

# Effects of institutionalizing limited obstetric ultrasound services on utilization of maternal and neonatal health services: a pre-post study

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## Research Article

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# Abstract

## Background

A minimum of one ultrasound scan is recommended for all pregnant women before the 24th week of gestation. In Ethiopia, there is a shortage of skilled manpower to provide these services. Currently, trained mid-level providers are providing the services at the primary healthcare level.

## Methods

A pre and post intervention observational study was conducted to understand maternal health service utilization rates before and after institutionalizing Vscan access limited obstetric ultrasound services between 2017 and 2020.

## Results

The observed monthly increase on the mean rank of first ANC visits after the introduction of Vscan limited obstetric ultrasound services shows a statistically significant difference at KW-ANOVA  $H(3) = 17.09$ ,  $P = 0.001$ . The mean rank of fourth ANC utilization increment shows statistically significant difference at KW-ANOVA  $H(3) = 16.24$ ,  $P = 0.001$ . The observed mean rank in skilled birth attendance shows a statistically significant positive difference using KW-ANOVA  $H(3) = 23.6$ ,  $P < 0.001$ . The mean rank of increased utilization in postnatal care shows a statistically significant difference using KW-ANOVA  $H(3) = 17.79$ ,  $P < 0.001$ .

## Conclusion

The introduction of limited obstetric ultrasound services by trained mid-level providers at primary healthcare levels was found to have improved the utilization of antenatal care, skilled birth attendance, and postnatal care services. It is recommended that limited obstetric ultrasound services be scaled up, and a further comparative study between facilities with and without ultrasound services be conducted to assess the effect of the introduction of the services on maternal and perinatal outcomes.

## Background

Globally, 295,000 women died during and following pregnancy and childbirth in 2017. Most of these deaths occurred in low-resource settings [1]. The World Health Organization (WHO) had estimated a total death of 2.5 million children within the first month of their life, in 2018 [2]. Furthermore, 2.6 million babies are stillborn, with half of these deaths occurring at home [3].

Ethiopia is a low-income country with high incidences of maternal and neonatal mortalities. Over the past couple of decades, the Government of Ethiopia, its citizens, and development partners have successfully implemented most global and national commitments. During the implementation of health sector development programs spanning 20 years, the country has heavily invested its resources into improving maternal, neonatal and child health outcomes [4]. Despite this, the country has gained minimal results in the reduction of maternal and neonatal mortalities [5]. Although maternal mortality has declined from 708 per 100,000 live births in 1990 to 497 per 100,000 live births in 2013, the country has failed to achieve the millennium development goals (MDG) [6]. Similarly, the decline in neonatal mortality has been slow, from 63 per 1,000 live births in 1990 to 28 per 1,000 live births in 2015 [7]. Furthermore, the latest Ethiopian mini-demographic and health survey report documented a high neonatal mortality rate of 33 per 1,000 live births [8].

The WHO aims for a world where every pregnant woman and newborn receives quality care throughout pregnancy, childbirth, and postnatal periods [9]. To meet the sustainable development goals (SDGs), Ethiopia has developed its second five-year health sector transformation plan (HSTP), from 2020/21 to 2024/25. One of the strategic objectives of the HSTP is reducing maternal mortality from 401 per 100,000 live births to 279 per 100,000 live births, and neonatal mortality from 33 per 1,000 live births to 21 per 1,000 live births [10].

Most maternal and perinatal deaths are preventable with the institution of high impact and cost-effective interventions during pregnancy, labor, delivery, and postpartum periods. One of these interventions is the delivery of quality antenatal care (ANC) services. In 2016, the WHO recommended a minimum of eight ANC contact visits for expectant women, with specified evidence-based and beneficial interventions being administered during those contacts. One of the recommendations is mandatory ultrasound (U/S) scanning of all pregnant women at least once before the 24th week of gestation by skilled providers [9].

The attainment of the Ministry of Health (MoH) of Ethiopia's vision "to see productive and prosperous citizens" is challenged with extreme shortage of human resources [3, 11]. During the year 2020, there were 95 radiologists and 462 obstetricians and gynecologists available to provide obstetric ultrasound services in the country, which has population of over 110 million. Optimizing the capacity of existing human resources, and distribution of tasks and responsibilities among various health professionals will improve access to, and quality and equity of health services [12].

The United States Agency for International Development (USAID) funds the USAID Transform: Primary Health Care project (2017- 2022) to support the MoH in line with its long-term goal of preventing maternal and child deaths (PCMD) [13].

To improve access to, and quality and equity of basic maternal and neonatal health services, the project, in collaboration with its technology partner General Electric Co. introduced Vscan access—a small portable ultrasound device, for obstetric scanning by trained mid-level providers in 100 health centers [14]. The project strategizes to increase skilled birth attendance (SBA), introduce point of care ultrasound scanning services during ANC, and improve the proper management of complications of pregnancies in

referral health facilities all of which will contribute to improvements in maternal, fetal, and neonatal positive health outcomes [13, 15].

Studies have documented improvements in maternal and neonatal health service utilization and favorable pregnancy outcomes for both mother and baby, as a result of availing obstetric point of care ultrasound services and improved quality of services in remote places around the world [16–27]. In addition, during the second HSTP, the MoH of Ethiopia has a plan to introduce ultrasound services in about one thousand health centers. This study aims to assess the effects of institutionalizing Vscan access limited obstetric ultrasound services on ANC, skilled delivery, and postnatal care (PNC) service utilization in Ethiopia. To the authors' knowledge, this study is of the first of its kind in the country and will be used to guide policy on the area.

## **Methods**

### **Design, period, and setting**

A pre and post intervention observational study was conducted to understand maternal and neonatal health service utilization rates before and after institutionalizing Vscan access limited obstetric ultrasound services between 2017 and 2020. The study was conducted in Amhara, Oromia, and Southern Nations, Nationalities and Peoples' (SNNP) Regions. These regions were selected due to the presence of Vscan limited obstetric ultrasound services in selected health centers, for over two years. A health center is a public health facility serving 25,000 inhabitants within the primary healthcare system of Ethiopia, which has a mandate to provide promotive, preventive, curative, and rehabilitative outpatient care including basic laboratory and pharmacy services with a capacity for 10 beds for emergency and delivery services [28].

### **Intervention**

In October 2018, the USAID Transform: Primary Health Care project facilitated a ten-day classroom didactic course and practical, hands-on Vscan ultrasound machine operation demonstrations, followed by three sessions of two-day-long onsite and off-site mentoring for each trainee, for a total of 3 months. The contents of the training curriculum consisted of normal pregnancy, ultrasound basics, first trimester pregnancy, fetal dating, biometry measurements, second trimester pregnancy, third trimester pregnancy, and complications. The training was facilitated by experienced obstetrician and gynecologist, a radiologist, and a GE Healthcare technical expert using the Vscan access ultrasound machines.

The course delivery modalities included an interactive lecture delivered by trainers, facilitated discussions on selected cases, management algorithms, and ultrasound images, and report presentations by trainees. After each of the classroom sessions, a practical demonstration on pregnant women by trainers was followed by hands-on supervised exercise among trainees. The practical exercises continued for three months, within the regular work assignment places of each of the trainees. The project supported each facility with provisions of a startup ultrasound gel, recording books, and reporting forms. Trainees stored

the ultrasound images and maternal biodata within the ultrasound machine. The information was used to facilitate experience sharing and face-to-face mentoring sessions. During the mentoring sessions, trainers assess image quality and determine the consistency of the trainees' reports. Then, hands-on supervised scanning sessions were arranged for trainees with identified gaps in skills of scanning and report writing. Furthermore, trainees were encouraged to share their images via a Telegram group phone application and received real time feedback from trainers. At the end of the three-month-long mentoring, (end of December 2018), trainees were certified after the minimum requirements in both knowledge and skills were met. The district health offices disseminated the introduction of the limited obstetric ultrasound services using different community platforms. The number of mothers that received ultrasound scanning services for the first, second, and third or more times within the two years after the introduction of the services were 10,186, 2,974, and 1,509 respectively.

## Sample size and sampling

The Vscan limited obstetric ultrasound services were institutionalized in one hundred targeted health centers. The sample size was determined using the rule of thumb recommendation of The Aga Khan Foundation (1997) [29]. To conduct the service quality assessment —based on the size of targeted population —the foundation suggests four sample size approaches: (1) if the number of facilities is very large (500 – 1,000), take a ten percent sample, (2) if it is medium size (100 -500), take a 15 – 20 percent sample, (3) if it is small (50 -100) take a 20 – 30 percent sample, and (4) if it is very small (less than 50), take a 30 – 50 percent sample. Therefore, for this study, 30 health centers were sampled (30% of the 100 health centers). The three regions were selected based on the accessibility and functionality of the ultrasound services during the time of data collection. Finally, a simple, random sampling technique was applied to identify individual facilities.

## Data collection

Three supervisors and thirty data collectors who are health science professionals were recruited from the targeted three regions. A two-day training on the objectives of the study, data collection techniques, ethical principles, and field pretesting was carried out. The data were extracted from a routine health information management system (HMIS) database using a pre-tested tool. To ensure the quality of data, three trained supervisors with master's degrees in public health were deployed in the field and provided close technical support with feedback given daily to the data collectors. The supervisors were responsible for checking and rechecking the collected data for completeness and consistencies.

The **dependent variables** were all pregnant women that attended ANC (ANC1 and ANC4 visits per month), gave birth with the assistance of skilled birth attendants, and had utilized PNC services.

The **independent variables** were years of services.

## Data analysis

The data were entered and cleaned using Microsoft Excel 2016 then were exported to SPSS V25 for descriptive and inferential analysis. The effects of institutionalizing Vscan limited obstetric ultrasound

services were determined using 1,440 data collected from the 30 health centers. The results of the statistical tests were presented using tables and graphs. To analyze F tests (one-way analyses of variance, ANOVA), the data violated the assumption of homogeneity of variances of a parametric test using Shapiro-Wilk test of normality  $P < 0.05$  (**Additional file 1**). Hence, an equivalent non-parametric test called The Kruskal-Wallis H test or a 'one-way ANOVA on ranks' was employed to determine statistically significant differences between four groups of independent variables, years of services. The statistical differences were claimed at  $P < 0.05$ . However, the investigators maintained and ensured the following assumption of Kruskal-Wallis H tests: (1) the dependent variables (ANC, SBA, and PNC) are interval data, (2) the independent variable has four categories, (3) there were no relationship between observations in each group, and (4) the distribution of scores in each group were not identical [30]. Finally, a statistical analysis was employed to compare data twenty-four months (2017 and 2018) preceding the introduction of Vscan limited obstetric ultrasound services and twenty-four months (2019 and 2020) following the intervention. The mean rank monthly first ANC, fourth ANC, SBA, and PNC were compared before and after ultrasound services were initiated using a nonparametric test called Kruskal-Wallis H test.

## **Ethical considerations**

Ethical clearance was granted from the John Snow, Inc., Institutional Review Board (IRB) –IRB reference number IRB#20-26E. Informed individual written consent was obtained from each facility manager. The investigators maintained national and international ethical principles including ensuring the anonymity and confidentiality of research participant and collected data throughout the research process. Data were abstracted from a routine HMIS database. In addition, no personal identifiers were captured.

## **Results**

### **Description of the study population**

Characteristics of the study area and population categorized by region and service years are presented in Table 1. The majority (13/30) of the health centers were enrolled from within the Oromia Region. On average, each health center is located 58.6 kilometers away from a referral receiving hospital. At the endpoint, there were about 1.19 million people living within the study areas. Of these, the estimated number of pregnant women eligible for maternal and neonatal health services for the year 2020 were 40,506 (3.4%) (Table 1).

Table 1  
 Characteristics of the study area and population, USAID Transform: Primary health Care project  
 intervention sites, Ethiopia, 2017- 2020.

Characteristics	Amhara	Oromia	SNNP	Total
Number of health centers	9	13	8	30
Average distance from a referral receiving facility in kilometers	59.5	70.4	38.4	58.6
Population				
2017	329,038	529,008	242,815	1,100,861
2018	337,822	543,129	249,298	1,130,249
2019	346,841	557,628	255,953	1,160,422
2020	356,100	572,513	262,785	1,191,398
Eligible women				
2017	11,873	19,270	8,858	40,001
2018	11,949	19,333	8,884	40,166
2019	12,028	19,398	8,909	40,335
2020	12,106	19,464	8,936	40,506

## Maternal and neonatal health service utilization

A Kruskal-Wallis test was conducted to determine if there were differences in first ANC, fourth ANC, SBA, and PNC service scores between groups that differed in service years. The adjusted p-values are presented.

Figure 1 and Table 2 depict the results of a retrospective assessment of maternal and neonatal health service beneficiaries and coverages with a category of prior to and post the introduction of ultrasound services in the thirty health centers.

The coverages of service utilization for first ANC were 43.6% and 72.9% for the years 2017 and 2020, respectively. In addition, the mean numbers of the first ANC visits were 765 ( $\pm$ SD) and 1126.9 ( $\pm$ SD) for equal reporting periods of pre- and post-ultrasound introduction in the thirty selected health centers. The observed monthly increase on mean rank of first ANC visits after introduction of Vscan limited obstetric ultrasound service shows a statistically significant difference at KW-ANOVA  $H(3) = 17.09, P=0.001$ .

The average fourth ANC visit coverages were 43.8% and 68.3% for the years 2017 and 2020, respectively. Similarly, the mean numbers of fourth ANC visits were 534 ( $\pm$ SD) and 777.5 ( $\pm$ SD) during the pre- and post-ultrasound introduction periods, respectively. The mean rank of fourth ANC increased utilization shows statistically significant difference at KW- ANOVA  $H(3) = 16.24, P=0.001$ .

The average SBA service utilization coverages were 40.2% and 75.6% for the years 2017 and 2020 respectively. The mean numbers of SBA in the thirty health centers were 487.9 ( $\pm$ SD) and 761.5 ( $\pm$ SD) twenty-four months pre- and twenty-four months post-ultrasound introduction, respectively. The observed mean rank SBA has shown a statistically significant positive difference using KW-ANOVA  $H(3) = 23.6$ ,  $P < 0.001$ .

The average PNC service coverages were 44.4% and 75.4% for the years 2017 and 2020, respectively. The mean numbers of PNC service utilization for 48 months in the 30 health centers were 511.8 ( $\pm$ SD) and 790.1 ( $\pm$ SD) during prior to and after the introduction of ultrasound services, respectively. The mean rank of PNC service utilization increase has shown a statistically significant difference using KW-ANOVA  $H(3) = 17.79$ ,  $P < 0.001$ .

Table 2  
 Number of monthly ANC, SBA, and PNC services utilization in thirty health centers pre and post-  
 ultrasound introduction in Ethiopia, 2017-2020.

Measurements	Time	Facility- months	Mean (SD)	Median	Min- Max	95%CI
Number of first ANC visits	2017	720	705.7 (378.8)	636.5	136 - 1859	564.3 - 847.2
	2018	720	824.3 (512.2)	625.0	251 - 2253	633.1 - 1015.6
	Pre-ultrasound introduction	1440	765 (450.6)	625.0	136 - 2253	648.6 - 881.4
	2019	720	1130.3 (617.6)	905.5	254 - 2916	899.6 - 1360.9
	2020	720	1123.6 (625.7)	905.5	254 - 2916	889.9 - 1357.3
	Post-ultrasound introduction	1440	1126.9 (616.5)	905.5	254 - 2916	967.7 - 1286.2
Number of fourth ANC visits	2017	720	475.7 (243.8)	454.5	126 - 964	384.7 - 566.8
	2018	720	592.3 (409.4)	455.5	218 - 1955	439.5 - 745.2
	Pre-ultrasound introduction	1440	534 (339.2)	454.5	126 - 1955	446.4 - 621.6
	2019	720	802.9 (378.5)	754.0	177 - 2007	661.6 - 944.3
	2020	720	752.1 (431.9)	665.5	148 - 1989	590.8 - 913.4
	Post-ultrasound introduction	1440	777.5 (403.4)	715.0	148 - 2007	673.3 - 881.7
Number of SBA	2017	720	423.7 (224.0)	377.5	116 - 964	340.0 - 507.4
	2018	720	552.0 (384.8)	437.0	218 - 1756	408.3 - 695.7
	Pre-ultrasound introduction	1440	487.9 (318.8)	393.5	116 - 1756	405.5 - 570.2
	2019	720	747.6 (320.8)	679.5	232 - 1810	627.8 - 867.4
	2020	720	775.4 (455.8)	677.5	252 - 2427	605.2 - 945.7

Measurements	Time	Facility-months	Mean (SD)	Median	Min-Max	95%CI
	Post-ultrasound introduction	1440	761.5 (391.0)	679.5	232 - 2427	660.4 - 862.5
Number of PNC visits	2017	720	464.3 (248.9)	434.0	99 - 983	371.3 - 557.3
	2018	720	559.4 (410.4)	391.5	123 - 1756	406.2 - 712.7
	Pre-ultrasound introduction	1440	511.8 (339.9)	398.0	99 - 1756	424.0 - 599.6
	2019	720	774.6 (454.6)	652.0	201 - 2339	604.8 - 944.3
	2020	720	805.7 (455.9)	705.5	223 - 2427	635.5 - 975.9
	Post-ultrasound introduction	1440	790.1 (451.6)	675.0	201 - 2427	673.5 - 906.8

## Discussion

Maternal and neonatal health service utilization is affected by several factors including the introduction of new technologies or services which are believed to improve the quality of services provided at health facilities.

This study has shown that the introduction of limited obstetric ultrasound services by trained mid-level providers at health centers has significantly improved the utilization of first and fourth ANC services. These findings are in alignment with studies conducted elsewhere. A scoping review has shown that the introduction of a point of care ultrasound services into routine ANC resulted in higher ANC attendance [31]. A study in Uganda showed that the rate of ANC attendance was higher where portable ultrasound was advertised, and women can be motivated to attend ANC when offered the concrete incentive of seeing their baby [32]. Other studies in Uganda showed that the introduction of a low-cost antenatal ultrasound program at a healthcare clinic in rural Uganda was associated with increases in the monthly mean number of ANC visits and increases in the number of women receiving specific recommended ANC interventions [33, 34]. A study in Tanzania has also shown that the introduction of routine ultrasound scanning during ANC visits significantly increased the percentage of women attending ANC clinics four times or more [35].

Similarly, the introduction of limited obstetric ultrasound services at health centers by trained mid-level providers was found to have significantly improved the utilization of SBA services at time of delivery and the utilization of PNC services after delivery. These findings are also in alignment with studies conducted in other settings. The above-mentioned study in rural Uganda showed that, following the introduction of

ultrasound services, significant increases were seen in the number of mean monthly deliveries [34]. The study in Tanzania has also shown that the introduction of a simplified ultrasound scanning technology at the lowest levels of care has an effect of motivating women to select health facility deliveries [35]. A study conducted in Ghana showed that the use of a portable ultrasound scan during ANC increased the number of health facility deliveries [36]. Furthermore, a study in rural Eastern China has shown a statistically significant association between antenatal ultrasound scans and the uptake of cesarean section procedures [37].

## Limitations

One of the regions where Vscan access limited obstetric ultrasound services were introduced (Tigray), was not included in the study as services were interrupted due to security reasons. Confounding factors cannot be fully eliminated with a study of this design.

## Conclusion

Ethiopia is one of the countries in the world with low ANC, SBA, and PNC coverages. The introduction of limited obstetric ultrasound services by trained mid-level providers at health centers was found to have improved the utilization of ANC, SBA, and PNC services. Hence, it is recommended that limited obstetric ultrasound services by trained mid-level providers at health centers be scaled up. A further comparative study to assess the effects of the introduction of limited obstetric ultrasound services by trained mid-level providers in health centers on maternal and perinatal health outcomes is also recommended.

## Declarations

**Ethical approval and consent to participate:** Ethical clearance was granted from the John Snow, Inc., Institutional Review Board (IRB), IRB reference number IRB#20-26E. Informed individual written consent was obtained from each facility manager. The investigators maintained national and international ethical principles including ensuring anonymity and confidentiality of research participants and the collected data throughout the research process. Data were abstracted from a routine health management information system database. In addition, no personal identifiers were captured.

**Consent for publication:** Consent for publication is not applicable for this research.

**Availability of data and materials:** The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

**Competing interests:** All the authors declare that they do not have any competing interests.

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had no role in the design, data collection, analysis, interpretation, and writing stages of the study's undertaking.

**Authors' contributions:** HSA, MDA, ZTT, IAB and BFD were involved in the inception, concept note development, data collection, analysis, interpretation, and write up of the manuscript. AAG, AFH, BTM, TTM, and ZKG were involved during the data collection stage. HDD, MAK, and BFD validated the research findings and revised the final manuscript. All authors have read and approved to the manuscript. HSA submitted the manuscript as a corresponding author.

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## Abbreviations

ANC-Antenatal care, GE-General Electric, HMIS-Health Management Information System, HSTP-Health Sector Transformation Plan, IRB-Institutional Review Board, MDG-Millennium Development Goal, MoH-Ministry of Health, PCMD-Prevention of Child and Maternal Deaths, SBA-Skilled Birth Attendance/t, SD-Standard Deviation, SDG-Sustainable Development Goal, SNNP-South Nations Nationalities and Peoples', U/S-Ultrasound, USAID-United States Agency for International Development, WHO-World Health Organization,

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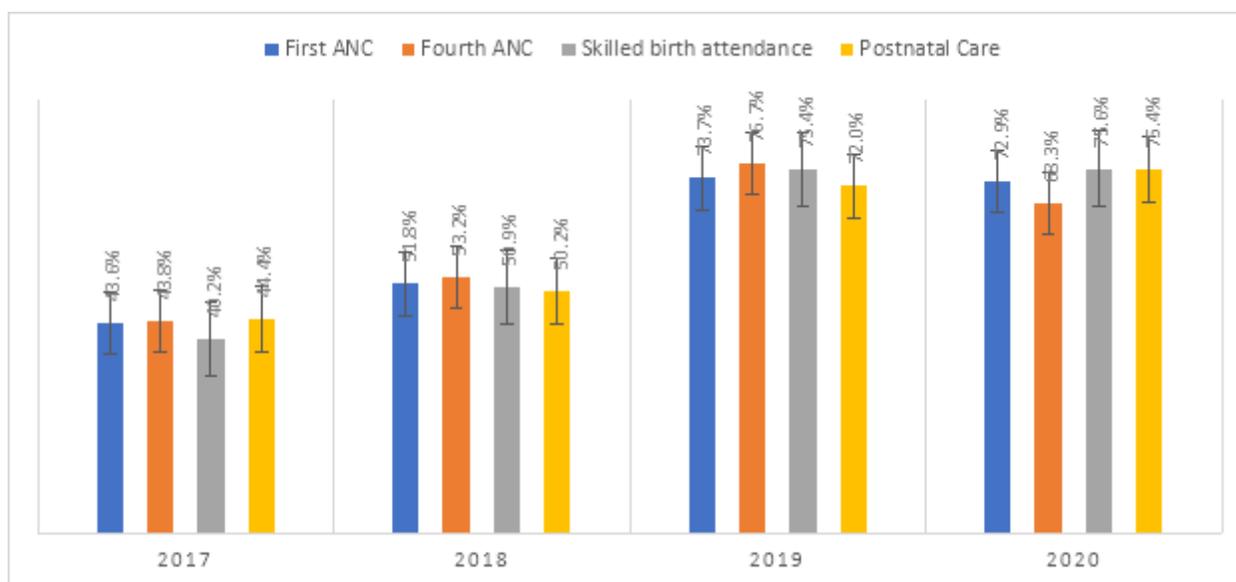
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## Figures



**Figure 1**

*Bar chart showing first ANC, fourth ANC, SBA, and PNC service utilization coverages prior to and post the introduction of ultrasound services at health centers, Ethiopia, 2017-2020.*