



BMJ Open Enablers and barriers to newborn screening for sickle cell disease in Africa: results from a qualitative study involving programmes in six countries

Natasha M Archer ¹, Baba Inusa,² Julie Makani,³ Siana Nkya,³ Léon Tshilolo,⁴ Veneé N Tubman,⁵ Patrick T McGann ⁶, Emmanuela Eusebio Ambrose,⁷ Natalie Henrich,⁸ Jonathan Spector,⁹ Kwaku Ohene-Frempong¹⁰

To cite: Archer NM, Inusa B, Makani J, *et al*. Enablers and barriers to newborn screening for sickle cell disease in Africa: results from a qualitative study involving programmes in six countries. *BMJ Open* 2022;**12**:e057623. doi:10.1136/bmjopen-2021-057623

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2021-057623>).

NMA and BI are joint first authors.

Received 05 October 2021
Accepted 08 February 2022



© Author(s) (or their employer(s)) 2022. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

Correspondence to

Dr Natasha M Archer;
natasha.archer@childrens.harvard.edu

ABSTRACT

Objectives Given the fundamental role of newborn bloodspot screening (NBS) to enable prompt diagnosis and optimal clinical management of individuals with sickle cell disease (SCD), we sought to systematically assess enablers and barriers to implementation of NBS programmes for SCD in Africa using established qualitative research methods.

Setting Childbirth centres and NBS laboratories from six countries in East, West and Southern Africa.

Participants Eight programme leaders involved with establishing and operating NBS programmes for SCD in Angola, Democratic Republic of Congo, Ghana, Liberia, Nigeria and Tanzania.

Primary and secondary outcome measures Data obtained through a structured, phased interview approach were analysed using a combination of inductive and deductive codes and used to determine primary themes related to the implementation and sustainability of SCD NBS programmes.

Results Four primary themes emerged from the analysis relating to governance (eg, pragmatic considerations when deploying overcommitted clinical staff to perform NBS), technical (eg, design and execution of operational processes), cultural (eg, variability of knowledge and perceptions of community-based staff) and financial (eg, issues that can arise when external funding may effectively preclude government inputs) aspects. Key learnings included perceived factors that contribute to long-term NBS programme sustainability.

Conclusions The establishment of enduring NBS programmes is a proven approach to improving the health of populations with SCD. Organising such programmes in Africa is feasible, but initial implementation does not assure sustainability. Our analysis suggests that future programmes should prioritise government partner participation and funding from the earliest stages of programme development.

INTRODUCTION

Sickle cell disease (SCD) is one of the world's most common haemoglobinopathies, estimated to affect in excess of 400 000 newborns annually with 80% of patients

Strengths and limitations of this study

- This is one of the largest studies of enablers and barriers to successful implementation and sustainability of sickle cell disease (SCD) newborn screening programmes in Africa, where no national-level programmes currently exist.
- Applying established qualitative research methods, this study investigated the first-hand experiences of clinical and coordinating leaders involved in establishing and operating programmes in six African countries: Angola, Democratic Republic of Congo, Ghana, Liberia, Nigeria and Tanzania.
- Six programmes were included in the analysis, which is a sample of the total number of newborn screening programmes for SCD that have been implemented in Africa.
- By design, a single or small number of participants were surveyed from each programme.
- The lessons learnt from one country may not always be immediately transferable to other countries due to various local factors.

born into populations living in low-income and middle-income countries.^{1 2} The disease is caused by a single point mutation in the beta-globin gene that results in the formation of sickle haemoglobin (HbS).³ Under certain conditions, including hypoxia, HbS polymerises and creates distorted (ie, 'sickle' shaped), adherent and less deformable red blood cells (RBCs).⁴ The result is easily haemolysed RBCs with a shortened lifespan, endothelial damage, vessel obstruction and other pathophysiological effects that collectively contribute to the development of a vast constellation of acute and chronic clinical manifestations and, often, premature mortality.

Fetal haemoglobin (HbF), the predominant haemoglobin during gestation and in neonates, is the most potent known inhibitor



of HbS polymerisation. As such, infants with SCD are asymptomatic until HbF levels decline to low levels, typically within the first 6–24 months of life. Early diagnosis prior to the predominance of HbS is critical to allow for provision of early lifesaving interventions. Since SCD cannot be diagnosed by clinical signs at birth, newborn bloodspot screening (NBS) materialised decades ago to be a standard approach in many high-resource countries for identifying babies with SCD before complications develop.^{5 6} Early detection enables the prompt initiation of parental education and evidence-based preventative care practices that include penicillin prophylaxis and pneumococcal vaccination.^{7 8}

In the 1980s, a randomised, placebo-controlled trial in the USA confirmed the efficacy of penicillin prophylaxis in significantly reducing incidence of and mortality due to *Streptococcus pneumoniae*, the leading cause of death in young children with SCD.⁵ Evidence from that study provided the impetus for the US National Institutes of Health Consensus Development Conference on Newborn Screening for SCD and Other Hemoglobinopathies to recommend that all babies born in the USA be screened for SCD.⁹ In the USA, where universal NBS for SCD (ie, testing newborn babies within the first few weeks after birth) has existed in all 50 states since 2006, NBS is largely acknowledged to be among the most important factors leading to high rates (well over 90%) of survival into adulthood.^{5 10 11} Universal screening for SCD now constitutes national policy in the USA, Brazil, UK, Germany, Spain, the Netherlands and Malta;^{12–15} longstanding NBS programmes have also been in place in other parts of Europe, Jamaica, Ghana and Canada.^{13 16 17} Targeted screening of newborns (eg, according to ancestry) is implemented in some regions but has been shown to be less effective compared with universal screening at identifying infants with disease and preventing deaths.¹⁸

The vast majority of people with SCD globally are born in Africa, where up to 2% or more of births are reported to be affected in some regions, contributing silently but significantly (8%–16%) to under 5 years of age mortality in high burden countries.^{19–21} While no country in Africa has yet implemented policies for universal screening, various national NBS programmes for SCD have been organised, and with heightened awareness about the impact of the disease, there is optimism for increased progress in the future.^{19 20 22–26} In this context, we sought to characterise the enablers and challenges to conducting NBS for SCD based on the experiences of previous and ongoing programmes. Specifically, we assessed programmes in Angola, Democratic Republic of Congo (DRC), Ghana, Liberia, Nigeria and Tanzania.^{19 20 23–25 27} Using established qualitative research methods,^{28–30} we conducted semi-structured interviews with clinical and coordinating leaders involved in each programme and extracted key messages to codify main lessons learnt. This analysis is envisioned to be a resource for patients, clinicians, policy-makers and other stakeholders seeking to improve health systems relating to NBS for SCD in Africa

and other limited resource settings globally where SCD occurs in high prevalence.

METHODS

Study design

We conducted a qualitative descriptive study that incorporated data from semi-structured interviews with individuals who were responsible for, or significantly involved in, the design and implementation of NBS programmes for SCD in an African country (hereafter referred to as ‘participants’).³¹ The purpose of the interviews was to describe the process for designing and implementing the programmes, identify enablers and challenges, and elicit lessons learnt in order to facilitate a concise summary of learnings that could be used to inform future SCD NBS programmes. Additionally, participants provided background information about their programme by email in advance of their interview. If a participant did not provide the information prior to their interview, then these questions were asked at the start of the interview. See online supplemental materials for the background questions and interview guide.

Interviews were conducted in two phases. The first phase included four participants (representing programmes in Ghana, Angola, DRC and Liberia), who answered a comprehensive set of questions about their programmes. Interviews were transcribed, coded and analysed after the first phase of data collection. From this analysis, the study team identified aspects of SCD NBS programme that warranted deeper exploration either because they emerged as critical to the success of the programme or because they were characterised by variability that prompted deeper investigation across programmes. The latter included aspects of the programme that were subjective (eg, cultural attitudes toward SCD) as opposed to mechanistic (eg, the type of test used to screen for SCD). The second phase included two participants (representing programmes in Nigeria and Tanzania), who answered questions on the topics determined in phase 1 that required further discussion. By limiting the number of questions asked in the second phase, the study team was able to conduct deeper exploration of each of the topics. The findings from phase 2 supplemented the results from the corresponding topics in phase 1. The results from the two phases were analysed together to identify key learnings for the establishment and maintenance of SCD NBS programmes in Africa.

Patient and participant involvement

Patients were not involved in this study. Participants were identified by study members as programme leaders after reviewing publications related to SCD NBS in African countries. Participants were recruited by email. During the recruitment, all participants confirmed that they were programme leaders and they reported various levels of public engagement in their respective countries. All participants were invited to review the results and to

contribute to identifying key messages and implications of the results, clarify or correct any information from their interviews, and co-author the resulting manuscript (ie, in alignment with a form of ‘member checking’ described in the literature).³² One participant was also a study member (KO-F). This study member was not involved in the coding, analysis or preliminary interpretations of the data to minimise the risk that this study member’s own experiences would bias the results.

Interview guide

We designed the interview guide to gain insight into how participants developed, implemented and, when applicable, sustained their programme. The team’s qualitative researcher (NH) led the creation of the interview guide with input from a study team member with extensive knowledge about SCD newborn screening programmes in Africa (KO-F) and from study team members with general expertise about SCD (JS and NMA). Collectively, the study team identified the key steps of establishing and implementing a screening programme as well as other factors that were likely to impact the success of the programme. These high-level topics included: programme partners, planning the programme, launching the programme, logistics of day-to-day operations, establishing and running the laboratory, patient notification and follow-up, funding and costs, programme disposition and perceptions of the programme by families of newborns. The interview guide was piloted with a member of the study team (KO-F) for clarity, flow and duration. Minor revisions to the interview guide were made based on his feedback and his responses were included in the dataset.

Data collection and analysis

Participants were interviewed one time for approximately 1 hour. Phase 1 interviews took place between October 2017 and December 2017. Phase 2 interviews took place between July 2019 and September 2019. All interviews were conducted by phone, audio recorded and transcribed verbatim. Phase 1 interviews were conducted by the qualitative specialist on the team (NH), who received training on SCD-specific content from the other team members and studied relevant literature to become additionally familiar with the topic. Phase 2 interviews were conducted by a team member with content expertise who had prior interviewing experience (JS).

We performed a thematic analysis of the interviews using a coding scheme developed with a combination of inductive and deductive codes. In phase 1, coding was performed in NVivo (QSR) and the content from each code was summarised in a table, including key quotes and identification of key findings. Key findings were used to identify areas that required more in-depth exploration during the second phase of data collection. Phase 2 interviews were analysed by directly adding key findings into the summary tables from phase 1. Results were shared with

the participants for feedback and, if needed, corrections, clarifications and the addition of missing information.

RESULTS

Study sample

The study involved data collection relating to NBS programmes in six countries in Africa (figure 1) with representation from West Africa (Ghana, Liberia and Nigeria), Central Africa (Angola and DRC) and East Africa (Tanzania). Participants were based at academic institutions and professional societies; many had worked in conjunction with government agencies and external collaborators. The planning period before the initiation of screening ranged from approximately 9 months to 4 years, and the duration of screening ranged from 21 months to 25 years. The number of birth centres involved in the NBS programmes ranged from 1 to approximately 250. Most programmes are ongoing in some capacity, although several with reported periods of inactivity due to various operational challenges as described below.

Qualitative findings

Four primary themes emerged in the analysis relating to (a) structure and governance; (b) technical aspects; (c) culture and (d) finances. Within these four main themes, we identified 12 subthemes that are summarised in table 1 and described below. A summary of major lessons learnt/recommendations is provided in table 2.

Primary theme I: structural and governance aspects

The role of national health authorities was universally felt to be a critical determinant of success. Government entities, including Ministries of Health and/or other national health service delivery units, were involved in each of the programmes with a level of engagement that ranged along a continuum from passive (eg, conceptual ‘support’ of the programme and allowance to proceed without allocating new resources) to active (eg, recognising the NBS programme as a core part of the health system and providing clinical staff and other resources to maintain its continuity). While in several countries the government was involved from the early stages of NBS programme design, in no country was the government, the initial actor, involved in establishing the NBS programme. Programmes that continued beyond a ‘pilot’ phase ascribed government involvement as a key enabler; likewise, programmes that met with challenges in achieving long-term sustainability pointed to a lack of government ownership as a main reason.

All participants reported the topic of programme structure and governance to be an essential consideration. Programmes were each championed by clinician-led teams with specialised expertise in caring for patients with SCD. All programmes focused mainly on births taking place in public health facilities (ie, government operated); private sector birth centres were less commonly included. Clinical and ancillary staff (eg, midwives and

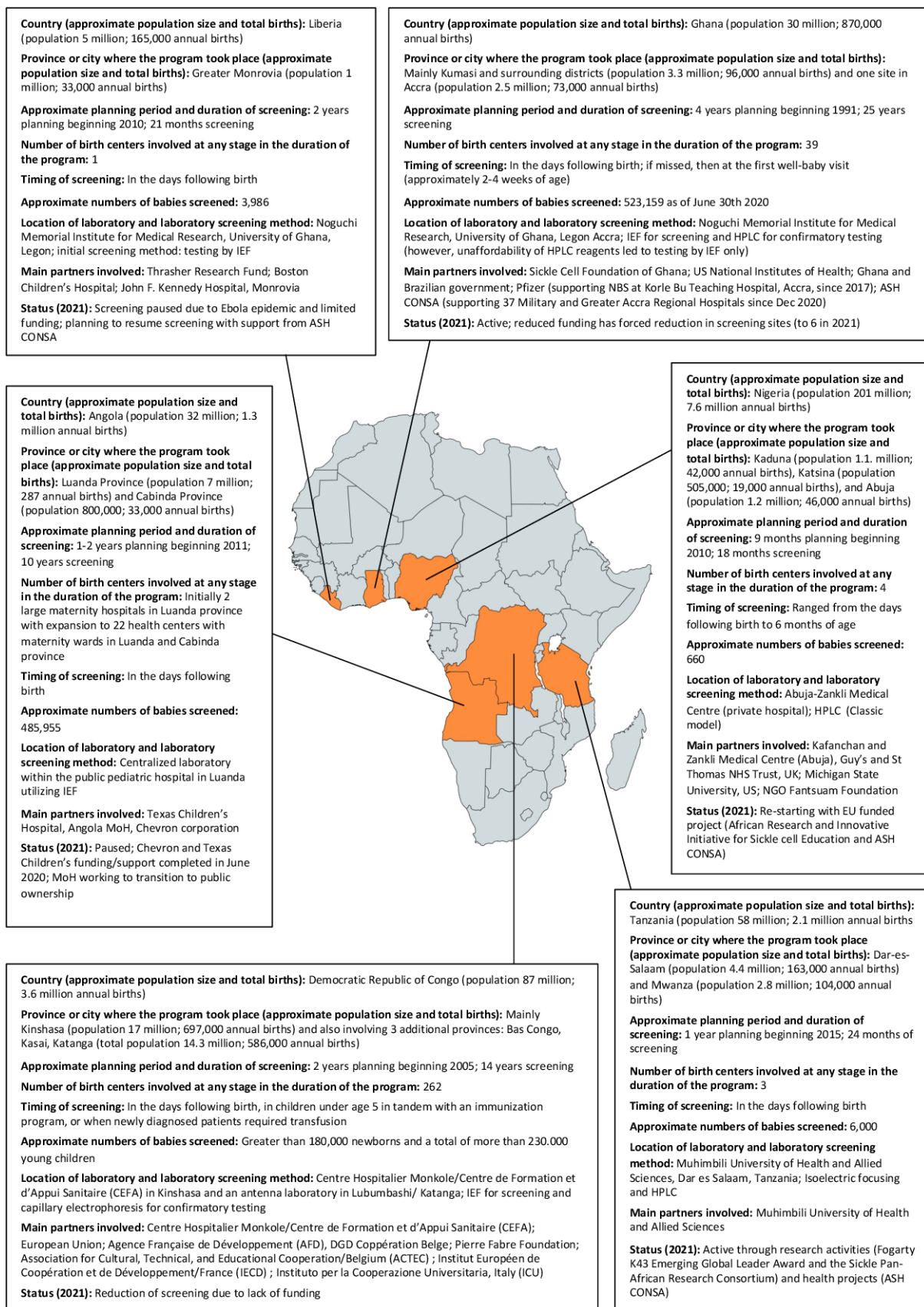


Figure 1 Location and characteristics of included programmes. Programme data provided by country participant(s) who were interviewed. Reference for demographic data: World Bank. Map design credit: Mapchart.net. ASH, American Society of Hematology; CONSA, Consortium on Newborn Screening in Africa; HPLC, high-performance liquid chromatography; IEF, isoelectric focusing; MoH, Ministry of Health; NGO, non-governmental organisation; NHS, National Health Services.

Table 1 Summary of main results

Subtheme	Core concept	Principal stakeholders	Enablers	Challenges	Examples
Theme: programme structure and governance					
Health authority endorsement	<ul style="list-style-type: none"> Endorsement by government and incorporation into core health systems is fundamental to operational success and sustainability 	<ul style="list-style-type: none"> Governments, ministries of health and other local health authorities 	<ul style="list-style-type: none"> Government involvement from the start, in particular with plans for financial investment by national health authorities, facilitates national 'ownership' of NBS programmes and rational integration with routine healthcare delivery processes 	<ul style="list-style-type: none"> Non-clear or unclear involvement of government risks prioritisation uncertainties, ineffective communication and implementation challenges Small-scale 'pilot' programmes can be useful for establishing proof-of-concept but may risk sustainability challenges if they do not involve buy-in from national government authorities from the outset 	<ul style="list-style-type: none"> In Ghana, support from Ashanti local government is recognised to be a main factor in the programme's 25+ year duration In Angola, while the MoH was involved in the programme design from the start and supported the programme conceptually, financial investment to launch the programme was received from a private sector partner and the motivation of MoH to fund the programme long term was unclear
Theme: technical					
Workflow mapping	<ul style="list-style-type: none"> Optimal workflows (eg, that involve sample collection, sample transfer to laboratories, testing and patient follow-up) must be fully integrated with local health systems 	<ul style="list-style-type: none"> Programme leaders, coordinators, health workers, laboratory staff and families 	<ul style="list-style-type: none"> Programme design conducted in collaboration with all local stakeholders Recognition that workflows will need to be tailored to local settings and may require iterative refinement after initial implementation 	<ul style="list-style-type: none"> Follow-up with patients for results notification and to enrol in comprehensive care programmes is recognised as a common challenge across programmes 	<ul style="list-style-type: none"> In Ghana, the Ghana Health Service (GHS) staff conducts most activities along the spectrum of sample collection to counselling families on results and referral for medical care; activities are integrated with the laboratory and coordinated by the dedicated staff at the Sickle Cell Foundation of Ghana
Theme: cultural					
Community engagement	<ul style="list-style-type: none"> Family participation is fundamental to screening and follow-up 	<ul style="list-style-type: none"> Programmes leaders, coordinators, families, patient organisations and support groups 	<ul style="list-style-type: none"> Providing education about SCD can help families to understand the importance of NBS and following up in the event of positive screening results 	<ul style="list-style-type: none"> Families may not believe positive test results or fail to follow-up for routine healthcare visits since babies are asymptomatic in early infancy SCD is stigmatised in many communities 	<ul style="list-style-type: none"> Newborn screening, similar to immunisation was described as a 'silent' public health activity that, when successful, works in the background to help keep the population healthy Some programmes described community engagement to be helpful at initiation, but specific ongoing engagement was often not necessary as long as the structures are in place for programme implementation.
Theme: funding					
Role of government	<ul style="list-style-type: none"> NBS must be prioritised by government in order to assure long-term sustainability 	<ul style="list-style-type: none"> Governments, Ministries of Health and other local health authorities 	<ul style="list-style-type: none"> Government involvement from the start facilitates national 'ownership' of NBS programmes and financial planning 	<ul style="list-style-type: none"> Government agencies in Africa have many competing interests for spending on health 	<ul style="list-style-type: none"> Typically, NBS is provided free of charge to families and may be funded through a national health insurance programme In private systems, the cost of NBS is often either paid by private insurance or families In Africa, unlike early childhood immunisation, no country's government fully funds NBS programmes

Table 1 summarises the main results of the study. It is organised by the four primary themes that emerged from the analysis, including governance (eg, considerations in deploying already overcommitted clinical staff to perform NBS), technical (eg, design and execution of operational processes), cultural (eg, variability of knowledge and perceptions of community-based staff) and financial (eg, issues when relying on external funding to the exclusion of government contribution). Subthemes are also highlighted as well as corresponding core concepts, stakeholders, enablers and challenges. Examples from various country programmes are also included for validity.

MoH, Ministry of Health; NBS, newborn bloodspot screening; SCD, sickle cell disease.

**Table 2** Major lessons learnt/recommendations

Subtheme	Lessons learnt/recommendations	Participant quotes
Theme: programme structure and governance		
Health authority endorsement	Receive endorsement by government at start of programming	<ul style="list-style-type: none"> ▶ It was designed as a pilot project within the Public Health Service so that it would be incorporated. That was the plan right from the start. That it would end with government takeover was our goal ▶ The deputy minister of health was always a huge supporter. I would have the opportunity to meet with her whenever I wanted to, and she was always a huge supporter of the programme. The Ministry wasn't able to financially support the programme, but they made sure that I was able to get around stumbling blocks. And continued to do so after the study ended ▶ With our Ministry of Health, we have an official partnership because all the different hospitals need to have relation with the health minister ▶ There was some interest by the First Female at the time, but ultimately their involvement or—especially from the Ministry of Health side was quite low
Theme: technical		
Workflow mapping	Integrate NBS into the local health system	<ul style="list-style-type: none"> ▶ We would rely on public health nurses and doctors working in that system ▶ The hospital director Helped to facilitate things primarily. So, we had a laboratory that we allocated within the hospital, so he helped allocate space for us to renovate a laboratory area. [This country] is one of the probably more difficult places to get either personally in and out of as a human being or to get materials in and out of. So, they helped to barter some of the supply chain stuff a little bit so that things weren't stuck in customs and people couldn't come into the country ▶ Whereas initially we thought once we get the funding, we thought we're going to go straight to screening. And when we went, we realised we actually had to have initial engagement with the traditional leaders and also to do some counselling work before we actually did the screening ▶ [One of our learnings was to] start in a place where some resources already exist (nurses, labs, etc) having a good lab in particular is crucial
Theme: cultural		
Community engagement	Maintain interest at the MoH and hospital administration level	<ul style="list-style-type: none"> ▶ There are a huge number of competing interests and everybody is overburdened and overworked and very dedicated. So, it's really easy for people to lose sight of what—of the long-term goal of all the different projects that are going on. So, it was important to keep people's attention ... at the ministry level and at the hospital administration level ▶ The Ministry of Health was always there to snap a photo. Unfortunately, not always there to do anything else
Theme: funding		
Role of government	Obtain financial commitment from government prior to the start of programming	<ul style="list-style-type: none"> ▶ But we have not financial support from the government. That's the real problem in most of the African countries. It's the reason why we have foreigner partners for the financial support ... It's the reason why we can say most of our partners are foreigners ▶ [A recurrent challenge was engagement on the Ministry of Health side.] So, for example, the people who we hired, these laboratory technicians, were supposed to be Ministry of Health employees which ... being a government employee is a complicated thing. And they—I don't even think still since—from when we started the programme until now, have had official quote unquote openings for jobs. So, they haven't hired anyone new into the system in five or 6 years ▶ There was severe engagement by the community leaders, but somehow, we could not follow that through with making the government—so I think one of the major challenges that I would think is really the government not only engaged by accepting that is their work, but actually to get funded. So, government funding is limited. And government implementation or what they have agreed to do is significantly limited

Table 2 summarises the most consistent lessons learnt/recommendations highlighted across country programmes for each of the primary themes. Select quotes from different respondents are included to support our recommendations. Quotes have been anonymised. MoH, Ministry of Health; NBS, newborn bloodspot screening.

nurses) that worked at birth centres and were responsible for the hands-on aspects of screening (ie, conducting heel sticks, communicating with families, etc) were generally government-employed workers who had been on staff prior to the initiation of the NBS programme. In most cases, therefore, the work associated with NBS constituted a new task they were asked to perform in addition to other duties. Across the programmes, coordinating staff

played a fundamental role in organising and overseeing a vast array of logistics and managing the relationships with multiple stakeholders that variably included families, birth centre staff, SCD clinical experts, government representatives and external collaborators, including clinician colleagues and funding partners.

An important subtheme relating to staffing concerned the availability of specialised clinical 'centres of excellence'

that would be capable of providing holistic preventative and treatment services for individuals that were diagnosed with SCD through the NBS programmes. Participants recognised that the existence of such centres, and their accessibility to patients, was a pre-requisite to the initiation of NBS programmes such that families could be immediately offered a clinical service for follow-up on notification of positive test results.

Primary theme II: technical aspects

While the general workflows involved in NBS programmes are conceptually straightforward (eg, sample acquisition, laboratory testing and notification of results), the design and execution of consistent operational processes were reported by several programmes to be an intensive and challenging exercise in practice. This was felt in part to be due to the very high level of coordination that was required between practitioners at birthing sites (who were responsible for collecting specimens, organising specimen transport to the laboratory, receiving laboratory results and notifying families), technicians in laboratories (who were responsible for receiving and testing specimens, and reporting laboratory results) and coordinators that oversaw NBS programmes (responsible for ensuring adequate training of staff, reliable availability of equipment and supplies, reporting to national authorities and other activities). In one programme, the laboratory was located in a different city from the birth centres, requiring the specimens to be transported by an approximately 7-hour car ride from the birthing sites to the laboratory. Another programme shipped specimens in a sealed container at 4°C by plane to the NBS programme laboratory in another country. The ambition of most programmes was to fully integrate the NBS workflows into routine health system processes; ultimately, this was achieved to a variable degree by different programmes. All programmes had a common aim to keep the cycle duration (ie, from the time of specimen acquisition to the time when families were notified of results) as short as possible. One commonly cited reason for delays in the NBS workflow was tracking down families to share laboratory results—some families were not able to be contacted by phone, which necessitated in-person visits that were time consuming for NBS staff and not always successful.

Robust data collection and management systems were important to support workflows (ie, registering babies that underwent testing, storing laboratory results and keeping record of when families were notified of results), facilitate quality improvement of NBS programmes (ie, as a means to identify when the workflows were operating suboptimally) and generate evidence that could be used for advocacy, research or to inform health policy (eg, incidence data, cost effectiveness or impact on health outcomes). Most programmes used a hybrid model that involved some paper-based record keeping and some digital components. One of the programmes (Ghana) converted entirely to a digital ‘app’-based system beginning in 2018

accessible on the phones of birth attendants, laboratory technicians and programme coordinators.

All programmes, except Nigeria (where high-performance liquid chromatography (HPLC) was used), used isoelectric focusing (IEF) as the primary technique for screening or diagnosis, and some programmes used HPLC or capillary electrophoresis for confirmatory testing after screening. While none of the programmes surveyed reported that NBS laboratory equipment was a main barrier, virtually all of the programmes reported challenges with maintaining regular maintenance of equipment or reliable access to reagents. In some cases, periodic unavailability of reagents led to delays in testing.

Primary theme III: cultural aspects

Some NBS programmes reported quick adoption of new technical practices by staff (eg, conducting heel sticks and managing bloodspot specimens), whereas other programmes met with some challenges in fully integrating this practice due to the perception of increased workload. Some programmes described clinical staff ‘champions’ who became highly dedicated to the programme (in the same way that many of the participants were), helped to advocate for the programme and trained other staff members. Ultimately, most programmes reported achieving a state of cultural adaptation resulting in a sense of pride among the programme staff for being involved in a novel programme with profound implications for the health of individuals with SCD.

Community engagement was highlighted by several programmes as an important determinant of success. It was reported that knowledge about SCD among community members varied widely and was occasionally confounded by false perceptions about the disease or stigmatisation. In some cases, the cultural aspects of community engagement were noted to be a determinant in the ability of NBS programme staff to follow-up with families to provide notification of test results (ie, if families were fearful of receiving results). Participants noted that families could also be dubious of positive results in the face of a baby who is healthy appearing (since babies with SCD are universally asymptomatic in early infancy).

Primary theme IV: financial aspects

In all programmes, NBS services were provided free of charge to families. Participants reported an idealised scenario, where NBS programmes were entirely funded by local or national governments such that programmes were fully integrated as part of routine public health services.

Several programme leaders raised the idea of cost sharing between NBS programmes as a potential approach for reducing the costs borne by each individual programme. One example that was implemented was the shipping of laboratory specimens from one country to another for testing. Another example that was raised as a concept but not yet implemented was purchasing materials such as reagents for laboratory equipment in bulk.

All programmes received some form of external funding, defined as funding from out-of-country entities. Sources of external funding included foundations, non-governmental organisations, private sector companies and governments of other countries. Many participants reported external funding to have been an important enabler in helping to establish and/or maintain operations, and in some cases the cessation of external funding resulted in the need to scale down or halt the programme. External funding was, therefore, generally perceived to be a ‘double-edge sword’, whereby it had been necessary for some programmes to manifest but at the same time it complicated the attainment of long-term sustainability since permanent funding from outside sources was not feasible.

DISCUSSION

Newborn screening programmes constitute a standard approach for diagnosing SCD in several countries and are urgently needed in Africa to assure that affected individuals promptly receive essential counselling as well as preventative and therapeutic care.^{2,33} The reality, however, is that the establishment and sustained operation of NBS programmes in Africa is complex due to many factors. In an effort to better understand experience-based and pragmatic determinants of success, this study sought to harness lessons learnt from participants involved in establishing and operating NBS programmes that took place across West, Central and East Africa. While there are numerous published reports of progress achieved with subnational NBS programmes for SCD in individual countries,^{19 20 23–25} we had identified only a single previous report that analysed cross-country experiences; that study described pilot programmes in DRC and Burkina Faso and presented an excellent review of the rationale for SCD NBS programmes along with high-level guidance for selected aspects of their implementation.³⁴ Thus, to the best of our knowledge, the current study involving programmes in six countries constitutes the first attempt to integrate learnings from a ‘critical mass’ of NBS programmes for SCD in Africa. Through standard qualitative methods, four main themes encompassing 12 subthemes emerged that highlighted enablers and barriers to implementation.

A main and crucial finding of this study was confirmation that NBS programmes for SCD are feasible to successfully implement in Africa, as evidenced by the large numbers of babies screened (eg, tens of thousands) and the long duration of screening (eg, more than 25 years) that was demonstrated in some programmes. Nevertheless, a consistent narrative emerged that feasibility did not ensure sustainability. Many of the programmes reported periodic setbacks in their capabilities to maintain their planned level of operations or to expand, and some programmes were forced to cease operations. Technical or workflow issues were never the primary challenge; rather, there was general consensus that the greatest barrier to the long-term success of NBS programmes resulted from their incomplete adoption into routine health systems. This was attributed mostly to inter-related aspects

of governance (in particular, government involvement) and funding.

Government commitment was recognised by all interviewees as an essential element of success, and government entities routinely played important roles in the design and implementation of programmes. Even so, in none of the programmes was the government the primary driver behind programme inception and, as a result, several programmes innovatively sought and applied external resources (eg, grants or philanthropy) in order to initiate NBS with the hope that demonstrated success would provide evidence that governments could use to rationalise investing in NBS programmes. While that logic stands to reason, unfortunately, none of the programmes have been fully integrated widely into public health systems despite all six of the programmes having achieved operational success in different ways. Furthermore, it is possible that external funding received from some programmes complicated the ‘handover’ to government agencies, even while that funding was foundational to establishing the NBS programmes in the first place, a paradox that perhaps could only be avoided by confirming full government support from the outset (ie, NBS designated as a core service and budgeted accordingly). Indeed, the longest running NBS programme in Africa (Ghana) appears to have had the most substantial commitment from local government.

Another finding was the high degree of effort and dedication on the part of teams of SCD clinicians and advocates that was required to establish NBS programmes. Planning routinely took a year or longer before screening started, during which time many team members worked without extra compensation and in addition to an already full workload. Therefore, progress in each of the NBS programmes was all the more remarkable given the natural barriers that existed to establish them. At the same time, the achievements of each programme also served to highlight how much more work is needed given the coverage gaps resulting from high numbers of unscreened babies in each country (figure 1). Other learnings from this study related to operational considerations (eg, data collection and management systems) and cultural aspects (eg, strengthening the education of community members about SCD and the rationale for screening).

Limitations of this study include the sample of programmes assessed, which is less than the total number of NBS programmes for SCD that have been implemented in Africa and, therefore, is associated with an inherent bias based on the selection of included programmes. For practical reasons, we surveyed a single or small number of participants from each programme, and it is possible that by involving a larger cohort then additional perspectives may have been captured. Finally, it is recognised that local factors between countries, and even within countries, can influence health programmes and so the lessons learnt in one region will not always be immediately transferable to another. The above notwithstanding, the methodology was designed to involve a sufficiently large number of programmes across different parts of the continent in order that lessons learnt would be as applicable as possible across countries.

CONCLUSION

This study codified learnings that may be useful to help inform the design and conduct of future NBS programmes for SCD in Africa. A key finding was that the capability of establishing a new programme was not a guarantee that the programme would endure; on the contrary, some aspects of programmes that were recognised enablers of their establishment (eg, funding from external sources) may have ultimately confounded sustainability (ie, by complicating ownership from government entities). Put another way, simply demonstrating that a programme is feasible, and gathering evidence to show it is associated with positive outputs and health outcomes, may not be sufficient to garner the support needed to sustain the programme in the long term. Being aware of this scenario at the outset may help stakeholders to emphasise certain aspects of programme design, including the role of government, with an aim to incorporate NBS programmes into routine public health services. As such, continuing to increase awareness of the burden of SCD and the critical importance of NBS among policymakers in Africa may be a priority in order to improve the timely detection of patients and promote optimal health outcomes.

Author affiliations

¹Division of Hematology/Oncology, Dana-Farber/Boston Children's Cancer and Blood Disorders Center, Boston, Massachusetts, USA

²Evelina London Children's Hospital, London, UK

³Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania

⁴Institut de Recherche Biomédicale/CEFA and Centre Hospitalier Mère-Enfant Monkole, Kinshasa, Congo

⁵Texas Children's Cancer and Hematology Centers, Houston, Texas, USA

⁶Division of Hematology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA

⁷Department of Paediatrics and Child Health, Bugando Medical Centre, Mwanza, Tanzania

⁸Ariadne Labs, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA

⁹Department of Global Health, Novartis Institutes for Biomedical Research, Cambridge, Massachusetts, USA

¹⁰Sickle Cell Foundation of Ghana, Accra, Ghana

Twitter Natasha M Archer @NatashaArcherMD

Contributors NMA, BI, NH, JS and KO-F planned the study, developed the interview guides and related questions, recruited participants and reviewed revisions, including final revision. NMA, BI, NH and JS reviewed the transcripts and data and wrote the initial draft of the paper. JM, SN, LT, VNT, PTM and EEA shared their work with the newborn bloodspot screening programmes in respective countries and reviewed revisions, including final revision. NMA is responsible for the overall content as the guarantor.

Funding This work was supported by National Institutes of Health (grant number: K23-HL148548-01A1) and the National Institute of Diabetes and Digestive and Kidney Diseases (grant number: 1K08DK123386-01A1). Novartis provided funding for the qualitative researcher (NH) to participate in this study.

Map disclaimer The inclusion of any map (including the depiction of any boundaries therein), or of any geographic or locational reference, does not imply the expression of any opinion whatsoever on the part of BMJ concerning the legal status of any country, territory, jurisdiction or area or of its authorities. Any such expression remains solely that of the relevant source and is not endorsed by BMJ. Maps are provided without any warranty of any kind, either express or implied.

Competing interests NMA received clinical trial fees from Global Blood Therapeutics outside of this submitted work. VNT has served as a consultant for Novartis Pharmaceuticals, Global Blood Therapeutics, Forma Therapeutics and Perkin Elmer. JS is an employee of the Novartis Institutes for BioMedical Research. BI received support to attend a virtual meeting from Novartis PLC, payment for

educational events from Novartis PLC and Global Blood Therapeutics, participated on a data safety monitoring board/advisory board for Astrazeneca, Novartis PLC and Global Blood Therapeutics and was the chair of a national haemoglobinopathy panel in England. KO-F has served as a consultant for Novartis PLC.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants, and was approved by the institutional review board (IRB) of Boston Children's Hospital (IRB-P00025918). The IRB reviewed the above referenced protocol and determined that it qualifies as exempt from the requirements of 45 CFR 46. This protocol was determined to be exempt because it is limited to research activities in which the only involvement of human subjects will be in the following category/ies described in 45 CFR 46.101. (b): research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (a) research on regular and special education instructional strategies or (b) research on the effectiveness of or the comparison among instructional techniques, curricula or classroom management methods. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. Not applicable as background questions and the interview guide are provided in the online supplemental materials.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Natasha M Archer <http://orcid.org/0000-0002-6460-5872>

Patrick T McGann <http://orcid.org/0000-0001-6198-4785>

REFERENCES

- Weatherall DJ. The challenge of haemoglobinopathies in resource-poor countries. *Br J Haematol* 2011;154:736–44.
- Piel FB, Hay SI, Gupta S, et al. Global burden of sickle cell anaemia in children under five, 2010–2050: modelling based on demographics, excess mortality, and interventions. *PLoS Med* 2013;10:e1001484.
- Pauling L, Itano HA, Singer SJ. Sickle cell anemia a molecular disease. *Science* 1949;110:543–8.
- Eaton WA. Hemoglobin S polymerization and sickle cell disease: a retrospective on the occasion of the 70th anniversary of Pauling's science paper. *Am J Hematol* 2020;95:205–11.
- Vichinsky E, Hurst D, Earles A, et al. Newborn screening for sickle cell disease: effect on mortality. *Pediatrics* 1988;81:749–55.
- Consensus conference. Consensus conference. newborn screening for sickle cell disease and other hemoglobinopathies. *JAMA* 1987;258:1205–9.
- Gaston MH, Verter JI, Woods G, et al. Prophylaxis with oral penicillin in children with sickle cell anemia. A randomized trial. *N Engl J Med* 1986;314:1593–9.
- Davies EG, Riddington C, Lottenberg R, et al. Pneumococcal vaccines for sickle cell disease. *Cochrane Database Syst Rev* 2004:CD003885.
- Newborn screening for sickle cell disease and other hemoglobinopathies. *NIH Consensus Statement Online* 1987;6:1–22.
- Quinn CT, Rogers ZR, McCavit TL, et al. Improved survival of children and adolescents with sickle cell disease. *Blood* 2010;115:3447–52.
- Therrell BL, Lloyd-Puryear MA, Eckman JR, et al. Newborn screening for sickle cell diseases in the United States: a review of data spanning 2 decades. *Semin Perinatol* 2015;39:238–51.



- 12 El-Haj N, Hoppe CC. Newborn screening for SCD in the USA and Canada. *Int J Neonatal Screen* 2018;4:36.
- 13 Lobitz S, Telfer P, Cela E, *et al.* Newborn screening for sickle cell disease in Europe: recommendations from a pan-European consensus conference. *Br J Haematol* 2018;183:648–60.
- 14 Silva-Pinto AC, Alencar de Queiroz MC, Antoniazio Zamaro PJ, *et al.* The neonatal screening program in Brazil, focus on sickle cell disease (SCD). *Int J Neonatal Screen* 2019;5:11.
- 15 Lobitz S, Kunz JB, Cario H, *et al.* Introduction of universal newborn screening for sickle cell disease in Germany-A brief narrative review. *Int J Neonatal Screen* 2021;7:7.
- 16 Benson JM, Therrell BL. History and current status of newborn screening for hemoglobinopathies. *Semin Perinatol* 2010;34:134–44.
- 17 Brandelise S, Pinheiro V, Gabetta CS, *et al.* Newborn screening for sickle cell disease in Brazil: the Campinas experience. *Clin Lab Haematol* 2004;26:15–19.
- 18 Panepinto JA, Magid D, Rewers MJ, *et al.* Universal versus targeted screening of infants for sickle cell disease: a cost-effectiveness analysis. *J Pediatr* 2000;136:201–8.
- 19 Ohene-Frempong K, Oduro J, Tetteh H, *et al.* Screening newborns for sickle cell disease in Ghana. *Pediatrics* 2008;121:S120–1.
- 20 McGann PT, Ferris MG, Ramamurthy U, *et al.* A prospective newborn screening and treatment program for sickle cell anemia in Luanda, Angola. *Am J Hematol* 2013;88:984–9.
- 21 Fleming AF, Storey J, Molineaux L, *et al.* Abnormal haemoglobins in the Sudan Savanna of Nigeria. I. prevalence of haemoglobins and relationships between sickle cell trait, malaria and survival. *Ann Trop Med Parasitol* 1979;73:161–72.
- 22 Kafando E, Nacoulma E, Ouattara Y, *et al.* Neonatal haemoglobinopathy screening in Burkina Faso. *J Clin Pathol* 2009;62:39–41.
- 23 Tshilolo L, Aissi LM, Lukusa D, *et al.* Neonatal screening for sickle cell anaemia in the Democratic Republic of the Congo: experience from a pioneer project on 31 204 newborns. *J Clin Pathol* 2009;62:35–8.
- 24 Nkya S, Mtei L, Soka D, *et al.* Newborn screening for sickle cell disease: an innovative pilot program to improve child survival in Dar ES Salaam, Tanzania. *Int Health* 2019;11:589–95.
- 25 Tubman VN, Marshall R, Jallah W, *et al.* Newborn screening for sickle cell disease in Liberia: a pilot study. *Pediatr Blood Cancer* 2016;63:671–6.
- 26 Rahimy MC, Gangbo A, Ahouignan G, *et al.* Newborn screening for sickle cell disease in the Republic of Benin. *J Clin Pathol* 2009;62:46–8.
- 27 Inusa BP, Juliana Olufunke YD, John Dada L. Sickle cell disease screening in northern Nigeria: the co-existence of α -Thalassemia inheritance. *Pediatr Therapeut* 2015;05:3–6.
- 28 Sandelowski M. Whatever happened to qualitative description? *Res Nurs Health* 2000;23:334–40.
- 29 Fereday J, Muir-Cochrane E. Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *Int J Qual Methods* 2006;5:80–92.
- 30 Castleberry A, Nolen A. Thematic analysis of qualitative research data: is it as easy as it sounds? *Curr Pharm Teach Learn* 2018;10:807–15.
- 31 Kim H, Sefcik JS, Bradway C. Characteristics of qualitative descriptive studies: a systematic review. *Res Nurs Health* 2017;40:23–42.
- 32 Creswell JW, Miller DL. Determining validity in qualitative inquiry. *Theory Pract* 2000;39:124–30.
- 33 Odame I. Developing a global agenda for sickle cell disease: report of an international Symposium and workshop in Cotonou, Republic of Benin. *Am J Prev Med* 2010;38:S571–5.
- 34 Tshilolo L, Kafando E, Sawadogo M, *et al.* Neonatal screening and clinical care programmes for sickle cell disorders in sub-Saharan Africa: lessons from pilot studies. *Public Health* 2008;122:933–41.