

ASSESSMENT OF THE EFFECTIVENESS OF OBSTETRIC ULTRASOUND PILOT PROGRAM IMPLEMENTATION AT THE HEALTH CENTER LEVEL AND ITS IMPACT ON MATERNAL HEALTH SERVICES UPTAKE IN THE SOMALI REGION, EASTERN ETHIOPIA

Abdi Ahmed^{1*}, Muhumed Mohamed², Muse Ibrahim¹ and Mahamud Abdi³

¹Somali Regional Health Bureau, Somali region, Ethiopia and Jigjiga University, College of Medicine and Health Science, Ethiopia.

²Warder Hospital, Somali region, Ethiopia.

³Somali Regional Health Bureau, Somali region, Ethiopia.



***Corresponding Author: Abdi Ahmed**

Somali Regional Health Bureau, Somali region, Ethiopia and Jigjiga University, College of Medicine and Health Science, Ethiopia.

Article Received on 28/02/2024

Article Revised on 19/03/2024

Article Accepted on 09/04/2024

ABSTRACT

The use of obstetric ultrasound imaging for pregnant women receiving prenatal care has become popular in many developing countries around the world in the past few decades. Therefore, this study aimed to assess the competencies, effectiveness, and impacts of an obstetric ultrasound pilot program implemented at the health center level on maternal health services in the Somali region. A descriptive study using a retrospective medical record review was conducted at 22 health centers in the Somali region. The participants in the study were 329 pregnant women and 22 midlevel service providers who had undergone obstetric ultrasound training and worked at the studied health centers. The results of this study indicate that out of the 87 ultrasound scans performed by the evaluated service providers under direct observation by obstetricians, 64 (73.6%) were correctly scanned, and the scan findings were correctly interpreted. The overall average service provider competency level was 73.6%. The ultrasound skills that service providers failed the most on the OSCE were IUFG restriction identification skills (64 out of 87), fetal weight estimation (64 out of 87), GA estimation (65 out of 87), amniotic fluid index (AFI) assessment (74 out of 87), and accurate imaging of placental locations (78 out of 87). This study also demonstrated that the introduction of obstetric ultrasound has changed how service providers made clinical decisions by 55.1%. The health centers in the Siti zone experienced the greatest change in clinical decision-making (CDM) skills (76.9%), followed by the health centers in the Shabele zone (59.1%). The lowest change in CDM was found in Korahay zone health facilities (41.9%). This study concluded that service providers without prior ultrasound expertise demonstrated proficiency in ultrasound usage and performed effectively in obstetric applications after only ten days of training on obstetric ultrasound followed by online mentorship. Implementing ultrasound intervention improved CDM abilities and service utilization rates for maternal health services.

KEYWORDS: Routine ANC Ultrasound, Obstetric Ultrasound, Ultrasound, and Somali regional state.

1. INTRODUCTION

Maternal mortality is a long-standing global public health problem that has not yet been fully resolved and still needs special attention. Globally, more than 800 maternal deaths occur every day, and the majority of these deaths are the result of easily preventable pregnancies and childbirth-related complications.^[1,2] More than 80% of these deaths are concentrated in poor resource settings, particularly sub-Saharan African and Southeast Asian countries, where there is a weak health system and emergency crisis and most of the population lacks access to quality and equitable essential maternal health services.^[1]

To address this situation, many countries in poor resource settings are engaged in the implementation of several initiatives directed toward improving maternal health service access, quality, and equity to reduce maternal morbidities; contribute to the reduction of unachieved maternal mortality; and achieve sustainable development goals by 2030.^[3,4]

In recent decades, one of the newly evolving initiatives that has gained acceptance and been used in many nations worldwide, particularly in poor resource settings, was the use of obstetric ultrasound for routine prenatal care service provision at the primary health care level by using a task-shifting approach with less specialized health professionals, particularly midwives and other

mid-level professionals, who could be easily available at front-line health facilities, even in an area where there is an extreme shortage of health workers.^[5,6] Thus, the implementation of obstetric ultrasound at the front of health facilities could improve the quality of health care provided to pregnant women and serve as a vital diagnostic tool for identifying placental location, number of fetuses, accurate estimation of gestational age, screening of fetal growth and fetal presentation, diagnosis of obstructed labor, and identification of other potential pregnancy-related problems, such as threatened abortion and ectopic pregnancy.^[4,7,8]

According to the newly revised 2016 ANC WHO guidelines, it is recommended that a pregnant woman receive one ultrasound scan before reaching 24 weeks of gestation as part of standard prenatal care, and the International Federation of Gynecology and Obstetrics (FIGO) also recommends at least two ultrasound screenings for all pregnant women in the first and second trimesters.^[9,10] Recent evidence suggests that the introduction of obstetric ultrasound services in primary care facilities and their use for regular prenatal care screening have been proven to substantially contribute to the diagnostic capabilities of health facilities, the quality of diagnostic service provision, and the enhancement of health workers' confidence, service provision skills, and clinical decision-making skills.^[11] This has resulted in the attraction of pregnant mothers to service delivery facilities and boosted the utilization of ANC, skilled birth attendance, and PNC services.^[12,13]

There has been significant progress in reducing maternal mortality in recent decades. The country has succeeded in reducing its maternal death rate from 1250 per 100,000 in 1990 to 267 per 100,000 in 2020. However, despite this progress, the rate of progress remains high, and the country is still far from achieving the national and global SDG target 70 per 100,000 by 2030.^[1]

Despite these findings, GOE is still working hard to improve the provision of maternal health services and achieve universal SRH through the implementation of an innovative initiative aimed at improving accessibility, equity, and quality SRH services.^[14,15] Consistent with the WHO recommendation for every pregnant mother to receive at least one ultrasound scan before reaching 24 weeks of gestation as part of standard prenatal care, the government of Ethiopia (GOE) has taken the initiative and started the decentralization of obstetric ultrasound services at the health center level by using nurses, HOs, and midwives given in-service training. With supporting partners, the Ministry of Health has procured ultrasound machines and distributed them to selected health centers. To date, only a few health centers have been established, and still, efforts are underway to expand the implementation of the initiative on a large scale and reach the target of the national SRH strategy 2021–2026 of at least one ultrasound per woreda.^[15,16]

The Somali Regional State Health Bureau prioritized the decentralization of ultrasound service provision to the health center level and started its implementation in 2022. To date, with the support of collaborating partners, RHB has procured and distributed 55 ultrasound machines to 55 health centers located in 55 woreda. This indicates that almost 54% of the woreda in the region had received at least one ultrasound machine. RHB also provided 10 days of ultrasound user training to 47 health workers selected from the health centers who received ultrasound machines. The bureau printed and distributed U/S logbooks for 47 health centers to document service provision. The bureau recruited one obstetrician to provide remote-assistant or online mentorship services after training by using Zoom meetings and what and direct calls. RHB has opened the WhatsApp platform and group to service providers trained immediately after training to help them communicate with each other and share experiences with their colleagues, as well as share scans and images of the difficult cases they face with obstetricians and obtain remote assistance. The health Bureau has also organized two sessions of annual review meetings for all service providers trained to review the performances and provide refresher training in common or difficult cases after reviewing their logbooks. During the implementation period, only 38 out of the 46 health centers that started the implementation of the program were eligible for this study, and the remaining 8 health centers were not eligible for this study because they were new sites that started the services late in the middle of 2023.^[17,18] A total of 16,257 obstetric ultrasound scans were performed at 38 health centers from Jan 2022 to November 2023.^[17] To date, different studies on obstetric ultrasound program implementation have been conducted worldwide, on the African continent, and in Ethiopia to determine how to improve the program performance, success, and gaps in obstetric ultrasound service provision tasks among primary health care health workers with shorter training and fewer qualifications. Several researchers have suggested that local or context-based evidence is needed for further adjustment to improve program implementation quality. Therefore, this study aimed to assess the competencies (skill retention), effectiveness, and impacts of an obstetric ultrasound pilot program implemented at the health center level on maternal health services in the Somali region.

2. STUDY AND MATERIALS

2.1 Study setting

The Somali Regional State is one of the 11 regional states in the Federal Democratic Republic of Ethiopia and is the second largest, with a total land area of approximately 376,000 km². The Somali region, located in the eastern and southeastern parts of Ethiopia, lies between 4- and 11-degree north latitude and 40- and 48-degree east longitude. It overlies an area of approximately 376,000 km², making it the second-largest regional state in the FDRE. Nationally, it shares borders with the Oromia Regional State in the west and southwest and the Afar Regional State in the northwest.

Internationally, it borders Kenya in the south; Somalia in the east, northeast and southeast, which is; and Djibouti in the northwest. The weather is hot most of the year. The temperature ranges between 18 and 45 degrees Celsius. The annual rainfall is between 386 and 660 mm. In terms of livelihood, the region is categorized into three major livelihood zones: pastoral, arcopastoral, and riverine livelihood zones. The region is divided into 11 administrative zones, 96 districts, 6 administrative cities, and 1,415 villages. The total population of the Somali region was estimated to be 4.4 million. The population is projected to reach 6.7 million in 2022, which indicates that this region is the most populous region and is 4th in the country. Eighty-six percent of the population lives in a pastoralist lifestyle. The highest total fertility rate is 7.2 births per woman.^[19]

The Somali region has a total of 1596 health posts, 227 health centers, and 18 hospitals, including 14 primary hospitals, 3 general hospitals, and 1 specialized hospital. In addition, the region has 29 special mobile health and nutrition teams that provide basic health services to the pastoral community. The region has 604 privately owned health facilities that provide health services; these facilities consist of 12 special clinics, 49 medium clinics, 42 primary clinics, and 176 drug vendors.^[18]

According to the 2019 mini-EDHS report, the regional coverage of key maternal health service indicators showed very low performance, and most of them were below national performance.^[20] Hence, only 30.2% of pregnant women in the Somali region received antenatal care from a skilled provider at least once during their previous pregnancy, 11.1% received four or more ANC visits for their most recent live birth, 26% of pregnant women had their babies delivered by a skilled provider (SBA), and only 10.3% received a postnatal check during the first two days following delivery.^[21]

2.2 Study Design and Period

A descriptive study using a retrospective medical record review was carried out at 22 selected health centers in the Somali regional state that implemented obstetric ultrasound services from January 2022 to November 2023. This study also used objective structured clinical examination (OSCE) assessment to assess the competency of health workers in ultrasound machine usage and the performance of the program during the study period. A quantitative data collection technique was employed for this study. The data collection started on November 27, 2023, and ended on January 30, 2024. The source population for this study was pregnant women who utilized maternal health services and health workers trained in ultrasound services who provided services at the target health centers from January 2022 to December 2023.

2.3 Sample size determination

To determine the sample size needed for the case review data used for this study, a single population proportion formula was used under the following assumptions.

$$n_0 = \frac{(Z\alpha/2)^2 P(1-P)}{d^2}$$

$$n_0 = \frac{(1.96)^2 0.317(1-0.317)}{(0.05)^2} = 332.7$$

Where

- n_0 = sample size
- The confidence interval ($Z(\alpha/2)$) was 95% = 1.96
- Desired degree of precision (margin of error) (d) = 0.05 or 5%
- Contingency for non-response rate = 5%,
- The proportion of pregnant women screened for abnormal ultrasound readings (P) was 31.7% according to a study conducted in the Philippines regions^[22,23]

$$n_f = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} = 327.97$$

- n_f = Sample size adjusted
- N = total population/patients scanned
- The total number of patients utilized underwent obstetric ultrasound (US) for a 2-year duration from the target health facility (N) = 23,000 from The Somali Regional State Health Bureau/Health Promotion Maternal Health Unit annual report.
- ❖ Therefore, the estimated adjusted sample size is 327.97, by adding 5% of the non-response rate, the final sample size for case review is 344.
- ❖ The sample size for assessing the competency and performance of ultrasound-trained service providers (health workers) was determined using the Aga Khan Foundation's rule of thumb recommendation.^[24] Among the 55 health centers, RHB has provided ultrasound machines; 37 of them have trained staff and provided services during the studied service provision period; the rest of the health centers were new, and some of them were nonfunctional.^[17] Thus, twenty-two health centers were sampled; 60% of the 37 health centers were selected for the study, which is equal to 22 health facilities.

2.4 Sampling technique

In this study, a stratified random sampling technique was used by dividing the region into 11 administrative zones, and 50% of the total zones in the region were sampled via the simple random sampling technique; these 6 zones out of 11 zones in the region were included. Then, in each selected zone, all districts with health centers that had been working on obstetric ultrasound initiatives for

at least 2 years were selected. At the district level, all health centers in the selected district that had provided obstetric ultrasound services for at least 2 years were selected and included in the study. To select the number of medical records to be taken from each selected health center for case review, simple random sampling techniques were employed by using the facility's medical record number.

2.5 Data collection Methods and Tools used

A structured data abstraction checklist adapted from different studies was used to extract information about ultrasound usage and performance over the past two years of implementing obstetric ultrasound at health centers to assess the performance status of the machine. During the data abstraction, ANC registers, tally sheets, health facility medical records, and ultrasound scan logbook registration formats were used in this study.

A maternal health service utilization data abstraction checklist was also used to collect data about ANC, delivery, and postnatal care service utilization two years before ultrasound introduction and two years after obstetric ultrasound implementation at the health center level to determine the change in key maternal health service utilization.

The information collected included three main categories of data recorded in the scan logbooks: (i). Information provided by the patient included whether the patient knew her LMP and the number of ultrasound scans she had thus far, including the index pregnancy. (ii) Information elicited by the trained clinician (ultrasound findings, follow-up action, patient trimester); (iii) machine-generated information: gestational age (GA) estimated by LMP, GA estimated by composite ultrasound, and biometric parameter measurements for BPD, FL, HC, CRL, and AC.

A clinical competency direct observation checklist intended to assess the clinical competency level of service providers on obstetric ultrasound usage was also used. The observation checklist included 12 questions directed at measuring key skills expected from service providers to have full capacity for the use of ultrasound machine imaging and clinical decision-making skills. To assess the competency level of each service provider, four patients were scanned via ultrasound under direct

observation by an obstetrician to acquire and identify basic obstetric ultrasound findings.

Pretesting was performed immediately after the questionnaire development process was finalized. Then, the data were converted to electronic forms using Kobo Collect software, and pretesting was performed before starting the actual data collection to simplify the data collection and reduce the data entry time. The data collectors for this study were obstetricians who had been conducting on-site mentorships for ultrasound-trained service providers in the studied health centers.

2.6 Data analysis

Immediately after finalizing the data collection, the collected data was downloaded from an online Kobo-Collect account using the Microsoft Excel 365 version. The data were checked for completeness, cleaned, and imported to IBM version 20 for analysis. The data were summarized via descriptive analysis, and frequencies, percentages, and descriptive statistics were computed and presented in graphs and tables.

The annual service utilization (caseloads) of five chosen maternal health service indicators was used as the dependent variable. These included ANC-1, ANC4, SBA, PNC, and the number of mothers who were referred for problems related to their pregnancy. All these variables were continuous (scale) but not normally distributed.), all of which were scales or ratios. The independent variables (groups to be compared) used for this study were categorical variables or service years between 2020 and 2023 and were grouped into pre-ultrasound (years 2020 and 2021) and post-ultrasound (years 2022 and 2023) data.

The Shapiro–Wilk test ($P < 0.05$) was used to determine if the data met the assumption of homogeneity of variances for a parametric test. The p values for the Shapiro–Wilk test results for all five variables were not significantly different (less than 0.05), which indicated that the data were not normally distributed (Table 2). The ANOVA results demonstrated that the ANOVA results did not satisfy the assumption of normality, proving that ANOVA is inappropriate for comparing groups. The Kruskal–Wallis test is the nonparametric equivalent of a one-way ANOVA.

Table 1: Tests of data normality.

	Kolmogorov-Smirnov ^a			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PW received ANC-1 Flow up	.157	88	.000	.842	88	.000
PW received ANC-4+	.164	88	.000	.845	88	.000
Women delivered in the HF	.173	88	.000	.810	88	.000
Mothers received PNC	.215	88	.000	.781	88	.000
Complicated mothers referred from HC	.134	88	.001	.926	88	.000

a. Lilliefors Significance Correction

The yearly number of cases (annual caseloads) was utilized as an independent variable to investigate the variation in service consumption data over a five-year period, which was two years before and two years after the implementation of obstetric ultrasonography at health facilities, to assess changes in maternal health care utilization. A Kruskal–Wallis test was used to determine whether there were variations in the mean ranks of yearly caseloads throughout different service years. Post hoc pairwise comparisons were performed for the four pairings of service years, with adjustments made using the Bonferroni correction to determine whether there were significant differences between pairs of service years or groups.

2.7 Operational definitions

The competency of trained service providers is measured by their ability to operate the ultrasound machine and to acquire and identify basic obstetric ultrasound findings. The OSCE, which comprises 12 questions administered to each provider under the direct supervision of an obstetrician, was assessed. Each question was measured using yes (1) for the correct measurement and no (0) for the incorrect response. Service providers who answered correctly on at least half of the questions were

categorized as having satisfactory competency, while those who failed to answer were given unsatisfactory competency.

3. RESULTS OF THE STUDY

3.1 Service provider competency

3.1.1 Service provider profile

A total of 22 service providers were included in the study; 16 (72%) of the study participants were female, while the remaining 6 (27%) were male. Fourteen (63.6%) of them were degree holders. Approximately 17 (77.3%) of the service providers were midwifery professionals. Half of the service providers had more than five years of work experience or service years.

Approximately 18 (81%) service providers received U/S training; 16 (88.9%) of them worked in ultrasound service provision at the health facility for at least two years, and the remaining 2 (11.1%) worked on U/S machines for more than a 2-year duration after in-service U/S training. Of the total service providers assessed, 13 (59.1%) performed fewer than 10 U/S scans per week, while the remaining ultrasound service providers had more than 10 scans per week (Table 2).

Table 2: Profile of OU/S-trained service providers assessed at 22 health centers in the Somali region.

Variable	Response	Freq (n=22)
Sex	Female	16 (72.7%)
	Male	6 (27.3%)
Age (Years)	21-25	4 (18.2%)
	26-29	17 (77.3%)
	≥ 30	1 (4.5%)
Education level	Degree	14 (63.6%)
	Diploma	8 (36.4%)
Profession	Midwife	17 (77.3%)
	HO	3 (13.6%)
	Nurse	2 (9.1%)
Work experience (Years)	< 5 years	11 (50%)
	≥ 5 Years	11 (50%)
U/S training status	Yes	18 (81.8%)
	No	4 (18.2%)
U/S training provider (n=18)	RHB	16 (88.9%)
	Other providers	2 (11.1%)
Duration after in-service US training (years) given (n=18)	2 Years	16 (88.9%)
	More than 2 years	2 (11.1%)
Average num-scan performed per week	< 10 scans per wk	13 (59.1%)
	≥ 10 scans per wk	9 (40.9%)

3.1.2 Service provider objective structured clinical examination (OSCE) assessment results

The competency and skill retention of ultrasound-trained service providers in 22 studied health centers were assessed using a 12-question objective structured clinical examination (OSCE). The goal was to evaluate the service provider's skills in operating the ultrasound machines and interpreting basic obstetric ultrasound results. The obstetrician visited each service provider in his facility, randomly selected four clients, and asked the

service provider to perform ultrasound examinations and document their results under his supervision. The obstetrician subsequently repeated the scan for each patient and cross-checked the results with those of the service provider to verify the findings.

According to the results of the OSCE assessment of the service provider, out of the 87 ultrasound scans performed by the evaluated service providers under direct observation by obstetricians, 64 patients (73.6%)

were correctly scanned, and the scan findings were correctly interpreted. The overall average service

provider competency level was 73.6% (Figure 1).

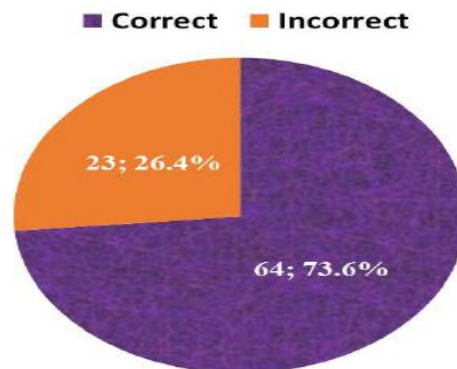


Figure 1: Overall service provider U/S use skills retention level (Competency).

The ultrasound skills that service providers failed the most on the OSCE were IUFG restriction identification skills (64 out of 87), fetal weight estimation (64 out of 87), GA estimation (65 out of 87), amniotic fluid index (AFI) assessment (74 out of 87), and accurate imaging of the placenta locations (78 out of 87). The evaluated

service provider correctly demonstrated skills such as turning machines on and off, probe orientation notch holding, measuring the fetal bilateral parietal diameter (BPD), 87 (100%) corrected fetal head circumference (FHC), visualizing fetal cardiac activity, and identifying the correct fetal presentation. (Fig-2).

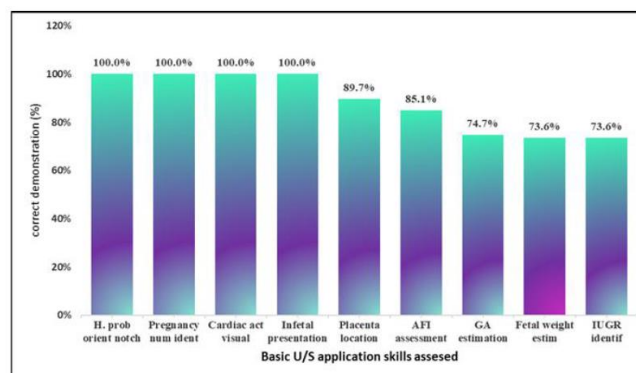


Figure 2: comparison of the performance status of service providers in nine basic obstetric ultrasound skills, as assessed in 22 health centers in the Somali region (n = 87 cases).

3.2 Service performance or effectiveness

3.2.1 Sociodemographic and Obstetric characteristics of the respondents

To assess the effectiveness or performance of the obstetric ultrasound service program, a medical record review was conducted using two-year data from January 2022 to December 2023 from ultrasound logbooks and medical records of pregnant women served during the program review period.

During the review period, the medical records of 329 women were reviewed from 22 target health centers that participated in this study. Among these, 222 (67.5%) lived within the city or village health center (semiurban), while the remaining 32.5% lived outside of the city or village health center (rural). Most of them were under 30 years old. The average age of the women was 28.2 [$\pm$ SD 4.4 years]. The ages of the participants ranged from a minimum of 20 years to a maximum of 38 years (Table 3).

Table 3: The sociodemographic and obstetric characteristics of the pregnant women served in the selected health centers who underwent surgery in the U/S region from March 2022 to October 2023. Somali region, Ethiopia.

Variables	Response type	Frequency (n=329)	Percent
Place of residence	Urban	222	67.5%
	Rural	107	32.5%
Age of respondents (in years)	<30	203	61.7%
	$\geq$ 30	126	38.3%
Gravidity	1	47	14.3%

	1-4	113	34.3%
	≥5	169	51.4%
History of Abortion	No	283	86.0%
	Yes	46	14.0%
Mother remembers LMP.	Yes	80	24.3%
	No	249	75.7%
GA estimated from LMP.	Unknown	249	75.7%
	Below 24Wk	47	14.3%
	Above 24wk	33	10.0%
GA estimation given by U/S assessment findings	Below 24Wk	83	25.2%
	Above 24wk	246	74.8%

Over 50% of the pregnant women had been pregnant five or more times, with only 14 (14.3%) experiencing their first pregnancy. Approximately 249 (75.7%) of the pregnant mothers could not recall their LMP, and only 80 (24.3%) could recall their LMP. Out of 65% of the clients who recalled their LMP, there was a significant >2-week disparity between the GA given by ultrasound assessment and the GA determined by LMP.

3.2.2 Performance of obstetric ultrasound

Among the 329 pregnant women who received antenatal care, 301 (91.5%) received an ultrasound scan during their index pregnancy, whereas 292 (97%) of the mothers scanned had the first scan they had ever had during their pregnancy. The purpose of the ultrasound scan for the majority of pregnant women was routine ANC checkup, and there was no visible risk associated with the use of U/S to aid in clinical decision making. Approximately half or 160 (53.3%) of the pregnant women scanned were in the third trimester, and only 60 (20%) of the scanned women were in the first trimester (Table 4).

Table 4: Performance of the obstetric U/S pilot program implemented in selected health centers from March 2022 to October 2023 in the Somali region, Ethiopia.

Variables	Response type	Frequency (n=329)	Percent
PW had history of U/S scan in her previous/S pregnancies	Yes	28	8.6%
	No	299	91.4%
PW received U/S scan during index pregnancy (n=329)	Yes	301	91.5%
	No	28	8.5%
Pregnancy trimester received index pregnancy U/S scan(n=300)	1 st trimester	60	20.0%
	2nd trimester	80	26.7%
	3rd trimester	160	53.3%
Index pregnancy scan type	First ever scan	292	97.0%
	Repeat scan	9	3.0%
Indication Reason for U/S/Purpose for U/S	Routine- ANC check-up scan	263	87.4%
	Mother had visible risks	38	12.6%
Reasons for referral (n=72)	Suspected anomalies	35	48.6%
	Asymptomatic expectant	37	51.4%

According to the results of this study, out of the 301 mothers who were scanned, 166 had pregnancy-related risks or complications that would not have been possible or easy to diagnose or find with regular physical exams before ultrasound services started. The overall change in clinical decision-making by obstetric ultrasound service

providers was 166 (55.1%). The greatest change in clinical decision-making was observed in Siti zone health centers (76.9%), followed by Shabelle zone health centers (59.1%). The lowest change in clinical decision-making was found in Korahay zone health facilities (41.9%) (Table 5).

Table 5: A comparison of the proportion of patients whose obstetric ultrasound scans prompted changes in clinical decision-making by zone.

Zones	Number of cases scanned	Number of high-risk cases identified	% change in CDM
Siti	52	40	76.9%
Shabelle	44	26	59.1%
Erar	14	8	57.1%
Fafan	128	64	50.0%
Jarar	32	15	46.9%
Korahey	31	13	41.9%
Total cases	301	166	55.1%

The most common obstetric ultrasound findings that prompted the greatest change in service providers' clinical decision-making during the implementation of obstetric ultrasound were the identified 34 (20.5%)

multiple pregnancies, 19 (11.5%) had a breach presentation, and 19 (11.5%) had polyhydramnios conditions (Table 6).

Table 6: Obstetric ultrasound findings that changed the clinical decision-making of service providers at 22 health centers participating in the study.

Obstetric ultrasound scan findings	Number of high-risk cases identified	Percentage (%)
Multiple pregnancy	34	20.48%
Breach presentation	19	11.45%
Polyhydramnios	19	11.45%
First TM abnormalities; (missed/Threatened abortion, Molar preg)	18	10.84%
Transverse lie	16	9.64%
Low-lying placenta/placenta previa	12	7.23%
Oligohydramnios	12	7.23%
Anencephalic fetus	11	6.63%
Intrauterine fetal death (IUFD)	7	4.22%
Hydrocephalic fetus	6	3.61%
Fetal growth anomalies (IUGR& large baby)	6	3.61%
Abruptio placenta	4	2.41%
Post date pregnancy	2	1.20%
Total Obstetric ultrasound scan findings reported	166	100.00%

Approximately 72 (23.9%) of the pregnant mothers who received ultrasound services from the studied health centers were identified as having pregnancy-related complications and were referred to the nearest referral points for further medical assistance.

Among these, 51.4% were asymptomatic mothers who utilized the service as part of their routine ANC checkup only and were not aware of the risks to which they had been referred prior to the ultrasound scan findings (Figure

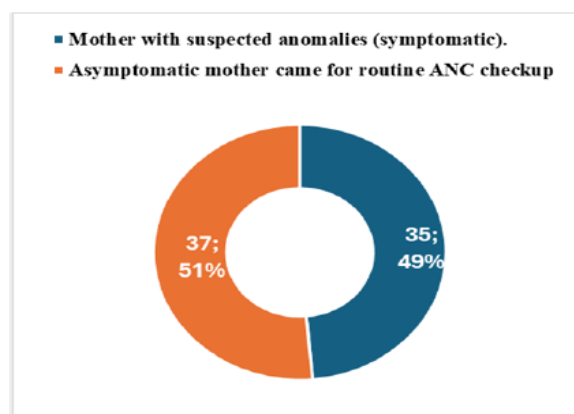


Figure 3: Changes in referral cases prompted by obstetric ultrasound introductions at the health center level.

3.3 Impact of US introduction on maternal health service utilization

To assess the impact of obstetric ultrasound introduction at the health center level on maternal health service utilization during implementation, four years of service utilization data taken from service delivery registers at 22 health centers were used. The data were organized

into a Pre-implementation period, which spanned from 2020 to 2021, and a Post-ultrasound implementation period, which was also from 2022 to 2023. Our study used five variables, namely, first- and fourth-visit ANC services, SBAs, PNCs, and referrals from mothers with pregnancy-related problems.

Table 7: Comparison of the average annual caseload of key maternal health indicators before and after the implementation of obstetric ultrasound in 22 health centers in the Somali region, March 2024.

Indicators	Time	N	Mean ($\pm$ SD)	Median	Min-Max	95%CI
ANC1	Pre-US (2020-21)	44	330.9(194)	238	86-855	(271.9-389.9)
	Post-US (2022-23)	44	521.4(296.2)	296	189-1350	(431.3-611.4)
ANC4	Pre-US (2020-21)	44	271(167.1)	482.5	69-765	(220.2-321.8)

	Post-US (2022-23)	44	450.9(252)	190.5	135-1200	(374.3-527.5)
SBA	Pre-US (2020-21)	44	264.3(218.3)	314	58-1053	(197.9-330.7)
	Post-US (2022-23)	44	422.3(260)	422	123-1216	(343.3-501.4)
PNC	Pre-US (2020-21)	44	255.1(224.1)	205.5	49-1036	(186.9-323.2)
	Post-US (2022-23)	44	399.3(257.7)	299.5	115-1098	(320.9-477.6)
Referral	Pre-US (2020-21)	44	19.6(11.2)	148	4-48	(16.2-23)
	Post-US (2022-23)	44	42.5(18.2)	204	12-72	(37-48)

Based on the findings of this study, the overall average annual caseload of the first ANC visit attendants in the 22 health centers studied was 330.9 (± 194 SD) before initiating the ultrasound services. Later, after the commencement of the ultrasound service, the average annual caseload reached 521.4 (± 296.2 SD), which indicates a 57.6% increase compared to the period before

the implementation of the service. Similarly, the annual caseload at the fourth ANC visit also changed from 271 (± 167 SD) to 450.9 (± 252 SD) for the same reporting period, while the average number of complicated cases referred to the next referral point showed a change from 19.6 (± 11.2 SD) before starting the U/S service to 42.5 (± 18.2 SD) after implementation (Table 7).



Figure 4: Changes in average annual maternal health service utilization during the implementation of obstetric ultrasound in 22 health centers in the Somali region in March 2024.

Among the five key maternal health services indicators studied, the identification and referrals of mothers with pregnancy-related problems indicator (117%) showed the highest proportion of service utilization change, followed by fourth-visit ANC (66.4%), skilled birth attendant service use (59.8%), and PNC service, which was the least common (Figure 4).

3.3.1 Comparison of the means ranks of annual caseloads for key maternal health services

The annual caseloads were compared two years before and two years after the introduction of the U/S at the health centers to analyze changes in maternal health service utilization. A Kruskal–Wallis mean rank test was conducted to determine if there were differences in the mean ranks of annual caseloads across different service years. Furthermore, post hoc pairwise comparisons were conducted for the four pairings of service years, with adjustments made using the Bonferroni correction to identify whether pairs of service years or groups exhibited significant differences.

According to the findings of the present study, the identification and referrals of mothers with pregnancy-related problems exhibited the greatest change in service utilization during the four years of the study period; the mean ranks of pregnant women referrals were 26.09 in

2020 and 32.61 in 2021. However, after the introduction of U/services, the mean rank of the referral cases changed to 52.07 in 2022 and 67.23 in 2023, which indicates a 103.2% mean rank average change. The Kruskal–Wallis mean rank test results showed that this change in referral cases was statistically significant for at least one service year (KW-ANOVA, $H = 35.59$, $P = 0.000$) (Table 6). The post hoc analysis revealed that the mean rank of pregnant women's referral caseloads significantly differed between the 2020 and 2022 ($P = 0.004$), 2020 and 2023 ($P = 0.000$), and 2021 and 2023 ($P = 0.000$) years. The remaining pairs of service years did not show any changes in the pregnant women's annual caseload (Table 7).

The findings of this study also revealed that the second highest change in service utilization observed over the four years was the fourth visit to ANC attendants' annual caseload. The mean ranks of the annual ANC4 caseloads in 2020 were 27.32 and 37.18 in 2021, while the mean ranks were 49.43 and 64.07 in 2022 and 2023, respectively. Hence, the caseload mean rank increments of the caseloads of fourth-visit ANC attendants between 2020 and 2023 were significantly different according to KW-ANOVA ($H = 25.487$, $P = 0.000$). The post hoc analysis revealed that the mean annual caseload rank of fourth-visit ANC attendants significantly differed

between 2020 and 2022 ($P = 0.025$), 2020 and 2023 ($P = 0.000$), and 2021 and 2023 ($P = 0.003$). The remaining

pairs of service years did not show any changes in the annual caseload of fourth-visit ANC attendants.

Table 8: Mean ranks of annual caseloads of the selected maternal health service indicators in 22 health facilities from 2020 to 2023 in the Somali region.

Service indicators	Service years	N=88	Mean Rank	Kruskal–Wallis H	df	Asymp. Sig.
Pregnant women received ANC-1 Flow up	2020	22	30.02	20.27	3	0.000
	2021	22	36.66			
	2022	22	49.3			
	2023	22	62.02			
Pregnant women received ANC-4+	2020	22	27.32	25.49	3	0.000
	2021	22	37.18			
	2022	22	49.43			
	2023	22	64.07			
Pregnant women delivered in the health facility	2020	22	27.27	22.55	3	0.000
	2021	22	38.91			
	2022	22	49.57			
	2023	22	62.25			
Mothers received PNC	2020	22	28.36	20.36	3	0.000
	2021	22	38.39			
	2022	22	50.2			
	2023	22	61.05			
Pregnant women with complication referred from health centers	2020	22	26.09	35.59	3	0.000
	2021	22	32.61			
	2022	22	52.07			
	2023	22	67.23			

Furthermore, the mean ranks of the caseloads of skilled birth attendants in 22 health facilities in 2020, 2021, 2022, and 2023 were 27.27, 38.91, 49.57, and 62.25, respectively. KW-ANOVA revealed a statistically significant positive difference ($H(3) = 22.55$, $P=0.000$), which indicated that the SBA caseloads significantly grew over the four years. The post hoc analysis revealed statistically significant differences in the mean annual caseload for SBA patients between the service years 2020 and 2022 ($P = 0.001$) and between 2020 and 2023 ($P = 0.023$). No changes were observed in the yearly caseload of SBA attendants for the remaining pairs of service years on the SBA.

Over the four-year study period, the smallest changes in service utilization were observed for first-visit ANC and PN compared to the other service indicators studied. The mean rank of first ANC visit attendants was 30.02 in 2020 and 36.66 in 2021. However, after the implementation of the U/S policy, the mean rank of ANC-1 changed to 49.3 in 2022 and 62.02 in 2023, corresponding to a change of 66.9%. These findings revealed statistically significant differences in the first ANC attendant caseload for 22 health centers that

participated in the study for at least one group or service year (KW-ANOVA, $H = 20.269$, $P = 0.000$). The mean rank of the first ANC visit attendant annual caseloads significantly differed between 2020 and 2023 ($p = 0.000$, adjusted using the Bonferroni correction). Similarly, there were also very strong statistically significant differences between 2021 and 2023 service years ($p = 0.006$).

PNC service utilization was observed to have the least change in service utilization among the 22 health centers studied; the mean annual caseload rank for PNC visit attendants was 28.36 in 2020 and 38.39 in 2021, and the mean rank of PNC was 50.02 in 2022 and 61.05 in 2023, which also indicated a 66.7% average rank change over the four years. The Kruskal–Wallis mean rank test showed this finding to be statistically significant for at least one service year (KW-ANOVA, $H = 20.36$, $P = 0.000$). The post hoc analysis revealed that the mean rank of pregnant women's referral caseloads significantly differed between the 2020 and 2022 ($P = 0.004$), 2020 and 2023 ($P = 0.000$), and 2021 and 2023 ($P = 0.000$) years. The remaining pairs of service years did not show any changes in PNC service utilization (Table 7).

Table 9: Pairwise comparison of the annual caseloads of key maternal health service indicators selected over the four years (2020-2023).

Indicator	Sample 1-Sample 2	Test statistic	Std. error	Std. test statistic	Sig.	Adj. sig
ANC1	2020–2021	-6.636	7.702	-0.862	0.389	1.000
	2020–2023	-19.273	7.702	-2.502	0.012	0.074

	2020–2022	-32.000	7.702	-4.155	0.000	0.000
	2021–2023	-12.636	7.702	-1.641	0.101	0.605
	2021–2022	-25.364	7.702	-3.293	0.001	0.006
	2023–2022	-12.727	7.702	-1.653	0.098	0.591
ANC4	2020–2021	-9.864	7.702	-1.281	0.200	1.000
	2020–2023	-22.114	7.702	-2.871	0.004	0.025
	2020–2022	-36.750	7.702	-4.771	0.000	0.000
	2021–2023	-12.250	7.702	-1.590	0.112	0.670
	2021–2022	-26.886	7.702	-3.491	0.000	0.003
	2023–2022	-14.636	7.702	-1.900	0.057	0.344
SBA	2020–2021	-11.636	7.702	-1.511	0.131	0.785
	2020–2023	-22.295	7.702	-2.895	0.004	0.001
	2020–2022	-34.977	7.702	-4.541	0.000	0.023
	2021–2023	-10.659	7.702	-1.384	0.166	0.998
	2021–2022	-23.341	7.702	-3.030	0.002	0.015
	2023–2022	-12.682	7.702	-1.647	0.100	0.598
PNC	2020–2021	-10.023	7.702	-1.301	0.193	1.000
	2020–2023	-21.641	7.702	-2.836	0.005	0.027
	2020–2022	-32.682	7.702	-4.243	0.000	0.000
	2021–2023	-11.818	7.702	-1.534	0.125	0.750
	2021–2022	-22.659	7.702	-2.942	0.003	0.020
	2023–2022	-10.841	7.702	-1.407	0.159	0.956
PW referred to the level	2020–2021	-6.325	7.696	-0.847	0.847	1.000
	2020–2023	-25.977	7.696	-3.375	0.001	0.004
	2020–2022	-41.136	7.696	-5.345	0.000	0.000
	2021–2023	-19.455	7.696	-2.528	0.011	0.069
	2021–2022	-34.614	7.696	-4.497	0.000	0.000
	2023–2022	-15.159	7.696	-1.970	0.049	0.293

*Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level was .05. a. Significance values were adjusted by the Bonferroni correction for multiple tests.

4. DISCUSSION

The goal of this study was to determine the capacity of service providers to provide ultrasound services, the effectiveness of ultrasound service provision and the impact of such services on service utilization during its implementation.

The study showed that ultrasound service providers had an average performance of 64 (73.6%) patients in imaging and interpreting the results. This achievement is relatively good compared to that of mid-level service providers with no previous training or background on ultrasound use or experience who have been given only 10 days of training; however, it is lower than that of previous studies in Kenya in 2017 (99.63% accuracy by midwives) and Uganda in 2020 (90.4% accuracy).^[26,27] In contrast, the findings of our study are also higher than those of another study conducted in Australia, which reported 46% of HWs' performance^[28] and 62% of HWs' performance in a study conducted in Zanzibar.^[29] A possible explanation for this could be the difference in training duration, exposure time and presence of service providers who did not receive ultrasound in service training in some of the health facilities.

The present study revealed that the introduction of obstetric ultrasound at the health center level has

demonstrated effective performance during the implementation period. The fact that the program's implementation has had a significant impact on the clinical decision-making abilities of service providers in the 22 health centers that participated in the study is evidence of this. The overall service provider clinical decision-making change was 55.1%, which is greater than that reported in the other study conducted in Tanzania, which reported only a 28.8% change in service provider decision-making.^[30]

Furthermore, this study revealed that implementing ultrasound scan services in health centers significantly improved the identification and referral of pregnant women with pregnancy complications for medical treatment. Thus, 51.4% of the mothers referred from 22 health centers were asymptomatic, used the service for routine ANC checkups, and were unaware of the risks found in the ultrasound scan findings. These findings are supported by the findings of other studies conducted in primary health centers in Eastern Uganda, which reported an increase in referral of 48.4% ($P < 0.001$), and a scoping review conducted in some African countries in 2023.^[6,31-33]

The results of our study demonstrated that the implementation of obstetric U/S had a positive effect on

the identification and referral of pregnant women with pregnancy-related complications. The obstetric U/S implementation changed the mean rank of the referral cases from 26.09 in 2020 to 67.23 in 2023, which indicates a 103.2% mean rank average change (KW-ANOVA, $H = 35.59$, $P = 0.000$). This finding is consistent with that of another study conducted in Ethiopia, which reported a referral rate of 98.4%; other studies conducted in the Philippines; and a study conducted in a low-resource setting, where obstetric U/S use had also been reported to have a positive impact on pregnant women's referrals.^[23,33-35]

Based on the findings of this study, the introduction of ultrasound has shown a positive contribution to prenatal care, particularly for women who receive the fourth ANC service, which showed the greatest change or improvement following the introduction of ultrasound, with an increase in the annual caseload for the fourth ANC visit of 66.4%. This finding aligns with previous studies in Nepal and Ethiopia, indicating the effectiveness of obstetric ultrasound in improving antenatal care services.^[32-36] Similarly, another study conducted in six rural districts in the Coast Region of Tanzania also revealed a significant change in the percentage of fourth-visit ANC attendants after the introduction of ultrasound (27.2 % at baseline and 60.3 %; $p = 0.001$).^[37] In contrast to our study findings, another study conducted in Ethiopia reported a decrease in fourth-visit ANC attendants in the PHCU after obstetric ultrasound intervention was implemented.^[38]

According to this study, the initiation of obstetric ultrasound improved the annual caseload in SBA patients by 59.8%, and the mean rank of the annual SBA in 22 health centers increased from 33.3 average annual caseloads before implementation to 55.9 after obstetric ultrasound was implemented in 22 health centers, which indicates a 66.9% average rank change. This finding is supported by a study conducted in selected primary health care facilities that implemented obstetric ultrasound in four regions of Ethiopia and other studies conducted in Uganda and Nigeria.^[13,39] A study conducted in six rural districts in the Coast Region of Tanzania also revealed a significant change in the percentage of fourth-visit ANC attendants (27.2 % at baseline and 60.3 %; $p = 0.001$).^[40] Our study also revealed that the introduction of obstetric ultrasound improved the utilization of the PNC service annually by 56.5%, and the mean rank of annual PNC service utilization in 22 health centers increased from 33.4 average annual caseloads before implementation to 55.6 after implementing obstetric ultrasound in 22 health centers. This finding is consistent with the findings of other studies conducted in Uganda and Ethiopia, which also reported an increase in PNC services at intervention facilities after obstetric ultrasound was performed.^[38]

4.1.1 Limitations of the study

The findings of this study might not be sufficiently representative of the general population since it included data from only certain health centers in specified zones. Furthermore, because of the observational study design, which lacks a control group, our study used a medical record review that might pose challenges related to information completeness and accuracy, which might have an impact on our study findings. The study is deficient in a qualitative component, which would provide us with further insights into the issue.

5. CONCLUSION AND RECOMMENDATIONS

We conclude that the service providers without prior ultrasound expertise who received training only ten days with online mentoring demonstrated adequate levels of proficiency in ultrasound usage and performed effectively in obstetric ultrasound applications. Furthermore, the implementation of ultrasound intervention at the health center level has proven to be very effective, resulting in a significant improvement in the clinical decision-making abilities of service providers in the studied health facilities. In addition, this approach has enhanced the service utilization rate of important maternal health services, such as ANC-1, ANC-4, skilled birth attendant (SBA), and postnatal care (PNC), as well as the identification and referral of pregnant women with pregnancy-related problems. Hence, this study provides recommendations for scaling up ultrasound services to other parts of the region not yet covered. Our study also recommends implementing frequent refresher training supported by both online and onsite mentorships led by the nearest hospital by providing a special focus on the most difficult area (cases), where most of the providers missed further service provider competency. This study also recommends conducting further in-depth analysis or studies on challenges that can impede the institutionalization of the program and factors affecting program performance.

6. DECLARATION

6.1.1 Ethics Approval and Consent to participate

The principal investigator has submitted the research proposal to the Somali Regional Health Bureau for review and approval and an official permission letter from the Somali Regional Health Bureau, particularly the Directorate HPDP. To obtain permission for access to the necessary files, facility data, and information for the study, the health bureau submitted an official permission letter to Woreda Health offices and target health centers. Written informed consent was obtained from all subjects, and this study was performed in accordance with the Declaration of Helsinki procedures.

6.1.2 Consent for publication

This study does not involve details, images, or videos related to an individual. Therefore, consent for publication is not applicable.

6.1.3 Availability of data and materials

All the data generated or analyzed during this study are available and attached to the appendix of the manuscript.

6.1.4 Competing interests

The authors declare that they have no competing interests.

6.1.5 Funding

The Somali Regional State Health Bureau has provided financial support to the authors to cover all the expenses required for this research.

6.1.6 Authors' contributions

Abdi Ahmed had the idea for the study and developed the study design and data collection tools. He also performed the analysis and interpreted the data and wrote the manuscript. Muhumed Mohamed developed the study design; collected the data; and wrote and interpreted the manuscript. All the other authors reviewed the final manuscript.

6.1.7 ACKNOWLEDGMENTS

The authors would like to express their deep gratitude to the Somali Regional Health Bureau, Directorate HPDP, for providing financial support for this study. The authors express gratitude to the leaders and personnel of district health offices (DHO) and health facilities who participated in this study for their cooperation and support throughout the data collection period. The authors express gratitude to the leaders and staff of the district health offices (DHO) and health centers involved in this study for their cooperation and support during the data collection. We would also like to thank supervisors and data collectors for taking the time to collect the data. We are glad to thank the respondents who participated in this study and took the time to provide additional information.

6.1.8 Authors' information (optional)

1. Somali Regional Health Bureau, Somali region, Ethiopia/Jigjiga University, College of Medicine and Health Science, Ethiopia.
2. Warder Hospital, Somali region, Ethiopia.
3. Somali Regional Health Bureau, Somali region, Ethiopia.

7. REFERENCES

1. Cresswell, J. and W.H. Organization, *Trends in maternal mortality 2000 to 2020: estimates by WHO, UNICEF, UNFPA, World Bank Group and UNDESA/Population Division*, 2023: World Health Organization.
2. WHO, *Trends in maternal mortality 2000 to 2020: estimates by WHO, UNICEF, UNFPA, World Bank Group and UNDESA/Population Division: executive summary*, 2023.
3. WHO, *Health in 2015 from MDGs to SDGs*, 2015; 204.
4. Luntsi, G., et al., *Achieving universal access to obstetric ultrasound in resource constrained settings: a narrative review*. Radiography, 2021; 27(2): 709-715.
5. Mubuuque, A.G., et al., *Point of care obstetric ultrasound training for midwives and nurses: implementation and experiences of trainees at a rural based hospital in Subsaharan Africa: a qualitative study*. BMC Research Notes, 2023; 16(1): 287.
6. Lukhele, S., et al., *The training of midwives to perform obstetric ultrasound scan in Africa for task shifting and extension of scope of practice: a scoping review*. BMC Medical Education, 2023; 23(1): 764.
7. Yetwale, A., et al., *Prenatal Ultrasound Utilization and Its Associated Factors among Pregnant Women in Jimma Town Public Health Institutions, Ethiopia*. Health services research and managerial epidemiology, 2022; 9: 23333928221085881.
8. Kumsa, M.J. and Z.W. Haile, *The Role of Ultrasound in Women's Health*, 2023.
9. WHO, *WHO recommendations on antenatal care for a positive pregnancy experience*, 2016. World Health Organization.
10. Practice, F.W.G.O.B., I.M.-F. Medicine, and I.F. of Gynecology, *Best practice in maternal-fetal medicine*. International journal of gynecology and obstetrics: the official organ of the International Federation of Gynecology and Obstetrics, 2015; 128(1): 80-82.
11. Kim, E.T., et al., *Obstetric ultrasound use in low and middle income countries: a narrative review*. Reproductive health, 2018; 15: 1-26.
12. Msuega, C.D., et al., *Obstetric Ultrasonography Beliefs, Expectations, and Experiences among Women Attending a Tertiary Healthcare Center in North-Central Nigeria*, 2023.
13. Luntsi, G., et al., *Impact of ultrasound scanning on pregnant women's compliance with attendance at antenatal care visits and supervised delivery at primary healthcare centers in northern Nigeria: initial experiences*. Radiography, 2022; 28(2): 480-486.
14. Health, F.D.R.o.E.M.o., *Health Sector Transformation Plan II 2020/21-2024/25*. 2021, Federal Ministry of Health Ethiopia.
15. FMOH, *National reproductive health strategy ethiopia 2021-2025*, 2021.
16. FMOH, *National MNH Quality of Care Roadmap (2017/18-2019/2020)*, MCH, Editor, 2017, MOH.
17. RHB, *Obstetric Ultrasound Program implementation annual performance reports*, HPDP_directorate, Editor, 2023.
18. SRHB, *Somali region health sector annual performance reports*, 2023.
19. SRHB, *Health Sector Transformation Plan II 2020/21-2029/30 (2013-2022EFY)*, Planning_Directorate, Editor, 2020.

20. Basha, G.W., *Factors affecting the utilization of a minimum of four antenatal care services in Ethiopia*. Obstetrics and Gynecology International, 2019; 2019.
21. EPHI_and_ICF., *Ethiopia Mini Demographic and Health Survey Final Report*. 2021, Ethiopian Public Health Institute (EPHI) and ICF.: Rockville, Maryland, USA, 2019; 76-97.
22. Mersha, D.T., *PRACTICE OF WATER AVAILABILITY, SANITATION, AND HYGIENE AND FACTORS AFFECTING HYGIENIC PRACTICE AMONG STUDENTS ATTENDING SECOND CYCLE PRIMARY SCHOOLS IN HARARI REGION: EASTERN ETHIOPIA*, 2018.
23. Dalmacion, G.V., et al., *Handheld ultrasound to avert maternal and neonatal deaths in 2 regions of the Philippines: an iBuntis® intervention study*. BMC pregnancy and childbirth, 2018; 18: 1-8.
24. Foundation, T., *Primary care advancement program: assessing the quality of service*. The Aga Khan Foundation Washington DC, 1997.
25. WHO, *Imaging ultrasound before 24 weeks of pregnancy: 2022 update to the WHO antenatal care recommendations for a positive pregnancy experience: technical brief*, 2022.
26. Shah, S., et al., *Efficacy of an ultrasound training program for nurse midwives to assess high-risk conditions at labor triage in rural Uganda*. PLoS one, 2020; 15(6): e0235269.
27. Vinayak, S., et al., *Training midwives to perform basic obstetric point-of-care ultrasound in rural areas using a tablet platform and mobile phone transmission technology—A WFUMB COE project*. Ultrasound in medicine & biology, 2017; 43(10): 2125-2132.
28. Bidner, A., E. Bezak, and N. Parange, *Evaluation of antenatal point-of-care ultrasound training workshops for rural/remote healthcare clinicians: a prospective single cohort study*. BMC Medical Education, 2022; 22(1): 906.
29. Hall, E.A., et al., *Analysis of an obstetrics point-of-care ultrasound training program for healthcare practitioners in Zanzibar, Tanzania*. The Ultrasound Journal, 2021; 13: 1-12.
30. Reynolds, T.A., et al., *Impact of point-of-care ultrasound on clinical decision-making at an urban emergency department in Tanzania*. PLoS one, 2018; 13(4): e0194774.
31. Santos, N., et al., *Effect of a labor triage checklist and ultrasound on obstetric referral at three primary health centers in Eastern Uganda*. International Journal of Gynecology & Obstetrics, 2021; 153(1): 130-137.
32. Joshi, J., et al., *Effectiveness of Focused Obstetric Ultrasound Training to Nurses from Remote Health Posts to Improve Pregnancy Outcome and Reduce Morbidity*. Journal of Nepal Health Research Council, 2023; 21(2): 303-308.
33. Casmod, Y. and S.J. Armstrong, *Obstetric ultrasound training programmes for midwives: A scoping review*. Health SA Gesondheid, 2023; 28(1).
34. Abawollo, H.S., et al., *Contribution of portable obstetric ultrasound service innovation in averting maternal and neonatal morbidities and mortalities at semiurban health centers of Ethiopia: a retrospective facility-based study*. BMC pregnancy and childbirth, 2022; 22(1): 368.
35. Doig, M., et al., *Exploring the availability and impact of antenatal point-of-care ultrasound services in rural and remote communities: A scoping review*. Australasian Journal of Ultrasound in Medicine, 2019; 22(3): 174-185.
36. Abawollo, H.S., et al., *Institutionalization of limited obstetric ultrasound leading to increased antenatal, skilled delivery, and postnatal service utilization in three regions of Ethiopia: A pre-post study*. PLoS One, 2023; 18(2): e0281626.
37. Mbuyita, S., et al., *Effects of introducing routinely ultrasound scanning during Ante Natal Care (ANC) clinics on number of visits of ANC and facility delivery: a cohort study*. Archives of Public Health, 2015; 73: 1-6.
38. Yitbarek, K., et al., *Effect of USAID-funded obstetric ultrasound service interventions on maternal and perinatal health outcomes at primary healthcare facilities in Ethiopia: a propensity score matching analysis*. BMJ open, 2022; 12(10): e065351.
39. Kawooya, M.G., et al., *Impact of introducing routine antenatal ultrasound services on reproductive health indicators in Mpigi District, Central Uganda*. Ultrasound quarterly, 2015; 31(4): 285-289.
40. Roro, M.A., et al., *Enablers and barriers to introduction of obstetrics ultrasound service at primary care facilities in a resource-limited setting: a qualitative study in four regions of Ethiopia*. BMC Pregnancy and Childbirth, 2022; 22(1): 278.