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Cost-Effectiveness Analysis of a Community Emergency Transport System for Maternal Care in Northern Ghana

Winfred Komla Ofosu[1*], Patrick Opoku Asuming[2], Maxwell A. Dalaba[3], Benjamin Ahenkorah[4], James Akazili[5], and Theresa Awiah[6]

[1]Regional Health Directorate, Ghana Health Service, Koforidua, Eastern Region, Ghana
[2]Department of Finance, University of Ghana Business School, Legon, Accra, Ghana
[3]Centre for Non-Communicable Diseases Research, Institute of Health Research, University of Health and Allied Sciences, Ho, Volta region, Ghana
[4]Department of Medical Laboratory Science, Bolgatanga Technical University, Bolgatanga; Upper East Region, Ghana
[5]School of Public Health, C. K. Tedam University of Technology and Applied Sciences, Navrongo, Upper East region, Ghana
[6]Kintampo Health Research Centre, Kintampo, Bono East region, Ghana

Abstract

Maternal mortality is a function of economic underdevelopment. Obstetric complications are the major cause of maternal mortality. Early detection, rapid transportation and prompt care utilizing Emergency Obstetric and Newborn Care (EmONC) can help end preventable maternal mortality. However, poor referral transportation limits utilization of lifesaving EmONC in least developed countries. Korea International Cooperation Agency supported Ghana to implement a 5-year Primary Health Care project in Upper East region in 2016. This project had a Community Emergency Transport System (CETS) component. CETS was implemented using customized 'motorking' tricycle ambulances to strengthen maternal referral transportation. We conducted cost-effectiveness analysis to determine CETS' value-for-money (VfM). The incremental cost-effectiveness ratio (ICER) and incremental net-benefit (INB) were estimated. The study perspective was societal. The comparator was traditional transportation system (TTS). The cost-effectiveness threshold was Ghana's GDP for 2020 (USD2,254.15/GH₵11,045.34). The study respondents were women with pregnancy experience in 2020 within the project area who utilize a referral transport. Respondents were randomly selected from CETS and TTS areas. Primary and secondary data were collected at households and health facilities respectively. Data was analyzed with STATA 15.0. The ICER computed was GH₵559.69 (USD114.22). CETS was deemed cost-effective because ICER was below the cost-effectiveness threshold. The net-benefit was GH₵31,456.96 (USD6,419.79). The INB was less than zero (-2002.61) implying CETS was not cost-effective. There was a conflict between ICER and INB on VfM of CETS. Affordability should be considered in Policy adoption.

Keywords: *Community emergency transport system, Cost-effectiveness, Ending preventable maternal mortality, Northern Ghana, Traditional transport system.*

Introduction

Maternal mortality is a function of economic underdevelopment as depicted by the wide variation in lifetime risk of maternal death between rich and poor nations [1]. Every year, nearly 300,000 women die in childbirth globally and millions more suffer serious pregnancy-

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****Corresponding Author: wkofosu@yahoo.co.uk***

related illness or disability following birth [2, 3, 4]. About 94% of maternal deaths occur in least developed countries (LDC) of sub-Saharan Africa (SSA) and Southern Asia [5]. The global target for ending preventable maternal mortality (EPMM) by 2030 is maternal mortality ratio (MMR) lower than 70 maternal deaths per 100,000 live births and not more than 140 per 100,000 live births in countries with very high burdens [6]. Ghana, a SSA country is among countries with high MMR of 310 deaths per 100,000 live births [7].

The major causes of maternal morbidity and mortality are hypertensive disorders of pregnancy, hemorrhage, sepsis, obstructed labor, ruptured uterus and unsafe abortion [2, 3]. Maternal deaths mostly occur around time of birth from obstetric complications [8]. These complications are often unpredictable and estimated to affect 15% of pregnant women [8, 9, 10]. Management of obstetric complications requires specialized care of Emergency Obstetric and Newborn Care (EmONC) [9, 10]. The EmONC is a strategy for reducing maternal and neonatal mortality by focusing on identification, referral and treatment of women with obstetric complications [2]. Maternal mortality and stillbirth rates correlate highly with access to EmONC [2].

In 1994, Thaddeus and Maine introduced the concept of three delays to contextualize factors contributing to maternal mortality from obstetric complications. These delays were delay in decision making to seek care, delay in reaching the health facility and delay in provision of prompt care at the health facility [11]. The second delay, which is due to poor referral transportation to an EmONC facility is most neglected in LDC [12] and known to be responsible for a significant proportion of maternal and newborn deaths in these countries [9]. In Ghana, one in every five births occur at home with no access to skilled attendant especially in rural areas due mainly to poor access to referral transportation [7].

In 2016, Korea International Cooperation Agency (KOICA) supported Ghana to implement a 5-year Primary Health Care (PHC) project titled "Project for improving community-based primary health care through Community-based Health Planning and Services (CHPS) strengthening *(CHPS+)"*. Among other interventions, this project implemented a Community Emergency Transport System (CETS) for maternal care using customized 'motorking' tricycle ambulances. The PHC project was implemented in 120 CHPS zones. CHPS zone is a 'national mechanism to deliver essential community-based health services involving planning and service delivery with communities. It refers to a demarcated geographical area of a 4-kilometer radius and between 4500-5000 persons or 750 households in densely populated areas' [13]. The 120 project CHPS zones were selected with the primary criteria based on quality in terms of equipment and supplies availability, personnel and infrastructure. This strategy obtained the overall measure of quality of each facility, rank them in order of quality and selected the 120 least endowed CHPS zones for project implementation. The overall measure of quality was obtained from principal components analysis (PCA) to extract relevant variation. In all, 249 different indicators of quality of CHPS zones were used in the PCA analysis for CHPS zones with compounds (health facility structure) while 181 different indicators were used for PCA analysis for CHPS zones without compounds [14]. Once the 120 CHPS zones were selected, random sampling into the three intervention arms of Community Health Volunteer (CHV) incentives, Sustainable Emergency Referral System (SERC) or CETS and SERC/CETS with incentives. The random selection was done using the sample command in STATA with stratification by district. CETS was rolled out in a staggered fashion [14]. This paper examined the cost-effectiveness of implementing CETS to strengthen referral transportation system for improved access to emergency maternal care compared to Traditional Transport System (TTS) in rural and impoverished communities in the Upper East region of Ghana.

Materials and Methods

Study Area

This study was conducted in Upper East region of Ghana, located in the northeast corner of the country. It occupies a land mass of 8,842 km^2 (2.7%). The region's projected population in 2020 was 1,302,718 with an annual growth rate of 1.2% and total fertility rate of 4.9. Women in fertility age (WIFA) were 312,652 and annual expected pregnancies was 52,109. The traditional transport system (TTS) in the region comprised of commercial minibuses, taxis, pickup vehicles, private cars, tricycles, motorcycles, bicycles, donkey carts and walking [15].

Study Design

A cost-effectiveness analysis study was conducted on CETS intervention for maternal care. The societal perspective which involved the estimation of both individual women perspective and provider perspective was applied in the analysis. The study evaluated the costs and effects of CETS intervention by measuring the difference in the maternal consequences of referral transportation with use of customized motorking tricycle ambulances and the comparator, TTS. The study measured the incremental cost-effectiveness ratio (ICER), net benefit and incremental net benefit (INB).

Study Population and Sampling Strategy

The study population was all women aged 15 - 49 years with experience of pregnancy within the period January to December 2020 in the 120 CHPS zones of the CHPS+ project in Upper East region of Ghana. This included reference populations that accessed a health facility using a referral transport and excluded referenced populations that did not access a health facility and also did not utilize a referral transport. Using Taro Yamane formula, $n = \frac{N}{1+Ne^2}$ for proportions [16] at a precision level (e) of 0.05 with N, as the population (1,302,718), the sample size estimated was 400. The final sample size was 440 after adding 10% for non-response.

The study adapted the CHPS+ project implementation sampling strategy to select 50 CHPS zones with CETS intervention and 50 CHPS zones with TTS. A multi-staged random selection was used to select at least one community and households from the selected CHPS zones. In each of the selected households, all females aged 15 - 49 years with pregnancy experience between January1 – December 31, 2020, in the household who met the inclusion criteria were selected into the sample until a sample of 5 respondents was achieved. In all 440 respondents constituting the sample were selected made up of 220 CETS and 220 TTS.

Variables and Data Collection

Primary and secondary data were collected. A structured tool was used to collect primary data from respondents at the household level through face-face interviews. The data collected included socio-demographic, means of referral transport to health facility for childbirth and obstetric emergency as well as all Out-Of-Pocket (OOP) payments made during the period. Secondary data on these respondents were extracted from obstetric records at respective health facilities. Data was also extracted from project records and ambulance logs. Data were collected using an electronic platform, KoBoCollect.

Cost data on CETS intervention was extracted from project records and reports. The capital costs made up of purchase price of customized motorking tricycle ambulance, vehicle registration with Vehicle Driver Licensing Authority (VDLA) and recurrent costs including insurance premium were extracted from project accounting. The recurrent costs of maintenance/repair cost, fuel cost, driver's allowance/time, incentives, mobile phone communication cost and cost of logistics provided in tricycle ambulance were extracted from ambulance logs. Respondents provided cost information on transportation, caregivers, and medical services at the household level. Medical costs were also extracted from the health facility records. The costs were estimated for both CETS and TTS.

Data Analysis

STATA 15.0 was used for data analysis and both descriptive and inferential analysis were carried out. The descriptive analysis was conducted on socio-demographic variables, obstetric care variables and transportation and communication variables. The results were presented with p-values to measure the significant differences between variables of interest. The Pearson Chi-Square statistical procedure was used to determine association between variables. The inferential analysis was carried out to determine factors that were associated with households' increased ICER and net benefit.

Measurement of Health Effects

The health effects to the respondents in both intervention and comparator areas was the number of complications detected and attended to at health facilities which was represented as Maternal Near Miss (MNM). We used the adapted sub-Saharan Africa criterion to classify MNM [17].

The maternal complications were severe pre-eclampsia/eclampsia, prolong labor, cephalo-pelvic disproportion, antepartum hemorrhage, severe anemia, blood transfusion, cord prolapse, emergency caesarean section, postpartum hemorrhage, hysterectomy, and abortion complications. Women who met the outcome criterion were classified as 'effective transfers' and all other women were 'non-effective transfers' for both CETS and TTS. Thus, the health effects (outcome) to the respondents in both CETS and TTS areas were the number of MNM cases detected and transported to health facilities (effective transfers) to avert maternal death.

Measurement of Costs

Mean costs were used for the analysis. The individual (patient) cost analysis involved the summation of direct medical costs and direct non-medical costs. The direct medical cost involved OOP for delivery (Delivery costs) and complications (Treatment of complications) related costs. Direct non-medical costs included OOP for transportation to and from health facility (patient transport cost) and caregiver transport cost (Caregiver cost) during care for the woman at the health facility. The provider costs included CETS intervention costs such as motorking tricycle ambulance cost, Servicing/Maintenance cost of ambulances, tricycle ambulance insurance premium per year, Tricycle ambulance registration cost by Driver Vehicle Licensing Authority, training of riders/drivers cost, driver call credit, driver incentive and other related running cost. Capital cost (cost of motorking tricycle ambulances) was annualized by discounting to allow for differential timing of capital costs over the useful life, thus obtaining equivalent annual cost. A discount rate of 3% and a useful life of 5 years was used to compute the equivalent annual cost. A discount rate of 3% was chosen, which is usually the rate used in most economic evaluation studies conducted in developing countries [18, 19] and based on expert opinion and literature review, a useful life of 5 years was used for motorking tricycles [18, 20]. Annual equivalent cost of the capital cost was estimated by dividing the total cost (GH₵967,750) of motorking ambulances by the annuity factor (4.58). The annuity factor was obtained from annuity table [18, 21] and using 3% discount rate and 5 years useful life. The mean provider cost and the individual cost were used.

Cost-effectiveness Analysis

Cost-effectiveness analysis compared the incremental difference in costs to the incremental difference in effectiveness [3]. The incremental cost-effectiveness ratio (ICER) was used to compute the cost-effectiveness of the

CETS intervention. The ICER is expressed as the ratio of the difference in cost to the difference in effect between the two comparators as presented in the formula:

$$ICER = \frac{(Mean\ cost\ of\ A - Mean\ cost\ of\ B)}{(Mean\ effect\ of\ A - Mean\ effect\ of\ B)}$$

where A is the CETS intervention and B is the TTS comparator.

To determine the cost-effectiveness of an intervention, ICER needs to be compared with a threshold. The cost-effectiveness threshold or maximum acceptable Willingness-to-pay [WTP] set prior to the study was Ghana's GDP per capita for 2020 = USD2,254.15 [22] as recommended by WHO [23]. Using the 2020 average exchange rate of 1USD = GH₵4.9, the GDP per capita was converted to GH₵11,045.34. An intervention is considered cost-effective if ICER is below a set threshold.

Net Benefit Framework Analysis

The net benefit regression analysis was done using the ordinary least square (OLS) regression to estimate incremental net benefit (INB) of CETS intervention. The mean costs and effects for both CETS and TTS were used in the regression equation. With this analysis, confounders of cost-effectiveness were controlled. The net benefit framework used linearization of ICER, thus

$$\frac{\Delta C}{\Delta E} = ICER$$

where ΔC was incremental cost and ΔE incremental effect. ICER was replaced by a ceiling ratio, R_o (R_o is maximum acceptable willingness to pay, and in this case R_o = GDP per capita for Ghana in 2020, » $\Delta C = \Delta E * R_o$. The net benefit statistic was computed as, $\Delta E * R_o - \Delta C = \Delta NB$. For an individual, the net benefit statistic was, $NB_i = \Delta E_i * R_o - \Delta C_i$. This equation was similar to the traditional regression equation,

$$Y_i = \alpha + \beta CET_i + \delta'^{X_i} + \varepsilon_i$$

where Y was the dependent variable; δ was a vector of parameters estimated as coefficient of explanatory variable, CET in the intervention was a dummy variable that took a value of 1 for a pregnant woman who used CETS and 0 for a pregnant woman who used TTS arm, X was a vector of covariates of the woman, α was the intercept (constant) and ε was the error term [24]. The effect of CETS was estimated by β, as incremental net benefit of CETS. The results were interpreted as follows: If the coefficient, β is positive or > 0, then the incremental benefit for additional one unit of effectiveness is below the ceiling ratio, R_0, the intervention (CETS) will be deemed cost-effective compared to the TTS comparator. Similarly, if the coefficient, β is negative or < 0, then the incremental cost for additional one unit of effectiveness is above the ceiling ratio, R_0, and the standard, comparator (TTS) will be deemed more cost-effective than the intervention. The independent variables associated with increased net benefit were adjusted to determine their impact on the probability that CETS was cost-effective. Net benefit sensitivity analysis was done by varying GDP per capita (WTP) from 0-50,000 representing an increase and decrease in GDP per capita and the effect on net benefit determined.

Factors Associated with Households' Increased ICER and Net-Benefit

To determine the factors that were associated with households' increased ICER, Ordinary Least Squares (OLS) regression was used. The outcome variable was ICER (continuous variable) and the independent variables were intervention area (dummy variable, 1=Intervention; 0= No intervention), education (categorical variable), occupation (categorical variable) and distance (categorical variable).

In addition, factors associated with households' increased net-benefit were determined using OLS regression. The outcome variable was net benefit (continuous variable) and the independent variables were intervention area (dummy variable, 1=Intervention; 0= No intervention), education (categorical variable), occupation (categorical variable) and distance (categorical variable).

Sensitivity Analysis

A one-way sensitivity analysis was conducted to determine whether changes to important variables will significantly change the results. In doing so, discount rates were varied to determine the effects on ICER. This was carried out to test the extent to which the uncertainty in the ICER value was attributable to the impact of discount rates on the parameter. A discount rate of 0%, 6% and 10% were used for the sensitivity analysis. Net benefit sensitivity analysis was done to ascertain the extent of uncertainty in the net benefit resulting from variations of WTP value. WTP represented as 2020 GDP per capita for Ghana, was varied from 0 to GHC50,000.

Results

Socio-demographic Characteristics

Primary data on 416 respondents made up of 214 (51.4%) CETS and 202 (48.6%) TTS were analysed. The ages of respondents ranged from 15-45 years with a mean of 27.4±6.4 years for CETS respondents compared to 15-47 years with a mean of 27.3±6.4 years for TTS respondents. Almost all the respondents (97.7% CETS and 98.0% TTS) were married. Majority of respondents were Christians. Over two-fifths of the respondents (40.2% CETS and 42.0% TTS) had no formal education and only 9.4% CETS and 6.4% TTS respondents had tertiary education. The most common occupation for both CETS and TTS respondents were farming and then trading. Ethnic composition of respondents was different ($p<0.001$) between CETS and TTS respondents. Fundamentally, respondents from both CETS and TTS were similar with respect to socio-demographic characteristics except for ethnic composition.

Physical Access and Means of Referral Transportation to EmONC Facilities

The main means of referral transport to health facility for childbirth was motorking tricycle ambulance (78.4%) for CETS women compared to motorbike (56.3%) for TTS women. The difference in referral transport for childbirth between the two groups was statistically significant ($p<0.001$). Similarly, the means of transport during obstetric emergency was motorking tricycle ambulance (60.6%) for CETS respondents and motorbike (73.6%) for TTS respondents. The variation in utilization of means of referral transport for obstetric emergency was statistically significant ($p<0.001$). About 70% of respondents in both CETS area and TTS area lived within 5 kilometres of an EmONC health facility.

Health Effects for CETS and TTS Respondents

MNM was used as the effectiveness indicator and in all, there were 47 MNM that affected 11.3% of respondents. These constituted effective transfers of 25 (53.2%) health effects for CETS women and 22 (46.8%) health effects for TTS women (Table 1).

Table 1. Effects of the Intervention and Comparator Women

Variable	Category	Total health effects (n)	Intervention (n)	Comparator (n)
Type of complication and critical intervention	Severe pre-eclampsia/ Eclampsia	5	1	4
	Severe Pre-eclampsia/Eclampsia &C/S	5	3	2
	Prolong labour, CPD & C/S	2	2	0
	APH &C/S	2	1	1

	Severe Anemia + Blood transfusion	10	7	3
	C/S + PPH + Blood transfusion	1	1	0
	Cord prolapse+ C/S	1	1	0
	Emergency caesarean section	19	8	11
	Ruptured uterus + C/S + hysterectomy	1	0	1
	Septic Abortion	1	1	0
Total Health Effects		**47**	**25**	**22**

C/S- Caesarean section; CPD- Cephalo-Pelvic Disproportion; APH- Antepartum Hemorrhage; PPH- Postpartum Hemorrhage

Cost of CETS Intervention and TTS Comparator

The average provider cost (CETS intervention cost) was GH₵1,732.53. The total individual average cost for women in CETS intervention group was GH₵121.81 and those in TTS comparator group was GH₵168.45. Overall, the mean societal cost for the intervention and the comparator were GH₵1,847.51 and GH₵168.45 respectively with the intervention more costly by GH₵1,679.06. In both the CETS and TTS arms, the cost of treating complications represented the highest cost component of the individual cost (Table 2).

Table 2. Cost of the Intervention and the Comparator

Cost variables	Intervention (Mean, GH₵)	Comparator (Mean, GH₵)
Average intervention/provider cost*	1,732.53	-
Individual cost		
Cost of delivery	99.16	129.58
Treatment for complications	218.33	410.00
Transport cost	23.55	27.25
Caregiver cost	131.67	75.00
Mean total cost	***121.81***	***168.45***
Overall mean cost	***1847.51***	***168.45***

*The average cost is the total cost of intervention divided by the number of women in the intervention arm(N=214). GH₵4.9 = 1USD

Cost-effectiveness Estimation

Based on the incremental cost of GH₵1,679.06 and the incremental effect of 3, the corresponding ICER was GH₵559.69 (114.22 USD). The ICER was the additional resources required per additional maternal near miss (obstetric complication) case to be transported to a health facility for treatment (effectiveness). The net benefit of CETS was GH₵31,456.96 (USD6,419.79) (Table 3).

Table 3. Cost-Effectiveness Estimates

Group variables	Mean
Overall analysis	-
Comparison district (N = 202)	-
Cost (GHC)	168.45

Effect	22
Intervention district (N = 214)	-
Cost (GHC)	1847.51
Effect	25
Incremental Cost (GHC)	1,679.06
Incremental Effect	3
ICER	**559.69**
WTP=GDP per capita	11,045.34
Net Benefit*	31,456.96

*Net Benefit= (Incremental Effect * GHC11,045.34)- Incremental cost. GH₵4.9 = 1USD

Effects of Covariates on the Overall ICER of CETS Intervention

The regression results on the association between women background characteristics and the ICER showed that variables of intervention area, education, distance to health facility and occupation explain about 95% (R square=0.9494) of ICER (Table 4). The intervention Area (*p* < 0.01) and education (p < 0.05) were the statistically significant variables that determine change in ICER.

Table 4. ICER Regression Estimates with Covariates

ICER	Coefficient	Std. Err.	P-Value	[95% Conf. interval
Area				
Comparator (B)				
Intervention	667.54	7.07	0.00***	653.64, 681.43
Education				
No education(B)				
Middle/JHS	-7.66	9.93	0.44	-27.18, 11.86
Primary	-1.55	6.37	0.81	-14.07, 10.98
SHS/Vocational	13.18	20.49	0.52	-27.09, 53.45
Tertiary	69.89	30.23	0.02**	10.47, 129.32
Distance				
Less than 1 km(B)				
1-5 km	-13.99	9.76	0.15	-33.17, 5.18
Above 5 km	-8.77	11.87	0.46	-32.10, 14.57
Don't know	-47.68	44.43	0.28	-135.03, 39.67
Occupation				
Housewife(B)				
Artisan	-22.48	23.41	0.34	-68.50, 23.53
Farming	10.76	15.75	0.50	-20.21, 41.72
Formal/salaried employee	-32.23	28.58	0.26	-88.41, 23.94
Trading	2.49	14.41	0.86	-25.84, 30.82
_cons	-46.74	19.85	0.02	-85.76, -7.72

* p < 0.1, ** p < 0.05, *** p < 0.01; B represents the base category

ICER Sensitivity Analysis

Sensitivity analysis showed that using a discount rate of 0% (no discounting of intervention cost), resulted in an ICER value of GH₵1,737.96 which is lower than the cost-effectiveness threshold. An increase in discount rate from 0% to 3% resulted in a reduction of ICER value to GH₵559.69 which presented the intervention to be more cost-effective. However, when the discount rate was increased from 3% to 10%, ICER value increased slightly from GH₵559.69 to GHC628.29, still cost-effective but suggested that ICER is sensitive to discount rate and increasing discount rate increases ICER (Table 5).

Table 5. ICER Sensitivity Analysis

Sensitivity parameters	**Intervention**		**Comparator**		**Incremental**		**ICER**
Discounting	Costs GH₵	Ben	Costs GH₵	Ben	Costs GH₵	Ben	
0%	5382.33	25.00	168.45	22.00	5213.88	3.00	1737.96
3%	1847.51	25.00	168.45	22.00	1679.06	3.00	559.69
6%	1934.29	25.00	168.45	22.00	1765.84	3.00	588.61
10%	2053.32	25.00	168.45	22.00	1884.87	3.00	628.29

Ben= Benefit; GH₵4.9 = 1USD

Net Benefit Framework Analysis

The net benefit analysis showed that CETS intervention was statistically significant (p <0.01) but the coefficient of the CETS intervention dummy, INB was -2002.6, a value less than zero (Table 6), controlling for covariates of education, distance to health facility, and occupation in the model. This suggests the intervention is not cost-effective when these covariates are included in the model.

Table 6. Net Benefit Regression Estimates with Intervention and Covariates

Net Benefit	**Coefficient**	**Std. Err.**	**P-Value**	**[95% Conf. Interval]**	
Area					
Comparator (B)					
Intervention	-2002.61	21.20	0.00***	-2044.29	-1960.92
Education					
No Education (B)					
Middle/JHS	22.98	29.79	0.44	-35.59	81.55
Primary	4.65	19.12	0.81	-32.93	42.22
SHS/Vocational	-39.53	61.46	0.52	-160.35	81.28
Tertiary	-209.68	90.68	0.02**	-387.95	-31.41
Distance					
Less than 1 km(B)					
1-5 km	41.98	29.27	0.15	-15.55	99.51
Above 5 km	26.31	35.61	0.46	-43.70	96.31
Don't know	143.04	133.30	0.28	-119.01	405.08
Occupation					
Housewife(B)					
Artisan	67.45	70.22	0.34	-70.59	205.49
Farming	-32.27	47.25	0.50	-125.17	60.62
Formal/salaried employee	96.70	85.73	0.26	-71.83	265.23

Trading	-7.46	43.23	0.86	-92.45	77.53
_cons	6902.68	59.55	0.00	6785.61	7019.74

* p < 0.1, ** p < 0.05, *** p < 0.01; B represents the base category

Net Benefit Sensitivity Analysis

Net benefit sensitivity analysis was done to ascertain the extent of uncertainty in the net benefit resulting from the WTP value. As the WTP value increases, the net benefit value increases and vice versa (Table 7). Thus, net-benefit was sensitive to values of WTP.

Table 7. Net Benefit Analysis with Varying Ceiling Ratios (WTP=GDP per Capita)

	Intervention			**Comparator**		**Incremental Cost (GH₵)**	**Incremental Benefit**	**Net Benefit**
	WTP (GH₵)	**Cost (GH₵)**	**Benefit**	**Cost (GH₵)**	**Benefit**			
R0	0	1847.51	25	168.45	22	1679.06	3	-1,679.06
R1	5,000.00	1847.51	25	168.45	22	1679.06	3	13,320.94
R2	10,000.00	1847.51	25	168.45	22	1679.06	3	28,320.94
R3	15,000.00	1847.51	25	168.45	22	1679.06	3	43,320.94
R4	20,000.00	1847.51	25	168.45	22	1679.06	3	58,320.94
R5	25,000.00	1847.51	25	168.45	22	1679.06	3	73,320.94
R6	30,000.00	1847.51	25	168.45	22	1679.06	3	88,320.94
R7	35,000.00	1847.51	25	168.45	22	1679.06	3	103,320.94
R8	40,000.00	1847.51	25	168.45	22	1679.06	3	118,320.94
R9	45,000.00	1847.51	25	168.45	22	1679.06	3	133,320.94
R10	50,000.00	1847.51	25	168.45	22	1679.06	3	148,320.94

*Net benefit= (Incremental benefit * WTP)- Incremental cost; GH₵4.9 = 1USD

Discussion

This study evaluated the cost-effectiveness of CETS intervention in comparison to TTS comparator. The socio-demographic characteristics of women in both CETS and TTS areas were fundamentally the same. Additionally, about 70% of the women in both CETS and TTS areas were resident within 5 kilometers of an EmONC facility. Therefore, majority of the women in the study had good access to obstetric services in accordance with Vanden Broek et al. [25]. However, there was statistically significant difference between women in CETS areas and those in TTS areas with respect to type of referral transport used to access health facility care during childbirth and treatment of obstetric complications. Whilst the women in CETS area used mostly motorking tricycle ambulances, the women in TTS mostly used motorbikes to health facilities for both childbirth and management of obstetric complications. The high patronage of motorking tricycle ambulance by pregnant women in CETS areas implied acceptance of this mode of referral transportation in comparison to the motorbike. This finding was comparable to that in Malawi where customized motorcycle ambulance was found to be more affordable means of referral transportation conveying large numbers of women from primary health facilities to district hospitals compared to 4-wheel ambulance [9].

In this study, the incidence of MNM was 11.30% compared to Ethiopian studies that reported 16.1% and 20.8% [26 and 27]. This proportion was lower than the estimated 15% of pregnant women likely to have obstetric complications [8-10]. Women in CETS area had slightly more MNM than women in TTS area but the cost of treating obstetric complications was higher in TTS women. The higher treatment cost for TTS women could be due to worsen state of complications before arrival at the health facility due to delays with TTS means of referral transportation due possibly to cost compared to CETS which was free for the women.

The estimated ICER for CETS was GH₵559.69 (114.22 USD). This value was lower than Ghana's 2020 GDP per capita of GH₵11,045.34 (2,254.15 USD), the a priori cost-effectiveness threshold of the study. CETS was therefore deemed a cost-effective intervention [23]. The Gini index of Ghana in 2020 was 0.44 corresponding to high income disparity, making GDP per capita ineffective especially to the ordinary person [28]. According to WHO guide to cost-effectiveness analysis, an intervention with ICER less than USD150 is attractive [23]. CETS intervention was thus considered an attractive intervention since ICER was less than USD150. Furthermore, the intervention area, covariates of education, distance to health facility and occupation explained 95% (Coefficient of determination, R square =0.9494) of ICER. This measured the correlation between the dependent and the independent variables and explained how much of the variability in the dependent variable was due to the independent variables. Since the R square was higher than 80%, it corresponds to a perfect goodness of fit [29]. Furthermore, the intervention area and education covariate were statistically significant variables that determined change in ICER of CETS. The relationship between the regression model and the dependent variable (ICER) was therefore perfect since almost all the variance in ICER is predictable by covariates of intervention area, education, distance to health facility and occupation collectively [30, 29]. The one-way sensitivity analysis on ICER showed that the ICER was sensitive to the discount rate with a positive correlation. The discount rate was therefore a source of uncertainty in the estimated ICER value. This finding was comparable to that of Bae et al. where discount rate was reported as the second highest structural uncertainty that impacted ICER in the evaluation of uncertainties in the pharmacoeconomic dossiers [31]. The discount rate as used in the estimation of ICER in this study was therefore an important source of uncertainty in VfM evaluation [32] and needs to be considered in decision making on cost-effectiveness of CETS.

The estimated net benefit of CETS which was the difference in benefit between CETS and TTS was GH₵31,456.96 (USD6,419.79). Since the net benefit was greater than zero, then CETS was superior and more beneficial than TTS [24]. Additionally, the net benefit regression analysis found that CETS intervention was statistically significant ($p<0.01$).

However, the INB, the coefficient of CETS intervention dummy was less than zero (-2002.61) implying the incremental cost of CETS was above the maximum acceptable provider WTP (Ghana's GDP per capita for 2020, USD2,254.15). Since the INB estimated the difference in value between extra benefits and extra costs of CETS and TTS and that value was -2002.61, the intervention was considered not cost-effective by INB [24, 33, 34, 35]. These covariates therefore had confounding effect on cost-effectiveness of CETS [36]. Consequently, by INB, TTS was deemed more cost-effective than CETS based on higher cost compared to health benefit gained [24, 33, 37, 38, 39]. In this study, net benefit was also sensitive to WTP with positive correlation. WTP was therefore a potential source of uncertainty in the estimated net benefit value [33, 38]. The ICER and INB methods were used to compute cost-effectiveness of CETS in this study. The ability of net benefit approach to address uncertainties associated with ICER by adjusting or controlling for confounding variables make it superior to ICER [38]. The INB value of -2002.61 was therefore equivalent to ICER value of 559.69 except that INB value was adjusted by addressing for confounding variables [36, 40].

Limitations of the study

The limitations of this study were recalled bias from respondent and some poor documentation in secondary data sources. However, we belief that the probing techniques used in collecting data reduced the recall bias. Additionally, the assumption that the decision making to seek care at health facilities and quality of care at the health facilities were same for women in both CETS and TTS areas could be incorrect. Furthermore, there was element of some contamination in the comparator area where some women used motorking tricycle ambulance which was exclusive for CETS area, and this could have suppressed the effects of the CETS. Notwithstanding, we belief the limitations had minimal effect and the results are robust, comparable, and relevant for policy decisions.

Conclusion

An economic evaluation of a new intervention is important to determine its value-for-money before adoption to ensure prudent use of scarce health resources. The CETS intervention was cost-effective by ICER and had high positive net benefit. Based on the foregoing, CETS intervention is recommended for adoption. However, the incremental net benefit (INB) revealed that CETS intervention was not cost-effective since the incremental cost was above the maximum provider willingness to pay. There was therefore a conflict between ICER and INB on the cost-effectiveness of CETS intervention. Affordability of the new intervention within the context of the specific health system should be considered in policy decisions for such situations where ICER and INB conflict with respect to cost-effectiveness.

Declarations

Author Contribution Statement

WKO conceived and designed the study. WKO, POA and BA conducted the study. MAD, WKO and POA analyzed and interpreted the data. WKO, POA, MAD, BA, JK and TA contributed resources, materials, analysis tools or data. All authors read and revised the manuscript and gave final approval of the manuscript.

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Data Availability Statement

The datasets used and analyzed during the current study are available upon reasonable request.

Ethical Approval

Ethical approval was obtained for the study with number GHS-ERC:016/01/22 from the Ghana Health Service Ethics Committee.

Declaration of Interest Statement

The authors declare that they have no competing interest.

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