualizes social determinants as influential factors in a child's survival.

Socioecological and biosocial factors could alter the survival of children living with sickle cell hemoglobin. Mance et al. (2019) have suggested the relationship between a child's adverse health outcomes, social behaviors, family's stress, and socioeconomic status. Stigma experienced from chronic disease could influence a child's quality of health (Brandow & DeBaun, 2018). Bioku et al. (2020) have suggested that health determinants (e.g., stigma, parent's situation, financial constraint, and culture) could

influence a child's milestone. Socioecological system is a mechanism of determining the effect of the environment on children characteristics and well being (Figure 1).

Figure 1

Mapping of Study Variables From the Lens of Bronfenbrenner's (2021) Systems



Note. From "Children and COVID 19: Understanding impact on the growth trajectory of an evolving generation," by S. Haleemunnissa, S. Didel, M.K. Swami, K. Singh, K. and V. Vyas, 2021, *Child and Youth Services Review, 120*, p.105754. (https://doi.org/10.1016/j.childyouth.2020.105754). Copyright 2020 by the Elsevier Ltd.

Because Bronfenbrenner's conceptual framework focused on the ecological factors, screening for social risk factors could lead to improved health outcomes. Gubbels et al. (2019) found that a child's health outcomes were affected by microsystems such as socioeconomic status, culture, structural violence, and peers' influence. Authors argued that childhood health outcomes were based on the interaction between the micro-, meso-, and exo-systems in the society (Center for Child & Family Well-Being, n.d.). As previously mentioned, stigma could interact with environmental factors to determine

health status in childhood. Michaelson et al. (2021) found that parent's skill formed an integral part of the social factor that could influence a child's health outcome. Kuerten et al. (2020) focused on the determinants of societal health outcomes such as psychology, socioeconomic status, environment, and family. Overall, Bronfenbrenner's socioecological theory could aid the understanding of the interconnection between the environment and a child's development.

Authors focused on the complex relationship between disparity, stigma (e.g., perceived, internalized), socioeconomic status, geography, environmental stress, culture, and childhood sickle cell disorders (Gubbels et al., 2019; Leger et al., 2018). Also, the families of children living with sickle cell hemoglobin could experience chronic sorrow due to recurrent hospitalizations, low socioeconomic status, and psychosocial issues (Olwit et al., 2018). Using Bronfenbrenner's theoretical framework, researchers documented the interplay between culture, health-seeking behavior, and a child's health status (Buser et al., 2021). Children living with sickle cell disorders are subjected to environmental stress (e.g., structural violence) that may lead to reduced health outcomes.

Early life adverse experiences could predispose to reduced life expectancy. Adverse childhood experiences were related to negative health outcomes (such as mortality and morbidity) in the communities (Jones et al., 2019). Also, Brandow and DeBaun (2018) have suggested socioecological theory to examine risk factors of childhood adverse events. Buser et al. (2021) have provided socioecological approach to examine health problems in sickle cell disorders. Thus, Bronfenbrenner's theoretical

framework could be used to examine the impact of social determinants on survival in children under 5-years-old.

Bronfenbrenner's ecological model could invariably explain the relationship between a child's growth and the environment. Researchers focused on multiple domains that could determine the psychological burden in childhood sickle cell disorders (Kuerten et al., 2020). Similarly, Leger. (2018) have provided the use of Bronfenbrenner's socioecological concepts to address the impact of social, individual, and environmental factors on childhood sickle cell disease. Agorastus et al. (2018) have suggested that early life environmental stress could predispose to reduced health quality later in adulthood. Bronfenbrenner's ecological theory was provided as a tool to guide application of a study's finding (Erickson et al., 2018). The Bronfenbrenner biopsychosocial phenomenon considered the interaction between individual characteristics (e.g., gene), environment-related stress, physiology, and social structure (Brandow & DeBaun, 2018; Fogelman & Coli, 2019). Overall, Bronfenbrenner's concepts could be used to explain the relationship between the independent and dependent variables in research.

Brandow and DeBaun (2018) have suggested the significant relationship between austere environment, disparity, inequalities, biopsychology, and health outcomes. Also, Fu et al. (2020) have investigated the interaction between socioecological factors, caregiver's skills, behavior, and a child's health status. Similarly, Downes et al. (2019), Drummond et al. (2020), and Shinkawa et al. (2021) have focused on the interaction between family's social skills, exposure to stress, psychosocial problems, and a child's

adverse events. A child's health status could be influenced by the interaction between biopsychology, behavior, environment, inequities, and disparity.

Bronfenbrenner systems could explore the interaction between a child's health status and the environment. Zhong et al. (2021) have focused on the use of socioecological model to align elements in genetic research, especially in low-and middle-income countries. Dahl et al. (2020) found that a child's genetic composition was a significant predictor of medical complications in chronic diseases. Based on the above, the Bronfenbrenner's systems allow the description of the interaction between ecology and human existence.

Krieger's Ecosocial Theory of Disease Distribution

The world is shaped by interaction between human being, ecology, inanimate object, and time. In 1994, Nancy Krieger developed ecosocial theory of disease distribution (Krieger, 2020, 2021). Also, ecosocial theory provided the interplay between up-, mid-, and down-streams social determinants of health (Mkhize et al., 2019). Ecosocial theoretical framework conceptualized the interaction between social determinants of health (e.g., infection prevention, geography, education, healthcare use, nutrition, ecology, ethnicity, and race) and health outcomes (Finkelstein et al., 2020; Kiragga et al., 2019; Zerihun et al., 2019). The ecosocial theoretical framework illustrated the relationship between the health outcomes, environment (e.g., healthcare access), residence (e.g., rural, urban), trait, behaviors, and health literacy (Berhe et al., 2019; Gebreyesus et al., 2019). Taken together, Krieger's ecosocial theory was provided

in this study to explain the relationship between the social determinants of health (mid-, down-, and up-stream) and childhood sickle cell disorders.

The ecosocial theory addresses the association between a child's health outcomes and social risk factors. According to Jang (2022), Krieger's ecosocial theory was used to examine the factors responsible for distribution of diseases in the community. Also, researchers provided the socioecological framework to explain the relationship between innovation uptake, drugs adherence, healthcare use, and childhood sickle cell hemoglobin (Crego et al., 2020). According to Wastnedge et al. (2018), childhood sickle cell hemoglobin adverse health outcomes were influenced by the social determinants. Ismainar et al. (2020) emphasized on factors contributing to chronic diseases such as culture, health literacy, and healthcare access. Briefly, this study illustrated the relationship between social risk factors and the childhood sickle cell disorders.

Women's well being and health needs to be addressed in the context of social determinants. Bhandari and Burroway (2018) and Chae et al. (2018) have focused on ecosocial theory to explain the association between women's legal rights and health outcomes. Chambers et al. (2018) presented the ecosocial theory to show the relationship between institutional violence, premature birth, low birth weight, and disparity. Similarly, Hahn et al. (2018), Harnois and Bostos (2018), and Khubchandani et al. (2018) have showed the complex interplay between women's civil right, healthcare use, housing, employment, disparity, and health outcomes. Hence, women's civil right need to be considered as a determinant of a child's health outcomes.

The ecological theory could be a method of finding solution to a child's misadventure in life. Jacoby et al. (2018) have alluded to socioecological concepts in the examination of the interplay between structural violence (e.g., gender disparity), race, ethnicity, geography, and health status. In addition, authors have used ecological theoretical framework to show the relationship between individual's behavior, healthcare use, and health outcomes (Ismainar et al., 2020). Researchers considered the interlink between microorganisms and human being using the ecosocial conceptual framework (Aguirre et al., 2019; Cabrera et al., 2021; Twintoh et al., 2021). As previously mentioned, the socioecological theory could be a tool in determining the relationship between a child's growth failure and social determinants of health.

A child's life course could be influenced by the social determinants of health. Researchers have alluded to the impact of social determinants on childhood diseases (Merck et al., 2018). Islam (2019) emphasized on the upstream determinants of health (e.g., health policy) as playing a role in a child's life course. In addition, Power-Hays et al. (2020) have suggested that understanding the social determinants of health allowed the policy formulation at national level. Engels and Zhou (2020) have suggested that policy implementation was associated with improved health outcomes in every child. As mentioned, screening for social determinants of health in pediatric sickle cell disorders could enable improved health quality.

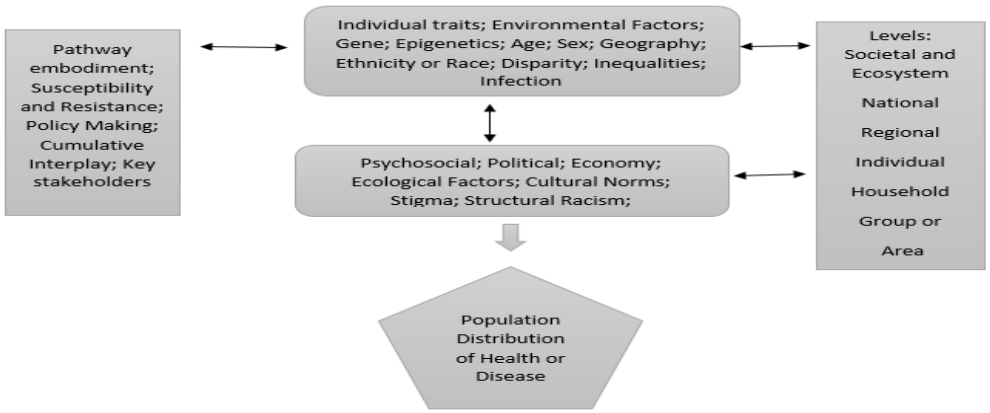
The socioecological theory may be used to achieve improved external validity in research. Krieger (2020) have focused on ecological theory to delineate the interaction between gene, life course, culture, structural violence, policy, and history. Similarly,

researchers examined the relationship between structural violence, race, disparity, and health outcomes (Agenor, 2020; Homan et al., 2021). Berman et al. (2018) have examined the interaction between social determinants of health (e.g., poverty) and adverse health outcome. Also, Lopez et al. (2021) have utilized ecosocial to examine the interplay between variables such as social, ecology, environment, trait, epigenetics, and neonatal health outcomes. Boparai et al. (2018) and Zheng et al. (2018) have focused on the relationship between the environment (e.g., ethnicity and poverty) and a child's health outcomes. From the above mentioned, child's well being could be influenced by social risks factors and genetic composition.

The integration of a social and cultural factors could affect a child's health outcomes. Wild (2019) have examined the relationship between health inequities and health outcomes using ecological theory. Similarly, Harris and McDade (2018) have examined the relationship between social determinant (e.g., environment and biology) and a child's growth using embodiment pathway. As mentioned, the socioecological theory may be utilized to show the impact of health inequities on a child's health status (Figure 2).

Figure 2

Mapping of the Study Variables Using Krieger's (2020) Ecosocial Theory



Note. From "Measures of racism, sexism, heterosexism, and gender binarism for healthy equity research: From structural injustice to embodied harm an ecosocial analysis," by N. Krieger, 2020, *Annual Review of Public Health, 41*, p. 46. (https://doi.org/10.1146/annurev-publhealth-040119-094017). Copyright 2020 by the Annual Reviews.

According to Krieger (2020), embodiment was an important construct in ecosocial theory of disease distribution. Similarly, embodiment was illustrated in the interaction between biology, social, and a child's growth by Harris and McDade (2018). Dahl et al. (2020) have examined human development using ecological theory of disease distribution. Ecosocial model could integrate the pathways between various factors such as biology, social, individual, and the environment. The ecosocial model of disease distribution could be used to the interaction between health determinants (mid-, down-, and up-stream) and a child's well being.

Literature Review Related to Concepts and/or Key Variables

Epidemiology of Sickle Hemoglobin in Children

The WHO declared Nigeria as the epicenter of sickle cell in the world (Oluwadamilola et al., 2021; Islam et al., 2021). In Sub-Saharan Africa, childhood sickle cell disorders were associated with increased morbidity and mortality (Claeys et al., 2021). In addition, sickle cell hemoglobin prevalence in the six geopolitical regions of Nigeria was 2% in 2018, as mentioned in the literature (Kouagheu, 2018; NPC, 2019). Researchers documented 100, 000 death in 2014 in Nigeria and 490 per 1000 live births death in 2003-2013 (Nnodu et al., 2021; Onyeji, 2018). In 2018, at least 150,000 children were diagnosed with presence of sickle cell hemoglobin in Nigeria (Ifijeh, 2018; Islam, 2021; NPC, 2019; Ochaya, 2018). In Nigeria, childhood sickle cell disorders were linked to high morbidity and mortality (Famuyiwa, 2020; NPC, 2019). Considering the above statistics, the high mortality and morbidity rate in Sub-Saharan Africa could be connected to medical complications from unknown or undiagnosed sickle cell disorders in the community. Overall, childhood sickle cell hemoglobin is a public health problem in Sub-Saharan that deserves attention at local, state, or national level.

African America had a proportion of 7.7% of hemoglobin AS at a point in time (CDC, 2020a, WHO, 2019a). Uyoga et al. (2019) found a higher survival rate in hemoglobin AS in comparison to hemoglobin SS. Similarly, Ashorobi et al. (2021) found that hemoglobin AS was a predictor of severe complications in the community. Approximately 5% of the global population were in possession of hemoglobin AS and Sub-Saharan Africa showed the highest prevalence (De Villaverde Cortabarria et al.,

2021; Inusa et al., 2019; WHO, n.d.) In Nigeria, approximately 300,000 babies were delivered each year with sickle cell hemoglobin by Oluwole et al., 2020. Hemoglobin SS was due to the inheritance of two mutated heterozygous gene; in contrast, hemoglobin AS was due to the inheritance of one mutated gene by Arishi et al. (2021). The increased proportion of hemoglobin AS and AC in the community led to preservation of hemoglobin SS and SC in the community by Esoh et al. (2021). Although the mortality rate in children fell worldwide in the last 60 years, there was a high likelihood of death in a child born in Northern zone of Nigeria (Gates, 2021b).

The sickle cell disorders birth rate worldwide was divided into various groups such as Sub-Saharan Africa (10.68/1,000), North and South America (.49/1,000), Asia (.07/1,000), and Europe (.07/1,000) by Karadag et al. (2018). Approximately 75% of infants living with sickle cell disease were in Sub-Saharan Africa and 80% of the total population living with the disease (Archer et al., 2018; Esoh et al., 2021; Ochocinski et al., 2020). In addition, approximately 30% newborn were annually diagnosed with sickle cell hemoglobin in Nigeria, amounting to the highest prevalence in the global community (Islam et al., 2021). According to Nnodu et al. (2021), the prevalence of childhood sickle cell anemia was 1% in Nigeria. Tossea et al. (2018) found that the prevalence of hemoglobin AS was 24% in Nigeria. From the above statistics, a high prevalence rate of sickle cell disorders was recorded in Sub-Saharan Africa, Nigeria included.

Despite the rise in prevalence of childhood sickle cell hemoglobin worldwide, the statistics from developing countries were inaccurate due to poor surveillance methods (Dormandy et al., 2018; Marks et al., 2018). Similarly, children living with sickle cell

disorders in developing countries were unable to benefit from early hemoglobin genotype, leading to inaccurate capture at the national data (Olatunya et al., 2021). Researchers documented poor surveillance at every level of government in Sub-Saharan Africa, leading to inaccurate prevalence estimate in childhood sickle cell disorders (Nnodu et al., 2020). In a similar manner, De Martino et al. (2019) and Mukherjee et al. (2020) have alluded to the various benefits of early neonatal diagnosis of sickle cell disorders such as accurate national database and improved health. As mentioned above, effective surveillance program in low- and middle-income countries could predispose to improved health status in childhood sickle cell disorders.

The burden of sickle cell disease in developing countries is unbearable because of the high mortality and morbidity. Despite the annual birth rate of children living with sickle cell disorders totaling 312,000 annually, sickle cell hemoglobin was still a neglected chronic disease in Sub-Saharan Africa (Nnodu et al., 2019; United Nations Department of Economics and Social Affairs [UNDESA], 2018). The high disease burden of sickle cell disorders in the Africa descents was mentioned by Boadu et al. (2018). In Nigeria, sickle cell-related death was found before fifth birthday, but more than 90% of children in advanced countries enjoyed improved life expectancy (Allali et al., 2021; Nnodu et al., 2021; WHO, 2019b). The case fatality among children living with sickle cell hemoglobin in Africa was high, as mentioned by Chimbatata et al. (2021) and El-Kader and Al-Shreef (2018). Because of the increased mortality rate in childhood sickle cell disorders, there could be a need for health-related strategies in Sub-Saharan Africa.

To improve the national data on chronic disease, there was a need for improved surveillance in the community (Congress United States, 2018, Williams et al., 2018). Acceptance of pre-and post-natal genotype screening ensured improved prevention and control of sickle cell hemoglobin as well as enhance accurate national data (Ezenwosu et al., 2021). The misleading figures on prevalence of childhood sickle cell disorders in Nigeria must be addressed to ensure improved national surveillance. To summarize, the underestimation of the prevalence of children living with sickle cell disorders could result from unrealistic government strategies.

The UN goal to reduce the global children under 5-years-old mortality to 25/1,000 by 2030 needed to be embraced at the national, state, or local level (Jin et al., 2018; Karadag et al., 2018). In a similar manner, the UN initiative (i.e., sustainable development goals) indicated a reduction in mortalities of 25% per 1,000 live births in children under 5-years-old by 2030 by Yaya et al. (2018). In 2020, a total of 95.12 deaths/100,000 live births were recorded in Nigeria and a total of 750,000 children under 5-years-old deaths were recorded in 2015 (NPC, 2019; Wonkam & Kengne, 2021; WHO, 2019b). Approximately 10 million preventable children death was recorded between the ages of 6-59 months every year worldwide by Van Malderen et al. (2019). All things considered, the unfavorable statistics and information presented could be a wake up call to examine under-5 mortality in Sub-Saharan Africa.

Because of inaccurate national data in Nigeria, the prevalence of childhood sickle cell hemoglobin could be inaccurate (Nnodu et al., 2020). Authors suggested that the annual prevalence of childhood sickle cell hemoglobin was 300,000 worldwide (Sedrack

& Kondamudi, 2021). In 2018, approximately 150,000 children obtained genotype test in the six geopolitical zones of Nigeria (Ifijeh, 2018). The total population affected by sickle cell disorders in Sub-Saharan disease was between 3-30%, as mentioned by Ochaya et al. (2018). Nnodu et al.'s (2021) study documented the prevalence of hemoglobin SS genotype (1.21%) and hemoglobin SC (.08%). However, the prevalence could be inaccurate due to erroneous data, poor surveillance, decreased survival, and lack of research (Dormandy et al., 2018; Marks et al., 2018). The high prevalence of sickle cell disorders was an indication of effective prevention and control strategies (WHO, 2021a). Therefore, the national control and prevention strategies of sickle cell disorders could be undermined by poor surveillance program in low- and middle-income countries.

Acute and chronic complications of sickle cell disorders need to be addressed to reduce high infant mortality in Sub-Saharan Africa. The presence of hemoglobin SC and SS in children induced mild to severe complications, leading to increased mortality rate in the communities (Boadu et al., 2018; Esoh et al., 2021; Okongwu et al., 2018). Umeakunne and Hibbert (2019) suggested that management of acute and chronic medical complications of sickle cell hemoglobin (i.e., SS AS, AC, and SC) could lead to improved health outcomes or survival. Fetal hemoglobin repression was a noted mechanism of clinical manifestations of sickle cell disorders in the literature (Frangoul et al., 2021). As mentioned, the presence of the mutated hemoglobin could lead to unpleasant acute and chronic complications of sickle cell disease.

Adeyinka et al. (2020), Hug et al. (2019), and Olwit et al. (2018) classified periods of signs and symptoms manifestation in children into the following categories: (a)

neonatal period (0-27 days), (b) post-neonatal period (1-11 months), and (c) pre-school age (12-59 months). Also, Opoka et al. (2019) and Ochocinski et al. (2020) found that severe anemia was associated with increased mortality (8-17%) and morbidity (9-29%) in sickle cell hemoglobin. Recurrent sickle cell pain was a complication precipitated by accumulation of deoxygenated hemoglobin in blood (Simmons et al., 2019). Similarly, Galadanci et al., 2019, Boadu et al. (2018), and Partnanen et al. (2020) found that stroke and neurocognitive impairment were medical complications in childhood sickle cell disease. Children living with sickle cell hemoglobin could be susceptible to long- and short-term medical complications, leading high increased morbidity and mortality.

To reduce high neonatal mortality in Sub-Saharan Africa, infectious disease control strategies must be implemented. Hemoglobin AS predisposed to selective survival of children in malaria endemic zone, allowing perpetuation of hemoglobin SS and SC in Sub-Saharan Africa (Uyoga et al., 2019). Authors suggested possible interaction between the sickle cell disorders and environmental factors (e.g., socioeconomic factors, education level, social support services), leading to the variation of phenotypic presentation (Berghs et al., 2020; Serjeant & Vinchisky, 2018). Again, the presence of neglected tropical diseases could lead to acute and chronic complications (e.g., failure to thrive, malnutrition, vaso-occlusive crises, hemolytic anemia, and life-threatening infections) in childhood sickle cell disorders (Eleonare et al., 2020; Hotez et al., 2020; Islam et al., 2021; Ochocinski et al., 2020). As mentioned above, the social determinants (e.g., social services, infection, and education attainment) could influence the clinical symptoms in childhood sickle cell disorders.

The marginalized group must be protected from the deleterious effect of social determinants. Researchers provided culture as an influential factor of structural racism (e.g., mother's autonomy and gender equality) in Sub-Saharan Africa (Alradie-Mohamed, 2020; Danso and Danso, 2021; Lurie et al., 2020; Mahase, 2021; Tiku, 2021). Disability in the family of children affected with sickle cell disorders led to poor access to healthcare, low socioeconomic status, and low health literacy (Downes et al., 2019). Similarly, gender equality needed to be addressed in the realm of sickle cell disease, allowing the attainment of United Nations millennium development goals (Bulgin et al., 2018; Nnodu et al., 2021, NPC, 2019, WHO, 2021b). Ifijeh (2018) suggested that health literacy played an important role in health-related behaviors in the communities. Taken together, social determinants must be addressed in marginalized or vulnerable groups in the community.

Children living with sickle cell disorders were affected by structural violence, leading to a need for government policies at local, state, or national level (Alradie-Mohamed et al., 2020; Gbadebo et al., 2021; Lurie et al., 2020). In a similar manner, Ibemere (2021) found that cultural, religious, and political factors were responsible for adverse health outcomes in marginalized population. Hence, reduction of structural violence could ensure improved health status in children living with sickle cell disorders.

The increased in mortality and morbidity in sickle cell disorders could be due to austere environment and social risk factors. Uyoga et al. (2019) found a lower survival rate in children living with hemoglobin SS in comparison to hemoglobin AS. Vaso-occlusive pain crisis was documented as a medical complication of children living with

hemoglobinopathies (Esoh et al., 2021; Saramba et al., 2020; Sundd et al., 2019). According to Ashorobi et al. (2021), hemoglobin AS presented with life-threatening complications (e.g., self-induced splenectomy) under severe environmental stress (e.g., exposure to high altitude). In a similar manner, genetic and environmental factors (race, ethnicity, and stress) altered the clinical symptoms in children living with sickle cell hemoglobin (Arishi et al., 2021). Taken together, medical complications in childhood sickle cell disorders could lead to reduced survival in the society.

Social Determinants of Health Early in Life and Sickle Cell Hemoglobin

Early childhood life could determine the health status or life expectancy in adulthood. Children early in life were prone to the deleterious effects of inequalities and disparity, leading to poor health outcomes and well being (Islam, 2019; Ruckert et al., 2018; United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2021). Lee et al. (2019) alluded to health disparity as difference in access to health resources based on geography and race. Social determinants of health "Are the dominant situations in our lives based on where we live, born, grow, work and age" (Booysen et al., 2021, p. 21) and are the drivers of health inequalities in the society (Ford et al., 2021). As mentioned, both disparity and health inequalities need to be considered in the distribution of scarce health resources in the low- and middle-income countries. Therefore, a child's growth could be influenced by the health inequalities and disparity in the society.

Malnutrition early in life could lead to unpleasant effects of social determinants of health. Growth retardation early postnatal period could be associated with various causes such as undernutrition, infections, and inadequate healthcare access (Budreviciute et al.,

2020; Eleonare et al., 2020; Tan & Lewardwski, 2020; Suryawan et al., 2021). Early life experience of inequalities and disparities led to adverse health events later in life (Takeuchi et al., 2018; 2021; Vineis et al., 2020). Similarly, Lu et al. (2021) argued on the impact of environmental factors (e.g., socioeconomic status) on the fetal brain development. Therefore, maternal experience of inequalities and inequities could lead to adverse health events in the postpartum period.

Nutrition deficiency in childhood sickle cell hemoglobin could predispose to adverse health outcomes. Approximately 189 million children were predisposed to malnutrition early in life, leading to reduced survival later in life (Suryawan et al., 2021). Similarly, Hahn et al. (2018) focused on the need to revisit social determinants of health to avoid negative consequences in the community. According to Torlesse and Aguayo (2018) and Gebremariam et al. (2019), a child's health status depended on the health facilities care received at the pre- and post-natal period. As mentioned, mother's health in pregnancy and after birth may determine the susceptibility of children living with sickle cell hemoglobin to adverse health outcomes.

A child's neurodevelopment could be affected by social determinants of health. Approximately 7,000 daily newborn deaths were recorded due to poverty after delivery or postpartum (Munyuzangabo et al., 2020; WHO, 2019c). Takeuchi et al. (2021) have examined the interaction between socioeconomic status (e.g., parent's education and household wealth index) and infant brain growth (e.g., neural, hippocampus). Again, Suryawan et al. (2021) have suggested that intrauterine malnutrition was a risk factor of

cognitive impairment in children aged 6-59 months. In sum, brain development could be influenced by the prevailing social determinants (e.g., socioeconomic status).

Mother's welfare could influence attainment of improved health status in the communities. In Sub-Saharan Africa, improved mother's welfare could reduce the mortality and morbidity in children under 5-years-old (Hug et al., 2019). Also, researchers found that pregnancy outcomes were satisfactory using healthcare facilities (e.g., ante- and post-natal visits) and presence of skilled birth attendants (Manyeh et al., 2021; Sageer et al., 2019). That said, children were likely to experience adverse health outcomes due to various reasons such as reduced antenatal care, absent healthcare practitioners, disparity, and inequalities (Brandow & DeBaun, 2018). Thus, under-five mortality could be reduced by improved access to healthcare in pregnancy and after birth.

Wolde et al.'s (2019) study found that the pregnancy-related complications could be prevented by antenatal care attendance in the first, second, and third trimester. Researchers found that antenatal care visitation could predict the adverse outcomes in pregnancy (Ewunetie et al., 2018). Hence, a mother's welfare must be prioritized in pregnancy to prevent peri- and post-natal complications. Researchers have alluded to increased peripartum complications (e.g., stillbirth, intrauterine growth retardation, neonatal anemia, low birth weight, and maternal anemia) arose from pregnancy-related infections (Al Khaja & Sequeira, 2021; D'Alessandro et al., 2018). Similarly, placenta transfer of infection in pregnancy led to miscarriage, preterm delivery, and intrauterine growth retardation (Saito et al., 2020). Thus, antenatal care could lead to reduced intrauterine growth delay or restriction.

Parent's low socioeconomic status (e.g., poverty) could affect intrauterine growth and neuropsychological development later in life (Leijser et al., 2018). Similarly, children raised in a setting with low socioeconomic status were likely to experience late developmental milestone and unproductive adult life (Al Khaja & Sequeria, 2021; Olstad & McIntyre, 2019). Benavente-Fernandez et al. (2019) found that maternal low socioeconomic status (e.g., education level) led to cognitive impairment and brain injury as well as intraventricular bleeding. As mentioned above, socioeconomic status (e.g., education attainment and wealth index) could determine a child's well being and health later in life.

The social determinants of health could shape a child's health outcomes and well being. The midstream social determinants of health included occupation, education, and environment, as mentioned in the literature (Cortright et al., 2020; Islam, 2019; Surrey & Bayssie, 2021; Torres et al., 2021). In addition, Counts et al. (2021) suggested that promulgating health policies (i.e., upstream health determinant) was associated with improved healthcare access. In a similar manner, Olstad and McIntyre (2019) and Umeakunne and Hibbert (2019) reported that clinical features of childhood sickle cell disorders were affected by various factors such as environment, behavior, biology (e.g., gender, genetics), and social background. Krause et al. (2021) have argued on the interaction between social determinants health and well being. According to Omotoso and Koch (2018), addressing socioeconomic inequalities led to improved health status. From above, recognizing social risk factors that influence a child's health outcomes must be intensified or strengthened at each level of government.

The community must be aware of social risk factors influencing prognosis of sickle cell disorders. Equally, the deleterious effects of inequalities and disparity could worsen the acute and chronic medical complications in children living with sickle cell hemoglobin (Faremi et al., 2018; Ibemere et al., 2021; UNDESA, n.d.). Similarly, researchers found that childhood sickle cell disorders were easily susceptible to adverse effects of social risk factors (Eleonare et al., 2020; Karadag et al., 2018; Ochocinski et al., 2020). Alradie-Mohamed et al. (2020) found that gender equality was a factor in achieving reduction of medical complications in children. Enabling health equities could lead to improved treatment of acute and chronic medical complication in sickle cell disorders.

Berghs et al. (2020) and Raphael (2020) found that screening for social determinants of health was an effective method of reducing medical complications in childhood sickle cell disorders. Similarly, Brandow and DeBaun (2018), Krieger (2020), and Prout et al. (2018) found that health inequities led to reduced health outcomes or life expectancy in the society. Childhood experience was be affected by culture, physical abuse, stigma, environment, and discrimination by Jones et al. (2019). Similarly, Jacoby et al. (2018) found that structural violence (e.g., discrimination) was a determinant of a child's survival or well being. Hence, health outcomes could be improved by screening for social determinants at an early age.

Environmental risk factors as determinants of health could be associated with adverse health outcomes. Adeyinka et al. (2020) and Meier et al. (2020) found that children living with sickle cell hemoglobin were easily susceptible to the adverse effects

of harsh environment (e.g., school absenteeism, financial constraints, and parent's unemployment). In a similar fashion, Agorastus et al. (2018), Booysen et al. (2021), and Power-Hays et al. (2020) found that a child's health status was influenced by determinants of health such as environment, social services, food security, education, and employment. Again, Agorastus et al. found that early life stress could trigger high morbidity and mortality in the society. According to Krieger (2020) and Prout et al. (2020), chronic disease manifestations depended on interplay between health inequities, socioeconomic status, and a child's environment. Universal screening for social determinants could lead to improved health equity in every child.

As previously mentioned, researchers suggested low screening social determinants as a cause of increased life-threatening complications in the society (Nnodu et al., 2019; Omotoso & Koch, 2018; Saramba et al., 2020). Also, Fogelman and Canli (2019) examined the relationship between a child's health outcomes and the environment. Power-Hay et al. (2020) suggested the need for universal screening for social determinants of health in childhood sickle cell disease, leading to the attainment of universal health coverage. Based on the above, sickle cell disorders as a public health problem in Nigeria must be addressed at the local, state, or national level.

A pragmatic theoretical framework could explain the interconnection between social risk factors and health status. Authors have examined the relationship between social determinants and a child's life course using Bronfenbrenner's systems (Conway et al., 2019; Fitzsimong & Clark, 2021; Lopez et al. 2021). Also, Brandow and DeBaun (2018) have provided biopsychological model to examine the relationship between

psychology, inequalities, environment, disparity, and biology. Zheng et al. (2018) examined the association between genetic disorders and social determinants using socioecological theoretical systems. In a similar manner, Lopez et al., 2021 have focused on Bronfenbrenner's ecological model to show the relationship between a survival, child's health status and adverse health outcomes. Fogelman and Canli (2019) have provided ecosocial conceptual framework to examine the interaction between adverse health outcomes, genetic disorders, and early life stress. Using ecosocial theoretical framework, this research examined the impact of social determinants on under-5 mortality.

Healthcare and Sickle Cell Hemoglobin

Healthcare services and support must be provided to limit the deleterious effects of social determinants. Karadag et al. (2018) found that integrating social services into healthcare access led to improved health outcomes in childhood sickle cell disease. Similarly, Obse and Ategbua (2021) found that health equity led to the achievement of universal health coverage. Researchers found that healthcare use was limited by factors such as race, disability, and health literacy (Cerdena et al., 2020; Karter et al., 2020, 2021; Power-Hay et al., 2020; UN, 2019). Improved healthcare access could form an integral part of the health system, leading to health for every child. The huge barriers to healthcare access must be addressed at each level of government.

Disability could lead to infrequent use of provided health facilities in the communities. Tarasoff et al. (2020) have examined the interaction between caregiver's disability, unemployment, education, poverty, healthcare use, and postpartum outcomes.

Abreha et al. (2020) and Downes et al. (2019) have examined the relationship between family's decision making, literacy level, and healthcare access, and health outcomes. Fisher et al. (2018) have examined the relationship between infant mortality rate, family's skills, and the environment. Disabilities in children under 5-years-old must be addressed by each level of government.

Furthermore, Bartlett et al. (2021) and Engels and Zhou (2020) found that recurrent medical complications in childhood sickle cell were associated with disability and reduced life expectancy. Because of the increased medical complications in children living with disabilities, there was a need to allow an uninterrupted healthcare access (WHO, 2021c). Researchers called on the government to focus on health equity in children living with disabilities, allowing improved healthcare access in the society (UN, 2019). Also, disabilities altered the frequency of healthcare facility use in children living with sickle cell disorders, as mentioned by Oron et al. (2019). Similarly, parent's disability led to late screening for sickle cell hemoglobin as well as low healthcare access (Abreha et al., 2020; Nnodu et al., 2020). As mentioned, disability could perpetuate inequalities arising from inaccessible healthcare facilities in the community.

Downes et al. (2019) found that family's decision making was a significant determinant of health outcomes in childhood sickle cell disease. Patel et al. (2018) found that social services and support led to improved health status in the vulnerable or marginalized group. In a similar fashion, the burden of disability in childhood sickle cell disorders could predispose to reduced well being and life expectancy (Bartlett et al., 2021; Engels & Zhou, 2020; UN, 2019; WHO, 2021a). Finally, disability in childhood

sickle cell disease could lead to adverse health outcomes in children under 5-years-old living with sickle cell hemoglobin.

A child's health could be seen as the wealth of a nation. Authors found that family's health-related behavior was associated with healthcare use in childhood sickle cell disorders (Ahinkorah et al., 2021; Karter et al., 2020; 2021; Leger et al., 2018; Michaelson et al., 2021; Power-Hay et al., 2020). National health insurance system ensured improved healthcare access in the community, as mentioned by Alker et al. (2020) and Lubeck et al. (2019). Similarly, children living with sickle cell hemoglobin could encounter delayed provision of desirable healthcare services due to health inequalities, inequities, and disparity (Magnan, 2021; Nnodu et al., 2020). Improved healthcare access could be ensured in sickle cell disorders through universal health insurance coverage and basic income grant.

Health insurance use could ensure delivery of quality health by financing treatment cost. Ogamba et al. (2020) have focused on the interaction between selected variables such as health insurance, social class, hospitalization cost, household wealth index, health literacy, sickle cell disorders, and adverse outcomes. Similarly, Dadjo et al. (2021) have examined the relationship between childhood illness and health insurance use. Shobiye et al. (2021) found that health insurance use offered the necessary healthcare access in either public or private hospital. Given these points, family's healthcare access based on insurance could ensure improved health status and well being.

According to Etiaba et al. (2018), health status and well being were affected by health insurance use in the community. In addition, Lubeck et al. (2019) provided that

unaffordable treatment cost in sickle cell disorders could influence family's health-related behaviors. Murphy and Moosa (2021) found that providers' perspective were needed to ensure increased health insurance use in low- and middle-income countries. Ekouveni et al. (2018) and Dadjo et al. (2021) have examined the relationship between social determinants of health (e.g., poverty and education), health insurance, and healthcare access (e.g., use of antenatal care, childhood immunization). Researchers found that parent's education level was a key determinant of health-related behavior in the society (Kuyinu et al., 2020; McClintock et al., 2020; Mor-Anavy et al., 2021; Williams et al. 2018). Lastly, the availability of health insurance use could ensure timely treatment of medical complications in chronic diseases.

Mother's health literacy could lead to improved health-related behavior. Neonatal mortality rate was reduced by improved maternal access to healthcare, leading to achievement of UN millennium development goals (Ahinkorah et al., 2021; Manyeh et al., 2020; WHO, 2018b). McCormick et al. (2020) found that inability to provide the needed healthcare led to high morbidity and mortality rate in children under 5-years-old living with sickle cell disease. Besides, Fisher et al. (2018) have examined the interaction between infant mortality, health insurance use, gender equality, and healthcare access. Hence, attainment of universal health for every child could be ensured through improved access to healthcare facilities.

Reduction of pregnancy-related adverse events are possible through access to healthcare services. Antenatal care use provided a way of early diagnosis of neonatal sickle cell hemoglobin, as mentioned by Manyeh et al. (2020). Focus group research and

real-time surveillance were methods of achieving improved prevention and control of sickle cell disorders (Dormandy et al., 2018; Marks et al., 2018; Nkya et al., 2019; Nnodu et al., 2021). Therefore, researchers suggested that care givers' health-related behavior were determined by various factors such as knowledge, mother's age, healthcare access, treatment cost, a child's age, and marital status (Karadag et al., 2018).

Genetic screening based in the community could ensure improved control and prevention of childhood sickle cell disease. Meier et al. (2020) found that integrating genotype screening and childhood vaccination led to effective control and prevention of sickle cell disorders. Health-related behaviors influenced the healthcare visitation in childhood sickle cell disorders (Hochmuth & Sorensen, 2021; see also Mikomangwa et al., 2019; Nnodu et al., 2019; 2020; Ozkan et al., 2021). Overall, improved healthcare facilities visitation could lead to reduction of under-5 mortality.

Community health literacy program improved uptake of point-of-care screening for sickle cell hemoglobin, as mentioned by Caldwell and Rosonet (2021) and Danho et al. (2021). Furthermore, point-of-care genotype test was a cost-effective method to diagnosis in sickle cell hemoglobin in developing countries (Hernandez et al., 2021; Olatunya et al., 2020; Steele et al., 2019). Allali et al. (2021) found that genotype test was a method of limiting adverse health outcomes (e.g., medical complications) in the community. Again, Kasai et al. (2020, 2022) found that health literacy was a significant factor in uptake of an innovation (e.g., newborn genotype screening) in Sub-Saharan Africa. Clayton-Jones et al. (2021) and Nnodu et al. (2019) found that early genotype screening was a public health strategy of achieving improved health outcomes in the

society. Health education could lead to achievement of health-related behavior and improve uptake of point-of-care genotype test.

Olatunya et al. (2021) and Nnodu et al. (2020) have suggested the need to use public health prevention strategies (e.g., genotype test) to improve health outcomes in sickle cell disease patients. Authors found that a comprehensive program (e.g., health education and early genotype screening) led to the reduction of adverse health events in childhood sickle cell disorders (De Montalembert et al., 2019; Faremi et al., 2018; Kuyinu et al., 2020; Segbefia et al., 2021). Abreha et al. (2020), Adeyinka et al. (2020), and Alabi and Rasmeden (2021) have examined the interaction between mother's autonomy, father's attitude, and a child's health status. Therefore, improve uptake of genotype test could lead to improved health outcomes and life expectancy in childhood sickle cell disorders.

Authors found that health literacy was associated with uptake of genotype test and vaccination (Meier et al., 2020; Steele et al., 2019; Wilson et al., 2021). Also, Hsu et al. (2018) found that low uptake innovation (e.g., genotype test) arose from inadequate health literacy, leading to increased morbidity and mortality in sickle cell disorders. According to Power-Hay et al. (2020), Etiaba et al. (2018), and Taniguchi et al. (2020), screening for social determinants of health (e.g., poverty and healthcare access) ensured attainment of universal healthcare coverage and reduction of mortality and morbidity in the communities. Early diagnosis of sickle cell disorders could ensure reduced susceptibility to life-threatening medical complications and improved uptake of available social services.

Researchers emphasized on the need to reduce high cost of treatment (e.g., genotype test) to ensure improved diagnosis and surveillance of sickle cell disorders (NPC, 2019; Power-Hay et al., 2020). According to Mukherjee et al., 2020; Nnodu et al., 2019, and Wilson et al., 2021, point-of-care test must be reliable, inexpensive, sensitive, and specific. In a similar fashion to the above studies, De Martino et al. (2019) and Segbena et al. (2018) found that point-of-care genotype test was an inexpensive modality of achieving early diagnosis and early treatment of sickle cell disorders. For that reason, developing countries must embrace the use of point-of-care genotype screening, leading to cost-effective delivery of health services.

As previously mentioned, Nnodu et al. (2020) have showed the need for early genotype test in the community, leading to improved surveillance and a reliable national data. Ezenwosu et al. (2021) and Williams et al. (2018) have suggested that hemoglobin screening was a method of prevention and control of sickle cell disorders. According to Alvarez et al. (2019), low community uptake of hemoglobin genotype test led to inaccurate data capture. Sickle cell hemoglobin prevalence could be underreported due to various factors such as low uptake of proved innovation (e.g., genotype test) and inaccurate national data.

Although a detailed hemoglobin electrophoresis was an effective method to diagnose childhood sickle cell disease, an inexpensive point-of-care test is recommended to achieve improved surveillance (Nnodu et al., 2019; NPC, 2019, Steele et al., 2019). The use of hemoglobin genotype screening was an effective public health measure of mortality reduction in childhood sickle cell disease, as mentioned by De Haan et al.

(2020). Similarly, Wilson et al. (2021) have suggested the various advantages of early community-based genotype test such as early diagnosis, inexpensive, and mortality reduction. Meier et al. (2020) found that improved access to point-of-care genotype test led to improved healthcare coverage and reduced adverse health outcomes. To that end, a cost-effective screening method for childhood sickle cell disorders could ensure universal health.

Researchers found that financial constraint and low health literacy were factors associated with reduced healthcare use and high morbidity in sickle cell disorders (Caldwell, 2020; Karadag et al., 2018; Loo et al., 2021). Maina et al. (2018), Power-Hays et al. (2020), and Sonik et al. (2018) have indicated that addressing an individual's necessities of life could be associated with improved health equity in childhood sickle cell disease. Likewise, Houwing et al. (2021) and Lee et al. (2019) found that the reduction of disparity and inequalities ensured the affordability of healthcare services in sickle cell disorders. Faremi et al. (2018) have alluded to health literacy as a protective factor in the prevention and control of sickle cell disorders. Similarly, community health literacy ensured prevention and control of sickle cell disorders, as mentioned by Gyamfi et al. (2021). Thus, the reduction of societal inequalities and disparity could predispose to reduced health outcomes in childhood sickle cell hemoglobin.

Houwing et al. (2021) have emphasized on caregiver's decision making as a significant factor in the provision of equitable healthcare in childhood sickle cell disorders. In a similar fashion, Caldwell (2020) have showed the interaction between caregiver's health literacy, sickle cell disease, health outcomes, behavior, healthcare use,

media exposure, and trait. Parent's health literacy affected uptake of prescribed medical treatment in childhood diseases, leading to the need to improve education level in the society (Brega et al., 2021; Firmino et al., 2018; WHO, 2019c). As stated above, the determinants of health outcomes in childhood sickle cell anemia included various factors, such as parent's health-related behaviors, care giver's knowledge, and parent's education level. A mother's experience was important to limit the disabilities encountered by childhood sickle cell disorders by Bartlett et al. (2021) and Iebni et al. (2020). Researchers have stressed on the benefits of parent's health education in management of community-acquired infection and early diagnosis in sickle cell disorders (Brega et al., 2021; Liu, 2021; Middleton et al., 2018). Thus, caregiver's health education is a method of achieving control and prevention of sickle cell disease. Family's health literacy may determine the clinical outcomes in childhood sickle cell disease.

Gender-related violence is a social risk factor embedded in societal inequality. In Sub-Saharan Africa, women's decision making on health-related issues hinge on the extended family members, leading to reduced well being and health (Alradie-Mohamed et al., 2020; Gbadebo et al., 2018; Kandala et al., 2018; Sabahelzain et al., 2019; United Nations Population Fund [UNFPA], 2021; Vanguard, 2019). The WHO designated structural violence (such as gender inequality) as a violation of human rights and the need to address the problem at state, local, or national level (Cottler-Casanova & Abdulcadir, 2021; Elbendary et al., 2021; Shobila et al., 2021; WHO, 2019c). In a similar fashion, institutional or structural violence was associated with various health complications such as community-acquired infection, pre- and post-natal complications, and neonatal death

(Alradie-Mohamed, 2020; Lurie et al., 2020; UNICEF, 2021). As mentioned, mother's autonomy could influence the uptake of innovation affecting prognosis of childhood sickle cell disease.

Women's autonomy could be associated with improved survival or life expectancy in the society (Alradie-Mohamed et al., 2020; Gbadebo et al., 2021, NPC, 2019, Vanguard, 2019). An evidence-based awareness campaign could limit the health-related effects of gender-related violence in developing countries, Nigeria included (Awolola & Ilupeju, 2019). Similarly, Osunkwo et al. (2020) and Hood et al. (2022) indicated that stigma and institutional violence in childhood sickle cell disorders must be addressed by different government departments. According Mbanya et al. (2018) and Alradie-Mohamed et al. (2020), the lack of gender equality prevented eradication of structural or institutional violence in the society. Besides, Homan et al. (2021) have examined the interaction between structural violence and adverse health outcomes. Gender inequality could predispose to reduced life expectancy in childhood sickle cell hemoglobin. Campaign on dangers of gender-related violence could lead to improved survival in childhood sickle cell disorders.

Health care access to community-based genotype test could be essential in achieving improved health outcomes in children aged 6-59 months. Authors found that a child's well being depended on the provision of community-based genetic screening and counselling as well as health literacy (Nnodu et al., 2019; see also Meier et al., 2020; Steele et al., 2019; Wilson et al., 2021). Likewise, parent's uptake of innovation (e.g., genotype test) was influenced by various factors such as health-related behavior and

health education (Kuyinu et al., 2020; McClintock et al., 2020; Mor-Anavy et al., 2021). According to Oluwole et al. (2020), mother's acceptance of early genotype test led to prevention and control of sickle cell hemoglobin. Aboagye et al. (2019) found that health workers involvement in the dissemination of health-related information led to improved health status and well being in sickle cell hemoglobin participants. Community campaign on the importance of early diagnosis of sickle cell hemoglobin could lead to reduction in medical complications.

Health education could be a way of achieving health-related behavior among community members. Bhatt et al. (2019) and Inusa et al. (2020) stressed that health literacy was the ability to understand and use health-related information in the society According to Torlesse and Aguayo (2018), mother's health literacy enabled success of malnutrition prevention in pregnancy, leading to reduced adverse outcomes in *fetus* after birth. Also, health literacy affected decision making on prevention and control of chronic diseases (Liu et al., 2020). To summarize, health education must be ensured in the communities to ensure improved adherence to public health prevention measures, geared towards improved control and prevention of chronic diseases.

Furthermore, health literacy could be a way of achieving reduction of health cost, quality health, and improved health outcomes (Mor-Anavy et al., 2021; Hug et al., 2019; Xu et al., 2020). Niu et al. (2021) found that internet use was associated with improved dissemination of health-related information. Professional degrees accomplishment was lower in Sub-Saharan Africa compared to advanced countries due to social disparity (Gates, 2021a). According to Liu et al. (2020), exposure to health-related information

could impact family's decision making on health issues. Given these points, the uptake of an innovation could hinge on various factors such as parent's education, health literacy level, and women's decision making.

Authors examined the association between disabilities, health literacy level, healthcare access, and adverse health outcomes (Dormandy et al., 2018; Marks et al., 2018). In Nigeria, community access to healthcare services was determined by various factors such as health literacy, healthcare providers, family's decision making, and treatment cost (Koce et al., 2019). The unimplemented government policies in developing countries were associated with the inability to achieve improved healthcare coverage in developing countries (Akinyemi et al., 2021; Kruk et al., 2018). Health literacy could lead to the attainment of UN sustainable goals in Sub-Saharan Africa.

Also, researchers focused on the interaction or relationship between inadequate healthcare services, gender-related violence, disabilities, and childhood sickle cell hemoglobin (Alradie-Mohamed et al., 2020; Bartlett et al., 2020; Caldwell, 2020; Mann et al., 2021). Umeakunne et al. (2019) and Nerves et al. (2021) examined the relationship between health literacy, well being, and childhood sickle cell disorders in Sub-Saharan. According to Kanter et al. (2021), childhood sickle cell disorders treatment was influenced by lack of government initiatives designed to enhance improved survival in the communities. Overall, addressing social risk factors in children living with childhood sickle cell hemoglobin could ensure improved life expectancy.

Sickle Cell Hemoglobin and Socioeconomic Status

Families' social background could influence a child's health and well being. Accinelli and Leon-Abarca (2020) socioeconomic status was a determinant of health status and well being in childhood sickle cell disorders. Although children living with sickle cell disorders were susceptible to increased life-threatening infection, screening for social risk factors could allow improved health outcomes and life expectancy (Cortright et al., 2020; Creary, 2021; Ojelabi et al., 2019). Likewise, the socioeconomic determinants of health influenced the phenotypic or clinical variation in sickle cell disorders (Inusa et al., 2019). In light of the above challenges, health inequity could worsen survival of children living with sickle cell hemoglobin.

Ownership of household goods, wealth index, type of flooring material, and toilet facility were measures of socioeconomic status, as mentioned by Islam et al. (2021) and Lubeck et al. (2019). Children living with sickle cell disorders were predisposed to illness due to various risk factors such as healthcare cost, health system, hospital facilities, and education attainment (Karadag et al., 2018). Again, Lubeck et al. have examined the relationship between life expectancy, sickle cell disorders, and income. The economic burden of sickle disease could be reduced through provision of social services and services.

Household low socioeconomic status led to increased risk of life-threatening complications and adverse health outcomes (Stanaway et al., 2019). Because of the high poverty level in Sub-Saharan African, the case fatality rate in chronic diseases was invariably high (El-Kader & Al-Shreef, 2018; Lubeck et al., 2019). In a similar fashion,

researchers focused on the interaction between socioeconomic status, family's setting, environment, psychology, and sickle cell disorders (Downes et al., 2019). Thus, a child's phenotypic presentation could be affected by social, economic, and psychological factors.

First, Miao et al. (2021) showed that the measures of socioeconomic status in the community included various selected variables such as minority status, poverty, immigration status, employment status, and population density. Secondly, screening for social determinants of health was a form of public health strategies in the community, leading to improved clinical outcomes and enhanced patient's referral systems (Browne et al., 2021). Thirdly, unjust distribution of health resources was responsible for the variation in life expectancy and health outcomes (Hahn et al., 2018; Booysen et al., 2021). Fourth, Obse and Ataguba (2021) found that socioeconomic status was a determinant of adverse health outcomes in childhood sickle cell disorders. Lastly, screening for social determinant in childhood sickle cell hemoglobin could lead to attainment of universal health (Etiaba et al., 2018; Taniguchi et al., 2021).

Researchers indicated the need to address social determinants such as healthcare, vaccination, infections, and poverty (Berman et al., 2018; Ibemere et al., 2021; Nnodu et al., 2021; Ojelabi et al., 2019; Zheng et al., 2018). Yaya et al. (2020) found that the socioeconomic status was a determinant of childhood mortality and morbidity. Screening for social determinants of health in childhood sickle cell disorders led to increased resources allocation as well as improved health status (Cortright et al., 2020; Hardy et al., 2021; Power-Hays et al., 2020). Screening for social determinants in sickle cell disorders,

a secondary public health prevention measure, could lead to improved survival in the communities.

Menalu et al. (2021) and Van Malderen et al. (2019) have examined the relationship between residential areas, occupation, mother's education level, race, ethnicity, and religion. Also, Gavhi et al. (2020) have focused on the interaction between malnutrition, socioeconomic status (i.e., poverty), and healthcare access. Equal distribution of regional resources led to improved health outcomes or survival, as mentioned by Booysen et al. (2021) and Power-Hays et al. (2020). In a similar fashion, Victoria et al. (2021) and Htwe (2021) have provided that the prevalence and incidence of childhood diseases was affected by the prevailing social determinants of health (i.e., low education, rural residence, malnutrition, and poverty). The proportion or prevalence of childhood sickle cell hemoglobin could vary based on the dominating social determinants.

Because researchers needed accurate data to calculate prevalence of sickle cell disorders, there was a need to screen for health determinants (Congress United States, 2018; Lee et al., 2019; Ogu et al., 2021). Also, health inequalities and disparity in children could contribute to childhood growth failure (i.e., wasting, stunting, and anemia) and maternal anemia (Torlesse & Aguayo, 2108). Mahajan et al. (2021) found that children living with sickle cell anemia were burdened with low healthcare access arising from disparity and inequalities in the society. Besides, Williams et al. (2018) have examined the relationship between sickle cell hemoglobin, behaviors, socioeconomic status, and healthcare utilization. Studies addressed the interaction between inequalities

(i.e., food insecurity, low healthcare services, illiteracy, poor social support) and a child's health status (Htwe, 2021; WHO, 2021c). Given these points, a child's failure to thrive could be related to the dominant social determinants.

Infection Prevention Treatment and Sickle Cell Hemoglobin

Life-threatening infections could be associated with reduced health outcomes in the society. According to Eleonare et al. (2020) and Ochocinski et al. (2020), children living with sickle cell anemia were susceptible to life-threatening infection due to reduced immunity. Because malaria infection predisposed to selective sparing of children living with genotype AS, sickle cell hemoglobin was perpetuated in malaria endemic areas (Delgadinho et al., 2021). In Sub-Saharan Africa, a total of 50-90% childhood sickle cell disorders did not survive until adulthood due to health inequalities (e.g., malnutrition and austere environment), as mentioned by Islam et al. (2021) and Nnodu et al. (2021). Globally, malnutrition affected a total of 149 million children aged 6-59 months in the global community (UNICEF, 2018a). In Sub-Saharan Africa, the number of deaths in 2019 resulting from infections was 94% (WHO, 2021f). From the above statistics, infections and malnutrition are social risk factors linked to reduced life expectancy in childhood sickle cell disorders.

Malaria infection was a risk factor of increased mortality and morbidity in childhood sickle cell disease, indicating the need for evidence-based prevention and control strategies in developing countries (Eleonare et al., 2020; WHO, 2021e). Malaria infection was a common cause of death in Sub-Saharan Africa, raising question for effective prevention and control measures (Oppong et al., 2020). Besides, Eleonare et al.

showed that national malaria prevention and control programs led to improved survival in childhood sickle cell hemoglobin. Again, Oppong et al. found that high burden of malaria and malnutrition was associated with increased mortality and morbidity in sickle cell disorders. Malaria prevention and control strategies in the communities could be an effective intervention.

Researchers found that the presence of malaria infection led to increased blood transfusion rate in childhood sickle cell disease (Chou et al., 2020; Kosiyo et al., 2020; 2021; Ochocinski et al., 2020). Also, childhood sickle cell disorders benefited from different management methods such as immunization, malaria screening, antibiotics prophylaxis, blood transfusion, and nutrition therapy (CDC, 2020b; Chou et al., 2020; Roschnik et al., 2019; UNICEF, 2018b; Wemakor et al., 2018). Public health prevention strategies for childhood malaria fever included the following: (a) insecticide-treated net, (b) pharmacologic treatment, and (c) rapid confirmation test (Ameyaw et al., 2020; Bertozzi-Villo et al., 2021; Green et al., 2021; WHO, 2021d). As mentioned, malarial infection prevention could be an effective primary prevention strategy, leading to improved survival in childhood sickle cell disorders.

Islam et al. (2021), Torlesse and Aguayo (2018), and Umeakunne et al. (2019) suggested that fetal growth retardation was prevented through various actions such as infection prevention, nutrition supplementation, or both. Authors found that immune suppression in childhood sickle cell disease led to increased susceptibility to medical complications (Isa et al., 2020; 2021). Suryawan et al. (2021) documented childhood malnutrition as a social risk factor of life-threatening infection and growth failure. Thus,

childhood malnutrition resulting from societal inequalities could predispose to increased morbidity and mortality in the communities.

The UN sustainable development goals must be entrenched in the legislation, leading to improved universal health coverage in Sub-Saharan Africa (Taniguchi et al., 2021; UN, 2020). Researchers have suggested the need for a national policy formulation in children living with sickle cell disorders aged 6-59 months, leading to attainment of health for every child (Report of Nigeria's 2020 Voluntary National Review, 2020). Taken together, policy favoring improved survival in childhood sickle cell disorders could lead to improved achievement of global sustainable goals.

Nutritional therapy early in life could lead to reduction of under-5 mortality. Breastfeeding was a primary prevention strategy of reducing infections and malnutrition (Horword et al., 2018; Torlesse & Aguayo, 2018; West et al., 2019). Early life malnutrition was a risk factor for cognition impairment in children aged 6-59 months (Suryawan et al., 2021). Similarly, Ellis et al. (2020) have documented the benefits of micro- and macro-nutrient administration in genetic disorders. Again, West et al. suggested health workers counselling as a method of improving exclusive breastfeeding uptake. Nutritional therapy was a method for infection prevention, as mentioned by Ugboko et al. (2021) and Datta et al. (2019a). According to Badawy et al. (2021), treatment of medical complications in childhood sickle cell disorders improved health quality and life expectancy. Childhood sickle cell disorders could attain improved survival from exclusive breastfeeding and complementary feeding.

Feldman-Winter (2020) and Horwood et al. (2018) found that exclusive breastfeeding was a method of reducing morbidity and mortality in children under 5-years-old. Donkor et al. (2021) found that diet supplement (i.e., complementary feeding) was a method of achieving prolonged life expectancy. In a similar fashion, Nerves et al. (2021) found that complementary diet was a method of prevention of childhood malnutrition. Donkor et al. provided that complementary diet was a modality to prevent complications in chronic diseases. Thus, complementary feeding could accelerate infection prevention in children living with sickle cell disorders.

Considering the above, the following nutrition supplement led to infection prevention: (a) protein (such as African edible insect), (b) vegetables and fruits, and (c) carbohydrate (Hlongwane et al., 2021; Nerves et al., 2021; Thirumdas et al., 2021). Researchers suggested that diet supplement was a way of improving health outcomes in Sub-Saharan Africa (Nowakowski et al., 2021). Both palm beetles and grasshoppers were inexpensive modalities of childhood malnutrition prevention in low- to middle-income countries (Anaduaka et al., 2021). Besides, Nowakowski et al. suggested edible insect as an inexpensive source of protein in the community. Food supplement with edible insect fulfilled the UN development goals that considered the promotion of a safe environment and reduction of childhood diseases (Moruzzo et al., 2021). The advantages of diet supplement with micro- and macro-nutrient (i.e., omega fatty acids) was mentioned by Umeakunne and Hibbert (2019). Children in developing countries could benefit from inexpensive sources of energy such as edible insects, leading to reduction of adverse experiences.

Islam et al. (2021) and Oron et al. (2020) have examined the relationship between diet supplement, childhood sickle cell disorders, and health outcomes. Similarly, Hlongwane et al. (2021) and Roschnik et al. (2019) found that health-related behaviors (e.g., diet supplement) played a significant role in childhood sickle cell anemia. Researchers suggested malaria fever treatment methods such as such as pharmacology (e.g., quinine), vector reduction (e.g., insecticides), and poverty alleviation (Agyemang-Duah et al., 2018; Engels & Zhou, 2020, Muhammad et al., 2021; Tan et al., 2020). Equally, prevention of malaria infection with available public health measures could reduce childhood life-threatening complications (Chou et al., 2020; Delgadinho et al., 2021; Eleonare et al., 2020). Thus, childhood sickle cell hemoglobin survival may be reduced due to social risk factors such as infection, disabilities, and low socioeconomic status.

Because of the increased risk of poverty in developing countries, children living with sickle cell disorders were prone to nutrition deficiency (Islam, 2021). Also, Nartey et al. (2021) found that health-related knowledge led to improved clinical outcomes in sickle cell disease. Researchers pointed to nutrition as a determinant of phenotypic presentation in sickle cell disorders (Kamal et al., 2021). In a similar manner, Power-Hays et al. (2020) showed that the lack of nutrition-related information in sickle cell disorders did not lead to the achievement of universal health coverage. Islam et al. (2021), Menalu et al. (2021), and Suryawan et al. (2021) found that diet supplement was an effective method of achieving improved health status in children living with sickle cell hemoglobin aged 6-59 months. Again, Kamal et al. underscored that sickle cell disorders

medical complications were accentuated by nutrient deficiency, leading to the need for complementary diet early in life. Overall, the burden of sickle cell disorders in the community could be limited by screening for social determinants of health (e.g., undernutrition).

Children are susceptible to neglected tropical diseases due to disparity and health inequalities. Efunshile et al. (2019) and Engels and Zhou (2020), and Winkler et al. (2018) showed that fever management was a method of medical complications prevention in neglected tropical diseases. Datta et al. (2019a) found that zinc was an effective treatment in childhood diarrhea. In a similar fashion to above studies, Ugboko et al.'s (2021) cross-sectional study in Nigeria provided a statistically significant interaction between prevalence of childhood diarrhea, mother's education, and household wealth index, but age and gender did not show statistically significant findings. As mentioned, Engels and Zhou suggested various methods of treatment in neglected tropical diseases such as improved sanitation, safe water, and vector control. Health policy formulation and collaboration at the global response could address neglected tropical diseases in Sub-Saharan Africa.

Above 1.0 billion global population are affected by neglected tropical diseases (Reiner et al., 2018; WHO, 2022; Weng et al., 2018). Winkler et al. (2018) and Hotez et al. (2020) found that the high prevalence of neglected tropical diseases led to reduced life expectancy in the society. Similarly, Datta et al. (2019a) suggested that treatment of neglected tropical diseases was essential to limit disability. Authors focused on the burden of infectious diseases in low- to middle-income countries, leading to the need for

policy formulation to reduce medical complications (Ajisegiri et al., 2021; Eleonare et al., 2020). Hockham et al. (2018) suggested sickle cell hemoglobin as a neglected chronic disorder in developing countries. Effective treatment of neglected chronic diseases could warrant use of evidence-based guidelines.

Stanaway et al. (2019) and Reiner et al. (2018) found that adequate management of childhood diarrhea disease could allow improved health outcomes and well being in Sub-Saharan Africa. The management of childhood diarrhea included interventions such as deworming, alleviation of poverty, hand washing, oral rehydration therapy, intravenous fluid administration, and/or use of analgesics (Efunshile et al., 2019; Tan et al., 2020, WHO, 2021d). Similar to the studies in the above paragraph, Engels and Zhou (2020) found that fever treatment in neglected tropical diseases was associated with improved survival in childhood sickle cell disorders. Again, Engels and Zhou found that policy implementation was associated with reduction of adverse outcomes due to neglected tropical diseases. Therefore, multidisciplinary approaches on treatment of neglected tropical disease (e.g., childhood diarrhea) could lead to improved life expectancy in the society.

Vaccination coverage in developing countries could be visited using the lens of social determinants of health. Researchers found that vaccination in childhood sickle cell disorders was a significant method of reducing acute and chronic medical complications (Akrimi & Simiyu, 2018; WHO, 2021d). Also, vaccination was a public health prevention strategy associated with limitation of disabilities and community-acquired infections in the communities (Whittaker et al., 2019). Taniguchi et al. (2021) suggested

that wide coverage of immunization allowed reduction of disabilities from childhood diseases (such as measles, poliomyelitis, and tuberculosis). Similarly, Hlongwane et al. (2021) and Roschnik et al. (2019) found that behavior played a role in the uptake of an innovation (i.e., vaccination) in childhood sickle cell hemoglobin. Improved vaccination uptake could prevent disabilities in Sub-Saharan Africa.

Expanded program on immunization in Nigeria was below the projected figure, raising the need for equality in vaccination coverage (Bangura et al., 2020; Nnodu et al., 2020; Obasohan et al., 2018). Researchers have suggested the following vaccination regimen in childhood sickle cell disease (a) penicillin, (b) hydroxycarbamide, (c) pentavalent, and (d) pneumococcal (Ekouveni et al., 2018; Nnodu et al., 2020; Reeves et al., 2018). In similar fashion to above fashion, childhood immunization allows primary protection against infectious diseases in the community, allowing an argument for improved coverage in Sub-Saharan Africa (Budreviciute et al., 2020; CDC, n.d.; Nadella et al., 2019; UNICEF, 2018a). Neonatal infection prevention lead to improved health and well being in childhood sickle cell disorders.

Blood transfusion is a treatment of choice in managing neonatal infection in sickle cell disorders. Chou et al. (2020) and Darshana et al. (2021) found that blood transfusion improved the prognosis in childhood sickle cell disorders. Jakbowska et al. (2021) found that refusal of blood transfusion, a lifesaving procedure, was associated with increased susceptibility to community-acquired infection. Similarly, refusal of blood transfusion on religious ground raised an argument for law aimed at limitation of the practice, as

mentioned by Conti et al. (2018). Institution of an ethical framework aimed at limitation of blood transfusion refusal could allow improved survival in the vulnerable groups.

Demography and Sickle Cell Hemoglobin

The clinical manifestations of childhood sickle cell disorders could vary based on the influence of social risk factors. Isa et al. (2020, 2021) have alluded to the geographic variation of phenotypic or clinical presentation in childhood sickle cell disorders. Also, authors have pointed to environment as a determinant of health status and well being (Gebregziabher et al., 2018; Loo et al., 2021; Tanou et al., 2021). In Sub-Saharan Africa, geography affected the distribution of health resources and accounted for poor access to healthcare services (Magnan, 2021; Nnodu et al., 2019). Claeys et al. (2021) and Faremi et al. (2018) have focused on the environment as a predictor of phenotypic or clinical presentation in sickle cell disorders. In keeping with above studies, Serjeant & Vinchisky (2018) showed that environment (e.g., socioeconomic status, geography, education, psychology) and genetics affected the prognosis in sickle cell disorders. Policy on effect of health inequalities and geographical variation could lead to accurate national data on sickle cell disorders (Congress United States, 2018; Kanter et al., 2021; Sageer et al., 2019). Therefore, childhood sickle cell disorders medical complications could be altered by the harsh environmental factors.

According to Akrimi and Simiyu (2018) and Dwivedi et al. (2019), children living with sickle cell disorders were predisposed to disparity, leading to poor healthcare access in the communities. Also, health inequalities resulting from geography (i.e., biology, culture, and residence) were linked to poor health outcomes and reduced life expectancy

(Leon & Shkolnikov, 2021; Mitchell et al., 2022; Permanyer et al., 2022; Rashid et al., 2021). In a similar manner to previous studies, authors suggested that health inequalities and inequities were the reason for high mortality and morbidity in chronic diseases (Royal et al., 2020). The phenotypic variation (i.e., individual differences in expression of clinical features) differed based on age, gender, geography, climate, and social factors (e.g., health service access, and treatment adherence), and climate (Inusa et al., 2019). Hockham et al. (2018) asserted that medical complications in genetic disease were related to geographical variation. Demographic variation could alter the medical complications in childhood sickle cell disease.

Researchers found that children living with sickle cell hemoglobin in Sub-Saharan Africa were burdened by various challenges such as austere environment (e.g., infection and structural violence), female discrimination, infection (e.g., malaria and childhood diarrhea), disparity, and health inequalities (Alradie-Mohamed et al., 2020; Cortright et al., 2020; Ojelabi et al., 2019; Pittet & Posfay-Barbe, 2021). Similarly, Ibemere et al. (2021), Faremi et al. (2018), and Liu et al. (2020) have examined the relationship between childhood sickle cell disorders, healthcare access, disparity, and adverse health outcomes. Again, Cortright et al. found that reduced healthcare access arose from low socioeconomic status (e.g., poverty and unavailable health insurance). Limitation of disability in vulnerable groups could include screening for social risk factors such as regional variation of resources distribution and health inequalities.

Also, chronic disease manifestations were influenced by regional discrepancy in healthcare budget and spending (De Vries et al., 2018). Baum et al. (2020) indicated that

residence was a determinant of clinical presentation in chronic diseases. The age at diagnosis of sickle cell disorders was affected by the selected variables such as newborn genotypes screening, education, parents' wealth index, health literacy, environment, genetic composition, and culture (Claeys et al., 2021). In a similar manner to previous paragraph, geographic variation may culminate in different presentation of anemia in children under 5-years-old (Accinelli & Leon-Abarcha, 2020). As mentioned, the variation in the clinical presentation childhood sickle cell disorders could be influenced by genetic constitution and social determinant.

Migration was responsible for the geographic variation in the prevalence of sickle cell hemoglobin in different parts of the globe (De Franceshi et al., 2019; Delgadinho et al., 2021). Also, Yanamandra et al. (2018) found that severe environmental stress predisposed to health deterioration in children living with genotypes AS, SS, AC, and SC. The differences in phenotypic presentation of sickle cell disease were due to the dominant environmental factors in the society by Ameyaw et al. (2020) and Pertet et al. (2018). In a similar manner, Royal et al. (2021), Abdulwahab et al. (2021), and Inusa et al. (2019) found that the clinical variations in the presentation of sickle cell hemoglobin were based on a child's genetic composition and the environment. The environment could contribute to the variation in the signs and symptoms among children living with sickle cell hemoglobin.

Gage et al.'s (2021) cross-sectional study found that geographical variation was associated with neonatal mortality rate in Sub-Saharan Africa. Nevertheless, Roder-DeWan et al. (2020) found that geography and healthcare use were not predictors of

neonatal death rate. According to Antwi-Boasiako et al. (2020), sickle cell-related leg ulcer was higher in the male child in comparison to their female counterpart, indicating variation in clinical presentation based on gender. Dwivedi et al. (2019) and Gebregziabher et al. (2018) found a significant association between geography, health care, inequalities, and health quality. Besides, Mishra et al. (2019) suggested that clinical manifestations varied in population living with chronic diseases. Therefore, regional variation in medical complications of sickle cell disease could result geography and gender.

Race is a social construct connected to various clinical complications of chronic diseases. Vulnerable groups are easily susceptible to the disadvantages of unequal distribution of health resources and wealth in the society. Race led to decreased healthcare access and reduced health inequalities in the society (Cerdena et al., 2020; Mahajan et al., 2021). Similarly, Lee at al. (2021) asserted that health differences created by race could be revealed through accelerated medical complications (such as infection) in sickle cell hemoglobin. Faremi et al. (2018) examined the relationship between family's skills, sociodemographic characteristics, and childhood sickle cell hemoglobin. By and large, race could play a role in the clinical complications of childhood sickle cell disorders.

The patterns of morbidity in chronic diseases could differ based on ethnicity or race (Gebregziabher et al., 2018). Similarly, Leonard et al. (2019) and Reeves et al. (2018) found that genetic composition or trait played a role in clinical manifestation of sickle cell disease. Royal et al. (2020) have examined the association between social risk

factors (such as urban, rural, temperature, and healthcare access) and genetic factors (such as hemoglobin) in childhood sickle cell hemoglobin. Besides, the clinical variation in sickle cell hemoglobin was affected by race and ethnicity (Burton, 2019). Researchers found that a female gender was a significant predictor of sickle cell-related pain (Wonkam et al., 2018). Also, Chao et al. (2021) found that a female gender was significant predictor of adverse events. According to Tartaglione et al. (2021), the early age of sickle cell hemoglobin pain manifestation dictated the efficacy of interventions (e.g., pharmacological therapy, hospitalization, and blood transfusion). The interaction between demography and socioeconomic status could explain the phenotypic or clinical variation in symptoms of childhood sickle cell hemoglobin.

Cerdena et al. (2020) and Nembhard et al. (2019) found that race was a social construct in the variation of childhood acute and chronic medical manifestations (e.g., anemia, preterm birth, and small-for-age newborn). Authors examined the interaction between race, ethnicity, disparity, and health inequities (Bambra et al., 2020, 2021). According to Faremi et al. (2018), ethnic minority groups did not benefit from health-related information on early genetic screening. Overall, children living with sickle cell hemoglobin are at a disadvantage of disparity and health inequalities based on race.

Culture is a social factor linked to various clinical manifestations of chronic diseases. Religion affected the decision to accept blood in sickle cell disease, leading to the experienced adverse health outcomes by Aziz et al. (2021) and Jakubowska et al (2021). In a similar fashion to the above studies, researchers argued on the interaction between culture, health-related behavior, residence, health outcomes, and sickle cell

hemoglobin (Ibemere et al., 2021). Conti et al. (2018) have focused on the interaction between religion, blood transfusion and consent. Religion may influence consent for blood transfusion, a lifesaving treatment procedure, in childhood sickle cell disorders. The need for cultural sensitivity could be required during medical management of childhood sickle cell hemoglobin.

Gebregziabher et al. (2018) have examined the interaction between stigma, discrimination, healthcare use, and an innovation uptake. In a similar manner to the previous studies, Fisher et al. (2018) found that structural violence was a significant predictor of a child's adverse health outcomes. In addition, culture influenced the treatment of anemia and pain in childhood sickle cell hemoglobin (Vadehra et al., 2020). Therefore, institutional violence could be addressed by expansive, flexible, and timely policies.

Pain and Anemia and Sickle Cell Hemoglobin

Medical complications in sickle cell disease could vary early in life due to genetic composition and social risk factors. Because of the elevated level of fetal hemoglobin in infants in the first six months of life, sickle cell disease symptoms and signs were minimal early in life (Maakoron & Taher, 2020). However, the clinical features became apparent after the first 6 month of life (Datta et al., 2019b; Ramsay et al., 2021). The mechanism of acute pain in sickle cell anemia was mainly due blockage of the small vessels, leading to loss of oxygen supply to the major organs (Du et al., 2019; Renoux et al., 2018; Saramba et al., 2020). Children living with sickle cell hemoglobin are symptoms free in the first 6 month of life.

Sickle cell disorders could predispose to unendurable bone pain later in life, leading to reduced survival in the community. Also, researchers found that acute pain was a common complications of sickle cell disorders, amenable to the use of potent analgesic (Palermo et al., 2018; Uwaezuoke et al., 2018). Similarly, sickle cell-related bone pain was amenable to blood transfusion (Fikru et al., 2019; Karadag et al., 2018; Yaya et al., 2019). Simmons et al. (2019) have advocated for early management of pain in childhood sickle cell disease, culminating in improved survival in the community. Ochaya et al. (2018) have suggested a significant relationship between diet folate supplement, sickle cell hemoglobin, pain relief, and fever treatment. Tertiary prevention of medical complications (e.g., complementary therapy) in sickle cell disease could lead to improved survival in the communities.

Furthermore, Carroll (2019) and Brandow et al. (2020) found that the treatment of pain involved various pharmacological and complementary approaches such as antiinflammatory agents, opioid, psychology, health-related behaviors, and tricyclic antidepressants. Also, researchers found that acupuncture was an effective treatment of sickle cell-related pain in comparison to analgesic use (Mohammed et al., 2020). Management of sickle cell disorders involves assessment for health-related quality of life aimed at improved survival (Bartlett et al., 2021). In a similar fashion the above studies, authors emphasized on the effective response of acute chest syndrome and vaso-occlusive pain to analgesic use in childhood sickle cell disorders (CDC, n.d.; Darbari et al., 2021; Saramba et al., 2020; Willen et al., 2018a). Again, Willen et al. stated that management of sickle cell hemoglobin complications (such as bone pain) led to improved health

outcomes and life expectancy. Childhood sickle cell hemoglobin pain crisis management strategies could diminish mortality through judicious use of pharmacological and adjuvant approaches.

Childhood sickle cell disorders response to adjuvant therapy may vary based on the dominating social risk factors. Umeakunne and Hibbert (2019) have found that nutritional therapy was a modality to reduce medical complications in sickle cell disorders. According to Cisneros and Thein (2020), monitoring of medical complications (e.g., anemia and pain) in sickle cell disorders allowed improved quality of life. Also, Reeves et al. (2018) have examined the relationship between antibiotic prophylaxis, sickle cell hemoglobin, infection, and anemia. Similar to the above studies, researchers suggested that the management of medical complications in sickle cell disorder was possible using stem cell transplant, blood cell transfusion, and hydroxyurea (Abdullahi et al., 2021; Cisneros & Thein, 2020; Kapoor et al., 2018; Lamsfus-Calle et al., 2020). Hence, multidisciplinary management of childhood sickle cell hemoglobin can ensure improved health and well being.

According to Lopez et al. (2021), the childhood adverse health outcomes were determined by various variables such as epigenetics, social, ecology, genetics, and environment. Researchers stated that multidisciplinary pain management must target interventions such as psychosocial (e.g., provider's attitude, stigma, environment stress, disparities, depression, and anxiety), biology (hematological indices and multi-organ dysfunction), and geography (Brandow & DeBaunm, 2018; Brousseau et al., 2020; Kindzeka, 2018; Du et al., 2018; Kanter et al., 2018). Also, the use of rehydration therapy

in vaso-occlusive pain, precipitated by environment stress, was indicated in sickle cell hemoglobin (Gaartman et al., 2020; see also Darbari et al., 2021). Management of acute and chronic medical complications (such as oral hydration and intravenous fluid) could reduce mortality and morbidity in sickle cell disease.

Genetic and nutritional anemia could overlap in childhood sickle cell disorders. According to Abdulwahab et al. (2021), genetic markers was applied to improve treatment of vaso-occlusive crisis in sickle cell disorders. Also, Meier et al. (2018) found that hydroxyurea treatment limited recurrent blood transfusion in sickle cell disorders. Rees et al. (2018) indicated that red cell transfusion diminished the severity of medical complications (e.g., anemia and pain) in sickle cell disorders. As mentioned, Oron et al. (2020) found that blood transfusion was an effective method to reduce acute and chronic complications of sickle cell disorders. Ahmed et al. (2019) study in Sudan suggested the benefits of emergency blood transfusion in childhood anemia. Fasano et al. (2019) have mentioned that blood transfusion led to improved prognosis in childhood sickle cell hemoglobin. Researchers have focused on the benefits of blood transfusion in childhood sickle cell disorders, refractory to pharmacological treatment (Wonkam et al., 2018). Finally, life-threatening complications in childhood sickle cell disorders could be reduced by complementary and conventional medicine.

Key Variables

Healthcare Use

Manyeh et al.'s (2020) study in Southern Ghana focused on the significant interaction between antenatal care, mother's education, health literacy, and adverse

pregnancy outcomes. Also, Um et al.'s (2019) study in Cameroon suggested the relationship between healthcare use, health literacy, health quality, and childhood sickle cell hemoglobin. Similar to the above studies, researchers showed the interaction between parent's awareness, health literacy, infection prevention, and childhood sickle cell disorders (Hsu, 2018). Kasai et al.'s (2020) study in Congo suggested a significant interaction between age, socioeconomic status, and genotype screening. Cronin et al. (2019) found that financial insecurity was a significant predictor of healthcare facilities use. As mentioned, Ibemere et al.'s (2021) study in Sierra Leone focused on the relationship between culture and sickle cell disease.

Gebremariam et al. (2019) have suggested that antenatal care use was a significant predictor pregnancy-induced nutritional anemia. Besides, researchers have showed the relationship between genotype screening, sickle cell hemoglobin, place of delivery, pregnancy outcomes, and post-delivery care (Ezenwosu et al., 2021). Similarly, Nimako et al. (2021) have showed service delivery (e.g., hospital facilities) as a statistically significant predictor of newborn survival. In contrast, Roder-DeWan et al. (2020) have presented a statistically insignificant relationship between neonatal death rate and healthcare facility availability. In a similar fashion to other studies, Gyamfi et al. (2021) have examined the relationship between sickle cell disease, innovation uptake, and healthcare utilization. Researchers have suggested a statistically significant interaction between communication (e.g., verbal and written), healthcare access, and internet use (Houwing et al., 2021). As mentioned, Karadag et al. (2018) have indicated

the various determinants of health literacy in childhood sickle cell disease such as parent's education attainment, gender, age, social security, and awareness.

Mbanya et al. (2018) have examined the relationship between variables such as mother's education attainment, health-seeking behavior, and perceived stigma. Also, Abreha et al. (2020) have suggested women's decision making as a determinant of a child's health status and well being. Fortin et al. (2018) have presented the interaction between community knowledge, sickle cell disease, and health literacy. Besides, Takeuchi et al. (2018) and Niu et al. (2021) have examined the association between internet use, family's health literacy, and health outcome. From the above, Bulgin et al. (2018) and Hood et al. (2022) have argued on the association between stigma, healthcare use, and family's financial constraints.

Also, researchers have focused on factors affecting uptake of genotype screening such as healthcare access, socioeconomic status, environment (i.e., geography), and treatment cost (De Haan et al., 2020; Nnodu et al., 2020; NPC, 2019; Steele et al., 2021; Wilson et al., 2021). Also, Niu et al.'s (2020) cross-sectional study considered the relationship between age, education, annual family's income, and behavior. Similarly, Bhatt et al.'s (2019) cross-sectional study examined the association between health literacy, income, gender, education attainment, and socioeconomic status. Manyeh et al. (2020) have examined the interaction between education attainment and healthcare access (e.g., antenatal care). Alradie-Mohamed et al. (2020) have examined the relationship between women's decision making and health literacy. In keeping with above studies, Awolola and Ilupeju (2019) and Sabahelzain et al. (2019) have examined the relationship

between women's autonomy, health literacy, religion, and parent's education attainment. In addition, Fortin et al. (2018) found that behavior was a significant influential factor in blood transfusion.

Asnani et al. (2021) have examined the relationship between mother's behavior, health literacy, childhood sickle cell disease, and health outcomes. Again, Williams et al. (2018) have examined the relationship between behavior and healthcare utilization, and health status. Bills et al. (2020) focused on the interplay between family's health-related behavior and childhood sickle cell disease. Roschnik et al. (2019) have examined the relationship nutritional therapy, chronic disease, behavior, and medical complications. Likewise, Okedo-Alex et al. (2019) have examined the association between antenatal care, treatment cost, parent's education level, religion, ethnicity, parity, and culture.

Takeuchi et al. (2018) found that health education (e.g., internet use) was significantly associated with a child's health outcomes. Islam et al. (2021) have examined the relationship between mother's education attainment, and geography (e.g., residence). In the same way, Akinyemi et al. (2021) have examined the association between healthcare use, residence (i.e., urban), mother's deprivation index (e.g., employment status, healthcare use, facility distance, newspapers reading, and education), and mother's decision making. Similarly, Rocha et al. (2021) have examined the association between mother's knowledge and sickle cell hemoglobin.

Aboagye et al. (2019) have found that health worker's knowledge was a significant predictor of an efficient genetic counselling. Similarly, Adegoke et al. (2018) have suggested a significant interaction between health knowledge and sickle cell

disease. Ismainar et al. (2020) have suggested a significant association between women's behavior and antenatal care use ($p < .001$). Coupled with above findings, researchers examined the relationship between antenatal care, parity, poverty, mother's age and employment status, religion, father's education attainment, marital status, socioeconomic status, postpartum experience, and geography (Obse & Ataguba, 2021; Okedo-Alex et al., 2019; Tarasoff et al., 2020; Tessema et al., 2021). Rance and Skirton (2019) have showed a significant association between mother's knowledge and sickle cell disease. In the same way to the above studies, Olwit et al. (2018) have focused on the interaction between family's behavior and sickle cell disease.

Ogamba et al. (2020) have examined the relationship between treatment cost, sickle cell disorders, and out-of-pocket payment. Because of the recurrent hospital admissions in childhood sickle cell disease, families were not able to afford the treatment cost (Gardner, 2018). Children living with sickle cell disease were prone to adverse health outcomes due to health inequalities and disparity (Power-Hays et al., 2020). As mentioned, the geographic distribution of scarce resources may affect healthcare provision in sickle cell disease (Dave et al., 2019).

Socioeconomic Status

In a study conducted in Ghana, researchers have focused on measures of socioeconomic status such as insurance status, floor material, and handwashing facilities (Apanga & Kumbeni, 2021). In addition, the significant relationship between socioeconomic status and genotype test uptake was mentioned by Kasai et al. (2020). Islam et al. (2019) have provided the interaction between malnutrition, anemia,

socioeconomic status, and sickle cell disease. Abreha et al. (2020) have suggested the measures of socioeconomic status such as women's autonomy, mother's education attainment, and access to media. In the same way, researchers have documented the measures of socioeconomic status such as wealth index and health insurance use (Cortright et al., 2020; Duodu et al., 2021). Again, Nnodu et al. (2019) have considered measure of socioeconomic statu such as residential location. Coupled with the above, Gerardin et al. (2021) have examined the relationship between medical complications, socioeconomic status, environment, and childhood sickle cell disorders.

Islam et al. (2021) have suggested measures of socioeconomic status such as flooring, goods ownership, and drinking water sources. In addition, researchers have mentioned the following selected variables of socioeconomic status: (a) mother's education level and (b) child's diet diversity (Donkor et al., 2021; Trolesse & Aguayo, 2018; Ugboko et al., 2021). Likewise, Mahjan et al. (2021) have examined the relationship between socioeconomic status (e.g., household income) and race. Suryawan et al. (2021) have suggested various measures of socioeconomic status such as sanitation level, parent's occupation, healthcare access, and malnutrition. Likewise, Ngandu et al. (2019) have focused on measures of socioeconomic status such as maternal education, household wealth index, and mother's employment status. Family poverty, income, and education attainment were measures of socioeconomic status, as mentioned by Lu et al. (2021). As mentioned, Takeuchi et al. (2019; 2021) have considered measures of socioeconomic status such as annual household income and parent education level.

Takeuchi et al. (2019) and Ngandu et al. (2019) have suggested the following measures of socioeconomic status: (a) mother's education attainment, (b) internet use, and (c) annual household income. In the same way, authors have considered the measures of socioeconomic status such as household items and crowed households (Blake et al., 2018). Similarly, Bills et al. (2020) have suggested measures of socioeconomic status such as income, parent's education, and family's skills. Lubeck et al. (2019) have suggested the relationship between socioeconomic status (e.g., income) and life expectancy. Again, Blake et al. have examined the relationship between age, gender, socioeconomic status, illness uncertainty, and stigma. Ugboko et al. (2020) have focused on various measures of socioeconomic status such as sanitary toilet, running water, flush toilet, floor types, and drainage blockage. Also, Htwe (2021) have suggested measures of socioeconomic status such as healthcare access, drinking water, and hygiene. In a similar fashion to above studies, Castro and Viana (2019) have focused on the association between socioeconomic status and childhood sickle cell anemia.

Menalu et al. (2021) have emphasized on the measures of socioeconomic status such as food handling, household sanitation, and antenatal care. Equally, Gavhi et al. (2020) have focused on measures of socioeconomic status such as malnutrition, weight-for-length, and mid-upper arm circumference. Apanga and Kumbeni et al. (2021) have focused on various measures of socioeconomic factors such as health insurance scheme, mother's education, poverty, residence, and hygiene. Coupled with the above studies, Victoria et al. (2021) have considered the association between malnutrition and socioeconomic status. Van Malderen et al. (2019) and Yaya et al. (2020) have provided a

significant association between social determinants, childhood sickle cell disease, and health-related outcomes. Benavente-Fernandez et al. (2021) have examined the relationship between mother's education attainment and childhood adverse outcomes. Patel et al. (2021) illustrated the following measures of socioeconomic status among neonates: (a) birth size, (b) antenatal care, and (c) institutional delivery. As mentioned, researchers have suggested measures of socioeconomic status such as wealth index, education, water source, toilet facility, and flooring material (Islam et al., 2021).

Furthermore, Obse and Ataguba (2021) have considered measures of socioeconomic status such as women's economic empowerment, wealth index, education attainment, and residential area. Researchers have considered measures of socioeconomic status such as parent's education attainment, home ownership, and health insurance use (Accinelli & Leon-Abarca, 2020; Cortright et al., 2020; De Jesus et al., 2018; Ojelabi et al., 2019). Besides, Poulain et al. (2020) have focused on the interaction between social determinants of health (e.g., underserved community) and a child's health outcome. Chowdhury et al. (2018) have indicated a significant relationship between childhood malnutrition and household wealth index (OR = .44, 95% CI: [.37, .53]). In addition, Chowdhury et al. have suggested a significant association between childhood malnutrition and mother's education attainment (OR = .84, 95% CI: [.75, .94]). Ogamba et al. (2020) have suggested that health insurance was a statistically significant determinant of healthcare facilities utilization ($p < .001$) and household wealth index ($p < .001$). As previously mentioned, researchers have examined the relationship between socioeconomic status and women decision making (Alabi & Ramsden, 2021).

Apanga and Kumbeni (2021) have suggested measures of socioeconomic status such as handwashing facility, flooring material, household insurance status. Again, researchers have mentioned the measures of socioeconomic status such as genotype test, women's decision making, education attainment, media access, literacy level, household income, and parent's occupation (Abreha et al, 2020; Alabi & Ramsden, 2021; Kasai et al, 2020; Ngandu et al., 2019; Suryawan et al., 2021). Adeyinka et al.'s (2020) study have suggested the relationship between a child's health outcome and health inequality.

Infection Prevention

First, Datta et al. (2019a) have showed the significant use of zinc in the management of infection prevention. Second, Efunshile et al.'s (2019) study have examined the relationship between sickle cell disorders, oral rehydration therapy, antidiarrheal drugs, diet supplement, and intravenous fluid use. Third, Iliyasu et al.'s (2021) cross-sectional study in Nigeria examined the association between vector control, diet supplement, environment, mother's age, and household income. Fourth, Eleonare et al.'s (2020) retrospective study in Cameroon examined the relationship between hemoglobin level, level of consciousness, malaria infection, white cell count, fever, respiratory distress, and jaundice. Fourth, Anaduaka et al. (2021), Moruzzo et al. (2021), Nowakowski et al. (2021), and Vitalis et al. (2021) have suggested the significant benefits of exclusive breastfeeding and diet supplement in the management of childhood infection. Lastly, Johnstone et al. (2021) have considered methods of childhood diarrhea prevention such as good hygiene, safe drinking water, uncontaminated food, and oral rehydration therapy.

Bertozzi-Villa et al. (2021) have examined the association between vaccination, insecticide use, healthcare access, and childhood fever. Similarly, researchers have examined the relationship between insecticides, analgesics, poverty alleviation, and anthelminthic (Engels & Zhou, 2020; Muhammad et al., 2021; Tan et al., 2020). In a similar fashion, authors have focused on the interaction between malaria fever, mosquitoes' net, poverty, and geography (Ameyaw et al., 2020). In light of the above studies, Oppong et al. (2020) have revealed childhood sickle cell hemoglobin as a significant predictor of high malaria parasite level (*OR* = 5.51, 95% CI: [2.15, 14.10]) and anemia (*OR* = 3.03, 95% CI: [1.04, 14.10]) after controlling for covariates.

As mentioned, authors have indicated the association between childhood diarrhea treatment and health outcome (Efunshile et al., 2019; Reiner et al., 2018; Ugboko et al., 2021). Similarly, fever treatment led to enhanced quality of life in childhood sickle cell disorders (Houwing et al., 2021; Ogu et al., 2021). Kosiyo et al. (2020) have examined the relationship between full blood count indices, malaria infection, and sickle cell hemoglobin. Opoka et al. (2018) have suggested the interaction between childhood sickle cell disease, age, and gender. Besides, Ochocinski et al. (2020) indicated the measures of infection prevention such as malnutrition, vaccination, neglected tropical diseases, and healthcare access. Equally, researchers found that stem cell transplantation was a treatment of choice in sickle cell disorders (Badawy et al., 2021; Lidonnici et al., 2018). Islam et al.'s (2021) study examined the association between childhood sickle cell hemoglobin, malnutrition, and a child's hemoglobin level. In a similar manner to the

above studies, researchers have examined the relationship between vaccination, economic, health, social, and behavior (Rodrigues & Plokin., 2020; Wagner et al., 2020).

Datta et al. (2019a) have suggested the causes of medical complications in childhood sickle cell disorders such as malaria fever, diarrhea, meningitis, urinary tract infection, bacteremia, and pneumonia. Similarly, Ugboko et al. (2021) have documented various social risk factors in childhood diarrhea such as breastfeeding duration, water source, sanitation, age, and mother's education attainment. Reiner et al. (2019) have examined the relationship between infection (i.e., childhood infection) and health outcomes. Likewise, Johnstone et al. (2021) have demonstrated various determinants of childhood infection such as behavior, residence, dietary consumption, building material, homeownership, meat consumption, water sterilization, and vegetable consumption. In the same way to the above studies, Mann et al. (2021) found that the odds of malaria infection to be higher in stunted children under 5-years-old (*OR* = 1.89, 95% CI: [1.0, 1.4]) in comparison to underweight (*OR* = 1.11, 95% CI: [0.9, 1.4]) and wasting (*OR* = 0.89, 95% CI: [0.7, 1.2]).

Hlongwane et al. (2020) have focused on the impact diet supplement (e.g., edible insect) on health outcomes. Also, Ellis et al. (2021) and Robinson et al. (2021) have examined the relationship between diet supplement and health outcomes. In a similar manner, researchers examined the association between malaria prevention (e.g., wearing protective clothing), hemoglobin level, blood glucose level, positive malaria parasite, weight-for-age, and height-for-weight (Afolabi et al., 2020; Mann et al., 2021; Obasohan et al., 2021; Oyibo et al., 2021). Johnstone et al. (2021) have examined the association

between diarrhea infection and socioeconomic status (e.g., poverty, unemployment, poor hygiene, healthcare use, and safe water). Similarly, Efunshile et al. (2019) have examined the relationship between infection prevention, age, gender, mother's education, residence, exclusive breastfeeding, and toilet type. As mentioned, Ameyaw et al. (2020) have examined the association between geography, mosquitoes' net use, and a child's health outcomes.

Bertozzi-Villa et al. (2021) have focused on the impact of mosquitoes' net (e.g., insecticide-treated) on the prevention malaria infection in Sub-Saharan Africa. Besides, researchers have examined the interaction between vaccination, socioeconomic status (such as parent's education level and wealth index) and vaccination (Akwataghibe et al., 2019). Bangura et al.'s (2020) systematic review has alluded to determinants of immunization coverage such as employment, financial constraints, household number, and healthcare access. Likewise, Aelemi et al. (2020) have focused on the determinants of vaccination uptake such as mother's age, delivery place, healthcare use (e.g., antenatal care), family's income, and father's occupation. In a similar manner, Pertet et al. (2018) have showed the various determinants of vaccination coverage such as geography and vaccines availability.

Islam et al.'s (2021) cross-sectional study have examined the association between malnutrition, socioeconomic status, a child's age, gender, and sickle cell disorders. Again, Sagi et al. (2020) have examined the relationship between sickle cell disorders complications (e.g., vaso-occlusive pain) and diet supplement. Also, Ochocinski et al. (2020) examined the relationship between hemoglobin level, age, and childhood sickle

cell disorders. Kosiyo et al. (2020) have examined the association between variable such as full blood count and sickle cell hemoglobin adverse outcomes. Equally, Peng et al. (2021) found (46.5%) childhood vaccination in sickle cell disorders and (23.2%) in hemoglobin AA. McGavin et al. (2018) have examined the relationship between full childhood vaccination, antenatal care use, Christian religion, Igbo, Yoruba, household wealth, and education. Efunshile et al. (2018) have argued on the relationship between diet supplement (e.g., vitamin A and zinc) and infection prevention. Besides, Ameyaw et al. (2020), Belay et al. (2021), and Tan et al. (2020) have suggested measures of fever treatment such as insecticide-treated net, antipyretics, fluid use, and antimalarial drugs.

Wegner et al. (2020) have examined the relationship between vaccination, socioeconomic status, health outcomes, and behavior. Equally, Rodrigues and Plotkin (2020) have examined the relationship between vaccination, socioeconomic status, and health status. Peng et al. (2021) have provided a strong association between full vaccination and childhood sickle cell hemoglobin in comparison to undervaccination (*OR* = 2.8, 95% CI: [2.5, 3.1]). Again, Aluzet et al. (2021) have examined the relationship between influenza vaccination and infection prevention. Likewise, Peng et al. have showed a statistically significant association between vaccination and older children (13-17 years) living with sickle cell hemoglobin in comparison to their counterpart who were younger (*OR* = 2.2, 95% CI: [2.2, 2.2]).

At first, Reeves et al. (2019) have suggested a significant relationship between sickle cell hemoglobin (AS and SS) and acute otitis media (*OR* = 0.88, 95% CI: [0.87, 0.99]). At the same time, Reeves et al. have emphasized on a significant relationship

between sickle cell hemoglobin (AS and SS) and pneumonia (*OR* = 0.93, 95% CI: [.87, .99]). Next, the authors showed a statistically significant association between sickle cell hemoglobin (AS and SS) and outpatient's visitation (*OR* = 1.01, 95% CI: [1.01, 1.02]). Lastly, Reeves et al. have alluded to a significant relationship between sickle cell hemoglobin (AS and SS) and acute respiratory infection (*OR* = 0.94, 95% CI: [0.92, 0.97]).

Burroway and Hargrove (2018) have examined the association between vaccine uptake, mother's education, household wealth index, religion, and mother's age. Gebremariam et al. (2019) have provided a statistically significant association between diet supplement (e.g., iron and folate adherence) and antenatal care use (*OR* = 2.04, 95% CI: [1.94, 6.93]) after adjusting for confounders. In addition to the above, Gebremariam et al. have showed a significant association between women's autonomy (such as high literacy level) and health-related behaviors (such as adherence to nutrition supplement) after adjusting for confounders (*OR* = 2.22, 95% CI: [1.15, 4.29]).

Demissie et al. (2021) found that an older mother's age in comparison to younger mother's age was protective of developing diarrhea. Again, Demissie et al. suggested that mother's high education attainment in comparison to mother's low education was protective of developing diarrhea. Belay et al. (2021) showed the success rate of malaria fever prevention methods such as antimalarial drugs (86.3%) and household insecticide use (66%). Islam et al. (2021) showed a significant relationship between malnutrition and sickle cell hemoglobin (*OR* = 2.39, 95% CI: [1.26, 4.54]). Wagner et al. (2018) found that children living with sickle cell disorders had (63%) pneumococcal vaccine uptake and

(59%) uptake of meningococcal vaccine in comparison to children living without sickle cell disorders had (45.2%) pneumococcal vaccine uptake.

Demography

Mishra et al. (2019) have examined the interaction between geography and chronic diseases complications. Kerminen et al. (2019) showed that geographical variation was a significant determinant of medical complications in chronic diseases. According to De Vries et al. (2018), regional variation in resources distribution resulted in reduced well being and health in the society. From above, Tong et al. (2021) and Victoria et al. (2020) have examined the interaction between geography (i.e., residence), ethnicity, chronic disease, and a child's health outcome.

Baum et al. (2020) have examined the interaction between residence and chronic diseases. In addition, Nembhard et al. (2019) have suggested a significant relationship between race and adverse perinatal outcomes. Besides, Anand et al. (2020) have presented a statistically significant association between race, environment stress, and a child's well being. Accinilli and Leon-Abarch (2020) have documented anemia risk (8.5%) in lower altitude in comparison to (13.5%) anemia in higher altitude using a cross-sectional design. Willen et al. (2018b) have focused on the significant relationship between age and childhood sickle disorders. Likewise, age and ethnicity were associated with anemia in children aged 6-59 months, as mentioned by Ford et al. (2020). Ochocinski et al. (2020) have provided the significant relationship between age and anemia. Azupogo et al. (2019) have suggested the relationship between geography and

childhood anemia. In the same way to the above studies, Gage et al. (2021) have illustrated the interaction between demography (e.g., age), morbidity, and mortality.

Inusa et al. (2019) have examined the interaction between age, gender, geography, and climate, and childhood sickle cell hemoglobin. Also, Gebregziabher et al. (2018) have examined the interaction between race and sickle cell disorders. Royal et al. (2020) have examined the relationship between geography (urban, rural, and temperature) and childhood sickle cell hemoglobin. Wonkam et al. (2018) found that a female child was a statistically significant predictor of vaso-occlusive pain in sickle cell hemoglobin pain. Equally, Claeys et al. (2021) examined the interaction between gene, culture, environment, education, and health literacy, age, and childhood sickle cell disorders. Accinelli and Leone-Abarcha (2020) have presented the impact of geographic variation on childhood sickle cell disorders. Based on the above, Antwi-Boasiako et al. (2020) found that male sex was a significant predictor of leg ulcer in childhood sickle cell hemoglobin.

Lubeck et al. (2019) have examined the association between childhood sickle cell disease, age, gender, and ethnicity, and health outcome. In addition, Bhatt et al.'s (2019) study have focused on the relationship between gender, health literacy, and sickle cell disease. Takeuchi et al. (2019) have examined the association between gender, socioeconomic status, and health outcome. Karadag et al. (2018) have examined the relationship between childhood sickle cell disease age, behavior, hospital readmissions, and healthcare use. As mentioned in previous paragraph, Ramsay et al. (2021) found that

female gender was a statistically significant predictor of sickle cell hemoglobin pain using a cross-sectional design.

First, Karadag et al. (2018) have examined the relationship between family's skills, a child's age, health insurance use, mother's age, and genotype test. At the same time, Blake et al. (2018) have examined the relationship between demographic factors (e.g., age and sex), stigma, and childhood sickle cell hemoglobin. Next, Claeys et al. (2021) and Kerminen et al. (2019) found that a child's age was a significant predictor of sickle cell hemoglobin. Lastly, Maakoron and Taher (2021) found that clinical presentation of sickle cell hemoglobin could vary based on individual's trait or characteristics.

According to IIiyasu et al. (2021), a child's age, ethnicity, and residence were predictors of blood transfusion in sickle cell disorders. Likewise, Leonard et al. (2019) showed the significant interaction between anemia in children aged 6-23 months and gender (i.e., female). In a similar fashion to other studies, Patel et al. (2021) focused on the relationship between demography (e.g., residence and Nigeria geopolitical zones) and neonatal mortality.

Accinilli and Leon-Abarch (2020) have examined the relationship between age, altitude of residence, and childhood anemia, in Peru. Besides, Tossea et al.'s (2018) cross-sectional study in Ivory Coast showed regional variation as a determinant of prevalence of hemoglobin SC. In a multinational study, regional variation was associated with childhood sickle cell hemoglobin (Inusa et al., 2019). Religion was a significant predictor of neonatal mortality by Patel et al. (2021). In a similar manner to above

studies, Kanter et al. (2018) found that geographical variation of opioids was a significant predictor of sickle cell hemoglobin pain ($p = 0.044$, $r = 0.126$).

Alabi and Ramsden (2021) focused on the interaction between demography (e.g., religion, gender, and region), socioeconomic status, literacy, and women's decision making. In addition, Blake et al. (2018) found a significant relationship between stigma, sickle cell disease, and socioeconomic status after controlling for age and gender ($p = .001$). As mentioned, Braveman et al. (2021) found that race (i.e., Black) was a significant predictor of preterm birth.

Pain and Anemia Management

Wonkam et al. (2018) examined the relationship between age, gender, blood transfusion, and sickle cell disease. Cisneros and Thein (2020) examined the relationship between antibiotic prophylaxis, anemia, vaso-occlusive pain, and sickle cell hemoglobin. Similarly, researchers examined the association between blood transfusion and childhood sickle cell disease (Abdullahi et al., 2021; Ahmed et al., 2019; Fasano et al., 2019). Koppar et al. (2018) found that hematopoietic cells use was a significant treatment of anemia in sickle cell disorders. Tan et al. (2020) found that paracetamol and ibuprofen are significant management of childhood fever. Datta et al. (2019a) found that diet supplement (e.g., zinc) was a significant treatment of anemia. Drysdale et al. (2021), Lamsfus-Calle et al. (2020), and Tanhehco (2021) provided the use of gene therapy in the treatment of hemoglobinopathy complications. In keeping with above results, researchers suggested various modalities of pain and anemia such as diet supplement, gene therapy,

perception-related therapy, acupuncture, benserazide racemate, and enantiomers (Kanter et al., 2022; Pace et al., 2021; Balsamo et al., 2019; Sagi et al., 2020).

Saramba et al. (2020) provided a statistically significant association between fentanyl use, magnesium, and pediatric sickle cell disease pain ($p = .03$), but a statistically insignificant result was found in the interaction between intravenous fentanyl, magnesium, arginine, and inhaled nitric oxide. Also, Hejazi et al. (2021) examined the relationship between ibuprofen, pethidine, tinzaparin, and morphine, vaso-occlusive pain, and sickle cell hemoglobin. In a similar way, Nartey et al. (2021) suggested a significant association between nutritional therapy (e.g., fatty acid intake and oral arginine), vaso-occlusive pain, and sickle cell hemoglobin.

From the above, Russo et al. (2019) found that multimodal analgesia was significant in the treatment of pain crisis in sickle cell hemoglobin. Adbulwahab et al. (2021) suggested significant interaction between gene, environment, pain crisis, and sickle cell hemoglobin. Furthermore, Ballas and Darbari (2020), Kazak and Ozkaraman (2020), and Sil et al. (2020) suggested various treatment strategies in sickle cell disease such as behavioral therapy, relaxation exercise, and opioid. Oron et al. (2020) found that blood transfusion was a significant treatment in childhood sickle cell hemoglobin. In a similar way, Darshana et al. (2021) and Fortin et al. (2018) contributed a significant relationship between parent's knowledge, behavior, and blood transfusion uptake.

Carroll (2020), Du et al., (2019), and Goss et al. (2021) found that opioid use was a significant management modality in sickle cell-related pain. Similarly, Whitley et al. (2021) showed a male child in comparison to a female child presented with higher odds

of effective pain reduction (*OR* = 1.42, 95% CI: [1.9, 1.7]). Again, Whitley et al. found that participants on analgesic in comparison to their counterpart who were not on analgesic had a higher odds of pain reduction (*OR* = 6.6, 95% CI: [5.9, 7.3]). De Villaverde Cortabarria et al. (2021) suggested the use of stem cell replacement for the treatment of childhood sickle cell disorders. Brandow and DeBaun (2018) found that a child's age was as a significant predictor of pain in sickle cell disorders. In the same way to the above findings, Ataga et al. (2020) suggested the significant association between sickle cell disease, low hemoglobin level, and negative health outcomes.

Ochaya et al. (2018) and Simmons et al. (2019) found that efficient pain treatment was a significant predictor of improved health in sickle cell disease. In childhood sickle cell disease, vaso-occlusive pain resulted from uncontrolled tissue ischemia (Ashorobi et al., 2021; Bhatt, 2021; Renoux et al., 2018). From above, Tsitsikas et al. (2021) found that red blood cell transfusion was a significant treatment of sickle cell-related anemia.

Gaps in Literature

The literature addressed the interaction between socioeconomic status, demography, gender equality, health literacy, healthcare use (e.g., antenatal care), and childhood health outcomes; however, there was little information on children living with sickle cell hemoglobin aged 6-59 months in Nigeria (Abreha et al., 2020; Dadjo et al., 2021; Donald et al., 2019; Eleonare et al., 2020; Lu et al., 2021; Kanter et al., 2020, 2021; Leger et al., 2018; Munyuzangabo et al., 2020; Nnodu et al., 2021; NPC, 2019; Rocha et al., 2021; Serjeant & Vinchinsky., 2018; Takeuchi et al., 2019). The advantages of diet supplement and exclusive breastfeeding were mentioned in the literature; nevertheless,

there was no mention of childhood sickle cell disorders aged 6-59 months in Nigeria (Donkor et al., 2021; Feldman-Winter et al., 2020; Nartey et al., 2021). Besides, few studies provided information on the relationship between childhood sickle cell hemoglobin, gender equality, parent's health-related behaviors, disability, health literacy, early life genotype screening, and healthcare use (Alradie-Mohamed., 2020; Brega et al., 2021; Caldwell & Rosonet, 2021; Dormandy et al., 2018; Ezenwosu et al., 2021; Gage et al., 2021; Hood et al., 2022; Karadag et al., 2018; Lee et al., 2019; Nimako et al., 2021; Roder-DeWan et al., 2020).

Furthermore, more future research was suggested on the relationship between sickle cell disorders, socioecological theoretical framework, and health determinants (Cortright et al., 2020; Htwe, 2021; Lopez et al., 2021; Power-Hays et al., 2020; Raman et al., 2021; Ugboko et al., 2020) Researchers provided the need for more information on the use of national representative data in sickle cell hemoglobin research (Cronin et al., 2019; Islam et al., 2021; Nnodu et al., 2021; Saramba et al., 2020; NPC, 2019). Likewise, authors suggested the need for more information on the relationship between parent's skills, health literacy, employment, women's autonomy, structural violence, healthcare care use, and sickle cell hemoglobin (Abreha et al., 2020; Alradie-Mohamed et al., 2020; Caldwell, 2020; Downes et al., 2020; Gerardin et al., 2021; Ibemere et al., 2020; Karadag et al., 2018; Lee et al., 2019; Mbanya et al., 2018; Sabahelzain et al., 2019).

Authors have provided the need for more information on the relationship between sickle cell disorders, geographical variation, nutrition, and healthcare access (Baum et al., 2020; Cronin et al., 2019; Dwivedi et al., 2019; Inusa et al., 2019; Nartey et al., 2021).

Researchers have suggested vaccination as an effective treatment for infection prevention; nonetheless, children living with sickle cell disorders aged 6-59 month in Nigeria were not examined (Hill et al., 2019; Ochicinski et al., 2020; Pertet et al., 2018; Rodrigues & Plotkin, 2020; Wagner et al., 2020). Again, Ochocinski et al. have suggested the need for future research on immunization coverage in developing countries, Nigeria included.

According to Westnedge et al. (2018), more information was needed on the mortality burden in childhood sickle cell disorders. Authors have focused on the benefits health literacy in the uptake of genotype screening; on the other hand, children living with sickle cell disorders aged 6-59 month in Nigeria were not examined (Gyamfi et al., 2021; Faremi et al., 2018; Ibemere et al., 2021). Researchers have focused on the benefits of screening for social determinants of health; on the contrary, children living with sickle cell disorders aged 6-59 month in Nigeria were not examined (Accinelli & Leon-Abarcha (2020); Apanga & Kumbeni, 2021: Benavente-Fernandez; 2021; Gerardin et al. (2021); Htwe, 2021; Menalu et al., 2021; Power-Hays, 2019; Sulley & Bayssie et a 2021; Van Malderen et al., 2021; Van tonder et al., 2019; Victoria et al., 2021).

Although researchers focused on the health-related advantages of malaria infection prevention, there was no mention of children living with sickle cell disease aged 6-59 months in Nigeria (Al Khaja & Sequeira). Also, the susceptibility rate of hemoglobin SS and AS to malaria infection was still contentious in the literature (Eleonare et al., 2018; Kosiyo et al., 2020; Opaka et al., 2018). According to Westnedge et al. (2018), few research reported on the mortality burden of sickle cell disorders in

children under 5-years-old. Researchers focused on the efficacy of malaria prevention strategies in Nigeria; in contrast, children living with sickle cell disorders aged 6-59 month in Nigeria were not examined (Duodu et al., 2021). In addition, Islam et al.'s (2021) study have provided the need to examine the prevention and control of malnutrition in children living with sickle cell hemoglobin aged 6-59 months.

Also, researchers have suggested the need for future research on the association between the environment (e.g., infection) health insurance use, socioeconomic status (e.g., parent's financial constraints), healthcare use, malnutrition, nutritional therapy, and childhood sickle cell hemoglobin (Eleonare et al., 2020; Ellis et al., 2021; Cortright, 2020; Kamal et al., 2021; Kosiyo et al., 2020; Kruk et al., 2018, Lee et al., 2019; Ochocinski et al., 2020; Ogamba et al., 2020; Power-Hey et al., 2020; Van tonder et al., 2019). Anaduaka et al. (2021), Nartey et al. (2021), and Nowakowski et al. (2021) have examined the benefits of nutritional therapy in sickle cell disorders; on the contrary, children living with sickle cell disorders aged 6-59 month in Nigeria were not examined.

According to Uwaezuoke et al. (2018), few research addressed pain management in children living with sickle cell disorders aged 6-59 months. Researchers have showed the interaction between female gender, vaso-occlusive pain, and sickle cell disease; otherwise, children living with sickle cell disorders aged 6-59 month in Nigeria were not examined (Wonkam et al., 2018). Additionally, researchers have suggested the need for future research on blood transfusion and pain management in childhood sickle cell hemoglobin (Fortin et al., 2018; Isa et al., 2020, 2021). Researchers have suggested the need to examine the relationship between gene, age, race, ethnicity, geography, and

sickle cell disorders (Accinelli and Leon-Abarca., 2020; see also Australia Institute of Health and Welfare, 2021; Baum et al., 2021; Claeys et al., 2021; Deshpande et al., 2020; Hicken et al., 2018; Nembhard et al., 2019; Nnodu et al., 2020; Raman et al., 2021; Royal et al., 2021; Serjeant & Vinchinsky., 2018; Sun et al., 2020).

Ford et al. (2020) and Leonard et al. (2019) have examined the relationship between age, ethnicity, and anemia; on the other hand, children living with sickle cell disorders aged 6-59 month in Nigeria were not examined. Researchers have provided the need for future research targeting policy formulation in clinical practice (Shelton & Lee, 2019). Brousse et al. (2018) and Kanter et al. (2018) have focused on the need for more information on interaction between sickle cell disorders, gender, and geographical location. Because there was no one-size-fits-all approach, this study examined the identified gaps in the literature and allowed dissemination of evidence-based information.

Summary and Transition

In Chapter 2, this study addressed items such as demography, socioeconomic status, healthcare use, infection prevention, pain and anemia management, literature review on key variables, the purpose of the study, nature of the study, the literature search strategies, independent and dependent variables, covariates, theoretical frameworks, sickle cell hemoglobin epidemiology, and social determinants of health.

Because children living with sickle cell hemoglobin were subjected to environment stress, policy formulation on limiting adverse events among vulnerable groups was needed (Adeyinka et al., 2020). Also, environment stress in childhood sickle cell disease could accentuate mortality, morbidity, and life-threatening infection (Alradie-

Mohamed et al., 2020; Caldwell, 2020). The poor surveillance of sickle cell disorders in Sub-Saharan Africa led to inaccurate prevalence at the national level (NPC, 2019; see also Marks et al., 2018; Nkya et al., 2019; Nnodu et al., 2021).

Houwing et al. (2021) and Westnedge et al. (2018) have suggested a need to address health inequalities and inequities in childhood sickle cell disorders. In childhood sickle cell disorder, researchers have indicated the need for policy implementation on issues such as gender equality, women's autonomy, culture, religion, and stigma (Alradie-Mohamed et al., 2020; Ibemere et al., 2021; Smith & Brownell, 2018). This study suggested the need for gender equity among children living with sickle cell hemoglobin. Point-of-care screening for sickle cell hemoglobin must be embraced at the local, state, or national level. This study's findings could encourage screening for social determinants in sickle cell disorders. In sum, this study examined the interaction between presence of sickle cell hemoglobin, infection, anemia and pain, demography, healthcare access.

Chapter 3 is the discussion of research design and methodology. The methodology section addresses items such as population and research settings, sampling procedures, sample size and power calculation, participants' recruitment, instruments, and variables' operationalization. Also, data are identified based on various procedures such as data analysis table, data cleaning, and handling of missing data. This study's inferential and descriptive statistics are found in chapter 3. Finally, the threats to the validity will be addressed to ensure the trustworthiness of the findings.

Chapter 3: Research Method

This quantitative cross-sectional study utilized the 2018 Nigeria DHS to examine the relationship between the independent variables and the outcome. Also, this study explored the interaction between socioeconomic status, pain and anemia management, infection management, geographical location, and the proportion of sickle cell disorders in Nigeria. Gerardin et al. (2021) provided the use of cross-sectional method to explore the association between socioeconomic, environment, and parent's stress, and childhood sickle cell disease. This study's data were collected at one given point in time in the six geopolitical zones of Nigeria, indicating the cross-sectional nature of the design (NPC, 2019). Besides, this study explored the interaction between healthcare access, infection, anemia and pain management, demography, and childhood sickle cell disorders. This chapter addresses the design and rationale, sampling procedures, data collection, and participants' recruitment, operationalization of constructs, instruments, data analysis, ethical procedures, and threats to validity.

Research Design and Rationale

This cross-sectional study examined the association between presence of sickle cell hemoglobin and the independent variables. Also, the independent variables considered were household wealth index, household toilet facility location, household presence of water, mother's employment status, religion, residence, ethnicity, Nigeria geopolitical zones, a child's gender, a child's vaccination status, household use of mosquitoes' net, children's African diet supplement, mother's treatment of diarrhea, a child's breastfeeding status, antenatal care use, mother's use of health insurance,

mother's uptake of children genotype testing, mother's place of delivery, children's blood transfusion, mother's treatment of fever, children's antibiotic prophylaxis, and children's rehydration fluid use. The covariates in this study were mother's age, a child's age, children's weight-for-height, and mother's education level.

Researchers have suggested the use of cross-sectional study to examine selected variables in research (Badawy et al., 2021; Caldwell & Rosonet et al., 2021; Chimbatata et al., 2021; Claeys et al., 2021; Islam et al., 2021). Gerardin et al. (2021) have focused on cross-sectional study to determine the relationship between dependent and independent variables in childhood sickle cell disorders. Similarly, Brousseau et al. (2020), Farooq et al. (2020), and Islam et al. (2021) have emphasized on cross-sectional design to examine the relationship between the dependent and independent variables. Kesmodel (2018), Leleu et al. (2021), and Nnodu et al. (2021) have suggested the use of cross-sectional study to determine the prevalence of chronic diseases. Considering the above studies, this study examined the relationship between the selected variables using a cross-sectional design.

The research design provided an opportunity to examine the interaction between geography, demography, medical complications, healthcare use, socioeconomic status, and the presence of sickle cell disease. Tenny et al. (2020) suggested the need to align all the elements of a research to enhance the internal and external validity. In this study, Research Questions 1 through 5 were answered on the relationship between the presence of sickle cell hemoglobin and the selected independent variables. Equally, the missing data in the 2018 Nigeria DHS could affect the internal and external validity of the results.

Hence, this study considered alignment between the study design, methodology, data analysis, selected variables, research questions, and hypotheses.

Methodology

Population and Research Setting

This study considered the use of the 2018 Nigeria DHS secondary dataset. The data were representative of adult and children under 5-years-old population in Nigeria. In 2022, approximately 218 million population were recorded in Nigeria (World Population Review, n.d.). The field workers used validated questionnaire to collect information between August and December 2018 in the six geopolitical zones of Nigeria. The organization involved in the primary data collection were the NPC, the United States Agency for International Development, and the 2018 Nigeria DHS coordinator (Bolarinwa et al., 2021; Islam et al., 2021; Mann et al., 2021). The 2018 Nigeria DHS dataset allowed documentation of the following information:

- a total of 30,881 children under 5-years-old,
- children 6-59 months living with sickle cell hemoglobin,
- mother's characteristics in the households,
- father's characteristics in the households, and
- a total of 42,000 households selected from 774 local government areas in Nigeria (Demissie et al., 2021; NPC, 2019).

This study considered the six geographical zones of Nigeria and 37 states in Nigeria. A total of 42,121 women were identified in the survey; however, 41,821 women were interviewed by the field workers. A total of 13,422 men were identified across the

country; nevertheless, 13,311 men were interviewed in the survey. In other words, the total response rate in the primary study was 99%.

Equation 1: Response rate = $100 * C/C + HP + P + R + DNF$

Equation 1 showed the following components of the response rate formula in the 2018 Nigeria DHS dataset: C = household interview complete, HP = no competent respondent in household, R = interview deferred or refused, and DNF = dwelling not found. Children under 5-years-old were eligible for the genotype test and anemia screening. A total of 11,536 unweighted children aged 6-59 months were selected for the genotype test, leading to 97% of the population classified into hemoglobin genotypes AA, SC, AS, AC, AA, or others (NPC, 2019).

Sampling and Sampling Procedures

The 2018 Nigeria Demographic Health Survey included a two-staged stratified sampling method. Also, the sampling divided the six geopolitical zones of Nigeria into two settings (i.e., rural, urban), arriving at a total of 74 sampling strata. The sampling frame of the Nigeria housing census of 2006 was utilized. Consequently, the primary sampling unit was based on the census enumeration areas that arose from the cluster derived from 2006 Nigeria census. The 37 administrative states of the country were divided into local government wards. Each enumeration area was derived from the primary sampling unit. Therefore, the definite sampling frame was calculated based on the proportion probability sampling method (NPC, 2019).

In addition, a total of 74 sampling strata were identified in the 2018 Nigerian DHS. The first sampling stage considered the use of proportional probability to estimate

the size of the enumeration area. A total of 1,400 clusters were chosen from each of the six geopolitical zones. Based on the geopolitical zones of Nigeria, different strata were created using proportional probability sampling. Equally, the total number of households in the enumeration area were considered in the sampling procedure. A total number of 30 households were selected in each enumeration area using proportional probability. As mentioned, the sampling procedure gave equal opportunity to each household and improved external validity (NPC, 2019).

The second stage of the sampling enabled the selection 42,000 households in the primary study using systematic sampling approach. Also, the sampling weights were considered during the data screening phase and correction for nonresponse questions. However, the selected variables in this study were not weighted in the 2018 Nigerian DHS. The cluster randomized sampling was used for the selection of the final sample size, leading to the prevention of selection bias. The generalizability of the findings in this research was improved because of the systematic sampling method. As mentioned, the two-staged random stratified sampling allowed the selection of a representative sample in this research (NPC, 2019).

Furthermore, Taylor's method of linearization was used in the survey to determine the following statistics: (a) proportions, (b) means variances, and (c) ratio estimate. Sampling errors were determined to enable improved validity of the primary study. In addition, the reliability of the sample was determined using a sampling statistician. The total number of households interviewed by the field workers were from the random sampling procedures. The two-staged stratified random sampling allowed a

representative population. The program office software was used to correct for sampling errors analysis in the primary study. Overall, in this study, the sampling procedure enhanced the validity and reliability in this study (NPC, 2019).

Sample and Power Calculation

The sample size in the secondary data analysis considered statistics such as power (80%), 95% CI, (α) level (.05), and a beta value (20%). As a result, this study took into consideration a moderate effect size. Researchers suggested the need to determine Type I and Type II errors in research, leading to improved validity and reliability (Masha & Vetter, 2018). Both de facto and de jure population were interviewed in the primary study. The de facto population inferred the legal and nonlegal residents the night before the interview. The de jure population considered only legal residents. Finally, a total of 187,974 individuals were found in the night prior to the interview by the field workers, resulting in the interview of 40,427 households (NPC, 2019).

The proportion of children under 5-years-old found in the household was .52 in this study. The unit of analysis in this study was a child's aged 6-59 months living with sickle cell hemoglobin in Nigeria. A total of 11,536 unweighted children were divided into different hemoglobin genotypes. This study's inclusion criteria were a child's age (6-59 months) and mother's age (15-49 years). The exclusion criteria were dependent and independent variables not listed in the research questions; thus, father's characteristics (15-59 years) were not included in this research. Besides, SPSS software was used in this secondary dataset analysis. The primary study data analysis was done using various

statistical analyses such as census and survey processing system and computer-oriented interview (NPC, 2019).

Large sample size led to identification of influential points and margins of error as well as an accurate mean (Schuster et al., 2021; Serdar et al., 2021). However, a small sample size could predispose to reduced external and internal validity in research (Andrade et al., 2021). In sum, this study demonstrated a large sample size to ensure improved internal and external validity.

Procedures for Recruitment, Participation, and Data Collection

Data collection involved face-to-face interviews of the participants by field workers. Children aged 6-59 months were tested for sickle cell hemoglobin, anemia, and malaria infection. In the primary study, the field workers took a total of 5 months to collect the data. For 4 months, 11,536 children under 5-years-old were tested and diagnosed with sickle cell hemoglobin (NPC, 2019). The total sample size was 11,536 children living with sickle cell hemoglobin in Nigeria. Therefore, one third of the children's population in the 2018 Nigeria DHS dataset were involved in the genotype test.

Also, the selected team workers were subdivided into 37 teams before the primary data collection. The mother's recruitment eligibility criteria included age (15-49 years). After consent was sought for the interview, the women interviewed in the 2018 Nigerian DHS were 42,121. A total of 12,806 children under 5-years-old were eligible for height and weight measurements. Likewise, the proportion of children with malnutrition was determined based on the height and weight measurements. Anthropometric measurements

were obtained in 97% of eligible children. The anthropometric measurements in children included the following methods: (a) height-for-age, (b) weight-for-height, and (c) weight-for-age. The WHO definition of malnutrition, which considered the measured *z*-scores, was used in the primary study to categorize malnutrition (NPC, 2019). Hence, the field workers consisted of professional such as nurses and laboratory technicians (NPC, 2019).

A pilot or pretest study was instituted to enable field workers administer the questionnaire in three Nigerian languages (i.e., Yoruba, Igbo, and Hausa). As a result, the pilot or pretest study was utilized to determine anticipated problems during the interview and validate the questionnaire. The questionnaire was divided into following four subdivisions: (a) biomarkers, (b) household, (c) women, and (d) men. The biomarkers section showed the following designated information in this study: (a) genotype results, (b) malaria screening results, and (c) anthropometric values (NPC, 2019).

The primary study was initiated by the WHO, National Malaria Elimination Program, the United States Agency for International Development, UNFPA, Bill and Melinda Gates Foundation, Nigeria Federal Ministry of Health, and Global Fund. In addition, the primary study involved the use of census processing system. The 2018 Nigeria DHS dataset documented the following information:

- drinking water treatment,
- mass media exposure and literacy,
- structural violence and sanitation,
- education and occupation, and
- disability in the household (NPC, 2019).

The use of Jacknife repeated replication allowed the deduction of *SE*, allowing improved validity of this study's findings. The data collected were sent to the central office to confirm the details. As a result, the data editing resolved persisting inconsistencies in the information. Using the survey processing system package, the central office entered the data in an electronic format. Taken together, data entry stage examined for incorrect information and missing values (NPC, 2019).

After the application was accepted, the data were downloaded from the 2018 Nigeria DHS website. The Walden University Center for Research Quality and Institutional Review Board were approached to ensure doctoral dissertation rules were not breached. For instance, the Institutional Review Board was involved in the approval of the data analysis stage (see NPC, 2019).

Instrumentation and Operationalization of Constructs

Instrumentation

Measurements of the independent and dependent variables were accomplished using a standardized questionnaire. Equally, the field workers were involved in the measurement of the following parameters: (a) anemia, (b) height, (c) weight, and (d) genotype test. Sickle cell hemoglobin screening was accomplished using instruments such as SickleSCAN rapid test and liquid chromatography test.

Operationalization of the Variables

Infection prevention. Table 2 displays the measures of infection treatment.

Table 2

Infection Prevention Variables

Variable name	Variable description	Types of variables	Value	Recode value
Childhood vaccination	"Does your child receive vaccination to prevent him or her from getting diseases, including vaccinations received in campaigns, immunization, days, or child's health day?"	Nominal	1 = Yes 0 = No	
Children's African protein dietary supplementation	Mother's addition of small African protein food such as edible insects, winged termite, cricket, snails, periwinkle, and palm weevil larva.	Nominal	1 = Yes 0 = No	
Household use of mosquitoes' net	Did anyone sleep inside this mosquitoes' net (insecticide treated net) last night?			
Children's diarrhea treatment	"Do you seek advice or treatment for the diarrhea from any source?"	Nominal	1 = Yes 0 = No	
Children's weight-for-height	Children weight-for-height is expressed as *z*-scores from the median point, value more than two *SD* from the median of WHO denotes malnutrition	Continuous (scale)		
Child's breastfeeding status	"Do you ever breastfeed your child?"	Continuous (scale)		

Pain and Anemia Management. The measures of measures of anemia and pain are displayed in Table 3.

Table 3

Pain and Anemia Management Variables

Variable name	Variable description	Types of variables	Value	Recode value
Children's transfusion status	Children's blood transfusion status in the past three months	Nominal	1 = Yes 0 = No	
Mother's treatment of fever	Does mother seek advice to treat children's fever or illness	Nominal	1 = Yes 0 = No 2 = Don't know	
Children's antibiotic prophylaxis status	Does child take antibiotic for illness or disease?	Nominal	1 = Yes 0 = No 2 = Don't know	1 = Yes 0 = No
Children's hemoglobin	Children's hemoglobin (g/dl) is recorded based on the information in the secondary data	Continuous (scale)		
Children's rehydration status	Children treatment with rehydration fluid during illness	Nominal	1 = Yes 0 = No 2 = Don't know	1 = Yes 0 = No
A child's age	A child's age in the secondary dataset	Continuous (scale)		

Demography. The measures of demography are displayed in Table 4. The measures of demography were residence (nominal), ethnicity (nominal), religion (nominal), a child's gender (nominal), and a child's age (continuous).

Table 4

Demography Variables

Variable name	Variable description	Types of variables	Value	Recode value
Ethnicity	Nigerian ethnic group or tribal as captured in the 2018 Nigerian demographic and health survey secondary dataset.	Nominal	1 = Ekoi 2 = Fulani 3 = Hausa 4 = Ibibio 5= Igala 6 = Ijaw/Izon 7 = Kanuri/Beriberi 8 = Tiv 9 = Yoruba 10 = Other	1 = Hausa 2 = Yoruba 3 = Igbo 4 = Others
Nigeria geopolitical zones	Nigerian geopolitical zone as captured in the 2018 Nigeria demographic and health survey	Nominal	1 = Northcentral 2 = Northeast 3 = Northwest 4 = Southeast 5 = South 6 = Southwest	
A Child's age	Children's age as defined by the 2018 Nigeria demographic and health survey	Continuous (scale)		
Residence	Household residence as captured by the 2018 Nigeria demographic and health survey secondary dataset	Nominal	1 = Urban 0 = Rural	
Religion	Religion as stated in the dataset.	Nominal	1 = Catholic 2 = Christian 3 = Islam 4 = Traditionalist 5 = No religion	1 = Christian 2 = Islam 3= Traditionalist
A child's gender	Males and females are considered based on the 2018 Nigeria DHS	Nominal	1 = Female 0 = Male	

Socioeconomic Status. Table 5 displays the measures of socioeconomic status included selected variables such as household wealth index (nominal), household toilet facility location (nominal), household presence of water (nominal), mother's employment status (nominal), and mother's education level (nominal).

Table 5

Socioeconomic Status Variables

Variable name	Variable description	Types of variables	Value	Recode value
Household wealth index	Wealth quantile or index as stated Nigeria Demographic and Health Survey	Nominal	1 = Lowest 2 = Second 3 = Middle 4 = Fourth 5 = Highest	0 = Low 1 = Middle 2 = High
Household toilet facility location	The location of the household toilet	Nominal	1 = In own household 2 = In own yard/plot 3 = Elsewhere	1 = Toilet within Household 0 = Toilet outside Household
Household presence of water	Defined as the presence of water in the house	Nominal	1 = Water is available 0 = Water is not available	
Mother's employment status	"In the last 12 months has mother done any work"?	Nominal	1 = Yes 0 = No	
Mother's education level	Mother's education level living in the household	Nominal	1 = No education 2 = Some primary 3 = Completed primary 4 = Some secondary 5 = Completed secondary 6 = More than secondary	1 = Education 0 = No education

Healthcare Use. Table 6 displays the measures of healthcare use.

Table 6

Healthcare Use Variables

Variable name	Variable description	Types of variables	Value	Recode value
Antenatal care	Use of antenatal care in pregnancy	Nominal	1 = Yes in hospital 0 = No not in hospital	
Mother's reading of newspapers	"Do you read newspapers, or do you do not read a newspaper?"	Nominal	1 = At least once a week 2 = Less than a week 3 = Not at all	1 = Yes 0 = No
Mother's uptake of children's genotype testing	It indicates the mother's acceptance genotype testing in the child	Nominal	1 = Granted 2 = Refused	
Mother's use of health insurance	Mother's possession of a health insurance	Nominal	1 = Yes 0 = No	
Mother's place of delivery	Mother's place of delivery at public facility, private facility, or elsewhere	Nominal	In a health facility = 1 Not in a health facility = 0	
Mother's age	Mother's age as documented in the secondary dataset	Continuous (scale)		

Dependent Variables. Table 7 displays the measure of dependent variable in this study. The genotype results were recoded into two categories (i.e., 1 = *presence of sickle cell hemoglobin* and 0 = *absence of sickle cell hemoglobin*). The dichotomous variable met the assumption of binary logistic regression.

Table 7

Sickle Cell Hemoglobin Status

Variable name	Variable description	Types of variables	Value	Recode value
Sickle cell disease status	The proportion of children under 5-years-old with sickle cell hemoglobin (i.e., AS, SS, AC, SC, and others)	Nominal	1 = AA 2 = AS 3 = AC 4 = SC 5 = SS 6 = Others	1 = Presence of sickle cell hemoglobin (i.e., AS, SS, SC, AC, SC, and others) 0 = Absence of sickle cell hemoglobin (i.e., AA)

The Covariates. This study considered covariates such as mother's age (scale or ratio), a child's age (scale), children's weight-for-height (scale), and mother's education level (nominal).

Data Analysis

Data Cleaning and Screening

The research questions were answered by merging and appending the electronic files. The SPSS software was used for the analytic procedures and data cleaning. Hence, the selected variables were recoded or transformed in this study.

Data Analysis Table

The data analysis table took into consideration subjects such as research questions and the 2018 Nigeria DHS questions (see Table 8).

Table 8

Data Analysis Table

Secondary data analysis research question and reason for the question	2018 Nigeria demographic and health survey question	Important information to be derived from asking both research question and survey question
Research question 1: examines the association between socioeconomic status and the proportion of children under 5-years-old living with sickle cell hemoglobin in Nigeria.	Measures of socioeconomic status: household wealth index, household toilet facility location, household presence of water, mother's employment status, and mother's educational level.	It is important to know how social determinants of health influence the proportion of sickle cell hemoglobin (i.e., sickle cell associated genotypes) in children under 5-years-old.
Research question 2: examines the association between demography, geography, and the proportion of children under 5-years-old living with sickle hemoglobin in Nigeria.	Measures of demography: a child gender, religion, mother's age, and children's age) and geography (residence and Nigeria geopolitical zone) and ethnicity.	It is important to know the influence of geographical variability and religion on the proportion of sickle cell hemoglobin (i.e., sickle cell-related genotypes) in children under 5-years-old.
Research question 3: examines the association between infection treatment and the proportion of children under 5-years-old living with sickle cell hemoglobin in Nigeria.	Measures of infection treatment: childhood vaccination, household use of mosquitoes' net, children's African protein supplement, childhood diarrhea treatment, children's weight-for-height, and children's breastfeeding status.	It allows the examination of the influence of mother's belief, knowledge, attitude, or behaviors on infection prevention treatment (e.g., malaria and diarrhea), and on the proportion of sickle cell hemoglobin (i.e., sickle cell-related genotypes) in children under 5-years-old.
Research question 4: examines the association between pain and anemia management and the proportion of children under 5-years-old living with sickle cell hemoglobin in Nigeria.	The measures of pain and anemia selected variables such as children's blood transfusion, mother's treatment of fever, children's rehydration status, children's hemoglobin, and children's age.	Allows the examination of the influence of medical complications or conditions on the proportion of children under 5-years-old living with sickle cell hemoglobin in Nigeria.
Research question 5: examines the association between healthcare use, and the proportion of children under 5-years-old living	The measures of healthcare use such as antenatal care use, mother's delivery in a health facility, mother's uptake of children genotype testing, mother's reading of newspapers, and mother's age.	It provides information on the relationship between on healthcare access use, health literacy, women's decision-making, disability, stigma, and the proportion of children under 5-years-old living with sickle cell hemoglobin in Nigeria.

Thus, the data analysis table contained the following facts:

- secondary data analysis research questions and reasons for asking the questions,
- important information to be derived from asking the research questions, and
- the impact of the selected variables on children living with sickle cell hemoglobin (NPC, 2019).

Handling of Missing Data

The presence of missing data could lead to the reduction of statistical power and sample frame representativeness. Researchers found that test-retest analysis was beneficial in the handling of missing data (Lee et al., 2021). Missing values were controlled by multiple imputation methods and SPSS automatic deletion methods. Overall, this study considered the undesirable effects of missing data.

Descriptive Statistics

The data analysis considered descriptive statistics of the selected variables. Also, descriptive statistics addressed various features such as kurtosis, skewness, frequency tables, variance, *SD*, missing data, and valid numbers (Kaliyadan & Kulkami, 2019). Guetterman (2019) found that central tendency and variability measures were methods of dataset presentation in research. In other words, the selected variables were presented with various descriptive statistics terms such as range, *Mdn*, interquartile range (*IQR*), mode, *M*, histogram, and scatter plots. Table shells allowed an organized presentation of the epidemiological data in research (CDC, 2018b). Researchers have provided the use of descriptive statistics to report inherent outliers or extreme values in a dataset (Grant et al.,

2019; Knief & Forstmeier, 2021; Schober & Vetter, 2021). As a result, table shells were used to organize the selected variables in this study. Finally, the descriptive statistics showed measures of dispersion, central tendency, and population distribution.

Inferential Statistics

In this study, the binomial logistic regression was used to answer the research questions. Researchers focused on the use of binomial logistic regression to determine the relationship between the independent and dependent variables (Kalan et al., 2021; Schober & Vetter, 2021; Tesfaw & Fenta, 2021). Kwak and Park (2019) and Mishra et al. (2019) found that adherence to logistic regression assumptions led to improved validity in research. Similarly, Kim (2019) found that multicollinearity could predispose to errors in the statistical findings. Consequently, multicollinearity was tested between selected variable in this study. In short, the binary logistic regression assumptions were considered in the statistical analysis.

Also, this study considered the following assumptions of binary logistic regression: (a) dichotomous outcome variable, (b) adequate power, (c) absence of measurement, and (d) absence of extraneous factors. Researchers suggested the need to use a dichotomous outcome variable in a logistic binary regression analysis (Schober & Vetter, 2021). In addition, this study's data analysis involved the interpretation of the Cook's distance aimed at detection of extraneous values. The *Nagelkerke* R^2 indicated the amount of variance in the dependent variable determined by the independent variable (Chicco et al., 2018). As mentioned, each model's goodness of fit was based on various

criteria such as *Cox and Snell* R^2, Hosmer and Lemeshow test, and -2 Log likelihood estimation.

All five research questions were answered using logistic regression (see NPC, 2019). The covariates were introduced into the binomial regression analyses to examine for effect modification or confounding phenomenon. Zhao et al. (2020) and Andrade (2021) suggested that confounding phenomenon was a threat to internal validity in research. The covariates demonstrated in this study were children's height-for-weight, mother's educational level, children's age, and mother's age. Thus, this study considered effect modifiers and confounders as causes of spurious association between the selected dependent and independent variables.

This study considered a power (80%), Type II error (20%), a *p*-value (less than .05), and a moderate effect size (0.5). A *p*- value of less than .05 indicated a statistically significant contribution of the independent variables to the model; therefore, the null hypothesis was rejected. Researchers considered a *p*- value less than .05 as a statistically significant value (Andrade, 2021). Besides, the *OR* greater than 1 indicated a higher proportion of sickle cell hemoglobin (i.e., AS, SS, SC, AC, and others) in comparison to the absence of sickle cell hemoglobin (i.e., AA). The presence of sickle cell hemoglobin indicated an improved survival of children under 5-years-old living with sickle cell hemoglobin. On the other hand, the absence of sickle cell hemoglobin indicated a reduced survival of children under 5-years-old living with sickle cell hemoglobin.

Equation 2: $\text{Logit } (P/1\text{-}P) = B0 + B1*X1 + B2*X2 + B3*X3 + B4*X4 + B5*X5$

Equation 2 represented measures of socioeconomic status in Research Question 1.

Equation 3: Logit (P/1-P) = B0 + B1*Mother's employment level + B2*Mother's education level + B3*Household wealth index + B4*Household presence of water + B5*Household toilet facility location

Equations 3 showed the prediction equation for the binomial logistic regression to answer Research Question 1: P was the logit, B0 was the intercept, B1 was the slope of household presence (X1), B2 was the slope of household toilet facility location (X2), B3 was the slope of household wealth index (X3), B4 was the slope of mother's educational level (X4), and B5 was the slope of mother's employment level (X5). Thus, logistic regression was used to answer Research Questions 1 through 5.

Research Questions and Hypotheses

Research Question 1: Is there any association between socioeconomic status (as determined by household wealth index, household toilet facility location, household presence of water, mother's employment status, mother's education level), and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$1: There is no association between socioeconomic status (as determined by household wealth index, household toilet facility location, household presence of water, mother's employment status, mother's education level), and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a1: There is an association between socioeconomic status (as determined by household wealth index, household toilet facility location, household presence of water, mother's employment status, mother's education level), and the proportion of children with sickle cell hemoglobin in Nigeria.

Research Question 2: Is there an association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$2: There is no association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a2: There is an association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria.

Research Question 3: Is there an association between infection prevention (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$3: There is no association between infection treatment (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a3: There is an association between infection treatment (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-

height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria.

Research Question 4: Is there an association between pain and anemia management (as determined by children's blood transfusion status, mother's treatment of fever, children's rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$4: There is no association between pain and anemia management (as determined by children's blood transfusion status, mother's treatment of fever, children's fluid rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a4: There is an association between pain anemia management (as determined by children's blood transfusion status, mother's treatment fever, children's fluid rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

Research Question 5: Is there an association between healthcare use (as determined by antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria?

H_05: There is no association between healthcare use (as determined by antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

Ha5: There is an association between healthcare use (as determined by mother's antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

Threat Validity

External Validity

The sampling procedure did not include all the local governments in Nigeria; hence, predisposing to errors in the representativeness of the dataset. The concept of external validity provided the extent of application of a study's findings outside the original setting (Averitt et al., 2021; Fisher, 2018). Researchers indicated missing data as values not stored for an identified variable, leading to reduced validity in research (Carpenter & Smuk, 2021; Vibha & Prasad, 2020). As a result, the presence of missing information in the data could lead to reduced external validity in this study. Because of the civil unrest in Borno state, a total of 11 local government areas were dropped from the sample. Consequently, the reduction in the sample size could lead to threat to external

validity. The data were susceptible to information and selection biases, leading to threat to this study's external validity (NPC, 2019).

Internal Validity

In the primary study, the errors at the stage of data collection could pose an internal validity threat. In addition, internal validity threat could arise from inability to adjustment for bias in research, leading to reduced generalizability of the findings (Fisher et al., 2018; Haine et al., 2018; Handley et al., 2018; Nohr et al., 2018). The regression to the mean, which is an inherent problem of using binary logistic regression, could lead to internal validity threat. From above, the assumptions of binary logistic regression could not be met in all entireties in this study, leading to the threat to internal validity.

In this secondary data analysis, residual confounder could affect the validity of the results. Verbeek et al. (2021), VanderWeele (2019), and Trinh (2018) emphasized that residual confounders could affect a study's internal validity and application. The inability to control for confounders could lead to alteration of the internal validity. Equally, the field workers documentation of information could be influenced by inconsistencies and missing information. Ecological fallacy could result from the aggregation of files during the data analysis stage.

Ethical Consideration

The Walden University Institutional Review Board was approached before the data analysis stage (approval number 03-30-22-0996028). Researchers have suggested principles of ethics such as justice, consent, and beneficence (Varkey, 2021). Also, the

participants' identities were protected in this secondary data analysis. Finally, this study upheld the ethical principles in human research.

Summary and Transition

In this chapter, this quantitative cross-section study considered analysis of the 2018 Nigeria DHS dataset. Likewise, this study showed the association between the socioeconomic status, demography, healthcare use, pain and anemia management, infection prevention, and the presence of sickle cell hemoglobin. The total sample size was 11,536 children living with sickle cell hemoglobin in Nigeria (NPC, 2019). The methodology of the research consisted of various procedures such as recruitment, sampling procedures, sample sizes, data cleaning, and data collection. The instruments used in this study portrayed various attributes such as name, operation, developer, reliability, and validity. The operationalization of the constructs was mentioned in this study. In short, the methodology was presented to allow easy replication of this study.

The data analysis considered the various procedures such as data cleaning, data dictionary, data table, table shells, and handling of missing data. Also, the descriptive and inferential statistics focused on various measures such as central tendency, dispersion, odd ratio, *p*- value, 95% CI, Wald values, Hosmer and Lemeshow test, Omnibus test, and R^2 values. The data collection in the primary survey upheld the principles of ethics (NPC, 2019). As mentioned above, the data analysis began after approval from the Institutional Review Board. Chapter 4 will present details on data analysis and results interpretation.

Chapter 4: Results

This was a quantitative cross-sectional study that allowed the use of the Nigeria 2018 DHS dataset. Also, this study examined the association between the selected independent variables and the presence of sickle cell hemoglobin. The prescribed research questions and hypotheses were answered using the 2018 Nigeria DHS dataset and binomial logistic regression analysis. Also, this chapter included details on recruitment, data collection, response rate, and missing data. This study provided various statistical descriptions such as Pearson Chi-Square test, frequency tables, mean, median, outliers, cross-tabulation, valid numbers, kurtosis, skewness, and *SD*. Based on the above, the data analysis focused on the measures of central tendency and dispersion.

The research questions and hypotheses demonstrated the impact of selected independent variables on the presence of sickle cell hemoglobin. The binomial logistic regression assumptions were tested in the statistical analysis, leading to improved internal validity of the findings. As an example, a large sample size was used in the bivariate and multivariate analyses. The inferential statistics considered statistical descriptions such as *B* coefficient, *df*, *OR* (i.e., exponential *B* coefficient), 95% CI, *SE*, Hosmer and Lemeshow test, Omnibus test, the *Cox and Snell R2*, and the *Nagelkerke R²*.

Data Collection of 2018 DHS Nigeria Dataset

Data Collection

Data were collected in the survey using a cross-sectional design. In addition, a total of 774 local government areas were involved in this study. The two-staged stratified sample selection took place in the Nigerian 36 states and the Federal Capital Territory.

The primary sampling unit was known as the enumeration area, which came from the 2006 census frame. A total of 42,000 households were included in the secondary dataset. Equally, the secondary dataset showed the following population characteristics: (a) women (15-49 years), (b) men (15-59 years), and (c) children (6-59 months). The primary study showed a total of 77.1% of children (AA) in the unweighted dataset and 20.6% children (AC, AS, SS, AC, and others). Almost one third of the children's population in the 2018 Nigeria DHS dataset were involved in the genotype test.

The 2018 Nigeria DHS questionnaire was divided into the divisions such as biomarkers, household, women, and men. The survey was coordinated by the 2018 Nigeria DHS program office and the United States Agency for International Development, and NPC. The data editing allowed exclusion of inconsistencies and outliers. Besides, the sample *SE* estimation enabled accurate determination of the effect sizes. This study examined the relationship between demography, pain and anemia management, healthcare use, infection prevention, and the presence of sickle cell hemoglobin in children. From above, the outcome was depicted by the presence of sickle cell hemoglobin in children aged 6-59 months.

Furthermore, a national representative sample was derived using various methods such as weighting, stratification, clustering, random sampling, and complex sample analysis. As a result, the national representative sample allowed improved validity in this study. The 2018 Nigeria DHS program office instruction on sample weighting was utilized to ensure improved validity of the findings. The sample weighting involved using

various procedures such as sample strata for sampling errors variable (i.e., V023), primary sampling unit variable (i.e., V021), and sample weight variable.

From above, sample weighting allowed the compensation for oversampling errors and control for disproportionate stratification. The stratification strategy corrected for the nonresponse in certain groups or variables (e.g., residence, ethnicity, education, and gender). The weighted dataset reduced the disadvantages of the cross-sectional design and selection bias. In sum, the sample weighting allowed improved study's power as well as validity.

Univariate Analysis of Selected Variables

The univariate analysis showed participants with toilet in the household (73.4%, *n* = 12,458) in comparison to participants without toilet in the household (26.6%, 4,523). Less than half of the households belonged to middle-income category (47.7%, *n* = 16,297). Majority of participants belong to the rural setting (*n* = 21,023, 61.5%) and Hausa ethnicity (*n* = 17,476, 51.5%). Male children were higher (50.6%, *n* = 1,153) in comparison to female children (49.3%, *n* = 1,126). Majority of the children were vaccinated (*n* = 7,422, 67.4%) in this study.

Furthermore, the households use of mosquitoes' net (59.8%, *n* = 19,418) was more in comparison to households not using mosquitoes' net (40.2%, *n* = 13,040). Majority of the children were on African protein diet supplement (*n* = 32,210, 96.2%). Blood transfusion status of the children revealed only (1%, *n* = 20) receiving blood. Children on rehydration therapy were (40.0%, *n* = 1,582) in comparison to their counterpart not on rehydration therapy were (59.9%, *n* = 2,366). In addition, mother's

treatment of diarrhea illness was found in majority of the households (60.2%, *n* = 2,379). Mother's uptake of children's genotype test was found in the majority of households (*n* = 2,011, 98.6%). Mother's reading of newspapers was found almost two third of the households (*n* = 30,328, 88.7%). Mother's delivery place showed majority had used hospital facilities (68.8%, *n* = 20,175).

The correlation matrix showed $r < .8$ between the selected independent variables in this study. Consequently, the variables were included in the bivariate and multivariate logistic regression analyses. Also, mother's age histogram showed a mesokurtic shape, but a child's age histogram showed a platykurtic pattern. Also, children's hemoglobin histogram indicated a platykurtic shape. The selected continuous variables met the assumptions of binary logistic regression. As a result, the variables were introduced into the statistical analysis. The Chi-Square tests of association showed that the selected independent variables were independent of each other. Thus, the statistical or data analysis obeyed the binomial logistic regression assumptions.

Results

Descriptive Statistics

The sickle cell hemoglobin weighted sample is displayed in Table 9. The unweighted sample showed hemoglobin AA (77.7%, *n* = 8,741) in comparison to sickle cell hemoglobin (22.3%, *n* = 2,502). Mother's education attainment was high in more than half of the households (58.2%, *n* = 19,887).

Table 9

Descriptive Statistics of Weighted Dependent Variables

Variable	Frequency	Valid percentage	Cumulative percentage
Sickle Cell Disease Status			
Absence of sickle cell hemoglobin	1,607	79.4	79.4
Presence of hemoglobin sickle cell hemoglobin	418	20.6	100.0

Mother's educational status showed a maximum value (.0), minimum value (1.0), and range (2.0). Also, mode values of 1.0 were found in selected variables such as household wealth index, mother's educational status, household toilet facility, mother's employment, and household presence of water location. Skewness value of .0 indicated the normality of population distribution in this study. Thus, the normality of distribution was proved at a skewness value between -.5 and +.5.

In addition, residence showed a maximum value (2.0), a minimum value (1.0), and a range (1.0). Ethnicity showed a maximum value (4.0), a minimum value (1.0), and a range (3.0). Religion showed a maximum value (96.0), a minimum value (1.0), and a range (95.0). A child's gender showed a maximum value (1.0), minimum value (.0), and a range (1.0). Nigeria geopolitical zones revealed a maximum value (6.0), minimum value (1.0), and a range (5.0).

The weighted sickle cell disease status (i.e., outcome variable) revealed the descriptive statistics values such as sum (417.76), mode (0), range (1.0), minimum (.0) and minimum (1.0). Also, households belonging to the middle-income group revealed

(47.7%, *n* = 16,297), and mother's employment status showed (71.4%, 24,413) working in the last 12 months (see Table 10).

Table 10

Descriptive Statistics of Weighted Socioeconomic Variables

Variable	Frequency	Valid percentage	Cumulative percentage
Household wealth index			
Low	5,346	15.6	15.6
Middle	16,297	47.7	63.3
High	12,550	36.7	100.0
Total	34,193		
Household toilet facility location			
Toilet outside household	12,458	73.4	73.4
Toilet within household	4,523	26.6	100.0
Total	16,981		
Household presence of water			
Water is not available			
Water is available	14,285	48.1	48.1
Total	15,423	51.9	100.0
Mother's employment status	29,708		
No			
Yes	9,780	28.6	28.6
Total	24,413	71.4	100.0
	34,193		
Mother's educational level			
No Education	14,306	41.8	41.8
Education	19,887	58.2	100.0
Total	34,193		

Thirty-six percent (*n* = 12,304) households belong to the Christian religion or faith. Majority of participants belong to the Hausa race (see Table 11).

Table 11

Descriptive Statistics of Weighted Demography Categorical Variables

Variable	Frequency	Valid percentage	Cumulative percentage
Residence			
Urban	13,170	38.5	38.5
Rural	21,023	61.5	100
Total	34,193		
Ethnicity			
Hausa	17,476	51.1	51.1
Yoruba	3,749	11.0	62.1
Igbo	5,609	16.4	78.5
Others	7,360	21.5	100.0
Total	34,193		
Religion			
Christian	12,304	36.0	36.0
Islam	21,706	63.5	99.5
Traditionalist	182	.5	100.0
Total	34,193		
A child's gender			
Male	1,153	50.6	50.6
Female	1,126	49.4	100.0
Total	2,279		
Nigeria geopolitical zone			
Northcentral	4,619	13.5	13.5
Northeast	6,213	18.2	31.7
Northwest	12,558	36.7	68.4
Southeast	3,428	10.0	78.4
South	2,968	8.7	87.1
Southwest	4,407	12.9	100.0
Total	34,193		

More than half of the households used mosquitoes' net a night before the interview (56.8%, *n* = 19,418). Children's diarrhea treatment (60.2%, n = 2,379) was more their counterpart not treated for diarrhea (39.8%, *n* = 1, 571), as shown in Table 12.

Table 12

Descriptive Statistics of Weighted Infection Prevention Categorical Variables

Variable	Frequency	Valid percentage	Cumulative percentage
Childhood vaccination			
No	3,588	32.6	32.6
Yes	7,422	67.4	100.0
Total	11,010		
Children's African protein supplementation			
No	32,210	94.2	94.2
Yes	1,983	5.8	100.0
Total	34,193		
Household use of mosquitoes' net			
No	13,040	40.2	40.2
Yes	19,418	59.8	100.0
Total	32,458		
Children's diarrhea treatment			
No	1,571	39.8	39.8
Yes	2,379	60.2	100.0
Total	3,950		

The weighted continuous variable representing healthcare use (i.e., a mother's age) possessed Gaussian curve distribution on inspection of the histogram. A mother's age in this study showed values (M = 29.86, SD = 6.70). Table 13 displays the descriptive statistics selected measures of infection prevention measures in this study.

Table 13

Descriptive Statistics of Weighted Pain and Anemia Management Categorical Variables

Variable	Frequency	Valid percentage	Cumulative percentage
Children's transfusion status			
No	2,033	99.0	99.0
Yes	20	1.0	100.0
Total	2, 053		
Mother's treatment of fever			
No	2,600	31.8	31.8
Yes	5,571	68.2	100.0
Total	8,171		
Children's antibiotic prophylaxis			
No	2,801	70.9	70.9
Yes	1,136	28.8	99.7
Don't know	13	.3	100.0
Total	3,950		
Children's rehydration status			
No	2,366	59.9	59.9
Yes	1,582	40.0	99.0
Total	3,950		100.0

The measures of central tendency (i.e., sum and medium) and dispersion were considered for a child's age. In a child's age, a kurtosis of value of -1.2 indicated an abnormal population distribution. Besides, the normal value for a Gaussian distribution stayed between -1 to +1. The median and *IQR* were used to present a child's age because the histogram showed a platykurtic shape or pattern. A child's age revealed a descriptive statistic such as *Mdn* = 30.00 and *IQR* = 30.00, and a child's age showed statistics values (*M* = 29.81, *SD* = 17.51). Children's weight-for-height showed a statistics value (*M* = 67.80, *SD* = 1011.90).

Both religion and Nigeria geopolitical zone showed mode values of 3. The improved uptake of mosquitoes' net use was an indication successful strategy to reduce

malaria infection. Mother's knowledge was demonstrated by mother's uptake of children's genotype test and antenatal care use (see Table 14).

Table 14

Descriptive Statistics of Weighted Healthcare Categorical Variables

Variable	Frequency	Valid percentage	Cumulative percentage
Antenatal care use			
No	11,493	69.3	69.3
Yes	5,082	30.7	100.0
Total	16,575		
Mother's uptake of children's genotype testing			
Granted	2,011	98.9	98.9
Refused	21	1.1	100.0
Total	2,033		
Mother's use of health insurance			
No	33,466	97.9	97.9
Yes	727	2.1	100.0
Total	34,193		
Mother's place of delivery			
Not in a health facility	20,175	68.8	68.8
In a health facility	9,169	31.2	100.0
Total	29,344		
Mother's reading of newspaper			
No	30,328	88.7	68.8
Yes	3,865	11.3	100.0
Total	34,193		

The weighted continuous variable representing infection prevention (i.e., children's weight-for-height) showed *Mdn* = -29.00 and *IQR* = -29.00 (see Table 15). The histogram representing children's weight-for-height revealed an abnormal population distribution.

Table 15

Descriptive Statistics of Weighted Continuous Variable in the Research

Variable	Mean	Sum	Skewness *SE*	Interquartile range	Kurtosis *SE*
A child's age	30.0	67,938	.1	30.0	-1.2
Children's weight-for-height	-29.0	152,561	.0	-29.0	.1
Children's hemoglobin	105.0	243,979	.1	105.0	.1
Children's breastfeeding status	93.00	320,1264	.0	93.0	.0
Mother's age	30.0	405,295	.0	30.0	.0

Statistical Assumptions Considered and Post-Hoc Analyses

Binomial Logistic Regression Assumptions

Log Odds Linearity. Binomial regression analyses focused on the linearity between the logit of outcome variable and independent variables. In this study, the logit of the relationship between sickle cell disease status (i.e., outcome) and independent variables was linear. Scatter plots were used to demonstrate the linearity of logit in selected factors such as socioeconomic status, demography, infection prevention, pain and anemia management, healthcare use, and sickle cell disease status.

Binomial Distribution of Outcome Variable. This study focused on the binary distribution of the outcome variable that was categorized into yes or no. To put differently, the outcome variable was categorized into 1 = *yes* or 0 = *no*. As a result, one of the assumptions of binomial logistic regression was satisfied by categorization of the

outcome variable into 1 = *presence of sickle cell hemoglobin* or 0 = *absence of sickle cell hemoglobin.*

Multicollinearity. The assumption of multicollinearity was tested. Correlation matric value $r > .8$ denoted high correlation between variables in this study. On the contrary, the correlation analysis value $r < .8$ presented a low correlation between the selected variables in this study. There was absence of multicollinearity among the selected variables. Thus, the correlation analysis values favored the introduction of the selected variables into the binomial logistic regression analyses.

Correlation Matrix. The correlation matrix value of $r > .8$ indicated high correlation in this study. However, the correlation matrix $r < .8$ revealed absence of multicollinearity.

Large Sample Size and Independent Observations. This study took into consideration the assumption of presence of a large sample size and a minimum 10 independent observations per variable. The redundant variables were analyzed using no constant method in SPSS and application of the parsimony principle.

Chi-Square Test Assumption

Pearson Chi-Square test of association showed that the selected categorical variables were independent of each other. For that reason, the selected categorical variables were included in the binomial logistic regression analysis.

Bivariate Binomial Logistic Regression

Bivariate logistic analysis revealed the relationship between the presence of sickle cell hemoglobin and socioeconomic factors. In addition, the direction of the relationship between the selected variables were provided. Research Question 1 was answered with selected variables such as household toilet facility, household wealth index, mother's employment status, household presence of water, mother's employment status, and mother's educational level.

In addition, the Hosmer and Lemeshow test showed a model of good fit in mother's employment status ($p = .075$). For mother's employment status, the *Cox and Snell* R^2 was .001 and the *Nagelkerke* R^2 was .002. Consequently, a total of .1% of variance in sickle cell disease was explained by variance in mother's employment status using the *Cox and Snell* R^2. A total of .2% of variance in the presence of sickle cell hemoglobin was explained by variance in mother's employment status using the *Nagelkerke* R^2. Also, the -2 Log likelihood ratio was 2,058.336 for mother's employment status. The Omnibus test of model coefficient showed a statistically insignificant relationship between the mother's employment status and presence of sickle cell hemoglobin, X^2 (1) = 2.927, $p = .085$ (see Table 16).

Table 16

Bivariate Logistic Regression Summary of Socioeconomic Status Variables

Variable	*p*- value	95% CI interpretation	Hypothesis interpretation	Statistical significance
Mother's employment status	.085	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Mother's education level	.777	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Household toilet facility	.340	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Household presence of water	.456	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Household wealth index	.856	Does cross 0	Fail to reject null hypothesis	Not statistically significant

Mother's employment status did not show a statistically significant relationship with presence of hemoglobin, B = -.205, SE = .119, *Wald* (X^2) = 2.97, p = .085. For a mother's employment status, the odds of presence of sickle cell hemoglobin were 18.5% less than absence of sickle cell hemoglobin (OR = .815, 95% CI: [.646, 1.029]). To put it differently, mother's employment status in the last 12 months was less likely to show presence of sickle cell hemoglobin in comparison to mother's not employed in the last 12 months. Therefore, the null hypothesis was not rejected, indicating no association between mother's employment and presence of sickle cell disease.

The -2 Log likelihood ratio was 1,795.03 for household presence of water. Also, the Omnibus test of model coefficient did not show a statistically significant relationship between the household presence of water and presence of sickle cell hemoglobin, X^2 (1) =

2.927, p = .085. Besides, household presence of water did not show a statistically significant relationship with presence of sickle cell hemoglobin, B = -1.378, SE = .118, *Wald* (X^2) = .557, p = .456. For household presence of water, the odds of presence of sickle cell hemoglobin were 10% higher than absence of sickle cell hemoglobin (*OR* = 1.092, 95% CI: [.867, 1.375]). The presence of water in the household was more likely to show presence of sickle cell hemoglobin in comparison to absence of water in the household. Therefore, the null hypothesis was not rejected based on the above results.

The -2 Log likelihood ratio was 2,061.18 for mother's educational level. In addition, the Omnibus test of model coefficient did not show a statistically significant relationship between the mother's educational level and the presence of sickle cell hemoglobin, X^2 (1) = 2.927, p = .087. Mother's educational level did not show a statistically significant relationship with presence of hemoglobin, B = -.174, SE = .055, *Wald* (X^2) = 601.59, p = .777. Mother's high educational level was 16% lower than the presence of sickle cell hemoglobin in comparison with mother's low educational level (*OR* = .840, 95% CI: [.252, 2.802]). Therefore, the null hypothesis was not rejected based on the above findings.

The -2 Log likelihood ratio was 987.58 for household toilet facility location. Additionally, the Omnibus test of model coefficient for household toilet facility revealed an overall model possessing statistically insignificant p- value, X^2 (1) = .899, p = .343. Household toilet facility location did not show a statistically significant relationship with presence of hemoglobin, B = .168, SE = .176, *Wald* (X^2) = .81, p = .340. For household toilet facility location, the odds of presence of sickle cell hemoglobin were 18% higher

than the absence of sickle cell hemoglobin (*OR* = 1.18, 95% CI: [.838, 1.670]). Therefore, the null hypothesis was not rejected based on the above findings.

Also, the Hosmer and Lemeshow test showed a model of good fit for household wealth index, $X^2 = .033$, $p = .075$. The -2 Log likelihood ratio was 2,061.23 for household wealth index. The Omnibus test of model coefficient in household wealth did not show a statistically significant, $X^2 (1) = .899$, $p = .343$. Household wealth index did not show a statistically significant relationship with the presence of sickle cell hemoglobin. Household wealth index showed the strongest predictor of the presence of hemoglobin in the model. Therefore, the null hypothesis was not rejected, indicating no association between household wealth index and presence of sickle cell hemoglobin.

Multivariate Binomial Logistic Regression

Furthermore, the Hosmer and Lemeshow test showed a good fit model without controlling for covariate, $X^2 (2) = .921$, $p = .247$. After not controlling for mother's educational level, the *Cox and Snell* R^2 was .07 and the *Nagelkerke* R^2 was .012. Considering the *Cox and Snell* R^2, .7% of the variance in sickle cell disease status was explained by independent variables, without controlling for covariate (see Table 17).

Table 17

Weighted Socioeconomic Variables Multivariate Logistic Regression Without Covariate

Variable	*B*	Wald value	Odds ratio	*p*- value	*SE*	*df*	95% CI
Household wealth index		3.864		.145		2	
Household wealth index (1)	.771	3.065	2.162	.080	.440	1	.912, 5.123
Household wealth index (2)	-.105	.300	.901	.584	.191	1	.619, 1.310
Household toilet facility (1)	-.183	.926	.833	.336	.190	1	.574, 1.208
Household presence of water (1)	.021	.926	1.021	.904	.170	1	.732, 1.424
Mother's employment status	.264	.180	1.303	.142	.180	1	.915, 1.854
Constant	-1.308	56.209	.142	< . 001			

The -2 Log likelihood value was 905.43 after not controlling for covariate. After not controlling for covariate, the Omnibus test did not show a statistically significant association in the model, X^2 (5) = 6.66, p = .247. Also, households from the middle-income wealth index were 116.2% higher than those from low-income wealth index to show presence of sickle cell hemoglobin after not controlling for mother's educational level (*OR* = 2.162, 95% CI: [.912, 5.123]). However, households from high-income wealth index were 10% lower than those from low-income wealth index to show presence of sickle cell hemoglobin after not controlling for mother's education level (*OR* = .901, 95% CI: [.619, 1.310]). Middle-income wealth index was the strongest predictor

of the presence of presence of sickle cell hemoglobin after not controlling for mother's education level. Therefore, the null hypothesis was not rejected in household wealth index, after not controlling for mother's education level.

Household presence of toilet facility in comparison to household absence of toilet facility was insignificantly 16.7% lower than the presence of sickle cell hemoglobin after not controlling for mother's education level (*OR* = .833, 95% CI: [.574, 1.208]). Consequently, the null hypothesis was not rejected for household toilet facility after not controlling for mother's education level. Household presence of water in comparison to household absence of water was insignificantly 2.1% more than the presence of sickle cell hemoglobin, without controlling for mother's education level (*OR* = 1.021, 95% CI: [.732, 1.424]). As a result, the null hypothesis was not rejected for household presence of water based on the above findings. Mother's employment in the last 12 months in comparison to mother's unemployment in the last 12 months was insignificantly 30.3% higher than the presence of sickle cell hemoglobin after not controlling for mother's education level (*OR* = 1.303., 95% CI: [.915, 1.854]). Therefore, the null hypothesis was not rejected in mother's employment after not controlling for mother's education level.

The Hosmer and Lemeshow test showed a statistically insignificant value, X^2 *(2)* = .165, p = .921 after controlling for covariate. After controlling for mother's educational level, the *Cox and Snell* R^2 is .07 and the *Nagelkerke* R^2 is .012. Considering the *Nagelkerke* R^2, 1.2% of the variance in sickle cell disease status was explained by socioeconomic status variables after controlling for covariate. In addition, the -2 Log likelihood value was 905.43 after controlling for covariate. The Omnibus test did not

show association between socioeconomic variables and the presence of sickle cell disease with controlling for mother's educational level, X^2 (5) = 6.66, p = .247 (see Table 18).

Table 18

Weighted Socioeconomic Variables Multivariate Logistic Regression With Covariate

Variable	*B*	Wald value	Odds ratio	*p*- value	*SE*	*df*	95% CI
Household wealth index		3.566		.168		2	
Household wealth index (1)	.745	2.840	2.107	.080	.092	1	.886, 5.013
Household wealth index (2)	-.100	.274	.905	.601	.191	1	.622, 1.316
Household toilet facility (1)	-.182	.190	.833	.337	.190	1	.574, 1.209
Household presence of water (1)	.026	.023	1.026	.879	.170	1	.735, 1.432
Mother's employment status	.267	.717	1.306	.397	.821	1	.917, 1.859
Mother's educational level (1)	-.623	.570	.499	.397	.821	1	.100, 2.495
Constant	-.623	.570	.536	.450	.826	1	

Household presence of toilet facility in comparison to household absence of toilet facility was insignificantly 16.7% lower (*OR* = .833) to show the presence of sickle cell hemoglobin after controlling for mother's education level. Coupled with above findings, household presence of water in comparison to household absence of water was insignificantly 2.6% higher (*OR* = 1.026) to show the presence of sickle cell hemoglobin

after controlling for mother's education level. Mother's employment in the last 12 months in comparison to mother's unemployment in the last 12 months was insignificantly 30.6% higher (*OR* = 1.306) to show the presence of sickle cell hemoglobin after controlling for mother's education level.

Household from the middle-income wealth index was 110.7% higher than those from low-income wealth index to show the presence of sickle cell hemoglobin after controlling for mother's educational level (*OR* = 2.107, 95% CI: [.886, 5.013]). However, household from high-income wealth index was insignificantly 9.5% lower to show the presence of sickle cell hemoglobin after not controlling for mother's education level (*OR* = .905, 95% CI: [.622, 1.316]). Thus, middle-income wealth index was the strongest predictor of the presence of presence of hemoglobin after controlling for covariate.

This research did not show a statistically significant interaction between mother's educational level, household wealth index, household toilet facility, household presence of water, and mother's employment status. Also, mother's educational level did not show a statistically significant relationship with presence of sickle cell hemoglobin (*OR* = .499, 95% CI: [.100, 2.495]). Consequently, this study did not show effect modification by mother's educational level. The low proportion of sickle cell hemoglobin indicated failure of instituted public health program, but a high level of sickle hemoglobin indicated a success of public health program. Therefore, the null hypothesis was not rejected in the Research Question 1 after controlling for mother's educational level.

Research Question 2: Is there an association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$2: There is no association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a2: There is an association between residence, ethnicity, Nigeria geopolitical zones, male child, female child, religion, a child's age, and the proportion of children with sickle cell hemoglobin in Nigeria.

Bivariate Binomial Logistic Regression

The Hosmer and Lemeshow revealed a statistically insignificant *p*- values for residence. Moreover, the -2 Log likelihood ratio was 2060.84 for residence. Residence did not show a statistically significant relationship with the presence of hemoglobin in the bivariate model, $B = .088$, $SE = .118$, $Wald\ (X^2) = .418$, $p = .518$. For residence, the odds of presence of sickle cell hemoglobin were 7% lower than absence of sickle cell hemoglobin ($OR = .929$, 95% *CI*: [7.44, 1.61]). Therefore, null hypothesis was not rejected, indicating no association between residence and the presence of sickle cell disease.

Also, female gender showed a higher proportion or presence of sickle cell hemoglobin in comparison to a male gender. The Omnibus test of model coefficient in female gender revealed a statistical insignificant value for a child's gender. Female gender in comparison to male gender did not show a statistical significance relationship

with presence of sickle cell hemoglobin, *B* = .110, *SE* = .058, *Wald (X²)* = .276, *p* = .559. For female gender, the odds of presence of sickle cell hemoglobin were 5.9% higher than the absence of sickle cell hemoglobin (*OR* = 1.059, 95% *CI*: [.854, 1.314]). Therefore, null hypothesis was not rejected, indicating no association between female gender and the presence of sickle cell disease.

The -2 Loglikelihood ratio was 2,060.071 for Nigeria geopolitical zones. The Hosmer and Lemeshow test indicated model of poor fit in Nigeria geopolitical zone. In addition, the Omnibus test in Nigeria geopolitical zone revealed a statistically insignificant value. Nigeria geopolitical zone revealed a statistical insignificant relationship with presence of hemoglobin in the bivariate model, *B* = .276, *SE* = .037, *Wald (X²)* = .276, *p* = .559. For Nigeria geopolitical zone, the odds of presence of sickle cell hemoglobin were 5.9% higher than the absence of sickle cell hemoglobin (*OR* = 1.059, 95% *CI*: [.845, 1.314]). Therefore, null hypothesis was not rejected, indicating no association between Nigeria geopolitical zone and the presence of sickle cell disease.

In a child's age, the *Cox and Snell R²* was .003 and the *Nagelkerke R²* was .004. As a result, a total of .4% of variance in sickle cell disease status was explained by variance in a child's age, the *Nagelkerke R²*.and the *Cox and Snell R²*. Besides, the -2 Log likelihood ratio was 2,056.109 for a child's age. The Omnibus test of model coefficient for a child's age indicated an overall statistically significant model. A child's age did reveal a statistically significant relationship with presence of sickle cell hemoglobin, *B* = -.008, *SE* = .003, *Wald (X²)* = 5.31, *p* = .023. For a child's age, the odds of presence of sickle cell hemoglobin were .8% lower than the absence of sickle cell hemoglobin (*OR* =

.992, 95% *CI*: [.986, .999]). A low proportion of sickle cell hemoglobin indicated failure of public health program, but a high proportion of sickle cell hemoglobin indicated a success of public health program. Therefore, null hypothesis was not rejected, indicating no association between a child's age and the presence of sickle cell disease (See Table 19).

Table 19

Bivariate Logistic Regression Summary of Demography Variables

Variable	*p*- value	95% CI interpretation	Hypothesis interpretation	Statistical significance
Residence	.518	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Religion	.452	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Female gender in comparison to male gender	.599	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Child's age	.023	Does not cross 0	Reject null hypothesis	Statistically significant
Ethnicity	.388	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Nigeria geopolitical zone	.662	Does cross 0	Fail to reject null hypothesis	Not statistically significant

For ethnicity, the *Cox and Snell* R^2 was .001 and the *Nagelkerke* R^2 was .001. For that reason, a total of .1% of variance in sickle cell disease status was explained by variance in ethnicity, the *Nagelkerke* R^2. Also, the -2 Log likelihood ratio was 2,056.330 for ethnicity. The Omnibus test for ethnicity revealed a statistical insignificant value, X^2 (1) = 5.153, p = .338. Ethnicity did not show a statistically significant relationship

between and the presence of sickle cell hemoglobin, *B* = -.038, *SE* = .044, *Wald (X²)* = .745, *p* = .388. For ethnicity, the odds of presence of sickle cell hemoglobin were 3.7% lower than the absence of sickle cell hemoglobin (*OR* = .963, 95% CI: [.883, 1.049]). Therefore, null hypothesis was not rejected, indicating no association between ethnicity and the presence of sickle cell disease.

Multivariate Binomial Logistic Regression

Also, the Hosmer and Lemeshow test showed model of good fit after not controlling for a child's age. Hence, the *Cox and Snell R²* showed 0.9% of the variance in sickle cell disease status was explained by demography variables after not controlling for a child's age. The *Nagelkerke R²* revealed 15% of the variance in sickle cell disease status was explained by demography variables after not controlling for a child's age. Again, the -2 Log likelihood value was 2,071.456 after not controlling for covariate. After not controlling for a child's age, the Omnibus test did not show a statistically significant relationship between demography variables and sickle cell disease status.

After not controlling for a child's age, the households who belong to Yoruba ethnicity (*OR* = 2.090) were 109% higher, Hausa ethnicity (*OR* = 1.319) 31.9% higher, and Igbo ethnicity (*OR* = .987) were 1.3% lower than reference groups to reveal the presence of sickle cell hemoglobin. After not controlling for a child's age, female child was 4.1% higher than male child to reveal the presence of sickle cell hemoglobin (*OR* = 1.041, 95% CI: [.908, 1.918]), as shown in Table 20.

Table 20

Weighted Demography Variables Multivariate Logistic Regression Without Covariate

Variable	*B*	Wald value	Odds ratio	*p*-value	*SE*	*df*	95% CI
Residence (1)	-.125	.971	.883	.325	.127	1	.688, 1.131
Ethnicity		5.900		.117		3	
Ethnicity (1)	.277	2.112	1.319	.146	.092	1	.908, 1.918
Ethnicity (2)	.737	4.810	2.090	.028	.336	1	1.082, 4.037
Ethnicity (3)	-.013	.002	.987	.963	.286	1	.563, 1.728
Nigeria geopolitical zone		10.115		.072		5	
Nigeria geopolitical zone (1)	.707	4.499	2.028	.034	.333	1	1.055, 3.899
Nigeria geopolitical zone (2)	.413	1.315	1.511	.251	.360	1	.746, 3.058
Nigeria geopolitical zone (3)	.410	1.305	1.507	.253	.359	1	.746, 3.047
Nigeria geopolitical zone (4)	1.106	6.756	3.012	.009	.425	1	1.312, 6.956
Nigeria geopolitical zone (5)	.962	6.458	2.618	.011	.962	1	1.246, 5.500
Female gender (1)	.041	.135	1.041	.714	.111	1	.838, 1.294
Religion		2.322		.313		2	
Religion (1)	2.264	1.929	9.626	.165	1.630	1	.394, 235.127
Religion (2)	2.369	2.102	10.689	.147	1.634	1	.434, 263.069
Constant	-4.388	6.972	.012	.008	1.662	1	

After not controlling for a child's age, households who belong to the Christian religion were 862.6% higher than those in traditional religion to show the presence of sickle cell hemoglobin (*OR* = 9.626, 95% CI: [.944,235.12]). After not controlling for covariate, household who belongs to Islam religion were 968.9% higher than those in traditional religion to show the presence of sickle cell hemoglobin (*OR* = 10.689, 95% CI: [.434,263.069]). Above all, Islam religion was the strongest predictor of the presence of sickle cell hemoglobin without controlling for a child's age.

After not controlling for a child's age, households from Northwest geopolitical zone (*OR* = 1.511) were significantly 51.1%, Northwest geopolitical zone (*OR* = 3.021) were 116.8%, and those from South (*OR* = 2.618) were 161.8% higher than reference groups to reveal the presence of sickle cell hemoglobin. Also, after not controlling for a child's age, households whose ethnicity was Hausa were 39.1% (*OR* = 1.391) higher than those in other ethnicity to show the presence of sickle cell hemoglobin. In this study, the relationship between Northeast and the presence of sickle cell hemoglobin was not statistically hemoglobin at a *p*- value of .251 ($p > .05$), but statistically significant for Yoruba ethnicity at a *p*- value of .028 after controlling for a child's age.

For Northeast in comparison to Southwest, the odds of presence of sickle cell hemoglobin were 51.1% higher than the absence of sickle cell hemoglobin (*OR* = 1.511, 95% CI: [.746, 3.058]) after not controlling for a child's age. For Northwest in comparison to Southwest, the odds of presence of sickle cell hemoglobin were 51% higher than absence of sickle cell hemoglobin (*OR* = 1.507, 95% CI: [.746, 3.047]) after not controlling for a child's age. For Southeast in comparison to Southwest, the odds of

presence of sickle cell hemoglobin were 202.1% higher than the absence of sickle cell hemoglobin (*OR* = 3. 021, 95% CI: [1.312, 6.956]) after not controlling for a child's age.

For South in comparison to Southwest, the odds of presence of sickle cell hemoglobin were (*OR* = 2.168) 116.8% higher than the absence of sickle cell hemoglobin after not controlling for covariate. Igbo ethnicity in comparison to other ethnicity revealed odds of presence of sickle cell hemoglobin (*OR* = .987) 1.3% lower than the absence of sickle cell hemoglobin after not controlling for covariate. Hausa ethnicity in comparison to other ethnicity showed odds of presence of sickle cell hemoglobin (*OR* = 1.319) 31.9% higher than the absence of sickle cell hemoglobin after not controlling for covariate. Also, Yoruba ethnicity in comparison to other ethnicity revealed the odds of presence of sickle cell hemoglobin were (*OR* = 2.090) 109% higher than the absence of sickle cell hemoglobin after not controlling for covariate. For Northcentral geopolitical zone, the odds of presence of sickle cell hemoglobin were (*OR* = 2.208) 120.8% higher than the absence of sickle cell hemoglobin after not controlling for covariate.

After not controlling for a child's age, statistically significant findings were found in selected variables such as Northcentral, Southeast, South, and Yoruba ethnicity. As a result, null hypothesis was rejected after not controlling for a child's age. After not controlling for covariate, multivariate regression prediction suggested a statistical insignificant finding in selected variables such as urban, Hausa, Igbo, Northeast, Northwest, female child, Christian, and Islam. Therefore, the null hypothesis was not rejected in Research Question 2 after controlling for covariate (see Table 21).

Table 21

Weighted Demography Variables Multivariate Logistic Regression With Covariate

Variable	*B*	Wald value	Odds ratio	*p*- value	*SE*	*df*	95% CI
Residence (1)	-.121	.915	.886	.339	.127	1	.691, 1.136
Ethnicity		5.900		.117		3	.
Ethnicity (1)	.287	2.251	1.332	.134	.191	1	.916, 1.937
Ethnicity (2)	.704	4.377	2.022	.036	.337	1	1.045, 3.910
Ethnicity (3)	-.049	.030	.952	.864	.287	1	.542, 1.672
Nigeria geopolitical zone		10.244		.069		5	
Nigeria geopolitical zone (1)	.665	3.963	1.945	.047	.334	1	1.010, 3.746
Nigeria geopolitical zone (2)	.383	1.134	1.467	.287	.360	1	.725, 2.972
Nigeria geopolitical zone (3)	.379	1.114	1.461	.291	.359	1	.723, 2.956
Nigeria geopolitical zone (4)	1.137	6.435	2.615	.008	.426	1	1.353, 7.187
Nigeria geopolitical zone (5)	.961	6.458	2.618	.011	.379	1	1.244, 5.495
Female gender (1)	.040	.129	1.041	.720	.111	1	.837, 1.293
Religion		2.260		.323		2	
Religion (1)	2.242	1.891	9.414	.169	1.630	1	.385, 229.947
Religion (2)	2.343	2.056	10.416	.152	1.634	1	.423, 256.266
Child's age	-.008	5.261	.992	.022	.003	1	.985, .999
Constant	-4.085	6.006	.017	.014	1.667	1	

After controlling for a child's age, the Hosmer and Lemeshow test showed model of good fit, X^2 (8) = 10.230, p = .249. After controlling for mothers' educational level, the *Cox and Snell* R^2 was .012 and the *Nagelkerke* R^2 was .019. After controlling for covariates, Igbo ethnicity were 1.3% lower (*OR* = 0.987) more than other ethnic groups to show the presence of sickle cell hemoglobin. After not controlling for a child's age, a female child was 4.1% higher than a male child to reveal the presence of sickle cell hemoglobin (*OR* = 1.041, 95% CI: [.837, 1.859]). After not controlling for a child's age, households who belong to the Christian religion were 841.4% higher than those in traditional religion to show the presence of sickle cell hemoglobin (*OR* = 9.414, 95% CI: [.385, 229.947]). After not controlling for covariate, household who belonged to Islam religion were 942.3% higher than those in traditional religion to show the presence of sickle cell hemoglobin (*OR* = 10.423, 95% CI: [.423, 256.266]). Thus, Islam religion was the strongest predictor of the presence of sickle cell hemoglobin after controlling for a child's age.

After controlling for a child's age, households from Northwest (*OR* = 1.461) were insignificantly 46.1% and Northwest (*OR* = 1.461) were 46.1% higher than Southwest to reveal the presence of sickle cell hemoglobin. After controlling for a child's age, household from Southeast (2.615) were significantly 161.5%, Northeast (*OR* = 1.467) were 46.7% higher, and South (*OR* = 2.618) 161.8% higher than Southwest to reveal the presence of sickle cell hemoglobin. After controlling for a child's age, households whose ethnicity was Hausa ethnicity were 33.2% (*OR* = 1.332) higher than other ethnicity to show the presence of sickle cell hemoglobin. Additionally, Yoruba ethnicity in

comparison to other ethnicity revealed the odds of presence of sickle cell hemoglobin 102.2% lower than the absence of sickle cell hemoglobin (*OR* = 2.022, 95% CI: [1.045, 3.910]) after controlling for a child's age.

Additionally, Igbo ethnicity in comparison to other group showed the odds of presence of sickle cell hemoglobin were 4.8% lower than absence of sickle cell hemoglobin (*OR* = .952, 95% CI: [.542, 1.672]) after controlling for a child's age. Female gender in comparison to male gender revealed the odds of presence of sickle cell hemoglobin was 4.1% higher than absence of sickle cell hemoglobin (*OR* = 1.041, *95% CI*: [.837, 1.293]) after controlling for a child's age.

A child's age showed a statistically significant relationship with presence of sickle cell hemoglobin (*OR* = .992, 95% CI: [.985, .999]). Consequently, a child's age was an effect modifier in the full model. Also, *OR* less than 1 indicated a lower proportion of sickle cell hemoglobin (i.e., AC, AS, SS, SC, and others) compared to absence of sickle cell hemoglobin (i.e., AA). A low proportion of sickle cell hemoglobin indicated failure of instituted public health strategies, but a high proportion of sickle cell hemoglobin indicated a success of the public health strategies.

After controlling for a child's age, a statistically significant findings were seen in selected variables such as urban, Hausa, Igbo, Northcentral, Northwest, Christian, and Islam. As a result, the null hypothesis was not rejected in Research Question 2 after controlling for a child's age. After controlling for a child's age, a statistically significant findings were seen in selected variables such as Yoruba ethnic group, Northeast, South, a

child's age. Therefore, the null hypothesis was rejected in Research Question 2 after controlling for a child's age.

Research Question 3: Is there an association between infection prevention (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$3: There is no association between infection treatment (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a3: There is an association between infection treatment (as determined by childhood vaccination, household use of mosquitoes' net, children's African protein diet supplement, children's diarrhea treatment, children's weight-for-height, a child's breastfeeding status), and the proportion of children with sickle cell hemoglobin in Nigeria.

Bivariate Binomial Logistic Regression

Bivariate logistic analysis showed the relationship or association between infection prevention variables and presence of sickle cell hemoglobin. Also, the Hosmer and Lemeshow test goodness of fit test indicated a model of good fit in children's breastfeeding status, $X^2 = .299$, $p = .585$. The -2 Log likelihood ratio was 2,060.964 for

children's breastfeeding status. Equally, the Omnibus test children's breastfeeding status indicated a model with statistically insignificant value, X^2 (1) = 2.99, p = .585. Children's breastfeeding status did not show a statistically significant relationship with presence of sickle cell hemoglobin, B = .033, SE = .060, *Wald* (X^2) = .300, p = .584. For children's breastfeeding status, the odds of presence of sickle cell hemoglobin were 3.3% higher than absence of sickle cell hemoglobin (OR = 1.033, 95% CI: [.919, 1.162]). Therefore, null hypothesis was not rejected, indicating no association between children's breastfeeding status and the presence of sickle cell disease.

In childhood vaccination, the *Cox and Snell* R^2 was .002 and the *Nagelkerke* R^2 was .004. Consequently, a total of .02% of variance in sickle cell disease was explained by variance in childhood vaccination, the *Cox and Snell* R^2. A total of .04% of variance was sickle cell disease status was explained by variance in childhood vaccination, the *Nagelkerke* R^2. Besides, the -2 Log likelihood ratio was 623.442 for childhood vaccination. The Omnibus test of model coefficient in childhood vaccination indicated an overall model possessing statistical insignificance, X^2 (1) = 1.539, p = .215. Childhood vaccination did not show a statistically significant relationship with presence of hemoglobin, B = .256, SE = .206, *Wald* (X^2) = 1.555, p = .212. For childhood vaccination, the odds of presence of sickle cell hemoglobin were 21.6% higher than the absence of sickle cell hemoglobin (OR = 1.262, 95% CI: [.864, 1.934]). Therefore, null hypothesis was not rejected, indicating no association between childhood vaccination and the presence of sickle cell disease (see Table 22).

Table 22

Bivariate Logistic Regression Summary of Infection Prevention Variables

Variable	*p*- value	95% CI interpretation	Hypothesis interpretation	Statistical significance
Children breastfeeding status	.584	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Childhood vaccination	.206	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Household use of mosquitoes' net	.986	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Children's weight-for-height	.064	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Children's protein dietary supplementation	.772	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Children's diarrhea treatment	.351	Does cross 0	Fail to reject null hypothesis	Not statistically significant

The -2 Log likelihood ratio was 1,962.047 for household use of mosquitoes' net. Also, the Omnibus test of model coefficient in household use of mosquitoes' net did not reveal statistical significance, X^2 (1) = .000, p = .986. Household use of mosquitoes' net did not show a statistically significant relationship with the presence of sickle cell hemoglobin, B = -.002, SE = .115, *Wald* (X^2) = .000, p = .986. For household use of mosquitoes' net, the odds of presence of sickle cell hemoglobin were .2% lower than the absence of sickle cell hemoglobin (OR = .998, 95% CI: [.797, 1.249]). Therefore, null hypothesis was not rejected, indicating no association between household use of mosquitoes' net and the presence of sickle cell disease.

The Hosmer and Lemeshow test indicated poor fit model in children's weight-for-height, X^2 (8) = 21.531, p = .006. In children's weight-for-height, the *Cox and Snell* R^2 was .002 and the *Nagelkerke* R^2 was .002. As a result, a total of .02% of variance in sickle cell disease was explained by variance in children's weight-for-height, the *Cox and Snell* R^2. A total of .02% of variance in sickle cell disease status was explained by variance in children's weight-for-height, the *Nagelkerke* R^2. In addition, the -2 Log likelihood ratio was 2,058.117 for children's weight-for-height. The Omnibus test of model coefficient in children's weight-for-height indicated an overall model that was not statistically significant, X^2 (1) = 3.146 p = .076. This study did not reveal a statistically significant relationship between children's weight-for-height and the presence of hemoglobin, B = .00, SE = .00, *Wald* (X^2) = 3.441, p = .064. For children's weight-for-height, the odds of presence of sickle cell hemoglobin were 0% higher than the absence of sickle hemoglobin (OR = 1.000, 95% CI: [1.000, 1.000]). Therefore, based on the findings above, the null hypothesis was not rejected, indicating no association between children's weight-for-height and the presence of sickle cell disease.

Moreover, the -2 Log likelihood ratio was 2,071.385 for children's African protein dietary supplementation. The Omnibus test in children's African protein diet supplement indicated a statistically insignificant overall model, X^2 (1) = .000, p = .986. Children's African protein dietary supplementation did not reveal a statistically significant relationship with the presence of sickle cell hemoglobin, B = -.070, SE = .242, *Wald* (X^2) = 0.084, p = .772. For children's African protein dietary supplementation, the odds of presence of sickle cell hemoglobin were 6.8% lower than the absence of sickle

cell hemoglobin (*OR* = .932, 95% *CI*: [.580, 1.499]). Therefore, based on the findings above, the null hypothesis was not rejected, indicating no association between children's African protein dietary supplementation and the presence of sickle cell disease.

In children's diarrhea treatment, the *Cox and Snell* R^2 was .003 and the *Nagelkerke* R^2 was .005. As a result, total of 0.3% of variance in sickle cell disease was explained by variance in children's diarrhea treatment, the *Cox and Snell* R^2. A total of 0.5% of variance in sickle cell disease status was explained by variance in children's diarrhea treatment, the *Nagelkerke* R^2. Also, the -2 Log likelihood ratio was 274.814 for children's diarrhea treatment. The Omnibus test in children's weight-for-height indicated a statistically insignificant model, X^2 (1) = .86 p = .352. Children's diarrhea treatment did not show a statistically significant relationship with presence of sickle cell disease, B = -.291, SE = .301, *Wald* (X^2) = .870, p = .351. For children's diarrhea, the odds of presence of sickle cell hemoglobin were 24.5% less than the absence of sickle cell hemoglobin (*OR* = .755 95% *CI*: [.419, 1.362]). Therefore, the null hypothesis was not rejected, indicating no association between children's diarrhea treatment and the presence of sickle cell disease.

Multivariate Binomial Logistic Regression

After not controlling for children's weight-for-height, the Hosmer and Lemeshow test showed a statistically insignificant *p*- value, indicating a model of good fit model. After not controlling for children's weight-for-height, the *Cox and Snell* R^2 was .057 and the *Nagelkerke* R^2 was .087. Considering the *Cox and Snell* R^2, 5.7% of the variance in sickle cell disease status was explained by infection prevention variables after not

controlling for children's weight-for-height. Considering the *Nagelkerke R²,* 8.7% of the variance in sickle cell disease status was explained by infection prevention after not controlling for children's weight-for-height.

The -2 Log likelihood value was 116.279 after not controlling for covariate. After not controlling for children's weight-for-height, the Omnibus test did not show a statistically significant association between infection prevention variables and presence of sickle cell hemoglobin, X^2 (6) = 6.82, p = .338. After controlling for covariate, all the variables representing infection prevention did not show statistically significant association with presence of sickle cell hemoglobin.

Childhood vaccination was not significantly (*OR* = 1.698) 69.8%, household use of mosquitoes' net (*OR* = 2.107) 110.7% and children's African diet supplement (*OR* = 1.270) 27% higher than the reference groups to reveal presence of sickle cell hemoglobin after not controlling for children's weight-for-height. Children's diarrhea treatment was (OR = .833) 16.7% lower than the reference groups to reveal presence of sickle cell hemoglobin after not controlling for covariate. Also, childhood vaccination in comparison to under vaccinated children, the odds of presence of sickle cell hemoglobin were 69.8% higher than absence of sickle cell hemoglobin (*OR* = 1.698, 95% CI: [.670, 4.305]) after controlling for covariate. Household mosquitoes' use in comparison to their counterpart not using mosquitoes' net revealed odds of presence of sickle cell hemoglobin14. 3% higher than absence of sickle cell hemoglobin (*OR* = 1.143, 95% CI: [.456, 2.865]), without controlling for children's weight-for-height (see Table 23).

Table 23

Weighted Infection Prevention Variables Multivariate Logistic Regression Without Covariate

Variable	*B*	Wald value	Odds ratio	*p*- value	*SE*	*df*	95% CI
Childhood vaccination (1)		.529	1.698	.265	.475	1	.670, 4.305
Household use of mosquitoes' net (1)	.134	.081	2.107	.775	.469	1	.886, 5.013
Children's African protein diet supplement (1)	.239	.0276	1.270	.872	1.479	1	.070, 23.060
Children's diarrhea treatment (1)	.787	2.804	.833	.337	.470	1	.874, 5.524
Children's breastfeeding status (1)	-.153	.426	.858	.514	.234	1	.735, 1.432
Constant	-1.308	56.209	.142	< . 001			

Children's African protein supplement in comparison to their counterpart not on diet supplement revealed the odds of presence of sickle cell hemoglobin 27% higher than absence of sickle cell hemoglobin (*OR* = 1.270, 95% CI: [.070, 23.060]) after not controlling for children's weight-for-height. Children's diarrhea treatment in comparison to their counterpart not treated for diarrhea revealed odds of presence of sickle cell hemoglobin 119.8% higher than the absence of sickle cell hemoglobin (*OR* = 2.198, 95% CI: [.874, 5.524]) after not controlling for children's weight-for-height. Children's breastfeeding status in comparison to their counterpart not breastfed revealed odds of presence of sickle cell hemoglobin 14.2% lower than absence of sickle cell hemoglobin

(*OR* = .858, 95% CI: [.543, 1.358]) after not controlling for children's weight-for-height. After not controlling for covariate, statistically significant relationships were found in selected variables such as childhood vaccination, household use of mosquitoes' net, Children's African protein diet supplement, children's protein, children's diarrhea treatment, and children's breastfeeding. Therefore, the null hypothesis was not rejected after not controlling for children's weight-for-height.

For childhood vaccination, the odds of presence of sickle cell hemoglobin were 56.8% higher than the absence of sickle cell hemoglobin (*OR* = 1.568, 95% CI: [.610, 4.026]) after controlling for children's weight-for-height (see Table 24). For household use of mosquitoes' net, the odds of presence of sickle cell hemoglobin were 9.1% higher than the absence of sickle cell hemoglobin (*OR* = 1.091, 95% CI: [.431, 2.758]) after controlling for children's weight-for-height. For children's protein diet supplement, the odds of presence of sickle cell hemoglobin were 12.9% higher than absence of sickle cell hemoglobin (*OR* = 1.129, 95% CI: [.061, 20.770]) after controlling for children's weight-for-height. For children's diarrhea treatment, the odds of presence of sickle cell hemoglobin were 141% higher than the absence of sickle cell hemoglobin (*OR* = 2.410, 95% CI: [.9421, 6.168]) after controlling for children's weight-for-height.

Table 24

Weighted Infection Prevention Variables Multivariate Logistic Regression With Covariate

Variable	*B*	Wald value	Odds ratio	*p*-value	*SE*	*df*	95% CI
Childhood vaccination (1)	.450	.481	1.568	.350	.481	1	.610, 4.026
Household use of mosquitoes' net (1)	.087	.034	1.091	.855	.473	1	.431, 2.758
Children's Africa protein diet supplement (1)	.121	.007	1.129	.935	.935	1	.061, 20.770
Children's diarrhea treatment (1)	-.880	3.366	2.410	.067	.479	1	.942, 6.168
Children's breastfeeding status (1)	-.119	.250	.888	.617	.237	1	.558, 1.413
Children's weight-for-height	.000	.608	1.000	.436	.237	1	.558, 1.001
Constant	9.120	.1691	9135.653	.681	221.95		

Children's weight-for-height did not show a statistically significant relationship with the presence of hemoglobin. Consequently, the model did not show effect modification by children's weight-for-height. To put it differently, children's weight-for-height was not an effect modifier in Research Question 3. The low proportion of sickle cell hemoglobin revealed failure of public health program, but a high level of sickle hemoglobin revealed a success of public health program. After controlling for children's weight-for-height, statistically significant relationships were found in variables such as childhood vaccination, household use of mosquitoes' net, children's African protein diet

supplement, children's protein, children's diarrhea treatment, and children's breastfeeding. Therefore, the null hypothesis was not rejected in Research Question 3 after controlling for children's weight-for-height.

Research Question 4: Is there an association between pain and anemia management (as determined by children's blood transfusion status, mother's treatment of fever, children's rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria?

$H_0$4: There is no association between pain and anemia management (as determined by children's blood transfusion status, mother's treatment of fever, children's fluid rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

H_a4: There is an association between pain anemia management (as determined by children's blood transfusion status, mother's treatment fever, children's fluid rehydration status, children's antibiotic prophylaxis status, children's hemoglobin, a child's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

Bivariate Binomial Logistic Regression

The Omnibus test of model coefficient for a child's age indicated an overall model, which was not statistically significance, X^2 (1) = 2.99, p = .585. Again, a child's age did not show a statistical significant relationship with presence of hemoglobin, B = -

.008, *SE* = 5.131, *Wald* (X^2) = 5.131, *p* = .023. The -2 Log likelihood ratio was 2,056.109 for a child's age. For a child's age, the odds of presence of sickle cell hemoglobin were .8% less than the absence of sickle cell hemoglobin (*OR* = .992, 95% *CI*: [.986, .999]). Therefore, null hypothesis was not rejected, indicating no association between a child's age and the presence of sickle cell disease.

The Omnibus test in children's antibiotic prophylaxis indicated model that was statistically significant, X^2 (1) = .036, *p* = .850. Also, children's antibiotic prophylaxis did not reveal a statistically significant association with presence of sickle cell hemoglobin, *B* = .066, *SE* = .348, *Wald* (X^2) = .036, *p* = .846. For children's antibiotic prophylaxis, the odds of presence of sickle cell hemoglobin were 6.8% higher than the absence of sickle cell hemoglobin (*OR* = 1.068, 95% *CI*: [.540, 2.112]). Therefore, null hypothesis was not rejected, indicating no association between children's antibiotic prophylaxis and the presence of sickle cell disease.

In children's antibiotic prophylaxis, the *Cox and Snell* R^2 was .004 and the *Nagelkerke* R^2 was .005. As a result, a total of .04% of variance in sickle cell disease was explained by variance in children rehydration status, the *Cox and Snell* R^2. A total of .05% of variance in sickle cell disease status was explained by variance in children rehydration status, the *Nagelkerke* R^2. Also, the -2 Log likelihood ratio was 274.752 for children rehydration status. The Omnibus test in children's rehydration status was not statistically significant, X^2 (1) = .928, *p* = .355. Children's rehydration status showed a statistically significant relationship with presence of sickle cell disease, *B* = -.184, *SE* = .195, *Wald* (X^2) = .888, *p* = .347. For children's rehydration status, the odds of presence

of sickle cell hemoglobin were 17.7% less than the absence of sickle cell hemoglobin (*OR* = .832, 95% CI: [.567, 1.221]). Therefore, null hypothesis was not rejected, indicating no relationship between children's rehydration status and the presence of sickle cell disease.

Moreover, the Hosmer and Lemeshow test showed a statistically insignificant value, X^2 (8) = 9.368, p = .312. In children's hemoglobin, the *Cox and Snell* R^2 was .008 and the *Nagelkerke* R^2 was .013. Consequently, a total of .8% of variance in sickle cell disease was explained by variance in children's hemoglobin, the *Cox and Snell* R^2. A total of 1.3% of variance in sickle cell disease status was explained by variance in children hemoglobin, the *Nagelkerke* R^2. Also, the -2 Log likelihood ratio was 527. 667 for children's hemoglobin. The Omnibus test in children's hemoglobin indicated a statistically significant value, X^2 (1) = 16.216, $p < .001$. Children's hemoglobin showed a statistical significance relationship with presence of sickle cell hemoglobin, B = -.014, SE = .232, *Wald* (X^2) = 16.216, $p = < .001$. For children's hemoglobin, the odds of presence of sickle cell hemoglobin were 1.4% lower than the absence of sickle cell hemoglobin (*OR* = .986, 95% *CI*: [.980, .993]). Therefore, null hypothesis was rejected, indicating no relationship between children's hemoglobin and the presence of sickle cell disease (see Table 25).

Table 25

Bivariate Logistic Regression Summary of Weighted Pain and Anemia Management Variables

Variable	*p*- value	95% CI interpretation	Hypothesis interpretation	Statistical significance
A child's age	.023	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Children's antibiotic prophylaxis	.849	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Children's blood transfusion status	.476	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Mother's treatment of fever	.028	Does not cross 0	Reject null hypothesis	Statistically significant
Children's hemoglobin	.986	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Children's rehydration status	.347	Does cross 0	Fail to reject null hypothesis	Not statistically significant

Also, the -2 Log likelihood ratio was 2,060.678, children's blood transfusion. Also, the Omnibus test of model coefficient in children's blood transfusion showed an overall model in possession of statistically significance, X^2 (5) = 585, p = .444. Children's blood transfusion did not show a statistically significant association with the presence of sickle cell hemoglobin in the bivariate model, B = -.508, SE = .826, *Wald* (X^2) = .507, p = .476. For children's blood transfusion, the odds of presence of sickle cell hemoglobin were 44.5% lower than the absence of sickle cell hemoglobin (OR = .555, 95% CI: [.110, 2.803]). Therefore, null hypothesis was not rejected, indicating no relationship between children's blood transfusion and the presence of sickle cell disease.

Mother's treatment fever, the *Cox and Snell R²* was .09 and the *Nagelkerke R²* was .000. Consequently, a total of 9% of variance in sickle cell disease was explained by variance in mother's treatment of fever, the *Cox and Snell R²*. The -2 Log likelihood ratio was 527. 667, mother's treatment of fever). Also, the Omnibus test in mother's treatment of fever showed a statistically significant value, X^2 (1) = 4.707, p = .030. This study showed a statistically significant relationship between mother's treatment of fever and the presence of sickle cell hemoglobin, B = -.510, SE = .232, *Wald* (X^2) = 4.847, p = .028. For mother's treatment of fever, the odds presence of sickle cell hemoglobin were 40% lower than the absence of sickle cell hemoglobin (*OR* = .600, 95% *CI*: [.381, .946]). Therefore, null hypothesis was rejected, indicating no relationship between mother's treatment of fever and the presence of sickle cell disease.

Multivariate Binomial Logistic Regression

The Hosmer and Lemeshow test a model of good fit model after not controlling for covariate. Also, *Cox and Snell R²* was .048 and the *Nagelkerke R²* was .071 after not controlling for covariate. Considering the *Cox and Snell R²*, 4.8% of the variance in sickle cell disease status was explained by infection prevention without controlling for covariate. Considering the *Nagelkerke R²,* 5.7% of the variance in sickle cell disease status was explained by pain and anemia without controlling for covariate. The -2 Log likelihood value was 159.161 after not controlling covariate. The Omnibus test did not show a statistically significant association between pain and anemia management and the presence of sickle cell disease hemoglobin, X^2 (5) = 7.37, p = .195 after not controlling for covariate (see Table 26).

Table 26

Weighted Pain and Anemia Management Variables Binomial Multivariate Logistic Regression Without Both Constant and Covariate

Variable	*B*	Wald value	Odds ratio	*p*- value	*SE*	*df*	95% CI
Children's blood transfusion status (1)	1.984	3.566	7.273	.178	1.472	1	.406, 130.326
Mother's treatment of fever (1)	.456	1.214	2.107	.701	.414	1	701, 3.554
Children's rehydration status (1)	-.074	.026	.928	.873	.465	1	.373, 2.311
Children's antibiotic prophylaxis (1)	.080	.032	1.083	.859	.450	1	.449, 2.615
Children's hemoglobin	.032	5.628	.969	. 018	.013	1	.943, .994

Children blood transfusion status did not show statistically significant relationship with presence of sickle cell hemoglobin after not controlling for covariate. Mother's treatment of fever did not show statistically significant relationship with the presence of sickle cell after not controlling for covariate. Children's rehydration status did not show statistically significant relationship with the presence of sickle cell after not controlling for covariate. Children's antibiotic prophylaxis did not show statistically significant relationship with presence of sickle cell after not controlling for covariate. Therefore, based on above the results, the null hypothesis was not rejected after not controlling for covariate.

Children's hemoglobin did show a statistically significant relationship with presence of hemoglobin after controlling for covariate. The null hypothesis was rejected, considering the relationship between children's hemoglobin and presence of sickle cell hemoglobin. Mother's treatment of fever (*OR* = 2.107) 110.7% higher, children's rehydration status (*OR* = .928) 7.2% lower, and children's antibiotic prophylaxis (*OR* = 1.083) 8.3% higher than the reference groups to show the presence of hemoglobin after not controlling for covariate. After not controlling for covariates, null hypothesis was not rejected based on the above results.

For children blood transfusion status, the odds of presence of sickle cell hemoglobin were 627.3% higher than the absence of sickle cell hemoglobin (*OR* = 7.273, 95% CI: [.406, 130.326]) without a constant and after not controlling for covariates. As previously mentioned, the untrustworthy *OR* for children blood transfusion allowed the removal for further interpretation. The missing values in children's blood transfusion status could have contributed to the observed phenomenon.

After not controlling for covariate, this study did not show statistically significant association in the selected variables such as children's antibiotic prophylaxis, children blood transfusion status, children's rehydration status, and mother's treatment of fever ($p > .05$). On the contrary, this study showed a statistically significant association between children's hemoglobin and the presence of sickle cell hemoglobin after not controlling for covariate ($p < .001$). For mother's treatment of fever, the odds of presence of sickle cell hemoglobin were 55.7% higher than the absence of sickle cell hemoglobin (*OR* = 1.557, 95% CI: [.701, 3.546]) after not controlling for covariates. For children rehydration

status, the odds of presence of sickle cell hemoglobin were 5.5% lower than the absence of sickle cell hemoglobin (*OR* = .945, 95% CI: [.376, 2.376]) after not controlling for covariates (see Table 27).

Table 27

Weighted Pain and Anemia Management Variables Multivariate Regression With Constant and Without Covariate

Variable	*B*	Wald value	Odds ratio	*p*- value	*SE*	*df*	95% CI
Children's blood transfusion status (1)	19.695	3.566	7.273	.178	27311.925	1	.000,
Mother's treatment of fever (1)	.456	1.214	2.107	.701	.413	1	701, 3.556
Children's rehydration status (1)	-.056	.014	.945	.905	.470	1	.373, 2.311
Children's antibiotic prophylaxis (1)	.079	.031	1.082	.861	.449	1	.449, 2.609
Children's hemoglobin	-.030	4.492	.970	. 034	.014	1	.943, .994
Constant	-17.869	.000		.999	27311.925		

For children's hemoglobin, the odds of presence of sickle cell hemoglobin were 3% lower than the absence of sickle cell hemoglobin after not controlling for a child's age (*OR* = .970, 95% CI: [.943, .998]). After not controlling for covariate, the overall model was not statistically significant, X^2 (5) = 7.368, *p* = .195. Children's blood transfusion was insignificantly (*OR* = .178) 82.2% lower, mother's treatment of fever (*OR* = 2.107) 110.7% higher, children's rehydration status (*OR* = .905) 9.5% lower, and

children's antibiotic prophylaxis (*OR* = 1.082) 8.2% higher than the reference groups to reveal the presence of sickle cell hemoglobin after not controlling for child's age. After not controlling for child's age, a statistically significant prediction of presence of sickle cell hemoglobin was found in children's hemoglobin.

The goodness of fit test showed a good fit with inclusion of covariate. After controlling for covariate, the *Cox and Snell* R^2 was .077 and the *Nagelkerke* R^2 was .115. Considering the *Cox and Snell* R^2, 7.7% of the variance in sickle cell disease status was explained by infection prevention without controlling for covariate. Considering the *Nagelkerke* R^2, 11.5% of the variance in sickle cell disease status was explained by pain and anemia with controlling for covariate. The -2 Log likelihood value was 154.472 after controlling for covariate.

For children blood transfusion status (1) in comparison to the reference group, without control variable, no statistically significant prediction of outcome was found after controlling for covariate. Mother's treatment of fever did not show a statistically significant relationship with presence of sickle cell hemoglobin after controlling for covariate. Children's rehydration status did not show a statistically significant relationship with the presence of sickle cell hemoglobin after controlling for covariate. Children's antibiotic prophylaxis did not show a statistically significant relationship with presence of sickle cell hemoglobin after controlling for covariate. Children's hemoglobin did not show a statistically significant relationship with the presence of sickle cell hemoglobin after controlling for covariate (see Table 28). Because the *OR* in children's

blood transfusion status was untrustworthy, the interpretation was not provided in this study.

Table 28

Weighted Pain and Anemia Management Variables Multivariate Logistic Regression Without Constant and With Covariate

Variable	*B*	Wald value	Odds ratio	*p*- value	*SE*	*df*	95% CI
Children blood transfusion status (1)	2.226	2.048	9.261	.152	1.555	1	.439, 195.279
Mother's treatment of fever (1)	.357	.710	1.429	.701	.424	1	623, 3.277
Children rehydration status (1)	-.030	.004	.971	.971	.478	1	.381, 2.475
Children antibiotic prophylaxis (1)	.040	3.137	.427	.930	.455	1	.381, 2.475
Children hemoglobin	-.025	3.137	.975	.077	.014	1	.948, 1.003
A Child's age	-.028	4.539	.973	.077	.013	1	.948, .998

As mentioned in the paragraph above, the missing values in children's blood transfusion status could have contributed to the untrustworthy *OR*. For children's blood transfusion status, the odds of presence of sickle cell hemoglobin were 627.3% higher than the absence of sickle cell hemoglobin (*OR* = 7.273, 95% CI: [.406, 130.326]) without a constant and after controlling for covariates. For mother's treatment of fever, the odds of presence of sickle cell hemoglobin were 42.9% higher than the absence of

sickle cell hemoglobin (*OR* = 1.429, 95% CI: [.623, 3.277]) with controlling for covariates. For children's rehydration status, the odds of presence of sickle cell hemoglobin were 1.7% lower than the absence of sickle cell hemoglobin (*OR* = .983, 95% CI: [.383, 2.523]) with controlling for covariates. For children's antibiotic prophylaxis status, the odds of presence of sickle cell hemoglobin were 4.2% higher than the absence of sickle cell hemoglobin (*OR* = 1.042, 95% CI: [.427, 2.538]) without controlling for a child's age. For children's hemoglobin, the odds of presence of sickle cell hemoglobin were 3% lower than the absence of sickle cell hemoglobin (*OR* = .970, 95% CI: [.943, .998]), with controlling for a child's age.

This study did not show a statistically significant relationships with the presence of sickle cell hemoglobin in variables such as children's blood transfusion, mother's treatment of fever, children's rehydration status, and children's antibiotic prophylaxis. A child's age showed a statistically significant relationship with the presence of hemoglobin (p = .034). As a result, a child's age was not an effect modifier in the model after controlling for covariate. Therefore, the null hypothesis was not rejected based on the above findings (see Table 29).

Table 29

Weighted Pain and Anemia Management Variables Multivariate Logistic Regression With Both Covariate and Constant

Variable	*B*	Wald value	Odds ratio	*p*- value	*SE*	*df*	95% CI
Mother's treatment of fever (1)	.357	.710	1.429	.701	.424	1	.624, 3.273
Children's rehydration status (1)	-.017	.001	.983	.971	.481	1	.383, 2.523
Children's antibiotic prophylaxis (1)	.041	.008	1.042	.929	.454	1	.381, 2.475
Children's hemoglobin	-.024	2.586	.976	.108	.015	1	.948, 1.005
A Child's age	-.028	4.493	.973	.077	.013	1	.948, .998
Constant	-17.408	.000	.000	.999	27285.762	1	

Research Question 5: Is there an association between healthcare use (as determined by antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria?

H_05: There is no association between healthcare use (as determined by antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

Ha5: There is an association between healthcare use (as determined by mother's antenatal care use, mother's reading of newspapers, mother's use of health insurance, mother's uptake of children's genotype testing, mother's place of delivery, mother's age), and the proportion of children with sickle cell hemoglobin in Nigeria.

Bivariate Binomial Logistic Regression

The -2 Log likelihood ratio was 2,060. 691 for mothers' use of health insurance. The Omnibus test of model coefficient for mother's use of health insurance indicated an overall model that was statistically significant, X^2 (1) = .450. This research did not show a statistically significant relationship between mother's use of health insurance and the presence of sickle cell disease, B = .304, SE = .392, *Wald* (X^2) = .600, p = .438. For mother's use of health insurance, the odds of presence of sickle cell hemoglobin were 69.6% lower than absence of sickle cell hemoglobin (*OR* = .304, 95% *CI*: [.628, 2.922]). Therefore, null hypothesis was not rejected, indicating no association between mother's use of health insurance and the presence of sickle cell hemoglobin.

In mother's reading of newspapers, the *Cox and Snell* R^2 was .307 and the *Nagelkerke* R^2 was .409. As a result, a total of 30.7% of variance in sickle cell disease was explained by variance in mother's uptake of genotype testing, the *Cox and Snell* R^2. A total of 40.9% of variance in sickle cell disease status was explained by variance in mothers' uptake of genotype testing, the *Nagelkerke* R^2. Also, the -2 Log likelihood ratio was 2, 050. 559 for mothers' uptake of genotype testing. The Omnibus test in mother's uptake of genotype testing indicated a statistically significant, X^2 (1) = 737.458, p = <

.001. Mother's uptake of genotype testing showed a statistically significant relationship with the presence of sickle cell hemoglobin, B = -1.344, SE = .055, *Wald* (X^2) = 595.899, $p < .001$. For mother's uptake of genotype testing, the odds of presence of sickle cell hemoglobin were 73.9% lower than the absence of sickle cell hemoglobin (OR = .261, 95% CI: [.234, .291]). Therefore, null hypothesis was rejected, considering the association between mother's uptake of genotype testing and the presence of sickle cell disease.

Furthermore, the -2 Log likelihood ratio was 1758.934 for mother's place of delivery. For that reason, a total of 9% of variance in sickle cell disease was explained by variance in mothers' place of delivery, the *Cox and Snell* R^2. The Omnibus test for mother's place of delivery did not show a statistically significant relationship with sickle cell hemoglobin, X^2 (1) = 0.014, p = .905. Mother's place of delivery did not show a statistically significant relationship with sickle cell hemoglobin, B = .015, SE = .128, *Wald* (X^2) = .014, p = .905. For mother's place of delivery, the odds of presence of sickle cell hemoglobin were 1.5% lower than the absence of sickle cell hemoglobin (OR = 1.015, 95% CI: [.790, 1.305]). Therefore, null hypothesis was rejected, considering the association between mother's place of delivery and the presence of sickle cell disease.

In mothers' age, the *Cox and Snell* R^2 was .003 and the *Nagelkerke* R^2 was .005. A total of .3% of variance in sickle cell disease was explained by variance in mother's age, *Cox and Snell* R^2. Consequently, a total of .5% of variance in sickle cell disease status was explained by variance in mother's' age, the *Nagelkerke* R^2. In addition, the -2 Log likelihood ratio was 972.088 for a mothers' age. Mother's age did not show a

statistically significant relationship with the presence of sickle cell hemoglobin in the bivariate model, B = -.020, SE = .013, *Wald* (X^2) = 2.471, p = .116. For mother's age, the odds of presence of sickle cell hemoglobin were 2% less than the absence of sickle cell hemoglobin (*OR* = .980, 95% *CI*: [.957, 1.005]). Therefore, null hypothesis was rejected, considering the association between mother's age and the presence of sickle cell disease.

A total of .2% of variance in sickle cell disease was explained by variance in mothers' age, the *Cox and Snell* R^2. Consequently, a total of .4% of variance in sickle cell disease status was explained by variance in antenatal care use, the *Nagelkerke* R^2. Again, the -2 Log likelihood ratio was 972.088 for antenatal care use. The Omnibus test did not show a statistically significant between antenatal care use and presence of sickle cell hemoglobin, X^2 (1) = 2.205, p = .138. Antenatal care use did not show a statistically significant relationship with the presence of sickle cell hemoglobin, B = .262, SE = .179, *Wald* (X^2) = 2.151, p = .143. For antenatal care use, the odds of presence of sickle cell hemoglobin were 29.9% higher than the absence of sickle cell hemoglobin (*OR* = 1.299, 95% *CI*: [.916, 1.843]). Therefore, null hypothesis was rejected, considering the association between antenatal care and the presence of sickle cell disease (see Table 30).

Table 30

Bivariate Logistic Regression Summary of Weighted Healthcare Use Variables

Variable	*p*- value	95% CI interpretation	Hypothesis interpretation	Statistical significance
Mother's use of health insurance	.438	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Mother's reading of newspapers	.290	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Mother's place of delivery	.905	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Mother's uptake of genotype testing	< .001	Does cross 0	Reject null hypothesis	Statistically significant
Mother's age	.116	Does cross 0	Fail to reject null hypothesis	Not statistically significant
Antenatal care use	.143	Does cross 0	Fail to reject null hypothesis	Not statistically significant

Multivariate Binomial Logistic Regression

In answering Research Question 5, redundancy in one of the variables was handled and represented with a less parsimonious model. The SPSS software specified redundancy in the mother's uptake of genotype testing. For that reason, procedures for treatment of redundant variables in regression analysis followed procedures such as analysis without a constant, regrouping variables, and drooping the variable. The best fit model with the less variables and great explanatory power was considered in the statistical analysis. Overall, the principle of parsimony was observed in this study.

As previously mentioned above, multicollinearity between the independent variables could predispose to a redundant variable. The inclusion of mother's uptake of

genotype testing was known as the less parsimonious model. In the contrary, the exclusion of mother's uptake of genotype testing was known as the parsimonious model (see Table 31).

Table 31

Weighted Healthcare Use Variables Multivariate Logistic Regression Without Both Constant and Covariate

Variable	*B*	Wald value	Odds ratio	*p*-value	*SE*	*df*	95% CI
Antenatal care use (1)	.252	1.759	1.286	.185	27285.762	1	.887, 1.867
Mother's reading of newspapers (1)	.071	.279	1.074	.680	.279	1	.622, 1.867
Mother's use of health insurance (1)	.364	.001	.983	.971	.882	1	.255, 1.855
Mother's place of delivery (1)	-.073	.158	.930	.691	.182	1	.650, 1.330
Mother's uptake of genotype testing (1)	-1.935	4.860	.144	.027	27285.762	1	.026, .807

The Hosmer and Lemeshow test showed a model of good fit model in the parsimonious model without the control variable. After not controlling for covariate in the parsimonious model, *Cox and Snell* R^2 was .003 and the *Nagelkerke* R^2 was .005. Considering the *Cox and Snell* R^2, .3% of the variance in sickle cell disease status was explained by healthcare use in the parsimonious model after not controlling for covariate.

Considering *Nagelkerke R²,* .5% of the variance in sickle cell disease status was explained by healthcare use in the parsimonious model after not controlling for covariate. The -2 Log likelihood value was 762.279 in the parsimonious model after not controlling for covariate. The Omnibus test in the parsimonious model did not show a statistically significant association between healthcare use and the presence of sickle cell hemoglobin without control variable (X^2 (4) = 2.407, p = .661).

In the less parsimonious after not controlling for covariate, mother's uptake of genotype testing did not show a statistically significant relationship with presence of sickle cell hemoglobin. In the parsimonious model after not controlling for covariate, antenatal care use did not show a statistically significant relationship with the presence of sickle cell hemoglobin. In the parsimonious model after not controlling for covariate, mother's use of health insurance did not show a statistically significant with presence of sickle cell hemoglobin.

In the parsimonious model after not controlling for covariate, mother's place of delivery did not show a statistically significant with the presence of sickle cell hemoglobin. In the parsimonious model after not controlling for covariate, mothers' use of health insurance did not show a statistically significant with the presence of sickle cell hemoglobin. After not controlling for covariates in the parsimonious model, there was no statistically significant association found in variables such as antenatal care use, mothers reading of newspapers, mothers use of health insurance, and place of delivery, X^2 (4) = 2.407, p = .661 (see Table 32).

Table 32

Weighted Healthcare Use Variables Multivariate Logistic Regression Without Covariate and Without Constant

Variable	*B*	Wald value	Odds ratio	*p* value	*SE*	*df*	95% CI
Antenatal care use (1)	.264	1.936	1.302	.164	.264	1	.898, 1.887
Mother's reading of newspapers (1)	.031	.002	1.074	.680	.273	1	.593, 1.729
Mother's use of health insurance (1)	.396	.001	.983	.971	.882	1	.264, 8.366
Mother's place of delivery (1)	-.100	.304	.905	.581	.182	1	.650, 1.330
Constant	-1.911	4.748	.148	.027	.877	1	.026, .807

For antenatal care use in the parsimonious model, the odds of presence of sickle cell hemoglobin were 30.2% (*OR* = 1.302) higher than absence of sickle cell hemoglobin, without controlling for covariates. For mother's reading of newspapers in the parsimonious model, the odds of presence of sickle cell hemoglobin were 1.3% (*OR* = 1.013) higher than absence of sickle cell hemoglobin without controlling for covariates.

For mother's place of delivery in the parsimonious model, the odds of presence of sickle cell hemoglobin were 9.5% (*OR* = .905) lower than absence of sickle cell hemoglobin after not controlling for mothers' age. For mother's uptake of genotype testing in the less parsimonious model, the odds of presence of sickle cell hemoglobin were 85.6% (*OR* = .144) lower than absence of sickle cell hemoglobin after not

controlling for mother's age. After not controlling for mother's age in the parsimonious model, all the variables representing healthcare use did not show statistically significant relationship with presence of sickle cell hemoglobin. Therefore, the null hypothesis was not rejected after not controlling for covariate.

The Hosmer and Lemeshow test indicated a model of good fit model in the parsimonious model with the control variable. After not controlling for covariate in the parsimonious model, the *Cox and Snell* R^2 was .022 and the *Nagelkerke* R^2 was .033. Considering the *Cox and Snell* R^2, 2.2% of the variance in the presence of sickle cell hemoglobin was explained by healthcare use in the parsimonious model, with controlling for covariate. Considering the *Nagelkerke* R^2, 3.3% of the variance in sickle cell disease status is explained by healthcare use in the parsimonious model after controlling for covariate. The -2 Log likelihood value was 762.279 in the parsimonious model after controlling for covariate. The Omnibus test in the parsimonious model showed no statistically significant association between healthcare use variables and the presence of sickle cell hemoglobin after controlling for covariates (see Table 33).

Table 33

Weighted Healthcare Use Variables Multivariate Logistic Regression With Covariate and Without Constant

Variable	*B*	Wald value	Odds ratio	*p*-value	*SE*	*df*	95% CI
Antenatal care use (1)	-.278	.926	1.286	.757	289	1	.430, 1.334
Mothers reading of newspapers (1)	.0800	2.647	2.226	.104	.492	1	.849, 5.836
Mother's place of delivery (1)	-.029	.011	.000	.999	-.273	1	.650, 1.330
Mother's uptake of genotype testing (1)	-20.868	4.860	.144	.027	16382.187	1	.945, 1.017
Mother's age	-.020	1.125	.980	.289	.019	1	.945, 1.017

Mother's use of health insurance in the parsimonious model after controlling for covariate did not reveal a statistically significant relationship with presence with sickle cell hemoglobin. For antenatal care use in the parsimonious model, the odds of presence of sickle cell hemoglobin were 24.3% (*OR* = .757) than absence of sickle cell hemoglobin after controlling for covariates. For mother reading of newspapers in the parsimonious model, the odds of presence of sickle cell hemoglobin were 82.8% (*OR* = 1.828) higher than absence of sickle cell hemoglobin after controlling for covariate. The SPSS generated an untrustworthy *OR* for mothers' use of health insurance likely due to the significant missing values (see Table 34).

Table 34

Weighted Healthcare Use Variables Multivariate Logistic Regression With Covariate and Constant

Variable	*B*	Wald value	Odds ratio	*p*-value	*SE*	*df*	95% CI
Antenatal care use (1)	-.238	.690	.757	.406	.287	1	.449, 1.382
Mothers reading of newspapers (1)	.603	1.762	1.074	.680	.454	1	.750, 4.455
Mothers use of health insurance (1)	19.916	.000	.983	.971	.882	1	.255, 1.855
Mother's place of delivery (1)	-.063	.054	.930	.816	.271	1	.552, 1.598
Mother's age	-.019	1.011	.981	.981	.019	1	.026, .807
Constant	-20.791	.000	.000	.999	16468.557		

For place of delivery in the parsimonious model, the odds of presence of sickle cell hemoglobin were .97 times (*OR* = .971) lower than absence of sickle cell hemoglobin after controlling for mothers' age. For mother's age in the parsimonious model, the odds of presence of sickle cell hemoglobin were .981 times (*OR* = .981) lower than absence of sickle cell hemoglobin. Mother's age did not show a statistically significant relationship with other variables in the parsimonious model. As a result, the covariate was not an effect modifier in Research Question 5. After controlling for mother's age in the parsimonious model, a statistically insignificant prediction of outcome was found in all the variables representing healthcare use. Therefore, the null hypothesis was not rejected with controlling for covariate.

Summary and Transition

This study involved the use of the 2018 Nigeria DHS dataset to examine the relationship between selected variables and presence of sickle cell hemoglobin. The statistical analyses were accomplished in areas such as data collection, univariate analysis, bivariate analysis, multivariate analysis, and post-hoc analysis. This research considered various independent factors such as healthcare use, pain and anemia management, infection prevention, demography, and socioeconomic status. Also, the descriptive and inferential statistics took into consideration areas such as dispersion and central tendency measures, missing values, effect sizes, *p*- values, 95% CI, parsimony principle, and redundant variables.

In Research Question 1, the bivariate logistic regression analysis did not show statistically significant relationships with presence of hemoglobin in variables such as mother's employment status, household wealth index, mother's education level, household toilet facility, and household presence of water. Consequently, the null hypothesis was not rejected in Research Question 1, bivariate analysis. In the multivariate binary regression all the variables representing socioeconomic status did not show a statistically significant relationship after not controlling for covariate. The model did not show effect modification by mother's educational level in Research Question 1. Therefore, based on the above findings, the null hypothesis was not rejected in the multivariate analysis.

In Research Question 2, the bivariate logistic regression analysis did show a statistically significant relationship with presence of sickle cell hemoglobin in variables

such as residence, religion, female gender, and ethnicity. The model did not show effect modification by a child's age in Research Question 2. After not controlling for covariate, the multivariate analysis did not show statistically significant relationship in variables such as urban setting, Hausa ethnic group, Igbo ethnic group, and female child. After not controlling for a child's age, statistically significant predictions of the outcome were found in variables such as Yoruba ethnicity (p = .028), Northcentral (p = .034), Southeast (p = .009), and South (p = .011). Consequently, null hypothesis was rejected based on the findings After controlling for covariate in the multivariate logistic regression, statistically significant predictions of the outcome were found in various variables such as North Central (p = .047), Yoruba ethnicity (p = .036), Southeast (p = .008), South (p = .011), and child's age (p = .022). Therefore, null hypothesis was rejected based on the findings.

In Research Question 3, the bivariate logistic regression analysis did not reveal statistically significant relationship with presence of sickle cell hemoglobin in variables such as children's breastfeeding status, childhood vaccination, household use of mosquitoes' net, children's weight-for-height, children's protein diet supplement, and children's diarrhea treatment. The model did not show effect modification by children weight-for-height in Research Question 3. This study did not show statistically significant findings in all the variables considered in Research Question 3. Consequently, the null hypothesis was not rejected based on the findings. Therefore, the null hypothesis was not rejected based on the findings.

In Research Question 4, the bivariate logistic regression analyses revealed a statistically significant in selected variables such as a child's age (p = .023) and mother's

treatment of fever ($p = .028$). After controlling for covariate, all the selected variables representing pain and anemia management variables did not reveal statistically significant relationship with the presence of sickle cell hemoglobin. Consequently, the null hypothesis was not rejected based on the above findings. The model did not show effect modification by a child's age in Research Question 4.

In Research Question 5, all the selected variables representing healthcare use did not show a statistically significant relationship with presence of sickle cell hemoglobin the bivariate logistic regression. The model did not show effect modification by a mother's age in Research Question 5. This study did not find statistically significant association in selected variables such as antenatal care use, mother's reading of newspapers, mother's use of health insurance, and mother's place of delivery ($p > .05$), but revealed statistically significant relationship in mother's uptake of children's genotype testing ($p < .05$). Therefore, based on the above findings, the null hypothesis was not rejected with controlling for a mother's age.

In Chapter 5, an effort to confirm or reject previous findings is demonstrated. In addition, this chapter visits the theoretical frameworks, limitations, positive social implications, and recommendations.

Chapter 5: Discussion, Conclusions, and Recommendations

This study examined the relationship between the selected independent variables and the presence of sickle cell hemoglobin. Also, the independent variables considered were healthcare use, infection prevention, pain and anemia management, demography, and socioeconomic status. This quantitative cross-sectional study used the 2018 Nigeria DHS dataset to answer the Research Questions 1 through 5. This study considered the principle of parsimony in the binomial logistic regression. Likewise, the statistical analyses attended to the redundant variables and the missing values. In short, five research questions were used to show the relationship between the explanatory variables and the presence of sickle cell hemoglobin.

In Research Question 1, all socioeconomic status variables did not show a statistically significant relationship with the presence of sickle cell hemoglobin in the bivariate regression. The model did not show effect modification by mother's education level in Research Question 1. After controlling for mother's education level, all socioeconomic status variables did not show a statistically significant relationship with the presence of sickle cell hemoglobin in the bivariate regression.

In addition, Research Question 2 did not reveal statistically significant relationship in variables such as residence, Hausa, Igbo, and female. Also, after not controlling for a child's age, sickle cell disease status showed statistically significant predictions from various variables such as South ($p = .011$), Southeast ($p = .009$), Northcentral ($p = .034$), and Yoruba ($p = .028$). After controlling for covariate for a child's age, sickle cell disease status showed statistically significant predictions from

various variables such as a child's age (p = .022), Northcentral (p = .047), South (p = .011), Yoruba (p = .036), and Southeast (p =.008). The model did show effect modification by a child's age.

In Research Question 3, all the variable representing infection prevention were not statistically significant after not controlling for covariate. Also, all variables representing infection prevention were statistically insignificant after controlling for covariate. The model did not show effect modification by children weight-for-height.

In Research Question 4, children's hemoglobin showed a statistically significant relationship with the presence of sickle cell hemoglobin after not controlling for covariate (p = .034). Also, mother's treatment of fever revealed a statistically significant relationship with the presence of sickle cell hemoglobin (p =.028) in the bivariate regression. This study did not show statistically significant findings in selected variables such as children's antibiotic prophylaxis, children blood transfusion status, children's rehydration status, and mother's treatment of fever. However, this study showed statistical significance between children's hemoglobin and the presence of sickle cell hemoglobin ($p < .05$) after not controlling for covariates. The model did not show effect modification by a child's age.

In Research Question 5, mother's uptake of children's genotype testing showed a statistically significant relationship with the presence of sickle cell hemoglobin in bivariate regression ($p < .001$) in the bivariate regression. After not controlling for mother's age, the predictions of outcome variable were statistically insignificant in variables such as antenatal care, mother's place of delivery, mother's use of health

insurance, and mother's reading of newspapers. The model did not show effect modification by mother's age. Chapter 5 involves discussion on the theoretical frameworks, previous findings in the field, positive social implications, and recommendations.

Interpretation of the Findings

Childhood Sickle Cell Hemoglobin and the Literature

Sickle disease hemoglobin prevalence varies based on geography and participants' age as well as sample weight. This study found weighted children with presence of sickle cell hemoglobin (20.6%, *n* = 418) in comparison absence of sickle of hemoglobin (79.4%, *n* = 1,607). Also, this study revealed unweighted sample (77.7%, *n* = 8,741) hemoglobin AA in comparison to sickle cell hemoglobin (22.3%, *n* = 2,502). In other words, this study revealed high proportion of hemoglobin AA compared to sickle cell disorders. Similarly, many previous studies supported this study's finding (IIiyasu et al., 2021; see also Eleonare et al., 2020; Ezenwosu et al., 2021; Danho et al., 2021; Islam et al., 2021; Kosiyo et al., 2020, 2021; Nnodu et al., 2020, 2021; Oppong et al., 2020; Whyte et al., 2021). On the contrary, other previous studies did not support this study's finding (De Franceshi et al., 2019; Farrell et al., 2018; Isa et al., 2020; Nkya et al., 2019).

Chimbatata et al.'s (2021) study showed sickle cell hemoglobin proportion such as old cases (86.7%, *n* = 444) and new cases (13.3%, *n* = 68). Marks et al.'s (2018) meta-analysis review showed various sickle cell hemoglobin sample sizes such as Cameroun (*n* = 120), Republic of Congo (*n* = 1,422), Kenya (360), Malawi (*n* = 117), and Nigeria (*n* =

500). In the same way, this study evaluated the prevalence of sickle cell hemoglobin in Sub-Saharan Africa.

Bhatt et al.'s (2019) study alluded to hemoglobin genotypes such as SC (28.1%, *n* = 34) and SS (71.9%, *n* = 87). Power-Hays et al.'s (2020) study provided categories of sickle cell hemoglobin such as SS (74%), SC (20%) and others (5%). Manafa et al.'s (2018) study illustrated the divisions of hemoglobin genotypes such as SS (*n* = 39) and AS (*n* = 19). Tetteh et al. (2021) emphasized on hemoglobin AA (80.6%, *n* = 258) in comparison to AS (19.4%, *n* = 62). In a similar fashion, this study categorized sickle cell hemoglobin into various groups such as presence of sickle cell hemoglobin (AS, AC, SC, SS, and others) and absence of sickle cell hemoglobin (AA).

Diagnostic methods can affect screening for sickle cell disorders in developing countries, leading to the differences in the observed prevalence. Social risk factors can determine access to point-of-care genotype test. This research used liquid chromatography and sickleSCAN were used as diagnostic tests for sickle cell disorders. Similarly, other studies supported this study's finding (De Martino et al., 2019; De Haan et al., 2020; De Montalembert et al., 2019; Islam et al., 2021; Mukherjee et al., 2020; Nnodu et al., 2021; Olatunya et al., 2021; Oron et al., 2020; Segbena et al., 2018; Steele et al., 2019). On the other hand, previous studies did not support this study's finding (De Martino et al., 2019; Delgadinho et al., 2021; Kambale-Kombi et al., 2021; Kosiyo et al., 2021; Oppong et al., 2020).

Furthermore, Isa et al.'s (2020) study reported the use of alkaline electrophoresis (i.e., cellulose acetate) and liquid chromatography to diagnose the presence of sickle cell

hemoglobin. This present study did not use cellulose acetate (i.e., alkaline electrophoresis) to investigate the association between selected variables and proportion of sickle cell hemoglobin in children under 5-years-old in Nigeria. Also, Frangoul et al. (2021) revealed the use of liquid chromatography, a high-performance method, as a diagnostic method in sickle cell hemoglobin. Similarly, this current study used high-performance (i.e., liquid chromatography) diagnostic method to improve the findings validity.

De Villaverde Cortabarria et al. (2021) demonstrated the effectiveness of prenatal screening (i.e., chorionic biopsy) for the diagnosis of sickle cell hemoglobin. In contrast to previous studies, this current study did not use chorionic biopsy in the diagnosis of childhood sickle cell hemoglobin. This study demonstrated similarity with previous studies in the use of real-time diagnostic methods such as liquid chromatography and sickleSCAN.

Key Findings on Socioeconomic Status, Sickle Cell Disorders, and the Literature

The socioeconomic status is a factor which is connected to adverse childhood experiences. In this study, mother's employment showed 24,413 (71.4%) working in the last 12 months in comparison to mother's unemployment (28.6%, *n* = 9,780). Majority of women were not in possession of an indwelling toilet facility location (73.4%, *n* = 12,458) in this study. Equally, this study showed population in possession of household water (51.9%, *n* = 15,423) in comparison to absence of household water (48.1%, *n* = 14,285). Bivariate logistic regression in this study showed statistically insignificant predictions of presence of sickle cell hemoglobin in variables such as mother's

employment status, mother's education level, mother's toilet facility, household presence of water, and household wealth index.

This current study did not show a statistically significant relationship between socioeconomic status and the presence of sickle cell hemoglobin after adjusting for covariate. However, previous studies did not support this study's finding (Power-Hays et al., 2020; see also Aboagye et al., 2019; Booysen et al., 2021; Castro & Viana., 2019; Gerardin et al., 2021; Lu et al., 2020; Menalu et al., 2021; McClintock et al., 2021; Ngandu et al., 2019; Ojelabi et al., 2019; Partnanen et al., 2020; Sebalhelzain et al., 2019; Ugboko et al., 2021; Wolde et al., 2019). Similarly, previous studies supported this study's finding (Islam et al., 2021; Cortright et al., 2020), indicating an inverse relationship between childhood sickle cell disease health status and socioeconomic status.

In this current study, household wealth index showed various measures of socioeconomic status such as middle-income (47.7%, *n* = 16,297), low-income (15.6%, *n* = 5,346), and high-income (36.7%, *n* = 12,550). As such, household wealth index was documented which could play a role health outcomes in the community. Similarly, previous studies underscored this study's finding (Gerardin et al., 2021; see also Abreha et al., 2020; Alabi & Ramsden, 2021., Chowdhury et al., 2018; Cortright et al., 2020; Duodu et al., 2020; and Ngandu et al., 2019).

Apanga and Kumbeni et al.'s (2021) study in Ghana showed the interaction between childhood infection and poverty. Oldfield et al. (2021) and Ngandu et al. (2020) found that screening for social determinants of health led to improved health outcomes in

developing countries. Similarly, this study examined the relationship between the social determinants of health and health outcomes.

Women's welfare is needed to achieve a child's healthy growth or development. Berhe et al.'s (2019) study suggested fetal adverse outcomes in illiterate subjects (13.8%, *n* = 32) in comparison to well-educated subjects (4.9%, *n* = 15). Equally, Whyte et al.'s (2021) study provided participants' characteristics such as inability to read or write (19.5%, *n* = 75), informal education (12.7%, *n* = 49), 1-8 year of education (28.6%, *n* = 110), 9-12 years of education (28%, *n* = 108), and university graduate (11.2%, *n* = 108). Ameyaw et al.'s (2020) study suggested majority of participants with low educational attainment (55%). In a similar manner to the above findings, this present study documented majority of participants in the middle education level (47.7%, *n* = 16,297).

This study did not show statistically significant interaction between education level and the presence of sickle cell hemoglobin. Similarly, previous studies did not support this study's finding (Ameyaw et al., 2020; Burroway & Hardgrove., 2018; Claeys et al., 2021; Donald et al., 2019; Ezenwosu et al., 2021; Lu et al., 2021; McGavin et al., 2018; Menalu et al., 2021; Nadella et al., 2019; Ngandu et al., 2019; Takeuchi et al., 2019; Van Malderen et al., 2019; Wolde et al., 2019). In addition, Sonik et al.'s (2019) study in sickle cell hemoglobin participants revealed (21%) of parent with low education level in comparison to parent with education level (24%). In keeping with the studies above, this present study provided mother's high educational level (41.8% *n* = 14,306) in comparison to mother's low educational level (58.2%, *n* = 19,887).

Gender equality can be the driver of power to ensure a child's rights in the communities. Women's high education attainment may lead to health-related behaviors and improved health outcomes and well being. Awosolu et al.'s (2021) study in Nigeria documented mother's low educational attainment as a statistically significant predictor of a child's adverse health outcome ($p < .001$). Similarly, Menalu et al.'s (2018) study revealed mother's low educational attainment (13.8%, $n = 32$) in comparison to mother's high educational level (4.9%, $n = 15$). However, this study did not reveal a statistically significant interaction between low educational attainment and a child's health outcome. Nadella et al. (2019) showed a statistically significant interaction between poverty (i.e., low wealth index) and innovation uptake. However, this study did not reveal a statistically significant interaction between household wealth index and a child's health outcome. Isa et al. (2020) used a cross-sectional design to examine the association between the independent variables and sickle cell disorders. Similarly, this study illustrated a cross-sectional study design to determine the prevalence of sickle cell hemoglobin in children under 5-years-old.

Awosulu et al.'s (2021) study found a statistically significant between household water and a child's health outcome. Rather, this study did not show a statistically significant between household water and the presence of sickle cell hemoglobin. In a similar fashion to this study, Ugboko et al.'s (2021) study did not show a statistically significant interaction between presence of water and adverse events after controlling for covariate.

Deshpande et al.'s (2020) study showed (60%) of participants were on unimproved water facility. On the contrary, this study suggested that majority of the households were not on improved water facility. Awosolu et al.'s (2021) study provided a statistically significant interaction between childhood adverse health events and absence of household water after controlling for covariates. Again, Awosolu et al. provided a statistically significant association between childhood adverse events and poor sanitation after controlling for covariates. In contrast to other studies, this study did not reveal a statistically significant relationship between household presence of water and the presence of sickle cell hemoglobin.

Furthermore, this study did not reveal a statistically significant interaction between household toilet facility and improved health status. In contrast, previous studies did not support study's finding (Deshpande et al., 2020; Johnstone et al., 2021). This finding was similarly provided by Ugboko et al. (2021).

Htwe's (2021) study in rural Myanmar suggested 42% of households with lack of sanitation facility. Menalu et al.'s (2021) cross-sectional study in Ethiopia revealed the presence of flush toilet (37.6%, n = 146) in comparison to pit latrine (43.9%, n = 169). In a similar fashion, this study found the presence of toilet within the house (26.6%, n = 4,523) in comparison to toilet outside the house (73.4%, n = 12,458).

This present study did not show a statistically significant interaction between mother's employment status and the presence of sickle cell hemoglobin. In contrast, previous studies did not support this study's finding (Alabi & Ramsden, 2021; Hahn et al., 2018; Htwe, 2021; Kuyinu et al. (2020); Menalu et al. (2021); Okedo-Alex et al.

(2019); Tessema et al. (2021); Wolde et al., 2019). Berhe et al.'s (2018) study on fetal adverse experiences suggested mother's unemployment (70.1%, *n* = 213) in comparison to positive mother's employment stauts (9.9%, *n* = 30). Williams et al.'s (2018) study showed participants who were employed (*M* = 35.7, *SD* = 23.6) in comparison to their counterpart who not employed (*M* = 51.4, *SD* = 27.6). Similarly, this study showed mother's unemployment in the last 12 months (28.6%, *n* = 9,780) in comparison to their counterpart who were not employed (71.4%, *n* = 24,143).

Women's health-related behavior may be influenced by economic power they possess in the society. Gender equality is a social risk factor found in the setting of childhood sickle cell disorders. Ameyaw et al.'s (2020) study revealed higher odds of infection prevention in poorer households in comparison their counterparts from the poorest households after controlling for covariate. Poverty alleviation and community education were identified significant factors in childhood adverse outcomes (Victoria et al., 2021). Alradie-Mohamed et al.'s (2020) narrative analysis showed a significant relationship between gender equality and improved health status. In this study, the proxy variables for gender equality (e.g., employment status and education attainment) were not significant predictors of the presence of sickle cell disorders. In keeping with other studies, this study determined the significance of mother's autonomy on child's health outcomes.

Apanga et al (2021) study in Ghana indicated the presence of household water (i.e., handwashing) as a statistically insignificant predictor of childhood well being after controlling for covariates. In keeping with previous studies, this study revealed household

presence of water as a statistically insignificant predictor of presence of childhood sickle cell disease. Menalu et al.'s (2021) study showed indwelling water supply (1.6%, *n* = 6) in comparison to public water supply (84.9%, *n* = 327). This study showed presence of household water supply (51.9%, *n* = 15,423) in comparison to presence of household water supply (48.1%, *n* = 14,285).

The access to essential amenities in the community may be limited by social risk factors such as isolation and bias. Hahn et al. (2018) found that social factors (e.g., employment) were linked to social services access in the society. Booysen et al. (2021) alluded to the widening health gap as a cause of unjust distribution of resources in society. Poverty resulting from unemployment was associated with increased adverse outcome in children under 5-years-old (Htwe, 2021). In addition, proxy for gender equality (e.g., employment) was associated with improved childhood health status (Abreha et al., 2020). In similar manner to previous studies, this study demonstrated the relationship between proxies for health equality (i.e., educational attainment and employment status) and presence of sickle cell hemoglobin.

Key Findings on Demography, Sickle Cell Disorders, and the Literature

Phenotypic presentation of childhood sickle cell disorders may differ based on geographical locations. A child's immediate environment in childhood may determine the health status in adulthood. Children aged 6-59 months were males (50.6%, *n* = 1,153) in comparison to females (49.4%, *n* = 1,126). Also, Northwest geopolitical zone predominated in terms the total population (35.7%, *n* = 12,558) in comparison to other geopolitical zones in this study. Second, this study showed the proportion of participants

in the following Nigeria ethnic group: Hausa (51.1%, *n* = 17,476), Yoruba (11.0%, *n* = 3,749), Igbo (16.4%, *n* = 5,609), and others (21.5%, *n* = 7,360). The variation in the proportion of the ethnic groups resembles the substantial population differences in the six geopolitical zones of Nigeria. This study divided religion into categories such as Christian (36.0%, *n* = 12,304), Islam (63.5%, *n* = 21,706), and Traditionalist (.5%, *n* = 182). In the bivariate regression, this study did not reveal statistically significant findings in selected variables such as residence, religion, a child's gender, a child's age, ethnicity, and Nigeria geopolitical zones.

After not controlling for a child's age in this study, statistically significant relationship was found in variables such as Northcentral (*p* = .034), Yoruba (*p* = .028), South (*p* = .011), and Southeast (*p* = .009). After controlling for a child's age in this study, statistically significant relationship was found in variables such as Yoruba (*p* = .036), Southeast (*p* =.008), a child's age (*p* = .022), Northcentral (*p* = .047), and South (*p* = .011). Similarly, McGavin et al.'s (2018) study in Nigeria found that Southeast was a statistically significant predictor of innovation uptake (i.e., vaccination) after adjusting for covariate. Similarly, this study showed statistically significant findings in selected variables such as Southeast, Northeast, and south after adjusting for covariate. Tossea et al.'s (2018) cross-sectional study showed the predominance of SC hemoglobin (27%) among participants in Northern region of Ivory Coast. In keeping with other studies, this study showed the predominance of sickle cell disorders in the Northern region of Nigeria (i.e., Hausa ethnicity).

As previously mentioned, this study did show a statistically significant relationship between Nigeria geopolitical zones (i.e., Northcentral, South, and Southeast) and childhood sickle cell disorders. Similarly, previous studies supported this study's finding (Serjeant & Vinchinsky, 2018; see also Abreha et al., 2020; Accinelli & Leon-Abarcha, 2020; Ameyaw et al., 2020; Awosolu et al., 2021; Hahn, 2021; Htwe et al., 2021; Kerminen et al., 2019; Mkhize et al., 2019; Nnodu et al., 2019; Sun et al., 2020).

Race is a social construct which has consequence on childhood adverse experiences. Race may affect equal distribution of resources and wealth in the society. This study did show a statistically significant relationship between ethnicity (i.e., Yoruba ethnicity) and the presence of sickle cell hemoglobin. Similarly, previous studies did support this study's finding (Berhe et al., 2018; Chowdhury et al., 2018; Deshpande et al., 2020; Kosiyo et al., 2020; Lu et al., 2021; Mbanya et al., 2018; Menalu et al., 2021; Okedo-Alex et al., 2019; Oribhabor et al., 2020; Victoria et al., 2020).

This study did not provide statistically significant findings between ethnicity (i.e., Igbo and Hausa) and the presence of sickle cell disorders. On the other hand, previous studies did not support this study's finding (Alabi & Ramsden, 2021; Alradie-Mohamed et al., 2019; Awolola et al., 2019; Danso & Danso, 2021; McGavin et al., 2018; Okedo-Alex et al., 2019). Thus, this current study considered ethnicity as a social determinant of health.

This study revealed a high prevalence of sickle cell hemoglobin among Hausa ethnic group. In agreement with this study's finding, Nnodu et al. (2020) and IIiyasu et al. (2021) found that the prevalence of sickle cell disorder was high among the Hausa

ethnic group. Kosiyo et al.'s (2020) study found a significant association between culture and health outcomes after controlling for covariate.

Abreha et al.'s (2020) study showed the rural population (M = .89, SD = .39) in comparison to urban population. Also, Akinyemi et al. (2021) found that the odds of innovation uptake decreased by .27 in disempowered rural women (B = -.27, SE = .005, p < .001). Apanga and Kumbeni (2021) showed children under 5-years-old in urban residence with 22% lower odds of poor health outcome in comparison to rural residence. In a similar manner to other studies, this study demonstrated majority of the participants in the rural areas (61.5%, n = 21,023).

Geography is a determinant of health and well being, which needs to be understood in context of sickle cell disorders. The interaction between health inequalities, gender, and geography may lead the observed differences in survival of childhood sickle cell disorders. This study showed the predominance of rural residents compared to urban residents. Similarly, previous studies did support this study's finding (Ameyaw et al., 2020; Azupogo et al., 2019; Efunshile et al., 2019; Menalu et al., 2021; Van Malderen et al., 2019). However, Berhe et al. (2018), Patel et al. (2021), and IIiyasu et al. (2021) alluded to the predominance of urban residents in comparison to rural residents.

Also, Tessema et al. (2021) found that geographical zones (i.e., south, west, east, and central) were significant factors of innovation uptake (p < .001). McGavin et al. (2021) alluded to Northcentral in comparison to Southwest as a statistically significant predictor of innovation uptake after controlling for covariates. In a similar manner to other studies, this study showed a statistically significant relationship between

Northcentral zone and the presence of sickle cell hemoglobin. Again, McGavin et al. provided Northwest as a statistically significant predictor of innovation uptake after controlling for covariate. On the contrary, this study showed Northwest presented the odds of presence of sickle cell hemoglobin 50.7% (*OR* = 1.507) higher than absence of sickle cell hemoglobin after not controlling for covariate.

Disparity may influence health outcomes and well being in childhood chronic disorders. Akinyemi et al. (2021) found that the odds of innovation uptake decreased by .27 in disempowered rural women (B = -.27, SE = .005, $p < .001$). Westnedge et al. (2018) emphasized on the impact of geography on the health outcomes in children under 5-years-old. Similarly, Serjeant and Vinchisky (2018) provided significant relationship between environment (e.g., climate and geographical zone) and the presence of sickle cell hemoglobin. Although this study did not report on climate, it did reveal a statistically insignificant relationship between Nigeria geopolitical zones and the presence of sickle cell hemoglobin in the bivariate logistic regression.

Berhe et al.'s (2019) study focused on rural setting as a significant determinant of a child's health status (e.g., intra- and post-partum). Similarly, Royal et al.'s (2021) study suggested the significant association between environmental factors and health status. However, this study did not show a statistically significant relationship between urban residence and the presence of sickle cell hemoglobin. Apanga and Kumbeni (2020) study showed residence as a significant predictor of adverse health outcomes.

Gender as a social construct may influence the presentation of medical complications in childhood sickle cell disorders. This study did not show a statistically

significant relationship between a female child and the presence of sickle cell hemoglobin. In keeping with this study's finding, Acinelli & Leon-Abarcha et al. (2020) found a negative correlation between a child's age and adverse health outcomes. However, previous studies did not support this study's finding (Chao et al., 2021; see also Abreha et al., 2020; Afolabi et al., 2020; Bartlett et al., 2021; Htwe et al., 2021; Islam et al., 2020; Takeuchi et al., 2019; Ugboko et al., 2021).

The severity of acute and chronic medical complications of sickle cell disorders may be influenced by age. This study did not show a statistically significant relationship between a child's age and the presence of sickle cell hemoglobin. This study's finding was similarly suggested by Whyte et al.'s (2021) study in Jamaica. However, other studies did not support this study's finding (Accinelli & Leon-Abarca, 2020; Boadu et al., 2018; Donkor et al., 2021; IIiyasu et al., 2021).

Women's civil rights may be influenced by religion, leading to reduced health outcomes and survival in the society. This study did not show a statistically significant association between religion and improved health outcomes. However, other studies did not support this study's finding (Awolola et al., 2019; Aziz et al., 2021; Menalu et al., 2021; Okedo-Alex et al., 2019; Patel et al., 2021).

Key Findings on Infection Treatment, Sickle Cell Disorders, and the Literature

Infection prevention is a modality of prevention of disabilities in childhood sickle cell disorders. In this study, children vaccination status was full (21.7%, n = 7,422) in comparison to low vaccination status (32.6%, n = 3,588). In addition, this study showed households use mosquitoes' net (56.8%, n = 19,418) in comparison to those

households not using mosquitoes' net (40.2%, *n* = 13,040). This study revealed unavailable children's Africa protein diet supplement (94.2%, *n* = 32,210) comparison to children's Africa protein diet supplement (5.8%, *n* = 1,983). Also, a little less than half of the children were not being treated for fever (31.8%, *n* = 2,600) in this study. Children's diarrhea treatment revealed (60.2%, *n* = 2,379) in comparison to their counterpart who were not treated for diarrhea (39.8%, *n* = 1,571). This study did not show a statistically significant findings in the selected variables representing infection treatment.

Exclusive breastfeeding in the first 6 months of life is a method of infection prevention in children. Breastfeeding builds the immune system against infections and influence mother's emotional bond. Efunsile et al.'s (2019) study indicated majority of participants not receiving exclusive breastfeeding (71.9%, *n* = 144). Similarly, this study showed children's exclusive breastfeeding status values (*M* = 93.52, *SD* = .91).

This study did not show a statistically significant relationship between children's breastfeeding status and the presence of sickle cell hemoglobin after controlling for covariate. However, other studies did not support this study's finding (Donkor et al., 2021; Feldman-Winter et al., 2020; Tesfaw & Fenta, 2021; Nerves et al., 2021; Torlesse & Aguayo, 2018; Suryawan et al., 2021). This study's finding was similarly seen by Vitalis et al. (2021).

Controversies on complementary feeding are areas which need to be visited. Nutritional therapy in childhood sickle cell disease may replace increased energy expenditure in developing countries. This study did not show a statistically insignificant between children's African protein diet supplement and the presence of sickle cell

hemoglobin after controlling for covariate. This study's finding was similarly suggested by Feldman-Winter et al. (2020). However, other studies did not support this study's finding (Nartey et al., 2021; see also Afolabi et al., 2020; Anaduaka et al., 2021; Boadu et al., 2018; Budreviciute et al., 2020; Datta et al., 2019a; Efunshile et al., 2019; Eleonare et al., 2020; Feldman-Winter, 2020; Tan & Lewandowski, (2020); Kambale-Kombi et al., 2021; Kudirat et al., 2019; Nowakowski et al., 2021).

Vaccine hesitancy is another field which has a social context. This study did not show a statistically significant relationship between childhood vaccination and childhood sickle cell disease after controlling for covariate. This study's finding was similarly suggested by Akwataghibe et al. (2021). However, other studies did not support this study's finding (Reeves et al., 2018, see also Bangura et al., 2020; Budreviciute et al., 2020; De Montalembert et al., 2019; Hill et al., 2019; McGavin et al., 2018; Nadella et al., 2019; Obasohan et al., 2018; Pertet et al., 2018).

The susceptibility of sickle cell disorders patients to malaria infection is still a contentious issue in the literature. Family's health-related behaviors about infection prevention may affect the health outcomes in sickle cell disorders. This study did not show a statistically significant relationship between mosquitoes' net use and the presence of sickle cell hemoglobin. This study's finding was similarly seen by Oppong et al. (2020) and Kambale-Kombi et al. (2021). However, other studies did not support this study's finding (Afolabi et al., 2020; Aguirre et al., 2019; Apanga & Kumbeni, 2021; Belay et al., 2021; Eleonare et al., 2020; Farrell et al., 2018; Kambale-Kombi et al., 2021; Ochocinski et al., 2020; Tetteh et al., 2021).

This study showed the use of mosquitoes' net in more than half of the households (59.8%, *n* = 19, 418). Similarly, Oppong et al.'s (2020) study suggested the mosquitoes' net use more than two-third of participants (85.8%, *n* = 289). Also, Belay et al. (2021) documented the use of mosquitoes' net among majority of participants (75%, *n* = 201).

Nutrition as a social determinant of health could worsen medical complications in childhood sickle cell disorders. Additionally, this study did not show a statistically significant relationship between weight-for-height and the presence of sickle cell hemoglobin. This study's finding was similarly documented by Tesfaw and Fenta (2021). However, other studies did not support this study's finding (Heng et al., 2021; Islam et al., 2021; Nartey et al., 2021; Suryawan et al., 2021; Torlesse & Aguayo, 2018).

The nutritional status of a child can be deduced or extrapolated using weight-for-height *z*-scores. In this study, malnutrition was diagnosed with the use of anthropometric measurement (i.e., weight-for-height *z*-scores) in this study. Similarly, previous studies did support this study's finding (Islam et al., 2021; Nartey et al., 2021; Tesfaw & Fenta, 2021). This study's finding was not similarly seen by Heng et al. (2021) and Oppong et al. (2020).

Key Findings on Pain and Management, Sickle Cell Disorders, and the Literature

Vaso-occlusive pain in sickle cell hemoglobin needs to be addressed in terms of complementary treatment, leading to improved health outcomes and well being. In this study, children's rehydration status was subnormal in more than half (59.9%, *n* = 2,366) in majority. Children's transfusion status showed majority receiving blood (99.0%, *n* =

2,033) in this study. This study revealed mother's treatment of fever (68.2%, n = 5,571) in comparison (31.8%, n = 2,600) mother's not treating fever. Children's antibiotic prophylaxis was in almost two-third of households (70.9%, n = 2,801) in this study. This study suggested a statistically significant relationship between children's hemoglobin and the presence of sickle cell hemoglobin (p = .034). A child's age provided a statistically significant interaction in the model. This study showed effect modification by a child's age. The model did not show statistically significant findings in selected variables such as children's blood transfusion, mother's treatment of fever, children's antibiotic prophylaxis, and children's rehydration status.

Chemotherapy is a tertiary prevention of infection in the society. This study did not show a statistically significant relationship between children's antibiotic prophylaxis and the presence of sickle cell disease after controlling for covariate. However, other studies did not support this study's finding (Abdullahi et al., 2021; Babalola et al., 2019; Efunshile et al., 2019; Green et al., 2021; Houwing et al., 2021; Kambale-Kombi et al., 2021; Karadag et al., 2018).

This study did not show statistically significant relationship between the presence of sickle cell hemoglobin and treatment of medical complications. This study's finding was similarly suggested by Saramba et al. (2020). However, other studies did not support this study's finding (Brandow & Liem, 2022; Chimbatata et al., 2021; Kamal et al., 2021; Kanter et al., 2018; Iebni et al., 2021; Nartey et al., 2021; Okongwu et al., 2018; Whitley et al., 2021).

This study did not show a statistically significant relationship between children's rehydration status and childhood sickle cell disorders. This study's finding was similarly suggested by Hejazi et al. (2021). However, other studies did not support this study's finding (Bartlett et al., 2021; Brandow & Liem, 2022; De Villaverde Cortabarria et al., 2021; Goss et al., 2021; Kanter et al., 2018; Kapoor et al., 2018; Karadag et al., 2018; Kazak & Ozkaraman, 2020; Morrone et al., 2018; Partnen et al., 2020).

This study did show a statistically significant relationship between a mother's treatment of fever and the presence of sickle cell hemoglobin in the bivariate regression. Similarly, previous studies supported this study's finding (Brandow & Liem, 2022; Chimbatata et al., 2021; Cisneros & Thein, 2020; Datta et al., 2019b; Ford et al., 2020; Frangoul et al., 2021; Galadanci et al., 2019; Kamal et al., 2021; Kanter et al., 2018; Lamsfus-Calle, 2020; Leger et al., 2021; Meier et al., 2018; Nartey et al., 2021).

Blood transfusion decision making in sickle cell disorders may be affected by decision making in the society. This study did not show a statistically significant relationship between children's blood transfusion status and the presence of sickle cell disorders. However, other studies did not support this study's finding (Chou et al., 2021; Conti et al., 2018; Fasano et al., 2019; Fortin et al., 2018; Rees et al., 2018; Tanhehco, 2021).

Sickle cell disorders are susceptible to low hemoglobin (i.e., anemia) due to different risk factors (e.g., social determinants of health). This study did reveal a statistically significant relationship between children's hemoglobin level and the presence of hemoglobin. Similarly, other studies supported this study's finding (Accinelli & Leon-

Abarcha, 2020; see also Chimbatata et al., 2021; Cisneros & Thein, 2020; Fasano et al., 2019; Gbadebo et al., 2021; Kappor et al., 2018; Kosiyo et al., 2021; Lidonnici et al., 2018; Meier et al., 2018; Opoka et al., 2019; Nnodu et al., 2021; Wonkam et al., 2018). This study's finding was not similarly seen by Brousse et al. (2021) and Islam et al. (2021).

Opoka et al.'s (2018) study suggested children's hemoglobin level (M = 3.7, SD = .9) in sickle cell hemoglobin in comparison to hemoglobin AA. Also, Kosiyo et al. (2018) revealed a positive correlation between children's hemoglobin aged 1-190 months and genotype AS after controlling for age and sex (r = .55, p = .002). Kudirat et al.'s (2018) study provided children's hemoglobin level in sickle cell disorders (M = 9.4, SD = 1.4). In a similar fashion to the above studies, this study showed the value of children's hemoglobin level (M = 119.76, SD = 117.80).

Societal equality may enhance improved management of medical complications in childhood sickle cell disorders. This study showed a statistically significant relationship between childhood sickle cell disorders and mother's treatment of fever in the bivariate regression. Similarly, other studies supported this study's finding (Ford et al., 2020; see also Asnani et al., 2021; Brandow et al., 2020; Claeys et al., 2021; Conti et al., 2018; Cortright et al., 2020; Crego et al., 2020; Dougherty et al., 2020; Elbendary et al., 2021).

Key Findings on Healthcare Use, Sickle Cell Disorders, and the Literature

In this study, mother's acceptance of children's genotype testing was found in majority of the households (98.6%, n = 2,011). Also, this study revealed mother's reading

newspapers (88.7%, *n* = 30,328) in comparison to their counterpart not reading newspapers (11.8%, n = 3,865). Also, mother's antenatal care use was in less than two third of the households (30.7%, *n* = 5,082). Mother's use of health insurance was found almost in all households (2.1%, *n* = 727). This study did not show statistically significant relationship in the selected variables such as antenatal care, mother's place of delivery, mother's use of health insurance, and mother's reading of newspapers. However, this study revealed a statistically significant relationship between mother's uptake of children's genotype testing and the presence of sickle cell hemoglobin. Delivery in health facility was found in almost one third of the participants (30.7%, *n* = 5,082) in this study.

Point-of-care genotype test may lead to improved health status and well being. This study revealed a statistically significant relationship between mother's uptake of children's genotype testing (i.e., innovation uptake) and childhood sickle cell disorders. Similarly, previous studies supported this study's finding (Byrnes et al., 2022; Babalola et al., 2019; Esoh et al., 2021; Ezenwosu et al., 2021; Kasai et al., 2020; McGavin et al. (2018); McClintock et al., 2020; Okedo-Alex et al., 2019). However, previous studies did not support this study's finding (Cortright et al., 2020; Gage et al., 2021; McClintock et al., 2020; Okedo-Alex et al., 2020).

Antenatal care is a modality of reducing adverse events at the pre- and post-natal period. Mother's welfare may be affected by the prevailing social determinants of health. This study did not show a statistically significant between antenatal care use and the presence of sickle cell hemoglobin. Similarly, previous studies supported this study's finding (Cortright et al., 2020; Gage et al., 2021; Okedo-Alex et al., 2019). However,

previous studies did not support this study's finding (Farrell et al., 2018; Mahajan et al., 2021; Okedo-Alex et al., 2019; Tanou et al., 2021; Tessema et al., 2021; Sageer et al., 2019; Vitalis et al., 2021; Wolde et al., 2019; Xu et al., 2020).

Also, Bolarinwa et al.'s (2021) study provided that high socioeconomic status was associated with complete antenatal care (40.0%) in comparison to incomplete antenatal visits (60.0%). Similarly, this study showed mother's antenatal care use (30.7%, *n* = 5,082) in comparison to their counterpart who did not use antenatal care (69.3%, *n* = 11,493). Thus, the presence or absence of antenatal care could determine the survival of children living with sickle cell hemoglobin.

Face-to-face counselling may ensure improved health-related behavior in the society. Genetic counselling could provide information about the hereditary nature of sickle cell hemoglobin. Consequently, leading to reduced mortality and morbidity in childhood sickle cell disorders. This study did not show a statistically significant between healthcare use and the presence of sickle cell hemoglobin. Similarly, previous studies supported this study's finding (Claeys et al., 2021; Gage et al., 2021; Cortright et al., 2020; Shobiye et al., 2021). However, previous studies did not support this study's finding (Byrnes et al., 2022; Cronin et al., 2019; Demissie et al., 2021; Fisher et al., 2018; Frimpong et al., 2018; Hardy et al., 2021; Kanter et al., 2018).

Families are likely to pay out-of-pocket due to financial constraints and unavailable health insurance scheme. National coverage of health insurance scheme may increase access to healthcare services. This study did not show a statistically significant relationship between childhood sickle cell disorders and mother's health insurance use

after controlling for covariate. Similarly, previous studies supported this study's finding (Claeys et al., 2021; Cortright et al., 2020; Gage et al., 2021). However, previous studies did not support this study's finding (Borja et al., 2021; see also Byrnes et al., 2022; Famuyiwa et al., 2020; Fasano et al., 2019; IIiyasu et al., 2021; Kuersten et al., 2021; Iebni et al., 2021; Leleu et al., 2021; Mor-Anavy et al., 2021; Ogamba et al., 2020).

IIiyasu et al.'s (2021) study found that the majority of the participants living with sickle cell hemoglobin were not on health insurance coverage (96.8%, n = 360). In a similar fashion, this study found that majority of children living with sickle cell hemoglobin were not on health insurance coverage (97.9%, n = 33,466). Thus, healthcare insurance use could vary based on government policy and play a role in the community health outcomes.

The exposure of children to social risk factors before birth has consequences on growth early in life and adulthood. Also, mother's uptake of innovation may be based on their autonomy in the society. This study showed a statistically significant relationship between a proxy for health-related behaviors (i.e., mother's age) and childhood sickle cell disorders. Similarly, previous studies supported this study's finding (Claeys et al., 2021; Gage et al., 2021; Cortright et al., 2020). However, previous studies did not support this study's finding (Conway et al., 2019; Caldwell, 2020; Elbendary et al., 2021; IIiyasu et al., 2021; Nadella et al., 2019; Okedo-Alex et al., 2019).

Dissemination of information to the public can be a modality of achieving health-related behavior, leading to improved health outcomes and well being. Ability to use or acquire health knowledge is an inherent way of providing health for every child. This

study did not show a statistically significant relationship between mother's newspapers reading and the presence of sickle cell hemoglobin. Similarly, previous studies supported this study's finding (Claeys et al., 2021; Cortright et al., 2020; Gage et al., 2021). However, other studies did not support this study's finding (Kambale-Kombi et al., 2021, see also Dougherty et al., 2020; Ozkan et al., 2021; Kuyinu et al., 2020; Rance & Skirton., 2019; Sabahelzain et al., 2019; Tessema et al., 2021; and Yaya et al., 2018).

Health literacy may influence the decision to use healthcare facilities in the society. This study did not show a statistically significant relationship between mother's place of delivery and the presence of sickle cell hemoglobin. This study's finding was similarly seen by Gage et al. (2021) and Kang and Kim (2019). However, other studies did not support this study's finding (Asnani et al., 2021; Byrnes et al., 2022; Gebremariam et al., 2019; Khubchandani et al., 2018; Kuyinu et al., 2020; Mbanya et al. (2018); McGavin et al., 2018).

Theoretical Framework and Findings

The theoretical frameworks implemented in this study were the Krieger's ecosocial theory and Bronfenbrenner's systems. Because social determinants could influence a child's health, they were examined in the setting of children living with sickle cell disorders. Researchers demonstrated the relationship between social determinants of health framework and health outcomes using socioecological theory (Beltran et al., 2022; Booysen et al., 2018; Budreviciute et al., 2020; Buser et al., 2020; Hirani & Richter, 2019; Mercellus, 2018; Olstad & McIntyre, 2019). This study took into consideration the

association between the presence of sickle cell hemoglobin, socioeconomic status, infection prevention, pain and anemia management, healthcare use, and demography.

This study showed a significant relationship between ethnicity and childhood sickle cell disorders. Similarly, Buser et al. (2020) found a significant relationship between culture (i.e., ethnicity) and a child's health using ecological theory of disease distribution. In a similar fashion, researchers suggested the use of ecological theory to determine the interplay between structural violence, a child's growth, disparity, and health inequalities (Aguirre et al., 2019, Cabrera et al., 2021; Royal et al., 2020).

Using conceptual framework, researchers provided a significant relationship between urban environment, a child's health outcome, and health-related behaviors (Jacoby et al., 2018). Also, Golden and Wendal (2020) and Beltran et al. (2022) found that social determinants of health influenced the prevalence and distribution of infectious diseases in the community. In a similar fashion, this study showed a significant relationship between Nigeria geopolitical zones and childhood sickle cell disorders.

This study focused on Bronfenbrenner's meso-, chrono-, micro-, and macro-systems to answer the research questions. In a similar fashion, researchers illustrated Bronfenbrenner's systems to examine the relationship between a child's growth and chronic diseases (Bailey & Im-Bolter., 2018; Berghs et al., 2020; Berman et al., 2018). Bailey and Im-Bolter evaluated the impact of social risk factors on childhood chronic disorders. Again, Berghs et al. demonstrated the significant influence of social determinants of health on sickle cell disorders. Similar to this study, Berman et al. provided the significant impact of social determinants on childhood sickle cell disorders.

This study showed a significant relationship between a mother's health-related behavior (i.e., infection treatment) and childhood sickle cell disorders using Bronfenbrenner's systems. Similar to this study, Axelsson et al. (2020) suggested Bronfenbrenner's conceptual framework to examine the relationship between a child's environment and health outcomes. Furthermore, Buser et al. (2021) documented variables contributing to neonatal well being using Bronfenbrenner's model. Similarly, this study provided Krieger's ecosocial theory and Bronfenbrenner's systems theory to examine the association between an austere environment and a child's health outcomes.

As mentioned above, Bronfenbrenner's theory could be used to examine disease distribution in children. Erickson et al. (2018) focused on Bronfenbrenner's systems to examine the risk factors of health outcomes in the community such as culture, environment, biology or gene, family, and policy. Researchers suggested a well-grounded theoretical framework to show the pathways between stigma, ethnicity, race, geography, ethnicity, and health outcomes (Cerdena et al., 2020). Erickson et al. recommended Bronfenbrenner's theory to guide chronic disorders treatment and health policy formulation. Okedo-Alex et al.'s (2019) systematic review suggested a significant relationship between social determinants of health and antenatal care use in Sub-Saharan Africa. In keeping with other studies, this study showed a significant relationship between ethnicity and sickle cell disorders using ecological theory.

Walker et al. (2019) mentioned Bronfenbrenner's theoretical framework to delineate the interplay between a child's life, socioecological perspective, and disabilities. Krieger's (2019) study presented ecosocial model to examine the distribution

of disease in the society. Besides, Walker et al. alluded to the significant risk factors in chronic disorders using Bronfenbrenner's ecological systems. As mentioned, the Bronfenbrenner's systems and Krieger's ecosocial theoretical frameworks created an avenue to apply this study's findings to each level of health system.

Recommendations

Early screening for sickle cell hemoglobin is crucial to achieve improved health outcomes in the community. A comprehensive program may limit disabilities in childhood sickle cell disease at the state, local, or national level. Policies involving collaboration between different stakeholders may allow improved control and prevention of sickle cell hemoglobin. Caregiver's health education and skills must be improved in the six geopolitical zones of Nigeria. Gender equality may be a strategy of achieving health in every child. Partnership between health facilities and family may enhance delivery of needed therapeutic drugs for sickle cell disorders.

Establishment of SickleCellNigeria initiative may lead to improved survival of children living with sickle cell hemoglobin. The initiative will involve collaboration between different stakeholders (e.g., Africa sickle cell research network, the Federal Ministry of Health in Nigeria, WHO, Federal Ministry of Women's Affairs and Social Development in Nigeria, and UNICEF. In addition, this initiative will be goals directed and aimed to reach the six geopolitical zones of Nigeria. The goals will be measurable, reasonable, achievable, timely, and affordable. A comprehensive program will be formulated to enhance provision of social services such as health education, nutrition supplement, childhood vaccination, antenatal care, malaria prevention, and blood

transfusion. Also, the SickleCellNigeria initiative central office will be based in Abuja performing duties such as fund raising and campaign (e.g., genotype screening). The initiative will aim to establish a national registry that achieves real-time data collection and screening for social determinants of health. Thus, this initiative will ensure improved survival of children living with sickle cell disorders aged 6-59 months in Nigeria.

The national immunization or vaccination program coverage rate in the six geopolitical zones of Nigeria will be considered in the proposed initiative. Consequently, vaccine hesitancy as a drawback in the achievement of desired vaccination rate will be addressed. A multilateral strategy to address shortage of vaccines in developing countries will be implemented. Also, emergency response vaccines production for pandemic situations will be part of the initiative. Health workers must be trained on how to handle pre- and post-pandemic vaccines distribution in the six geopolitical zones of Nigeria. Future research should explore field of vaccine hesitancy in Sub-Saharan Africa.

Disparity needs to be addressed to limit regional variation in resources distribution. As a result, equitable distribution of amenities in the six geopolitical zones of Nigeria must be encouraged. The Federal Ministry of Health in Nigeria may need to formulate policies limiting structural violence. There is a need for collaboration between Federal Ministry of Health in Nigeria, Department of Women's Affairs and Social Development in Nigeria, UNICEF, and financial institutions. In the developing countries, government need to provide the needed transportation to health facilities.

Because of the deleterious effect of determinants of health early in life, inclusive programs targeting health inequalities need to be prioritized. Developing countries need

to implement nutrition-related policy to limit malnutrition in the community. Health-related behavior may be achieved through the use of communication tools such as media, telemedicine, eHealth, and mobile phone. National insurance scheme in Sub-Saharan Africa must involve families of sickle cell disorders patients. For instance, a national income grant may improve healthcare use in the society. The intervention programs mentioned above should ensure reduction of disabilities in childhood sickle cell disorders. Finally, future research in the field of childhood sickle cell disorders should explore factors such as children's blood transfusion status, mother's health insurance use, and mother's uptake of children's genotype test.

Limitations of the Study

Limitations of this study are the cross-sectional design and the missing data. This cross-sectional study did not allow causality inference to be deduced. Consequently, a longitudinal data could provide more information on the selected variables. The missing data led to loss of information in selected variables such as children's blood transfusion status, mother's uptake of children's genotype test, and mother's use of healthcare insurance.

Because sickle cell hemoglobin is a rare disease in some countries, cross-sectional design may not reflect the true association between the selected variables. Misclassification bias may occur from the allocation of wrong genotype to a child, leading to reduced internal and external validity in this study. Recall bias may be found in the presence of cross-sectional design. Selection bias may occur at the stage of data

collection because no secondary dataset is inviolable. Residual bias may lead to reduction in internal validity despite controlling for covariates or confounders in this study.

Delimitations of the Study

The laboratory confirmation of childhood sickleSCAN rapid tests by liquid chromatography test allows improved diagnostic sensitivity and specificity in this study. The large sample size allows improved internal validity and power in this study. The 2018 Nigeria DHS data answered the Research Questions 1 through 5.

Implications

Screening for social risk factors may allow building a formidable health system. Because of the negative consequences of social determinants early in life, inclusive programs targeting sickle cell disorders well being need to be proritized in developing countries (De Montalembert et al., 2019). Supportive care management are ways of improving health status and well being in sickle cell disorders (Meier, 2018). Nartey et al. (2021), Mohmood et al. (2021) suggested the need for holistic and comprehensive management of medical complication in sickle cell disorders. In short, provision of social support and services in childhood sickle cell disorders may allow improved life expectancy.

Wonkam and Makani (2019) have provided the need for comprehensive management in childhood sickle cell disorders in Sub-Saharan Africa aimed to reduce mortality and morbidity. Researchers have noted the need for community health education aimed to improve health-related behaviors (Niu et al., 2021). Deshpande et al. (2020) have mentioned good sanitation and adequate water as part of global sustainable

goals strategies. In Sub-Saharan Africa, food security is critical to ensure limitation of hunger and childhood undernutrition (Htwe, 2021).

Implications for Health Policy, Clinical, and Professional Change

Cultural competence or sensitivity among healthcare practitioners may be revisited, allowing improved consultation on medical complications. This study allows practitioners to use evidence-based clinical guidelines on blood transfusion in childhood sickle cell disorders. The need for integrative specialized care (e.g., hematologist, social workers, epidemiologist, genetic counsellor, biostatistician, microbiologist, occupational therapist, and family physician) in childhood sickle cell disease could be accelerated.

Health equity needs to be embraced at all levels of government in Nigeria. Screening for social determinants of health in the hematology clinic and genetic health centers may allow improved health outcomes in sickle cell disorders. The health system will be resilient at addressing the risk factors of health inequalities and inequities in the society. This study allows researchers to cover existing literature gaps in the field pediatric sickle cell disorders. Research funding in the field of pediatric sickle cell disorders could be stimulated.

Implications for Positive Social Change

Social determinants of health play a role in the health outcomes of children living with sickle cell disease. This study has provided evidence-based pathway to reduce inequalities and disparities in the society. This study provided evidence-based management in childhood sickle cell disease. At the individual level, mother's welfare may lead to improved health outcomes in childhood sickle cell disorders. At the family

level, parents' skills may play a role in achieving improved health status in childhood sickle cell disorders.

Social determinants of health may influence the health outcomes and well being in childhood sickle cell disorders. This study may stimulate timely referral of children living with sickle cell disorders to healthcare facilities. Health policy on the provision of health insurance scheme for vulnerable groups may be improved. In Nigeria, universal healthcare practice may be attained using medical aid insurance in every child. This study may stimulate the global movement for universal basic income to ensure that families can affordable high cost of treatment in sickle cell disorders.

Effective treatment of community-acquired infections may lead to improved health outcomes in childhood sickle cell disorders. As such, neonatal morbidity and mortality may be reduced through reduction of opportunistic infections in childhood sickle cell disease. Point-of-care screening for hemoglobin genotype and social determinants may reduce adverse experiences in childhood sickle cell disorders. Thus, social supports and services are needed to mitigate the deleterious effects of health determinants.

A child's right need to be enshrined in the federal constitution of Nigeria. Creation of advocacy groups on a child's rights may be a way of reducing the burden of childhood sickle disease in Nigeria. Also, improved antenatal care use may lead to reduction of infant mortality and mortality in the six geopolitical zones of Nigeria. Breastfeeding in the first 6 months of life need to be taught in the antenatal care facilities

of Nigeria. This study may stimulate the management of childhood sickle cell disorders at state-of-the-art health facilities.

Food safety in rural and urban locations come as a possible strategy of limiting malnutrition in children living with sickle cell disorders. This study could enable government to implement nutrition-related health policies in the community. After all, health-related behavior may be achieved through nationwide campaign on prevention and control of sickle cell disorders.

Conclusions

Sickle cell hemoglobin is a major cause of morbidity and mortality in Sub-Saharan Africa. The 2018 Nigeria DHS data were used to answer Research Questions 1 through 5. Also, this quantitative cross-sectional study used well-grounded theoretical frameworks to examine the relationship between the selected variables. Integrating social services into the medical management may lead to improved well being and health status. As a result, a comprehensive program may lead to improved survival in the communities. There is a need to ensure health equity in every child in Sub-Saharan Africa.

Using binary logistic regression, statistically significant findings were found in selected variables such as South, Northcentral, a child's age, children's hemoglobin, Yoruba ethnicity, mother's uptake of children's genotype testing, and Southeast. However, other selected variables did not show statistically significant findings in this study. Future research should be encouraged in the field of vaccine hesitancy, children's blood transfusion status, mother's health insurance use, and mother's uptake of children's genotype test.

The attainment of WHO goal of universal health must be embraced in Sub-Saharan Africa. The SickleCellNigeria initiative may allow the achievement of universal health. Childhood sickle cell disease burden in Sub-Saharan Africa needs to be addressed at national, local, or state level. Early life screening for social determinants and sickle cell disorders may allow a productive adult life. Health equity may lead to fair distribution of resources in the society.

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