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Research Article

Capacity building in obstetric and abdominal ultrasound for sickle cell disease pregnancies in Angola: a pre- and post-training evaluation

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Abstract

Objectives: **Sickle cell disease (SCD) increases risks in pregnancy, affecting both maternal and fetal outcomes. Ultrasound (US) is essential for monitoring these high-risk pregnancies. However, in countries like Angola, where SCD affects nearly 3% of pregnancies, access to skilled professionals is limited. This study evaluated the impact of an intensive US training program in Luanda, focusing on obstetric and abdominal US for SCD pregnancies.**

Methods: **A prospective pre-post intervention study was conducted with 24 healthcare professionals working in 2 maternity units. Participants completed a survey to assess confidence in performing US procedures before and after an 1-week intensive training program. The training consisted of didactic lectures, supervised hands-on practice with real patients, and case discussions. Statistical analysis included distribution analysis and frequency, Mann-Whitney U tests, and effect sizes.**

Results: **Pre-training, participants demonstrated limited experience with both abdominal and obstetric US in SCD pregnancies. Post-training, improvements were observed in assessments of abdominal organs and obstetric evaluations, with significance in Doppler assessments.**

Conclusion: **The program effectively improved US proficiency and confidence in assessing SCD pregnancies. Incorporating continuous mentorship and locally adapted protocols could sustain these gains, with potential long-term benefits in maternal and fetal outcomes. Future initiatives should incorporate digital mentorship and refresher training.**

Keywords ultrasound, obstetric ultrasound, capacity building, medical education, training programs

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Lay Summary

Sickle cell disease (SCD) increases risks during pregnancy for both mothers and babies. In Angola, about 3% of pregnancies are affected. Ultrasound (US) is a safe imaging exam that uses sound waves to check baby's growth and mother's health. However, many hospitals don't have enough trained professionals to perform these exams.

To address this gap, we organized a 1-week training program in Luanda for 24 healthcare workers from 2 maternity hospitals. Before the training, most participants had little experience with abdominal US (liver, spleen, kidneys), or pregnancy US, including blood flow checks (Doppler) between the mother and the baby.

The training combined short lessons, supervised practice on real patients, and group discussions of clinical cases. Participants filled out a questionnaire before and after the course to rate how confident they felt using US.

After training, participants reported feeling confident in performing US for pregnant women with SCD, especially checking blood flow and pregnancy-related complications, showing that short, focused training can improve US skills where they are most needed.

To maintain these improvements, ongoing mentorship, locally adapted guidelines, and regular refresher sessions, are recommended. With these steps, more mothers with SCD in Angola could receive timely expert US care.

Introduction

Sickle cell disease (SCD) is a hereditary condition with a global public health imprint, markedly accentuated in Africa where the incidence ranges between 1000 to 2000 per 100 000 live births.[1] The predominant variant of this disease is Sickle Cell Anaemia (HbSS). In Angola, the prevalence of sickle cell disease (including HbSS and compound heterozygosity such as HbS/β-thalassemia) may reach up to 3%, with sickle cell trait carriers surpassing 20% in some regions, such as Bengo.[2] Overall, Angola is severely affected by the mortality attributed to SCD, accounting for 2.2% (1.5-3.0) of all deaths in children under 5 years, and 4.3% (3.5-5.6) of all fatalities in the age bracket of 15-49 years.[1]

The surveillance of both mother and fetus during pregnancy is extremely important, especially for women afflicted with SCD. Ultrasound (US) has become an increasingly vital diagnostic tool in medical practice worldwide, particularly in obstetric US where it serves as a pivotal tool in monitoring fetal well-being and growth, detecting any anomalies, and accurately gauging gestational age to ensure optimal timing of delivery.[3] Obstetric US also enables morphological and functional assessment of the placenta, which is a source of complications in pregnant women with SCD (eg, abruption, hemorrhage, placental insufficiency). Assessment of fetal and uterine US Doppler is essential to this evaluation. Concurrently, abdominal US plays a crucial role in discerning maternal hepatic, renal, or splenic alterations, to diagnose the thrombotic complications, both venous and arterial, frequently associated with SCD, which could potentially impact the course and overall outcome of the pregnancy.[4] Such comprehensive internal imaging allows healthcare providers to anticipate and manage complications, thereby optimizing maternal and fetal outcomes in pregnancies complicated by SCD.[4]

However, integrating US into healthcare systems in low- and middle-income countries (LMICs) remains challenging,[5,6] primarily because the effectiveness of US as a diagnostic tool heavily depends on thorough training and proficiency of healthcare professionals.[5,7] Short-intensive US training courses have emerged as a promising solution, demonstrating significant positive impacts on healthcare delivery and clinical outcomes in resource-limited settings.[7-9] Such condensed training sessions have shown to effectively enhance medical personnel's diagnostic accuracy, improve clinical decision-making, and elevate the standard of patient care.[9-11] Studies indicate that focused workshops, even those conducted virtually due to constraints such as the COVID-19 pandemic, have successfully transferred practical US skills to healthcare providers, significantly bolstering their confidence and proficiency.[8,11] Despite infrastructural limitations, these training programs have facilitated better patient monitoring, early detection of complications, and optimized patient management strategies,[5,6,12] particularly for pregnant women with SCD.[13,14]

This study aimed to assess the impact of a 1-week intensive training course on abdominal and obstetric US specifically targeting pregnant patients with sickle cell disease, in healthcare professionals working in 2 maternity units in Luanda, Angola.

Materials and methods

Study design

A prospective pre-post intervention study was conducted to assess the effectiveness of a 1-week intensive training course in abdominal and obstetric US focused on pregnant patients with sickle cell disease. Participants' US confidence and perceived skills were evaluated at baseline (1 week before the training) and 1 month after completion of the training.

The intervention was conducted at 2 units in Luanda, Angola: Hospital Materno Infantil Dr. Manual Pedro Azancote de Menezes and Maternidade Lucrécia Paim. Both institutions were selected due to their significant role in maternal healthcare provision and their diverse patient populations, which included a substantial number of pregnant women diagnosed with sickle cell disease. The study was approved by the Angola Ethical Commission (CEMS) n°27/CEMS/2024.

Participants

Healthcare professionals (including physicians, nurses, midwives, and technicians) working regularly in the mentioned maternity units were recruited. Participants were selected based on their direct involvement in obstetric and maternal healthcare, ensuring that US training would directly enhance their clinical practice. Prior US training was not an exclusion criterion.

Intervention

The intervention consisted of an intensive, structured, 1-week US training program, incorporating:

- Didactic Lectures: Covering theoretical foundations of obstetric and abdominal US, interpretation of normal and pathological findings, with special emphasis on US features relevant to SCD complications in pregnancy. The obstetric US component focused on assessing fetal well-being and growth, detecting structural anomalies, and evaluating fetal and maternal US Doppler parameters, following the principles outlined in the POCUS and ISUOG programs.[15,16] The abdominal US component concentrated on maternal hepatic, renal and splenic changes associated with SCD, adhering to the guidelines established by the World Federation for Ultrasound in Medicine and Biology (WFUMB).[17]
- Practical hands-on sessions: Supervised sessions were conducted on actual patients, allowing participants to practice image acquisition, interpretation and clinical correlation. These sessions were conducted under the direct supervision of 2 expert sonographers, each with over 10 years of experience, one specializing in obstetrics and the other in abdominal imaging. Immediate feedback was provided to enhance learning and skill development.
- Clinical Case Discussions: Participants analyzed and discussed clinical cases focused on pregnancies complicated by SCD. Additionally, invited clinical specialists in SCD share their expertise and experiences, facilitating the integration of the theoretical knowledge with practical clinical applications.

Survey instrument

To assess the intervention, a survey was developed by adapting an existing validated tool.[12] The survey specifically addressed abdominal and obstetric US practices relevant to SCD and pregnancy management. The survey included the following dimensions: (i) Demographic information and professional background; (ii) Level and type of previous US training; (iii) Frequency and type of US studies performed in their clinical practice; (iv) Perceived clinical utility of US in managing complications associated with SCD pregnancies; (v) Comfort level with performing and interpreting abdominal and obstetric US exams (Table 1); (vi) Participants preferences on the course format; and (vii) Evaluation of the US training course, which included the following categories: Educational Content; Relevance to Practice; Questions and Discussions; Instructor Quality; Topic Selection; and Overall Quality of the course. Table 2 summarizes which dimensions were included in the pre-intervention survey, the post-intervention survey, or both.

The adapted survey was translated from English to Portuguese by 2 independent native speakers fluent in both languages and discrepancies were reconciled during a consensus review meeting, according to the ISPOR guidelines.[18] A re-reading method was employed, where a third Angolan clinician fluent in both languages reviewed the translated version and compared to the original to ensure contextual accuracy, consistency of clinical terminology and cultural appropriateness in Angola. For flexibility and ease of data collection, the finalized Portuguese version of the survey was implemented using Microsoft Forms, allowing participants to complete it electronically.

Data analysis

Quantitative analysis was conducted comparing pre-intervention results with post-intervention results. A five (5) point Likert-based scale was used and statistical methods included median values with interquartile ranges (IQR), Mann-Whitney U test results, *P*-values, and frequency distribution. To complement *P*-values and support interpretation of intervention effects, the rank-biserial correlation (*r*) was

Table 1. Topics assessed on the comfort level of the participants in obstetric and abdominal ultrasound.

Obstetric US topics	Abdominal US topics
Ectopic pregnancy	Liver assessment
Gestational age estimation	Liver measurement
Multiple pregnancy	Gallbladder assessment
Early Detection of Chromosomal and Structural Anomalies (11–14 weeks)	Gallbladder measurement
Fetal vitality	Spleen assessment
Fetal growth	Spleen measurement
Routine fetal anatomy	Kidneys assessment
Fetal dopplers (umbilical, middle cerebral artery, ductus venosus)	Kidneys measurements
Assessment of placental position	Abdominal aorta and VCI assessment
Amniotic fluid assessment	General abdominal Doppler assessments
Uterine artery doppler	
Maternal cervix assessment	

calculated as the effect size associated with the Mann-Whitney U test. The rank-biserial correlation quantifies the probability difference that a randomly selected observation from the post-intervention sample will exceed a randomly selected observation from the pre-intervention sample. Interpretation of effect-size magnitude followed published guidelines for non-parametric effect sizes,[19,20] defining as small effect an $r \approx 0.10\text{-}0.29$, moderate an $r \approx 0.30\text{-}0.49$ and a large effect $r \geq 0.50$. As this is a study with a small sample size, the reporting of both statistical significance and effect-size magnitudes provides a more complete understanding of the practical relevance of observed changes.[19,20] Statistical significance was set at $P < .05$ and python libraries were used to conduct the analysis.

Table 2. Overview of survey dimensions assessed pre- and post-intervention.

Survey dimensions	Pre-intervention assessment	Post-intervention assessment
(i) Demographic information and professional background;	✓	x
(ii) Level and type of previous US training	✓	x
(iii) Frequency and type of US studies performed in their clinical practice;	✓	x
(iv) Perceived clinical utility of US in managing complications associated with SCD pregnancies;	✓	x
(v) Comfort level with performing and interpreting abdominal and obstetric US exams	✓	✓
(vi) Participants preferences on the course format	✓	x
(vii) Evaluation of the US training course	X	✓

Results

Demographics

Twenty-four (24) healthcare professionals responded to the pre- and post-survey and the results are summarized in Table 3. These professionals included nurses ($n = 2$), physicians ($n = 21$), and one health technician. The age range varied from 31 to 64 years, with the gynecology/obstetrics group showing the widest variation (29-64 years). Gender distribution was uneven, with females ($n = 17$) outnumbering males ($n = 7$). Years since specialization also varied, with gynecology/obstetrics professionals having the highest variability (0-35 years), where 5 physicians were still undergoing their speciality training. Other specialities like pediatrics (4-10 years) and radiology (5 years) were more uniform.

Regarding US training, 4 participants received training during their speciality, 4 completed a recent US course (less than 12 months ago), 8 completed a past US course (more than 12 months), and 6 had no US training. Gynecology/obstetrics had the highest participation in US training, while surgery and pediatrics showed lower engagement. Despite US training, US exam frequency varied significantly, with 11 professionals performing no exams per week, 7 performing fewer than 6, and 6 conducting more than 6 exams weekly. The radiology and gynecology/obstetrics (15/21) groups had the highest US utilization, while some trained professionals were not actively using US, suggesting inconsistencies in US education and practice, and thus a need for standardized training to ensure the effective use of US.

Pre-intervention relation between the assessment of sickle cell disease patients and abdominal and obstetric ultrasound

Figure 1 presents 2 heatmaps illustrating the total number of paired responses linking each participant's pre-intervention comfort levels assessing SCD patients with their comfort in

Table 3. Distribution of healthcare professionals by speciality, US training, and weekly exam frequency.

Healthcare professionals (speciality)	Freq[b] ($n = 24$)	Age[a]	Gender		Years of speciality	Type of US training				US per week		
			Female	Male		DS	RC	PC	No	0	<6	>6
Nurse	**2**											
Gynecology/obstetrics	2	46 (46-48)	2	–	10 (10-12)	–	1	1	–	2	–	–
Physician	**21**											
Surgery	1	37	–	1	3	–	–	–	1	1	–	–
Gynecology/obstetrics	14	46 (29-64)	9	5	8 (0[b]-35)	2	2	7	1	3	7	4
Pediatrics	5	39 (30-54)	4	1	7 (4-10)	–	1	–	4	5	–	–
Radiology	1	50	1	–	5	1	–	–	–	–	–	1
Health technician	**1**											
Vascular	1	31	1	–	1	1						1

a Mean (min-max).
b 0 = still undergoing speciality ($n = 5$); Freq = Frequency; DS = during speciality; RC = Recent US course (<12 months); PC = Past US course (>12 months); No = No US training.

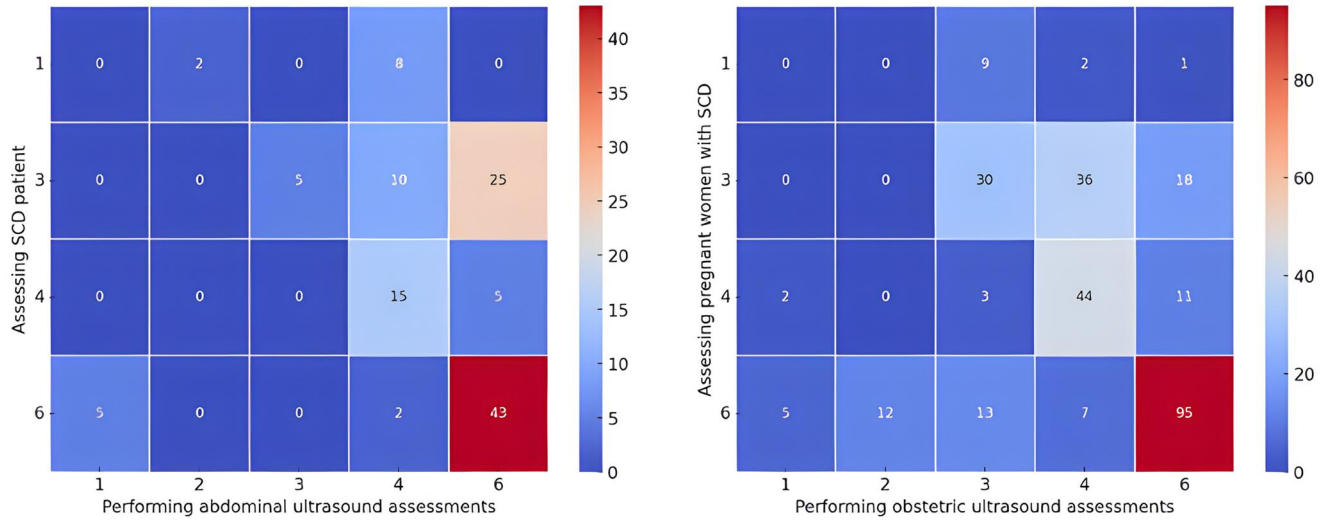

Figure 1 Pre-intervention heatmaps illustrating participants' comfort levels when assessing Sickle Cell Disease patients and performing abdominal (left) or obstetric (right) US assessments. Each cell shows the number of item-level paired responses. Each participant rated multiple abdominal and obstetric US topics (Table 1). Level of confidence rated on a 4-point Likert scale (1 = Very uncomfortable; 2 = slightly uncomfortable; 3 = slightly comfortable; 4 = very comfortable) and 6 = never performed. Color intensity represents response frequency, with darker red indicating more common comfort-level combinations and darker blue indicating rare combinations.

performing US assessments in either abdominal (left heatmap) or obstetric (right heatmap) US tasks, as defined in Table 1. These heatmaps summarize baseline (pre-intervention) confidence patterns. Color intensity reflects the frequency of these paired responses, with darker red indicating more frequent combinations and darker blue indicating rare combinations.

Regarding abdominal US assessments, participants who reported being very comfortable[4] or slightly comfortable[3] in assessing SCD patients also tend to express higher comfort in performing US assessments. Conversely, those with lower comfort levels (1 = very uncomfortable or 2 = sightly uncomfortable) in assessing SCD patients also report low comfort in performing US, suggesting a possible knowledge or experience gap. The highest frequency of responses is observed in category 6 ("Never performed"), particularly on the US axis, revealing that a significant number of participants have never performed an abdominal US assessment, even if they feel relatively comfortable assessing SCD patients.

Similar behavior is observed in the distribution of participants' comfort levels in assessing pregnant women with SCD and performing obstetric US assessments (Figure 2, right heatmap). A strong presence of responses corresponding to Very comfortable[4] and Never Performed[6] suggests that while some participants feel highly comfortable performing both tasks, a significant number have never performed them before. The slightly comfortable[3] response is widely distributed across multiple variables, suggesting that many participants may have limited experience or lack of confidence in these assessments. Lower comfort levels, Very Uncomfortable[1] and Slightly Uncomfortable,[2] appear less frequently, suggesting that extreme discomfort is not commonly reported.

Evaluation of the ultrasound training course

The evaluation of the US training course, summarized in Table 4, reveals generally positive feedback, with most categories scoring above the average. The mean scores range from 3.48 to 4.10, indicating a moderate to high level of satisfaction. The highest-rated aspect was Instructor Quality (mean = 4.10, SD = 1.04), where 45% of participants rated it as excellent and 30% as above average, reflecting a strong appreciation for the trainers. Conversely, questions and discussions received the lowest mean score (3.48, SD = 1.05), with 14% rating it as below average, suggesting potential areas for improvement in participant engagement and discussion facilitation.

Regarding content and relevance, educational content (3.57, SD = 1.14) and relevance to practice (3.60, SD = 0.92) were well-received, with a combined 53% rating them as above average or excellent. Topic selection (3.67, SD = 0.89) was also favorably rated, with 48% of participants selecting above the average and 14% excellent. The overall quality of the course (3.81, SD = 0.96) was highly rated, with 67% of respondents rating it as above average or excellent, and only 5% considering it unsatisfactory.

The evaluation of potential improvements to the activity format (Figure 2) reveals a strong preference for interactive and case-based learning methods. The most frequently suggested enhancements were "include more case-based presentations" and "increase interactivity with participants" both receiving 9 responses.

Additionally, "add group sessions for subtopics" was suggested by 7 participants, highlighting a desire for collaborative and focused discussions on specific areas. In contrast, "allocate more time for question" received only 3 responses, suggesting that while Q&A sessions are valued, they are not the primary concern compared to active learning strategies.

Pre- and post- intervention self-reported comfort level for ultrasound scanning

Table 5 summarize the changes in participants' comfort levels in performing US assessments of abdominal organs before

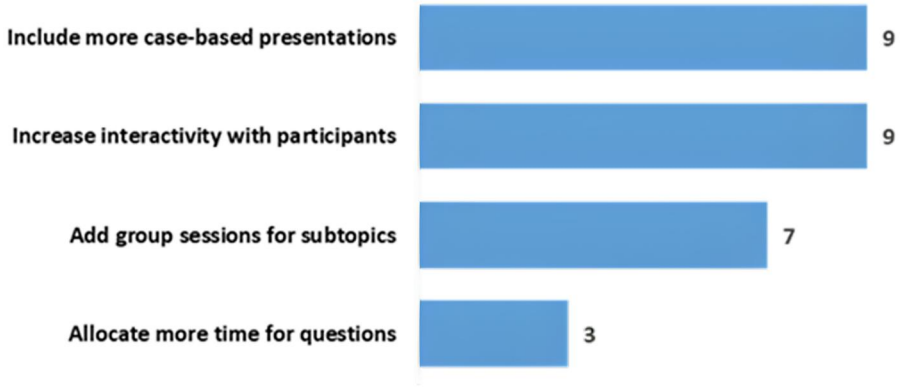

Figure 2 Participant recommendations to improve the US course.

Table 4. Summary of participant's evaluation of the US training course, presenting the mean and standard deviation (SD) of the used Likert scale and its frequency distribution.

Categories	Mean (SD)	Frequency distribution
Educational content	3.57 (1.14)	10% 0% 38% 29% 24%
Relevance to practice	3.60 (0.92)	5% 0% 40% 40% 15%
Questions and discussions	3.48 (1.05)	5% 14% 24% 43% 14%
Instructor quality	4.10 (1.04)	5% 0% 20% 30% 45%
Topic selection	3.67 (0.89)	5% 0% 33% 48% 14%
Overall quality of the course	3.81 (0.96)	5% 0% 29% 43% 24%

Unsatisfactory Below Average Average Above Average Excellent

and after the intervention. Liver and gallbladder assessments showed the largest increase in median comfort levels (from 1 to 3), while spleen and kidneys had smaller increases (1-2, 2.5, respectively). No statistically significant differences were found between the pre and post intervention assessments ($P > .05$), the spleen ($P = .104$) and gallbladder ($P = .125$). Effect size suggest a small-to-moderate impact of the course for the spleen (0.309) and liver/gallbladder (0.293), while kidneys had the smallest effect.

Before the intervention, many participants lacked experience in abdominal US ("never done it"), with 60% never having scanned the spleen, 63% the liver and gallbladder, and 50% the kidneys. After, inexperience dropped, reaching 10% for liver scanning (53% reduction), 14% for gallbladder (48% reduction), 14% for spleen (52% reduction), and 14% for kidneys (36% reduction).

Participants' comfort levels in obstetric US applications were assessed before and after the intervention and are summarized in Table 6. Most assessments showed minimal changes in median comfort levels, remaining at 3 (IQR: 1-4 pre-course; 2-3 post-course) for *ectopic pregnancy, fetal vitality, fetal growth, placental position, amniotic fluid, gestational age estimation, and multiple pregnancy* assessments. However, prior inexperience in these applications decrease by 29% – 37%. Improvements were observed in *routine fetal anatomy* scanning (median increased from 1 to 3; $P = .103$, effect size = 0.279) and *maternal cervix assessment* (median from 1 to 3; $P = .400$, effect size = 0.145), with inexperience reducing by 33%–41%.

Regarding umbilical and uterine artery US Dopplers, participant's comfort levels were significantly improved after the intervention, with median increases from 1 to 2 ($P = .013$ and 0.011, effect sizes = 0.420 and 0.426, respectively), and inexperience dropping by 45%–53%. Comfort levels in early detection of chromosomal and structural anomalies (11-14 weeks' scan) also improved (median from 1 to 3; $P = .123$, effect size = 0.265), with inexperience decreasing by 40%.

Discussion

This study highlights the impact of structured US training on healthcare professionals dealing with SCD pregnant women in Luanda, demonstrating improvements in confidence and competency in both abdominal and obstetric US assessments. The observed variability in prior US training and practice stresses the need for standardized and continuous educational programs to ensure consistent proficiency across different specialities.

SCD poses significant risks for pregnant women, including an increased likelihood of maternal and fetal complications

Table 5. Comparison of comfort levels in abdominal US pre- and post-intervention.

	Median (25%–75%)		U statistics	*P*-value	Effect size (*r*)	"Never Done It"		
	Pre	Post				Pre (%)	Post (%)	Change (%)
Liver	1 (1-4)	3 (2-3)	147.5	.324	0.29	63%	10%	53%
Gallbladder	1 (1-4)	3 (2-3)	114.5	.125	0.293	63%	14%	48%
Spleen	1 (1-4)	2 (1-2)	112	.104	0.309	67%	14%	52%
Kidneys	1 (1-4)	2.5 (2-3)	140.5	.492	0.133	50%	14%	36%

Table 6. Comparison of participants' comfort levels in performing specific assessments in obstetric scanning pre- and post-intervention.

	Median (25%–75%)		U statistics	*P*-value	Effect size (*r*)	"Never Done It"		
	Pre	Post				Pre (%)	Post (%)	Change (%)
Ectopic pregnancy	3 (1-4)	3 (2-3)	222	.979	0.007	38%	5%	33%
Fetal vitality	3 (1-4)	3 (2-3)	241	.601	0.093	33%	5%	29%
Fetal growth	3 (1-4)	3 (2-3)	199.5	.591	0.095	38%	5%	33%
Routine fetal anatomy	1 (1-3)	3 (2-3)	159	.103	0.279	46%	5%	41%
Umbilical Doppler	**1 (1-3)**	**2 (2-3)**	**128**	**.013**	**0.420**	**54%**	**10%**	**45%**
Assessment of placental position	3 (1-4)	3 (2-3)	217.5	.948	0.014	42%	5%	37%
Amniotic fluid assessment	3 (1-4)	3 (2-3)	194	.496	0.120	42%	5%	37%
Uterine artery Doppler	**1 (1-1)**	**2 (2-3)**	**126.5**	**.011**	**0.426**	**63%**	**10%**	**53%**
Maternal cervix assessment	1 (1-3)	3 (2-3)	188.5	.400	0.145	38%	5%	33%
Gestational age estimation	3 (1-4)	3 (2-3)	203	.656	0.079	38%	5%	33%
Multiple pregnancy	3 (1-4)	3 (2-3)	200	.601	0.093	42%	5%	37%
Early detection of chromosomal and structural anomalies (11-14weeks'-scan)	1 (1-3)	3 (2-3)	162	.123	0.265	50%	10%	40%

Bold values indicate statistically significant differences observed ($P < 0.05$).

such as preeclampsia, fetal growth restriction, infection, and preterm birth. US is a critical tool in the management of these high-risk pregnancies, allowing for the monitoring of fetal development, placental function, and maternal complications. Regular US Doppler evaluations, including umbilical artery and uterine artery US Dopplers, play a key role in detecting early signs of fetal compromise.[21]

The study revealed that many healthcare professionals have limited prior experience using US for SCD pregnancies. The findings suggest that confidence in clinical SCD assessment correlates with greater comfort in US use, while those with lower confidence exhibit less proficiency, highlighting a gap in training. A significant portion of participants had never conducted US examinations on SCD patients, reinforcing the need for targeted training. However, those with prior training demonstrated increased confidence, emphasizing the importance of hands-on practice in developing essential US skills for SCD patient management.

The US training program successfully increased participants' confidence in performing US assessments. In abdominal scanning, assessments of the liver, gallbladder, spleen, and kidneys showed substantial reductions in the proportion of participants who had never conducted these examinations before. While statistical significance was not reached for all organ assessments, effect-size estimates suggested potentially meaningful clinical impact, particularly in skills requiring hands-on practice, eg, the spleen assessment.

Similarly, obstetric US applications showed notable improvements, particularly in routine fetal anatomy scanning, placenta assessment, and Doppler evaluations. These skills are particularly critical in monitoring high-risk pregnancies such as those complicated by SCD, where vascular changes and placental insufficiency can significantly impact fetal outcomes.[22-25]

The findings regarding US training align with previous studies in low-resource settings, such as Uganda and Rwanda where short, intensive US training programs have been shown to enhance diagnostic proficiency.[8,26] The observed effect sizes in the current study suggest that hands-on training, even over short duration, contributes to skill acquisition and confidence-building.

Despite the improvements, challenges persist in ensuring long-term skill retention and routine US use in clinical practice. A significant proportion of trained participants were not regularly performing US exams, even when trained in their speciality. This inconsistency suggests barriers such as clinical workflow constraints and limited access to high-performance US equipment.[27,28]

Moreover, while gynecology & obstetrics specialists exhibited the highest engagement in US training, other specialties, such

as pediatrics and surgery, had lower participation rates. The presence of healthcare professionals with no prior US training further emphasizes an educational gap that must be addresses through continued professional development initiatives.[29-31]

Another key limitation was the need for more supervised practical experience beyond the training program. Despite the availability of the instructors for on-line help, some participants may require additional hands-on mentorship to reinforce learning and improve real-world application.[32-34]

From a methodological point of view, the significance of our results is impacted by the number of participants enrolled in this US training programme. Nevertheless, a general improvement in skills and confidence in performing US was observed. A next step would be to evaluate image quality before and after training to determine whether improvements in anatomical plane acquisition are also evidenced.

To strengthen the effectiveness and sustainability of US training, strategies should move beyond short-term interventions and align with evidence-based implementation frameworks, to reinforce US skills and guidance from experienced professionals.[32,35,36] Rather than relying solely on internships in European fetal diagnostic centers, which may be logistically challenging and insufficient for long-term sustainment, one should incorporate ERIC-informed strategies as a foundational approach that include development of audit and feedback guidance, centralized technical assistance, and structured mentorship programs.[37,38]

In addition, sustainability requires integration with global standards for SCD pregnancy care. The WHO 2025 recommendations emphasize comprehensive antenatal monitoring, including US Doppler assessment, fetal well-being evaluation, and early identification of complications.[39,40] Future training modules should, therefore, include dedicated content on these techniques, tailored to high-risk SCD pregnancies. This adheres to a context-sensitive protocols in LMICs,[41] while integrating a multidisciplinary care model, that have shown to improve outcomes in reference centers.[42]

Finaly, participant feedback highlighted the value of interactive, case-based learning and real-case simulations, which enhance clinical decision-making skills.[43] Embedding these approaches within a structured mentorship framework, supported by ERIC strategies and adapted to local resource constraints, offers a pathway to sustained skill retention and improved patient outcomes.

Conclusion

The study demonstrated the feasibility and impact that structured ultrasound training can effectively improve healthcare professionals' confidence and skills in ultrasound assessments in SCD pregnancy management, in Luanda. Addressing the identified barriers through enhanced hands-on training, institutional support, and ongoing education will be critical for ensuring sustained skill development. Given the challenges of managing SCD pregnancies, the integration of advanced obstetric ultrasound training could significantly improve maternal and fetal outcomes in this high-risk population.

Expanding this type of training initiative used in the funded UpScale project, particularly in the context of SCD pregnancy management, could contribute to broader improvements in maternal and neonatal health and emergency care diagnostics across Angola and similar settings.

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Author contributions

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Conflicts of interest

The authors declare no conflict of interest.

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Data availability

Data utilized in this study may be obtained from the corresponding author upon reasonable request.

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