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Evaluation of Sickle SCAN® As A Rapid Point-Of-Care System for Sickle Cell Disease Detection in The Gabonese Population

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Abstract
Sickle cell disease (SCD) represents a major inherited hemoglobin disorder with substantial consequences for childhood survival, chronic morbidity, and health-system capacity, particularly in sub-Saharan Africa. Gabon is characterized by a significant burden of sickle cell trait and documented clinical relevance of SCD, creating a need for diagnostic approaches that are rapid, accessible, and suitable for decentralized healthcare settings. Conventional diagnostic strategies may require laboratory infrastructure that is not uniformly available, whereas point-of-care testing offers the possibility of shortening the interval between presentation, diagnosis, and clinical intervention. This research and review article evaluates the potential role of Sickle SCAN® as a rapid point-of-care system for SCD detection in the Gabonese population. The analysis synthesizes the supplied literature concerning the epidemiology of hemoglobin disorders, the distribution of sickle hemoglobin in Africa and Gabon, the clinical burden of SCD, and the need for accessible diagnostic and monitoring technologies. A conceptual evaluation framework is developed around diagnostic accessibility, analytical performance, operational feasibility, clinical utility, and integration into screening pathways. The literature indicates that the epidemiological and healthcare context of Gabon provides a strong rationale for decentralized SCD detection. However, definitive assessment of Sickle SCAN® requires prospective comparison with an established reference method in representative Gabonese populations. The proposed framework therefore positions Sickle SCAN® as a potentially important component of decentralized screening while emphasizing the need for local validation, quality assurance, confirmatory testing, and appropriate clinical interpretation.

Keywords: Sickle Cell Disease; Sickle SCAN®; Point-of-Care Testing; Gabon; Hemoglobinopathy; Diagnostic Screening; Rapid Blood Test; Diagnostic Evaluation; Decentralized Healthcare.

1. Introduction

Sickle cell disease is an inherited hemoglobin disorder resulting from abnormal hemoglobin production and is associated with a broad spectrum of hematological and clinical complications. Its importance extends beyond individual disease manifestations because the condition can generate substantial demands on pediatric, emergency, transfusion, and long-term healthcare services. The clinical heterogeneity of SCD means that early identification is particularly important for establishing appropriate follow-up and reducing avoidable complications. Rees, Williams, and Gladwin (2010) characterize SCD as a major inherited disorder with multisystem consequences, emphasizing the relationship between abnormal hemoglobin biology, red-cell sickling, vascular pathology, and clinical disease.

The global distribution of sickle hemoglobin is highly uneven, with particularly high frequencies in sub-Saharan Africa. Piel et al. (2013) demonstrated substantial geographical variation in sickle hemoglobin prevalence and emphasized the importance of contemporary epidemiological mapping for understanding the population-level burden. Earlier global analyses similarly identified hemoglobin disorders as an important international health concern and linked epidemiological

burden to requirements for diagnostic and clinical services (Modell and Darlison, 2008). Thus, SCD detection cannot be considered solely a laboratory problem; it is also a health-system problem involving population screening, accessibility, referral, counseling, and continuity of care.

The Gabonese context is particularly relevant because sickle cell-related conditions have been documented in the country. A nationwide investigation reported the prevalence of sickle cell trait in Gabon, demonstrating that the genetic background necessary for clinically important sickle hemoglobin disorders is present at the population level (Délicat-Loembet et al., 2014). Neonatal screening has also been reported in Gabon, indicating an established interest in identifying affected individuals early in life (Vierin Nzame et al., 2012). Historical literature has additionally highlighted the importance of sickle cell anemia within the pediatric environment of Gabon (Thuilliez and Vierin, 1997).

The importance of timely diagnosis is reinforced by evidence concerning mortality and disease burden in African populations. Grosse et al. (2011) identified SCD as a neglected contributor to early childhood mortality in Africa, while Koko et al. (1998) documented the mortality associated with SCD among children in a Central African pediatric setting. These findings provide a strong public-health rationale for diagnostic systems that can function beyond highly specialized laboratories.

Point-of-care testing offers a potentially useful response to this diagnostic-access challenge. Rather than requiring every patient specimen to be transported to a centralized laboratory, a point-of-care approach can move an initial diagnostic decision closer to the patient. In Central Africa, the development and consideration of diagnostic and monitoring tools have been recognized as an important component of SCD management (J-p G, 2018). Sickle SCAN®, a blood-based point-of-care diagnostic technology designed for identification of clinically relevant sickle hemoglobin patterns, therefore represents a potentially relevant technological approach for the Gabonese setting.

The objective of this article is to evaluate the conceptual and practical suitability of Sickle SCAN® for rapid SCD detection in the Gabonese population using the supplied literature as the evidentiary foundation. The analysis focuses on epidemiological relevance, diagnostic accessibility, operational characteristics, potential clinical utility, implementation requirements, and limitations. The central proposition is that the value of a point-of-care diagnostic system should not be determined only by analytical accuracy but also by whether the technology can be reliably incorporated into real-world screening and referral pathways.

2. Literature Review

2.1 Epidemiological Foundation of Sickle Cell Disease

The epidemiological foundation for SCD screening is particularly strong in regions where sickle hemoglobin occurs frequently. Piel et al. (2013) developed a contemporary geostatistical model of sickle hemoglobin in neonates and demonstrated the extensive geographical distribution of the condition. This evidence establishes that SCD should be addressed through population-oriented health strategies rather than treated exclusively as a rare clinical diagnosis.

Modell and Darlison (2008) further demonstrated that hemoglobin disorders generate measurable service requirements at the health-system level. Their analysis connected disease prevalence with indicators of required diagnostic and clinical services. This is important for the evaluation of point-of-care technologies because diagnostic effectiveness has limited population impact when testing remains geographically or economically inaccessible.

Williams and Weatherall (2012) emphasized the health burden associated with hemoglobinopathies, while Weatherall (2010) described inherited hemoglobin diseases as an emerging global health burden. Collectively, these studies support a theoretical framework in which diagnosis is an essential component of disease-control infrastructure rather than an isolated laboratory activity.

2.2 Evidence from Gabon and Central Africa

Evidence specific to Gabon strengthens the case for targeted diagnostic strategies. Délicat-Loembet et al. (2014) investigated the prevalence of sickle cell trait across Gabon and demonstrated that sickle hemoglobin represents an important component of the country's genetic and epidemiological landscape. Vierin Nzame et al. (2012) reported neonatal screening for SCD in Gabon, indicating that early-life identification has practical relevance within the national healthcare context.

The pediatric importance of the disease was recognized earlier by Thuilliez and Vierin (1997), who addressed the importance of sickle cell anemia in the pediatric environment in Gabon. Evidence from the wider Central African region also illustrates the consequences of delayed or inadequate diagnosis. Koko et al. (1998) reported mortality among children with SCD in a Central African pediatric department, highlighting the clinical consequences associated with the disease.

Elguero et al. (2015) provide an additional epidemiological dimension by demonstrating continued selection for sickle cell trait by malaria in Central Africa. This observation is important because it helps explain why sickle hemoglobin remains epidemiologically relevant in the region. The persistence of the genetic trait reinforces the need for diagnostic systems capable of operating effectively in populations with substantial hemoglobinopathy burden.

2.3 Diagnostic Need and Point-of-Care Approaches

The clinical complexity of SCD creates a requirement for dependable diagnosis. Rees et al. (2010) describe SCD as a multisystem disorder involving vaso-occlusive and hematological processes, making accurate disease

identification foundational to subsequent clinical management. Kumar et al. (2012) similarly demonstrate the importance of molecular diagnosis and counseling within SCD care, illustrating that diagnostic information can have implications extending beyond the immediate clinical encounter.

However, highly specialized diagnostic approaches may be difficult to deploy uniformly across geographically dispersed populations. J-p G (2018) specifically discusses diagnostic and monitoring tools for SCD in Central Africa, emphasizing the relevance of technologies capable of addressing regional diagnostic constraints.

The literature therefore reveals a central gap: while the burden and epidemiological justification for SCD diagnosis in Gabon are documented, the supplied evidence does not provide a comprehensive local evaluation of Sickle SCAN® against an established reference diagnostic method. This gap creates the rationale for a structured evaluation focusing simultaneously on diagnostic performance and implementation feasibility.

2.4 Theoretical Positioning

The theoretical position of this study is based on the principle that an effective point-of-care diagnostic system must satisfy five interconnected dimensions: analytical reliability, speed, accessibility, operational simplicity, and clinical usefulness. A test may have strong analytical characteristics but limited population impact if it requires unavailable equipment, highly trained personnel, or complex sample transportation.

Accordingly, Sickle SCAN® should be evaluated not merely as a diagnostic device but as a component of a decentralized diagnostic pathway. Its potential contribution lies in reducing the distance between suspected disease and an actionable diagnostic result. Nevertheless, rapid screening cannot replace appropriate confirmatory procedures when diagnostic uncertainty remains. The literature on SCD diagnosis and counseling supports a broader diagnostic pathway rather than reliance on a single test in every clinical circumstance (Kumar et al., 2012).

3. Methodology

3.1 Research Design

This article adopts a research-and-review design combining structured literature synthesis with a conceptual diagnostic evaluation framework. Only the references supplied for this study were used to establish the epidemiological, clinical, and diagnostic context. No external evidence was introduced.

Because no primary patient dataset was supplied, the methodology does not fabricate sensitivity, specificity, predictive values, or patient-level outcomes. Instead, it establishes a framework that can be applied in a prospective Gabonese diagnostic evaluation of Sickle SCAN®.

3.2 Proposed Study Population

A practical evaluation would include individuals from relevant Gabonese screening and clinical populations, with particular attention to newborns, children, pregnant women, individuals presenting with clinical suspicion of SCD, and individuals identified through community or institutional screening. Inclusion of different age groups is important because the clinical presentation and screening context can vary substantially.

The epidemiological rationale for such sampling is supported by the documented presence of sickle cell trait and previous neonatal screening activity in Gabon (Délicat-Loembet et al., 2014; Vierin Nzame et al., 2012). A representative sample should ideally incorporate both urban and less-accessible healthcare environments so that the evaluation captures not only analytical performance but also real-world feasibility.

3.3 Diagnostic Evaluation Framework

The proposed evaluation framework can be represented as:

Patient/Screening Population → Capillary Blood Collection → Sickle SCAN® Testing → Rapid Interpretation → Reference Diagnostic Comparison → Clinical Classification → Referral/Counseling

The first component is specimen acquisition. A small blood sample appropriate for point-of-care testing would be collected under standardized conditions. The second component involves execution of Sickle SCAN® according to manufacturer-defined operating procedures. The result would then be interpreted by trained personnel.

The third component is reference comparison. To establish diagnostic performance, Sickle SCAN® results should be compared with an accepted laboratory reference approach capable of distinguishing clinically relevant hemoglobin patterns. This comparison is essential because an evaluation based solely on agreement between point-of-care operators cannot independently establish diagnostic accuracy.

3.4 Performance Measures

The primary analytical measures should include sensitivity, specificity, positive predictive value, negative predictive value, and overall agreement with the reference method. Where appropriate, subgroup analysis should examine performance across age groups, healthcare settings, and relevant clinical categories.

Sensitivity is particularly important in screening because false-negative results can delay identification of affected individuals. Specificity is equally relevant because excessive false-positive classification can increase unnecessary confirmatory testing, anxiety, and resource use.

The evaluation should also record invalid-test frequency, time required to obtain a result, operator training

requirements, sample-processing complexity, and operational interruptions. These variables are important because point-of-care value depends on the interaction between analytical performance and implementation conditions.

3.5 Operational and Health-System Evaluation

The operational component should examine whether Sickle SCAN® can realistically be incorporated into Gabon's healthcare infrastructure. Relevant dimensions include electricity dependence, storage requirements, environmental conditions, staff training, test availability, quality-control procedures, and referral mechanisms.

A decentralized testing model could be particularly valuable in settings where transportation of blood specimens to centralized laboratories introduces delays. The literature on Central African diagnostic tools indicates that strengthening accessible diagnostic and monitoring capacity is an important component of SCD care (J-p G, 2018).

3.6 Quality Assurance and Ethical Considerations

Any prospective implementation should include standardized operator training, internal quality controls, documentation of invalid results, and periodic comparison with reference laboratory results. Quality assurance is especially important when diagnostic systems are deployed outside specialized laboratories.

Ethically, individuals receiving a positive screening result should have access to appropriate counseling and confirmatory diagnostic services. Diagnostic information can influence reproductive counseling and long-term healthcare decisions, making accurate communication essential. The importance of diagnostic information for counseling is supported by the diagnostic and prenatal counseling context discussed by Kumar et al. (2012).

4. Results

The evidence synthesis indicates a strong epidemiological and health-system rationale for evaluating rapid point-of-care SCD detection in Gabon. Available literature demonstrates that sickle hemoglobin is relevant within the Gabonese population, including documented sickle cell trait prevalence and previous neonatal screening activity (Délicat-Loembet et al., 2014; Vierin Nzame et al., 2012). Consequently, a diagnostic strategy designed for early and accessible identification addresses a documented rather than hypothetical public-health need.

The second finding concerns the relationship between disease burden and diagnostic accessibility. SCD is associated with significant morbidity and mortality, particularly when diagnosis and comprehensive care are inadequate. African evidence has characterized SCD as a neglected contributor to early childhood mortality (Grosse et al., 2011), while Central African pediatric experience has demonstrated substantial mortality among affected children (Koko et al., 1998). Rees et al. (2010) further establish that SCD has systemic clinical consequences, making timely identification clinically meaningful rather than merely epidemiologically informative.

Third, the literature supports decentralized diagnostic development as a rational implementation direction. Central African diagnostic and monitoring requirements have been explicitly recognized, suggesting that diagnostic technologies should be evaluated according to their suitability for regional healthcare conditions rather than only their laboratory characteristics (J-p G, 2018). Sickle SCAN® potentially addresses this requirement through a point-of-care model in which diagnostic information can be generated closer to the patient.

However, the available evidence does not permit a numerical determination of Sickle SCAN® sensitivity or specificity in the Gabonese population. No original patient-level observations, reference-test comparisons, confidence intervals, or subgroup results were supplied. Therefore, claiming specific diagnostic-performance percentages would constitute unsupported empirical fabrication. The principal finding of the present research-and-review analysis is consequently that a structured local validation study is justified and should assess analytical accuracy alongside implementation feasibility.

The proposed evaluation model predicts that the greatest practical value of Sickle SCAN® would occur in settings where centralized laboratory access is limited or where rapid clinical decision-making is required. Conversely, the system's population-level benefit would be reduced if positive screening results could not be followed by confirmatory testing, counseling, and appropriate clinical referral.

Overall, the findings position Sickle SCAN® as a potentially useful first-line point-of-care screening technology within a broader diagnostic pathway, rather than as an isolated replacement for laboratory-based confirmation.

5. Discussion

The central implication of this analysis is that Sickle SCAN® should be evaluated within the epidemiological and healthcare realities of Gabon. The literature establishes a substantial rationale for strengthening SCD diagnosis: sickle hemoglobin is epidemiologically relevant in the country, neonatal screening has previously been undertaken, and SCD has recognized pediatric consequences (Délicat-Loembet et al., 2014; Vierin Nzame et al., 2012; Thuilliez and Vierin, 1997).

From a theoretical perspective, the potential value of point-of-care testing lies in shortening the diagnostic pathway. Traditional centralized models may require specimen collection, transportation, laboratory processing, result transmission, and subsequent patient referral. A point-of-care system can theoretically compress several of these stages into a single healthcare encounter. This feature is particularly relevant to populations where geographical or infrastructural barriers may interfere with laboratory access.

The potential clinical benefit is also connected to the natural history of SCD. Rees et al. (2010) describe the disease as a complex multisystem condition, meaning that delayed identification can have consequences for subsequent monitoring and management. Early identification may facilitate enrollment into appropriate care pathways, while neonatal detection can provide an opportunity for earlier counseling and follow-up. Evidence from Gabon concerning neonatal screening provides support for the feasibility and relevance of this orientation (Vierin Nzame et al., 2012).

Nevertheless, point-of-care testing presents an important trade-off between accessibility and diagnostic assurance. A rapid result is not inherently equivalent to a definitive diagnosis. Where a point-of-care result is uncertain, unexpected, or inconsistent with clinical circumstances, confirmatory laboratory evaluation remains necessary. This principle is consistent with the broader diagnostic and counseling requirements associated with hemoglobin disorders (Kumar et al., 2012).

The Gabonese epidemiological context also requires careful interpretation of sickle cell trait. Elguero et al. (2015) demonstrated that malaria continues to exert selection pressure associated with sickle cell trait in Central Africa. Therefore, population screening strategies must distinguish carrier states from clinically significant disease rather than treating all sickle hemoglobin findings as equivalent.

Another major consideration is implementation. A point-of-care device may perform effectively under controlled conditions but encounter reduced utility because of inadequate training, quality-control limitations, supply interruptions, inappropriate storage, or insufficient referral capacity. Modell and Darlison (2008) demonstrate why diagnostic services should be considered as part of broader health-system requirements. The technology therefore needs to be evaluated at both individual-test and system levels.

The evidence also highlights the importance of sustainability. A successful diagnostic program requires repeated access to testing materials, trained operators, documentation systems, confirmatory pathways, and mechanisms for linking screened individuals with long-term care. The existence of a substantial disease burden alone does not guarantee successful implementation.

A further limitation is that the supplied literature is stronger in epidemiology, clinical burden, and general diagnostic needs than in direct evaluation of Sickle SCAN® specifically in Gabon. Consequently, the present study establishes a scientifically justified evaluation framework rather than reporting independently observed diagnostic accuracy. Future empirical research should prospectively recruit a representative Gabonese population and compare Sickle SCAN® with an established reference method. Diagnostic accuracy should be accompanied by operational indicators such as turnaround time, invalid-test rate, operator usability, cost per correctly classified individual, and successful linkage to confirmatory care.

The practical implication is therefore not that Sickle SCAN® should automatically replace conventional laboratory diagnosis, but that it may serve as an important entry point into a tiered diagnostic system. Such a model could combine rapid decentralized screening with laboratory confirmation and specialist referral, thereby balancing accessibility with diagnostic reliability.

6. Conclusion

Sickle cell disease represents an important public-health and clinical challenge in Gabon and the wider Central African region. The supplied literature establishes the epidemiological relevance of sickle hemoglobin, documents sickle cell trait in Gabon, identifies previous neonatal screening activity, and demonstrates the substantial clinical burden associated with SCD (Délicat-Loembet et al., 2014; Vierin Nzame et al., 2012; Grosse et al., 2011).

Within this context, Sickle SCAN® represents a potentially valuable point-of-care approach because decentralized testing may reduce delays between patient presentation, screening, and diagnostic decision-making. Its principal potential advantage is therefore not simply rapidity but the possibility of extending diagnostic capability beyond centralized laboratory environments.

However, the present evidence does not support assigning numerical diagnostic-performance estimates to Sickle SCAN® in the Gabonese population because no primary diagnostic dataset was provided. A rigorous prospective evaluation should compare Sickle SCAN® with an established reference method and assess sensitivity, specificity, predictive values, invalid results, turnaround time, usability, and operational feasibility.

The principal contribution of this analysis is the positioning of Sickle SCAN® within a broader diagnostic framework consisting of point-of-care screening, confirmatory testing, counseling, referral, and long-term clinical follow-up. Future research should prioritize multicenter validation across representative Gabonese populations and healthcare settings. Such evidence would determine whether Sickle SCAN® can provide sufficiently reliable, accessible, and sustainable SCD detection to strengthen the country's diagnostic and public-health infrastructure.

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