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Critical factors associated with postpartum maternal death in Ethiopia

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Abstract

Background

Globally most maternal deaths occur during the postpartum period; however, the burden is disproportionately higher in some Sub-Saharan African countries including Ethiopia. According to Ethiopian Ministry of Health's annual report, in 2019 alone, nearly 70% of maternal deaths happen during the postpartum period. Although several studies have been conducted on postpartum maternal deaths in Ethiopia, most of the studies were focused either on individual-level or district-level determinants with limited emphasis on the timing of death and in relatively small and localized areas. Therefore, this study aimed at identifying the determinants of postpartum death both at an individual and districts level, which could shed light on designing pragmatic policies to reduce postpartum maternal death.

Methods

The study utilized secondary data obtained from the Ethiopian maternal death surveillance system. A total of 4316 reviewed maternal death from 645 districts of Ethiopia were included in the analysis. A multilevel multinomial logistic regression model was applied to examine factors significantly associated with postpartum maternal death in Ethiopia.

Result

The findings revealed that 65.1% of maternal deaths occurred during the postpartum period. The factors associated with postpartum death included previous medical history (history of ANC follow up and party), medical causes (obstetrics haemorrhage, hypertensive disorder of pregnancy, pregnancy-related infection, and non-obstetrics complication), personal factors (poor knowledge of obstetrics complication), and facility-level barriers (shortage of life-saving maternal commodities and delay in receiving treatment).

Conclusion

Almost seven in ten maternal deaths happen during the postpartum period. The rate was even higher for some women based on their previous medical history, level of awareness about obstetrics complication, medical conditions, as well as the readiness of the health facility at which the women was served. Since the postpartum period is identified as a critical

time for reducing maternal death, policies and actions must be directed towards improving health education, ANC service utilization, and facility-level readiness.

Introduction

Maternal death is the death of a woman while pregnant or within 42 days of termination of pregnancy [1]. Globally, between 2000 to 2017, the maternal mortality rate (MMR) dropped by 38% from 451,000 to 295,000. Despite this great reduction in MMR, it remains significantly high in low- and middle-income countries. Sub-Saharan African countries account for approximately 60% of the estimated global maternal deaths in 2017 [2]. To address this and other global development gaps, a new global strategy has been set in 2015 called the Sustainable Development Goal (SDG) which was aimed to replace the Millennium Development Goal (MDGs) that culminated in 2015. The SDG considers maternal mortality as one of the global health indicators and sets a target to reduce global maternal mortality to fewer than 70 deaths per 100,000 live births by 2030 [3].

In Ethiopia, the absolute number of maternal deaths has decreased by 55% from 31,000 in 1990 to 14,000 in 2017 [2, 4]. The country has made tangible strides in reducing maternal mortality in the last two decades. The MMR has declined from around 871 deaths in 2000 to 401 deaths in 2017; despite this achievement, there is noticeable variation among regional states [5–7]. Due to these regional variations the country has failed to achieve one of the MDGs goals, which had a target of dropping MMR to 267 in 2015 [4].

Intending to provide real-time data on the patterns and trends of preventable maternal death, Ethiopia established maternal death surveillance and response system (MDSR) in 2013 [8]. MDSR is a continuous process of identifying maternal deaths, gathering information on their cause and determinants, and analyzing the data to avert similar deaths in the future [9]. Moreover, using the evidence generated, different measures are being taken in different settings. At a health facility level, the actions are aimed at addressing provider-related barriers (skills, medical supplies, and referral mechanisms) [10], while at a higher level the focus is on interpreting patterns and trends in maternal deaths. It also facilitates decisions on targeting resources to reduce inequities and improve public awareness and health-seeking behaviour [11]. In line with this, maternal death has become one of the compulsory notifiable events under the Ethiopian public health surveillance system [12].

Along with the establishment of MDSR, Ethiopia has launched various initiatives to reduce preventable maternal death, which include the construction of maternity waiting rooms (MWRs) around health facilities [13, 14], utilization of non-pneumonic anti-shock garments (NASG) during referral [15, 16], and availability of free transport and maternity services [17]. However, despite all these efforts and interventions, MMR remains to be unacceptably high in Ethiopia [18].

Understating the timing of maternal death has paramount importance in planning health programs and setting priorities [19]. The timing of maternal death has three-time windows classified based on labour and delivery. These are; 1) death that happened before the onset of labour (antepartum death), 2) death that happened during the onset of labour (intrapartum death), and 3) death occurring after delivery (postpartum death) [20].

Globally, 57% of maternal deaths occur after the delivery, i.e during the postpartum period, however, there is a notable variation across countries [20, 21]. Among the postpartum deaths, the majority of the maternal deaths occur within 24 hours of childbirth, followed by death within seven days of delivery and from two to six weeks after childbirth, each accounting for 50%, 20%, and 5% of maternal mortality, respectively [22]. Similarly, in Ethiopia, most

maternal deaths occurred during the postpartum period with an estimated range from 51% to 75% of the total reported deaths [23–25].

Research findings have demonstrated that most maternal deaths occur during the postpartum period [20, 21, 25]. Postpartum maternal death has a connection with maternal service provision during the antepartum and intrapartum periods [26]. The maternal services include ANC visits, which play an integral role in screening, diagnosing, and managing potential maternal and child health threats such as anemia, malaria, worm infestation, HIV, and pre-eclampsia [27]. Besides, it has a pivotal contribution to safe delivery [28]. Similarly, intrapartum care also has a crucial role in maternal health, and it has a direct relation to facility-level readiness such as diagnosis of labour, ensure of clean delivery techniques, early detection, and referral of maternal complications [29]. The utilization and provision of both services have a cumulative impact on postpartum maternal death, and it is related to the quality of maternity service provision [30]. The quality of maternal service is largely dependent on the availability of trained personnel, essential maternal health commodities, and physical infrastructure [31]. The combination of factors such as service provision during the antepartum and intrapartum period in line with the quality of care makes the postpartum period the critical time for maternal survival and wellbeing [32].

Overall, the timing of maternal death is influenced by medical causes and contributing factors [33–35]. Haemorrhage, hypertensive disorder of pregnancy (HDP), severe anaemia unrelated to haemorrhage, and obstetric infection are the commonest cause of maternal death during the postpartum period [36–38]. However, medical factors are not the only factors that determine postpartum maternal death, it could as well be affected by facility-level readiness [39, 40], referral-related barriers [41, 42], and birth preparedness and complication plan of the women [43].

Several studies were conducted on maternal death in Ethiopia; however, none of the studies used both individual factors (medical factors and level of birth preparedness) [44–47], and facility-level factors (on barriers related to referral and services provision) [48, 49] simultaneously. In addition, most of the studies were conducted in a small geographical area with limited emphasis on postpartum maternal death. Nevertheless, the timing of maternal death is influenced by both individual and community-level factors. Thus, this study aims to identify the determinants of postpartum maternal death both at an individual and facility-level among reviewed maternal deaths across Ethiopia.

Methods

Study setting

This study is conducted in Ethiopia, which is in the horn of Africa. The country's population is generally categorized as city-based population, pastoralists, and agrarian. Ethiopia is one of the most populous countries in the continent, with a total population of more than 114 million, of which 34% (above 39 million) are women of the reproductive age group [50]. Most of the population, around 83%, lives in rural areas, while the remaining 17% resides in urban areas. The average household size in Ethiopia is 4.7 persons, although with notable variations among regions [51]. The country has a high neonatal, infant, and child mortality rate, averaging 30, 43, and 55 deaths per 1000 livebirth, respectively [52].

Data source and study participant

The study used data from Ethiopian Public Health Institutes (EPHI). It utilized an updated programmatical and epidemiological review of maternal death data obtained from all MDSR implementing regions for seven consecutive years (2013–2020).

The source population for this study is all mothers who were deceased due to pregnancy and related complications and reviewed by the MDSR committee during the study period. Accordingly, a total of 4316 reviewed maternal death were included in the study. The death review was conducted by the established maternal death review committee at each health facility within the 645 districts of Ethiopia.

Death identification and reporting

Population under surveillance. All women of the reproductive age group in Ethiopia are eligible for the surveillance system.

Case definition

The surveillance data is reported to the next level using pre-defined case definitions implemented in facility and community settings [53].

A. **Community case definition** (probable maternal deaths): Death of a woman of reproductive age group (between 15–49 years of age)

B. **Suspected maternal deaths:** Community case definition plus at least one of the following screening questions

   ✓ Died while pregnant

   ✓ Died within 42 days of termination of pregnancy or

   ✓ Missed her menses before she died

C. **Standard case definition**: Death of a woman while pregnant or within 42 days of the end of pregnancy (Irrespective of duration and site of pregnancy), from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes [53, 54].

Investigation and verification of death. After the death is distinguished using the above case definitions, it proceeds to the next step, which is the investigation and verification of death by the health extension workers at the community level; while, at a health facility level, public health emergency management (PHEM) focal person is responsible. Following that, a verbal autopsy is utilized to investigate and verify the community death. The investigation only proceeds after taking verbal consent from the family of the deceased woman. However, the facility-based abstraction format (FBAF) is utilized for facility deaths [53].

Review of death. Each completed verbal autopsy and facility-based maternal death abstraction must go through the review process by an established MDSR committee at the health facility. After the review, the death is reported to the next level using a case-based reporting format [53].

Study variables

Outcome variables. The dependent variable is the time of death relating to delivery. The multinomial dependent variable was classified as "Antepartum" (decreased before delivery), "Intrapartum" (decreased during delivery), and "Postpartum" (decreased after delivery).

Exposure variables. The selection of potential predictors of the time of death was based on previous literature and the availability of variables in reviewed case-based reports. An attempt was made to test all potentially relevant variables that existed on the nationally aggregated maternal death data before including/excluding them in the final model. Accordingly, all variables which showed a statistical significance or some sort of trend during bivariate analysis

were included in the analyses. Potential predictors were then categorized into two groups: individual-level predictors and district-level predictor variables.

Individual factors such as age at death, education level, religion, history of antenatal follow-up, parity, place of death, the medical cause of death (MCOD), and the non-medical cause of death (only delay one) were included in the study. The MCOD was assigned using the standard world health organization (WHO) tool of the International statistical classification of diseases and related health problems, the tenth revision (ICD-10), which was adopted for deaths during pregnancy, childbirth, and the puerperium [55]. The assigned cause of death for each reviewed maternal death was grouped based on underlying causes of death during pregnancy, childbirth, and the puerperium which were mutually exclusive from one another. Moreover, delay one, which is associated with delay in seeking care, was measured by 5 item questioners that include: 1) visited a traditional healer or traditional birth attendant first 2) the family had insufficient money 3) lack of awareness of obstetric complications 4) nearest healthcare facility was more than 1 km away 5) lack of decision to health facility due to perceived poor quality of care at health service. Responses to delay one questions were binary recoded "1" for Yes and "0" for No.

District-level factors include residence (urban and rural), contextual regions, delay two, and delay three. The 11 regions of Ethiopia are delineated for administrative purposes, and in this study, they were re-categorized into three contextual regions: pastoralist, agrarian, and city (which were defined based on the cultural and socio-economic backgrounds of their population) [56]. Delay two, which is indicative of delay in reaching a healthcare facility, was assessed using 5 item questions that include: 1) poor road condition or terrain 2) long travel time from home to a healthcare facility (more than an hour) 3) cost of transportation 4) lack of transportation and 5) no healthcare facility in the area (takes more than one hour to reach the healthcare facility). Furthermore, delay three, which is suggestive of delay in receiving care at the healthcare facility, was assessed using 4 item questions: 1) long travel time from health facility to health facility (which is usually related to inadequate referral system described through unavailability of ambulances, lack of fuel, technical failure of the ambulance while in service, and the use of public transport) 2) shortage of equipment and supplies 3) delay in management (service provision) after admission (more than 30 min from the time of arrival to the time of being assessed or receiving treatment) and 4) wrong assessment of risk, wrong diagnosis, and treatment.

Data analysis

Descriptive analysis. Descriptive statistics were conducted for the individual and district-level variables and are reported as frequency and percentage. Furthermore, to examine the crude association between the individual and community-level factors separately with a distinct time of death, p-values were calculated using Pearson's chi-squared test. A p-value of less than 0.05 was set for the statistical significance of an association.

Multivariate multilevel analysis. Two-level mixed-effects logistic regression analyses were employed using STATA version 17. The surveillance data was hierarchical, i.e., deceased women were nested in reporting facilities, and similarly reporting facilities were nested in districts. As a result of the nature of the data, mothers within the same district may be more similar to each other than mothers in the rest of the country. By considering the clustering effect, initially, a bivariate two-level mixed-effects logistic regression analysis was done to assess the association between the independent variables and the dependent variable of the study. The overall categorical variables with a p-value of <0.25 at the bivariate two-level mixed-effect logistic regression analysis were included in the final model of the multivariate two-level

mixed-effects multinomial logistic regression model, in which the relative risk ratio(RRR) with 95% confidence intervals were estimated to identify independent variables of time of death of the deceased women [57]. P-values less than 0.05 were employed to declare statistical significance. Fixed effect and random effect were calculated to assess the individual and district variations, respectively. For the multilevel multinomial logistic regression analysis, the Stata 'gsem' syntax was employed [58]. Thus, four models were utilized in this analysis, the empty model (model containing no factors), Model I (containing only individual factors), Model II (containing only districts factors), and Model III (both individual and district-level factors). The fitted model was:

$$\log[y_{ij} - s/p(y_{ij} - postpartum)] - X\beta^{(s)} + u_{oj}^{(s)},$$

where,

yij is the time of death for the deceased woman I who resided in district J.

S is the outcomes (antepartum, intrapartum, and postpartum).

X is the matrix of independent variables at both individual and district levels.

β(s) is the effect size of each independent variable on the probability of women dying during antepartum and intrapartum

μoj(s)is a constant term and cross-level interaction term.

The intra-class correlation (ICC) was calculated as the proportion of the between cluster variation in the total variation:

$$ICC = \frac{Var(Uoj)}{Var(Uoj) + \pi^2/_3}$$

Where Var (Uoj) is community-level variance and $\pi^2/_3$ is individual-level variance (VI) equal to 3.29. The ICC takes a value between 0 and 1 and a high ICC value indicates that neighbourhoods are important in understanding individual differences in postpartum [59]. The MOR is defined as the median value of the odds ratio between the area at highest risk and the area at the lowest risk when randomly picking out two areas and it depends directly on the area-level variance [60]. It can be calculated using the following formula:

$$MOR = (exp\sqrt{2\ X\ Var(Uoj)X\ 0.6745}) \approx \exp\ (0.95\sqrt{Var(Uoj)}$$

Where Var (Uoj) is the district-level variance, and 0.6745 is the 75th centile of the cumulative distribution function of the normal distribution with mean 0 and variance 1. In this study, MOR shows the extent to which the individual probability of experiencing death during postpartum is determined by the residential area [59]. The PCV is used to measure the total variation attributed to individual-level factors and area-level factors in the multilevel model [59, 61]. It was calculated using the following mathematical equation:

$$PCV = \frac{Ve - Vmi}{Ve}$$

Where Ve is the variance in antepartum and intrapartum in the empty model and Vmi is the neighbourhood variance in the subsequent model.

Model fit statistics. Akaike's information criterion (AIC) and Schwarz's Bayesian information criteria (BIC) were used to assess the goodness of fit and inform the selection of nested models (individual- and community-level models). The AIC and BIC values were compared in successive models and the model with the lowest value was selected as a best-fit model [62].

Ethical issues. Ethical approval was obtained from the Ethical Review Committee and Public Health Emergency.

Management unit of Ethiopian Public Health Institute (EPHI) with Ref. No. EPHI 4_1/37. To keep confidentiality, personal identifiers were not used in the study. Since the study used secondary data sources, consent and other ethical measures were not applicable.

Result

Selected background characteristics of maternal death reviewed facilities

The proportion of death during the postpartum period was estimated at 65.1%, during the antepartum period was 19.8% and during the intrapartum period was 15.0%. Among reported facilities, more than half (58.3%) of the deaths were reported from primary-level health care facilities, and 98.8% from public facilities. More than half (57.9%) of the reviewed maternal deaths were reported from Amhara and Oromia regions. Moreover, nearly half (49.3%) of the deaths were reviewed in 2016 and 2017, (Table 1).

Table 1. Selected background characteristics of reporting facilities by the time of death in Ethiopia, 2020.

Variable/category	Time of death			Total	P-value
	Antepartum n (%)	Intrapartum n (%)	Postpartum n (%)		
Type of health facility					
Primary level health care	489(19.4)	415(16.5)	1614(64.1)	2518	0.001
Secondary level health care	235(18.6)	170(13.4)	861(68.0)	1266	
Tertiary level heath care	132(19.8)	64(15.0)	336(65.2)	532	
Ownership of facility					
Private	2(16.7)	1(8.3)	9(75.0)	12	0.875
NGO	8(21.1)	4(10.5)	26(68.4)	38	
Government	846(19.8)	644(15.1)	2776(65.1)	4266	
Reporting region					
Tigray	97(17.2)	76(13.4)	393(69.4)	566	0.0001
Afar	28(45.2)	7(11.3)	27(43.5)	62	
Amhara	249(20.6)	179(14.8)	779(64.6)	1207	
Oromia	205(15.8)	235(18.1)	855(66.1)	1295	
Somali	3(12.5)	4(16.7)	17(70.8)	24	
Ben-Gum	24(30.8)	8(10.2)	46(59.0)	78	
SNNPR	139(25.0)	81(14.6)	335(60.4)	555	
Gambella	5(16.1)	5(16.1)	21(67.8)	31	
Harari	29(33.7)	7(8.1)	50(58.2)	86	
Addis Ababa	31(8.2)	42(33.7)	176(58.1)	249	
Dire Dawa	35(21.5)	16(9.8)	112(68.7)	163	
Year of reporting					
2013	2(15.4)	2(15.4)	9(69.2)	13	0.002
2014	38(12.8)	72(24.4)	186(62.8)	296	
2015	91(18.5)	93(19.0)	307(62.5)	491	
2016	156(18.8)	143(17.3)	529(63.9)	828	
2017	249(19.1)	209(16.1)	843(64.8)	1301	
2018	133(19.5)	93(13.6)	457(66.9)	683	
2018	133(19.5)	93(13.6)	457(66.9)	683	
2020	48(21.1)	15(6.6)	164(72.2)	227	

Sociodemographic characteristics of the deceased women

The proportion of women who died during the postpartum period was higher among women aged between 40–49 years (71.6%) compared to women who were aged between 10–19 years (60.2%). Women who resided in a rural area had a higher proportion of death during intrapartum (15.6%) compared to those who resided in an urban area (11.6%). The proportion of women who died during the antepartum period was higher among women with parity between 0 and 1 (22.2%) compared to those who had a parity above five (16.3%), (Table 2).

The proportion of assigned cause of death for reviewed maternal death

The proportion of women who died during the postpartum period was higher among women deceased due to pregnancy-related infection (81.5%) as compared to women who died due to other causes of death. Women who died due to unanticipated complications of management had a higher proportion of death during the intrapartum period (25.0%) compared to women who died due to other causes. The proportion of women who died due to abortive outcomes of

Table 2. Distribution of personal characteristics by time of death among reviewed maternal death in Ethiopia, 2020.

Variable/category	Time of death			Number	significant
	Antepartum(n) (%)	Intrapartum(n) (%)	Postpartum(n) (%)		
Age group					
10_19	60(24.4)	38(15.4)	148(60.2)	246	0.029
20_29	425(20.2)	294(14)	1382(65.8)	2101	
30_39	330(19.1)	289(16.7)	1107(64.1)	1726	
40_49	41(16.9)	28(11.5)	174(71.6)	243	
Residence area					
Urban	132(20.5)	75(11.6)	438(67.9)	645	0.032
Rural	724(19.7)	574(15.6)	2373(64.6)	3671	
Place of death					
On transit	116(19.7)	114(19.4)	358(60.9)	588	0.001
Home	117(15.6)	85(11.3)	550(73.1)	752	
Health facility	623(20.9)	450(15.2)	1903(63.9)	2976	
Marital status					
Unmarried	65(22.8)	39(13.6)	182(63.6)	286	0.41
Married	791(19.6)	610(15.2)	2629(65.2)	4030	
Religion					
Traditional	5(14.7)	8(23.5)	21(61.8)	34	0.303
Muslim	336(20.9)	247(15.4)	1021(63.7)	1604	
Christian	515(19.2)	394(14.7)	1769(66.1)	2678	
Educational status					
Secondary and above	60(17.0)	58(16.4)	235(66.6)	353	0.18
Primary	78(17.0)	78(17.0)	303(66.0)	459	
Illiterate	718(20.5)	513(14.6)	2273(64.9)	3504	
Parity					
0–1	335(22.2)	228(15.1)	945(62.7)	1508	0.001
2_4	342(20.0)	269(15.7)	1100(64.3)	1711	
5	179(16.3)	152(13.9)	766(69.8)	1097	
History of ANC follow up					
Yes	254(18.4)	168(12.1)	962(69.5)	1384	0.001
No	602(20.5)	481(16.4)	1849(63.1)	2932	

Table 3. Distribution of cause of death by time of death among reviewed maternal death in Ethiopia, 2020.

Variable/category	Time of death			Number	significant
Cause of death	Antepartum n (%)	Intrapartum n (%)	Postpartum n (%)		
Coincidental cause					
Yes	2(66.7)	0(0.0)	1(33.3)	3	0.12
No	854(19.8)	649(15.0)	2810(65.2)	4313	
Unanticipated complication of management					
Yes	15(25.0)	15(25.0)	30(50.0)	60	0.031
No	841(19.8)	634(14.9)	2781(65.3)	4256	
Other obstetrics complication					
Yes	24(18.9)	29(22.8)	74(58.3)	127	0.043
No	856(19.9)	649(14.8)	2811(65.3)	4316	
Abortive pregnancy outcome					
Yes	74(77.1)	2(2.1)	20(20.8)	96	0.001
No	782(18.5)	647(15.3)	2791(66.1)	4220	
Unknown /undetermined					
Yes	51(22.6)	47(20.8)	128(56.6)	226	0.12
No	805(19.7)	602(14.7)	2683(65.6)	4090	
Pregnancy-related infection					
Yes	45(12.8)	20(5.7)	286(81.5)	351	0.001
No	811(20.5)	629(15.9)	2525(63.7)	3965	
Non-obstetrics complication					
Yes	163(35.2)	46(10.0)	253(54.8)	462	0.001
No	693(18.0)	603(15.6)	2558(66.4)	3854	
Hypertensive disorder of pregnancy					
Yes	160(26.4)	85(14.0)	361(59.6)	606	0.01
No	696(18.8)	564(15.2)	2450(66.0)	3710	
Obstetric haemorrhage					
Yes	322(13.5)	405(17.0)	1658(69.5)	2385	0.001
No	534(27.7)	244(12.6)	1153(59.7)	1931	

pregnancy was higher among women who died during the antepartum period (77.1%) as compared to the remaining cause of death, (Table 3).

The proportion of contributing causes of death

The proportion of women who died during the postpartum period was much higher among women who were wrongly diagnosed and treated (72.9%) compared to other contributing factors. Women who died due to lack of transportation had a higher proportion of death during intrapartum (21.6%) compared to other contributing factors. The proportion of women who died due to lack of money for transportation was higher among women who were deceased during the antepartum period (25.6%) as compared to delay factors, (Table 4).

Factors associated with an antepartum time of death in Ethiopia among reviewed deaths

Women who died in transit were more likely to die during the antepartum period compared to those who died at home [RRR = 1.94,95% CI:(1.38–2.71)]. Women who had a parity of more than five were less likely to die during the antepartum period compared to those who were nulliparous [RRR = 0.74; 95% CI:(0.58–0.94)]. Women who died as a result of

Table 4. Distribution of contributing causes of death by time of death among reviewed maternal death in Ethiopia, 2020.

Contributing factor	Time of death			Number	P-value
	Antepartum n (%)	Intrapartum n (%)	Postpartum n (%)		
Delay -1(decision to seek care)					
Traditional practices					
Yes	133(18.6)	97(13.5)	486(67.9)	716	0.229
No	723(20.1)	552(15.3)	2325(64.6)	3600	
Family poverty (Low status)					
Yes	65(21.1)	47(15.3)	196(63.6)	308	0.821
No	791(19.7)	602(15.1)	2615(65.2)	4008	
Lack of awareness of obstetric complications					
Yes	270(23.3)	138(11.9)	749(64.8)	1157	0.001
No	586(18.6)	511(16.1)	2062(65.3)	3159	
Failed to decide to go to a health facility					
Yes	296(19.5)	215(14.1)	1010(66.4)	1521	0.364
No	560(20.1)	434(15.5)	1801(64.4)	2795	
Long-distance to a healthcare facility					
Yes	256(20.5)	203(16.2)	792(63.3)	1251	0.234
No	600(19.6)	446(14.6)	2019(65.8)	3065	
Delay 2(reaching care)					
Poor road condition or terrain					
Yes	62(20.0)	57(14.8)	218(65.2)	337	0.536
No	794(20.0)	592(14.8)	2593(65.2)	3979	
Long travel time from home to a healthcare facility					
Yes	206(20.0)	151(14.6)	674(65.4)	1031	0.921
No	650(19.7)	498(15.2)	2137(65.1)	3285	
Lack of money for transport					
Yes	33(25.6)	20(15.5)	76(58.9)	129	0.221
No	823(19.7)	629(15.0)	2735(65.3)	4187	
Lack of transportation					
Yes	95(16.6)	124(21.6)	355(61.8)	574	0.001
No	761(20.3)	525(14.1)	2456(65.6)	3742	
No healthcare facility in the area					
Yes	32(16.0)	30(15.0)	138(69.0)	200	0.361
No	824(20.1)	619(15.0)	2673(64.9)	4116	
Delay 3(receiving care)					
Long travel time from HF to HF¨					
Yes	208(21.8)	166(17.4)	578(60.8)	952	0.004
No	648(19.2)	483(14.4)	2233(66.4)	3364	
Shortage of equipment and supplies					
Yes	88(19.6)	48(10.7)	313(69.7)	449	0.019
No	768(19.9)	601(15.5)	2498(64.6)	3867	
Long waiting time before treatment was received					
Yes	81(15.9)	69(13.6)	359(70.5)	509	0.019
No	775(20.4)	580(15.2)	2452(64.4)	3807	
Wrong assessment of risk, wrong diagnosis, wrong treatment					
Yes	40(15.3)	31(11.8)	191(72.9)	262	0.024
No	816(20.2)	618(15.2)	2620(64.6)	4054	

pregnancy-related infection were less likely to die during the antepartum period compared to those who did not die due to pregnancy-related infection [RRR = 0.18, 95% CI:(0.110.31)]. A similar finding was observed in women who were deceased due to abortive outcome of pregnancy, obstetrics haemorrhage, HDP, and non-obstetrics complications. Women who failed to recognize the danger signs of pregnancy and those who were managed lately after admission were less likely to die during the antepartum period compared to those who recognized the danger sign or were treated immediately after admission, respectively [RRR = 0.78, 95% CI: (0.62,0.97)] for danger sing and [RRR = 0.33, 95% CI: (0.170.61)] for a time of treatment). Women who were not treated well due to a shortage of equipment and supplies were less likely to die during the antepartum period as compared to women who were treated well with the necessary supplies and equipment [RRR = 0.63, 95% CI: (0.45–0.88)]. The risk of death during the antepartum period was significantly higher among women who travelled long distances to reach a health facility or does not get transportation to a health facility compared to those who did not travel a long distance to reach a health facility or those who have access to transportation, respectively [RRR = 1.59, 95% CI:(1.23–2.04)] for long-distance and [RRR = 1.30–95% CI:(1.05–1.61)] for transportation), (Table 5).

Factors associated with an intrapartum time of death in Ethiopia among reviewed deaths

Women who died on transit [RRR = 1.64, 95%CI:(1.19–2.27)] or in health facility [RRR = 1.47,95% CI:(1.14–1.19)] were more likely to die during intrapartum period compared to women deceased at home. Similarly, women deceased due to abortive outcome of pregnancy [RRR = 10.79, 95% CI:(6.01–19.37)] and non-obstetrics complication [RRR = 1.61,95% CI: (1.15,2.24)]; who failed to recognize the danger signs [RRR = 1.23; 95% CI: (1.02–1.49)] and who resided in pastoralist region [RRR = 1.92, 95% CI: (1.10–3.34)] were more likely to die during intrapartum. The odds of dying during the intrapartum period were much lower among grand para women [RRR = 0.71, 95% CI: (0.56–0.89)], women with history of ANC follow-up [RRR = 0.77, 95% CI: (0.64–0.94)] and women treated lately after admission [RRR = 0.71, 95% CI:(0.54–0.95)]. Moreover, women deceased due to obstetrics hemorrhage [RRR = 0.47, 95% CI: (0.35–0.62)] and pregnancy related infection [RRR = 0.37; 95% CI: (0.25,0.57)] were less likely to die during the intrapartum period, (Table 5).

Multilevel analysis (random-effects analysis). Table 6 presents quantities based on random effects. The status of time of death varied across districts (τ^2 = 0.47, p = <0.001). The empty model revealed that 12.3% of the total variance in time of death was accounted for by between-cluster variation of characteristics (ICC = 0.123). The district variability declined over successive models, from 12.3% in the empty model to 10.6% in the individual-level only model, 9.9% in the districts-level only model, and 9.6% in the final (combined) model. The proportional change in variance indicated that the addition of predictors to the empty model explained an increased proportion of variation in the time of death. Similar to ICC values, the combined model showed a higher PCV, i.e., 46% of the variance in the status of time of death could be explained by the combined factors at the individual and community levels. Furthermore, the MOR confirmed that the time of death was attributed to district-level factors. The MOR for a time of death was 1.90 in the empty model, which indicated the presence of variation between districts for a time of death since MOR was nearly two times higher than the reference (MOR = 1). The unexplained districts' variation for time of death decreased to a MOR of 1.75 when all factors were added to the empty model. This indicates that 0.25 (25%) of the heterogeneity was explained by both individual and community level factors, but still, there is a residual effect that is not explained by individual and district-level variables at the final full

Table 5. Multilevel multinomial analysis of individual and community factors associated with the time of death among reviewed maternal death in Ethiopia, 2020.

Variables/Characteristics	Empty model	Model 2[b]		Model 3[c]		Model 4[d]	
		Individual characteristics		Community characteristics		Individual and Community characteristics	
	Post-partum[(a)]	Antepartum	Intrapartum	Antepartum	Intrapartum	Antepartum	Intrapartum
		RRR (95%CI)	RRR (95%CI)	RRR (95%CI)	RRR (95%CI)	RRR (95%CI)	RRR (95%CI)
Death of place							
Home®		1	1			1	1
On transit		2.17(1.56,3.01) ***	1.73(1.26,2.38) **			1.94(1.38,2.71) ***	1.64(1.19,2.27) **
Health Facility		1.69(1.28,2.22) ***	1.50(1.17,1.93) **			1.76(1.33,2.34) ***	1.47(1.14,1.90) **
Parity							
0–1®		1	1			1	1
5 and above		0.78(0.62,1.00) *	0.71(0.57,0.89) *			0.74(0.58,0.94) *	0.71(0.56,0.89) **
2–4		1.01(0.82,1.25)	0.90(0.74,1.09)			0.98(0.80,1.21)	0.88(0.73,1.08)
History of ANC follow up							
No®		1	1			1	1
Yes		0.66(0.53,0.82) ***	0.77(0.64,0.94) **			0.68(0.55,0.84) ***	0.77(0.64,0.94) ***
Abortive outcome of pregnancy							
No®		1	1			1	1
Yes		0.29(0.07,1.30)	11.00(6.13,19.75) ***			0.29(0.07,1.29)	10.79(6.01,19.37) **
HDP							
No®		1	1			1	1
Yes		0.60(0.42,0.85) ***	1.05(0.76,1.46)			0.58(0.41,0.83) **	1.02(0.74,1.42)
Obstetrics hemorrhage							
No®		1	1			1	1
Yes		0.60(0.45,0.79) ***	0.48(0.36,0.64) ***			0.57(0.42,0.75) ***	0.47(0.35,0.62) ***
Pregnancy-related infection							
No®		1	1			1	1
Yes		0.18(0.11,0.31) ***	0.39(0.26,0.59) ***			0.18(0.11,0.31) ***	0.37(0.25,0.57) ***
None- obstetrics complication							
No®		1	1			1	1
Yes		0.49(0.32,0.73) **	1.66(1.19,2.31) **			0.48(0.32,0.73) **	1.61(1.15,2.24) **
Failure to recognize the complication							
No®		1	1			1	1
Yes		0.78(0.63,0.97) *	1.24(1.03,1.50) *			0.78(0.62,0.97) *	1.23(1.02,1.49) *
Regional_Residence							
City administration				1	1	1	1
Pastoralist				1.34(0.70,2.54)	1.80(1.06,3.06) *	1.50(0.78,2.88)	1.92(1.10,3.34) *
Agrarian				1.51(1.00,2.28) *	0.97(0.67,1.4)	1.47(0.96,2.25)	1.1(0.75,1.61)

(*Continued*)

Table 5. (Continued)

Variables/Characteristics	Empty model	Model 2[b]		Model 3[c]		Model 4[d]	
		Individual characteristics		Community characteristics		Individual and Community characteristics	
	Post-partum[(a)]	Antepartum	Intrapartum	Antepartum	Intrapartum	Antepartum	Intrapartum
		RRR (95%CI)	RRR (95%CI)	RRR (95%CI)	RRR (95%CI)	RRR (95%CI)	RRR (95%CI)
Lack of transportation							
No®				1	1	1	1
Yes				1.55(1.22,1.97) ***	0.82(0.64,1.06)	1.59(1.23,2.04) ***	0.94(0.72,1.23)
Long travel time from home to a healthcare facility							
No®				1	1	1	1
Yes				1.41(1.14,1.74) **	1.30(1.07,1.57) **	1.30(1.05,1.61) **	1.32(1.08,1.62) **
Shortage of equipment and supplies							
No®				1	1	1	1
Yes				0.64(0.46,0.89) **	0.88(0.68,1.15)	0.63(0.45,0.88) *	0.84(0.63,1.11)
Delayed management after admission							
No®				1	1	1	1
Yes				0.93(0.70,1.23)	0.75(0.57,0.97) *	0.87(0.65,1.70)	0.71(0.54,0.95) *

*P < 0.05

**P < 0.001

***P < 0.0001

(a) Reference for the dependent variable

® Reference for the category of an independent variable

Table 6. Results from the random intercept model (a measure of variation) for the timing of death at the district level using multilevel logistic regression analysis.

Random effect	Model_1[a]	Model_2[b]	Model_3[c]	Model_4[d]
District level variance (SE)	0.47(0.11)	0.39(0.08)	0.36(0.08)	0.35(0.07)
P_values	<0.001	<0.001	<0.001	<0.001
ICC (%)	12.3%	10.6%	9.9%	9.6%
Explained variance (PVC) (%)	Reference	15.2%	21.1%	46.0%
MOR (95%CI)	1.90(1.68,2.27)	1.81(1.63,2.07)	1.76(1.58,2.01)	1.75(1.60,2.04)
Model fit statics				
AIC	7500	7153	7512	7111
BIC	7591	7216	7551	7206

SE = Standard Error; DIC = Deviance Information Criterion; ICC = Intra-Class Correlation; PCV = Percentage Change in Variance; MOR = Median Odds Ratio;

CI = Confidence Interval; AIC = Akaike's Information Criterion; BIC = Schwarz's Bayesian Information Criteria.

Model_1[a] is the empty model, a baseline model without any determinant variable

Model_2[b] is adjusted for individual-level factors

Model_3[c] is adjusted for community-level factors

Model_4[d] is the final model adjusted for the individual- and community-level factors

model (MOR = 1.75). This implies that even though individual- and district-level factors were considered, the effect of clustering is still statistically significant in the full model.

Model fit statistics.   As shown in Table 6 (model fit statistics), the values of AIC and BIC showed subsequent reduction which indicates each model represents a significant improvement over the previous model and it points to the goodness of fit of the final model built in the analysis.

Discussion

The study observed the hierarchal effect of various factors that determine the timing of death among reviewed maternal deaths in Ethiopia. Our study has demonstrated that the timing of maternal death is determined by both individual factors (previous medical history, medical cause, and knowledge of obstetrics complications) and districts level factors (lack of transportation, shortage of life-saving maternal commodities in a health facility, and delay in receiving treatment).

Women's parity was positively associated with postpartum maternal death. This finding was comparable with studies done in Tanzania [63], Nigeria [64], Saudi Arabia [65], and India [66]. The possible justification might be related to pre-existing health conditions of the women, as well as access and utilization of maternity services [67, 68] and the combination of these factors may affect the outcome of the mother after delivery. In agreement with this, women of advanced maternal age, who are believed to have a relatively high parity are at an increased risk of maternal death. Per the recent Ethiopian demographic and health survey, only 18%,36%, and 40% of women of advanced maternal age used contraceptives; attended more than 4 ANC visits; and delivered at a health facility, respectively [52]. These findings imply that more improvement in the access and utilization of maternal service is particularly needed for multipara women. This should be coupled with adequate service provision to reduce maternal death during the postpartum period.

History of ANC visit was also one of the individual-level factors significantly associated with postpartum maternal death. Women who had at least one ANC visit were less likely to die during the antepartum and intrapartum periods. In line with this, the study also revealed that nearly 70% of the women were deceased at health facilities after delivery. This partly explains that attending ANC service encourages institutional delivery; however, it is not a guarantee for obtaining quality maternity service [69]. The uptake of the service may be compromised by various factors including the educational status of the women, the residence of the women, distance from the facility, and previous history of successful home delivery [70–73]. This suggests that the integration of ANC services with other maternal services and programs should be a priority to meet the ultimate objective of the ANC service. Meanwhile, improvement in the managing capacity of obstetrics emergencies should be the other priority to reduce postpartum maternal death significantly.

Among individual factors, the medical cause of death—both direct (HDP, obstetrics haemorrhage, and pregnancy-related infection) and indirect (non-obstetrics complication)–were positively associated with maternal death after delivery. The finding was concurrent, in the case of obstetrics haemorrhage, with studies conducted in Ethiopia (Debere-Tabore, Yirgalem, and Harir) [74–76], Nigeria [77], South Africa [78], and Mozambique [79]. The possible reason might be related to the management of the third phase of labour, which is provided by a trained health professional at a health facility. Ethiopia has put in place various measures to tackle the burden of obstetrics haemorrhage. Some of the measures that were put in place include the utilization of NASG during referral [80], provision of Misoprostol at the community level [81]; construction of mattering waiting room [14], and augmentation of compressive

emergency obstetrics care (establishment of mini blood band and expansion of caesarean providing facility) [25, 82]. Despite all these efforts, due to poor utilization of innovative technologies such as the use of uterine balloon tamponade, and simplified dosing of magnesium sulfate [25, 83], postpartum haemorrhage remains unacceptably high in Ethiopia [25]. Overall, the result suggests that there is a huge gap in early detection, response, and treatment of postpartum haemorrhage.

As stated above HDP was also positively related to postpartum maternal death in Ethiopia. The finding was consistent with studies conducted in Ethiopia (Hawwasa, Yirgalem, and Hossana) [84], Nigeria [85], Turkey [86], Ghana [87], and Uganda [88]. The possible justification could be HDP's strong relation to the delay in seeking care and the delay in initiating anticonvulsant prophylaxis and antihypertensive drugs, which will result in irreversible damage to the brain because of intracranial haemorrhage. This result suggested the need for boosting the health system by providing innovative technologies, which improve proteinuria tests and blood pressure measurements [83]. In combination with efforts to enhance health-seeking behaviour, improving the referral system and availing essential drugs and supplies are required to reduce HDP during the postpartum period [89, 90].

In addition, pregnancy-related infection also has a vital role in maternal death after delivery. This finding was aligned with studies done in 52 countries [91], including Uganda [92], and India [93]. The possible explanations that could contribute to the infection might be related to pre-delivery factors (pre-labour rupture of membranes, prolonged labours, multiple vaginal examinations (more than five), the health status of the women (anaemia, primiparity, and poor nutrition), and clinical procedures during delivery (episiotomy, caesarean section, and other invasive procedures). However, the outcome of the women is determined by the adequacy of vital signs assessment and early administration of antimicrobial therapy. Contrastingly, in the last twenty years, Ethiopia has declined maternal mortality due to infection by practising infection control measures [94]. Generally, the finding indicated that pregnancy-related infection should be the other area of intervention since it is one of the major causes of maternal death in Ethiopia.

Furthermore, Non-obstetrics complication was also positively associated with postpartum maternal death. This finding is in line with studies done in Ethiopia (Jimma) [95] and Nigeria [37, 96]. In Ethiopia, the leading indirect cause of maternal death was severe anaemia unrelated to haemorrhage [25]. The possible explanation for anaemia related death during the postpartum period relates to women's circulatory decomposition, which is manifested by increased cardiac output and decreased ability to blood loss, which ultimately results in shock and death [97]. On the other hand, the risk factors of anaemia such as low dietary intake of iron, intestinal or blood parasite infection, and chorine illness [98, 99], could be handled during ANC visit by supplementation of iron, folic acid, and deworming.

Failure to recognize the complication of pregnancy is one of the individual factors related to postpartum maternal death. The finding of this study is parallel with studies done in Nigeria [100], Uganda [101], and Somalia [102]. The possible justification might be the fact that poor knowledge of obstetrics complications could make the women less prepared, which may have a negative consequence on accepting appropriate and timely referral to essential obstetric care. Similarly, knowledge of obstetric complications is influenced by educational status, the proximity of health facilities, and previous history of obstetric complications [103, 104]. To address this challenge, Ethiopia introduced a health extension program in 2003, aiming to bring health knowledge and basic care directly to the households at a grassroots level [105]. However, as depicted in the result, further work must be done at the community level.

District-level factors such as scarcity of equipment and supplies and late management after admission were significantly associated with postpartum maternal death. The finding was

congruent in case of shortage of equipment and supplies with studies done in Egypt [106], Tanzania [107], and Malawi [108]. This clearly shows that the shortage of blood and blood product is the main challenge in managing obstetrics complications in Ethiopia and other Sub-Saharan African countries [109, 110]. To this effect, the establishment of a mini blood bank at Comprehensive Emergency Obstetric and New-born Care (CEmONC) facilities in Ethiopia was considered as a mitigation plan; despite that, its implementation was challenged by a low blood donation rate, and inadequate testing and quality monitoring capacity [4, 25, 110]. Overall, this result suggests that addressing the gap in availing essential life-saving maternal commodities (medicines, medical devices, and health supplies) should be the target area of intervention to reduce preventable postpartum maternal death.

Finally, late management of women after admission is also one of the district-level factors associated with maternal death after delivery. It is usually framed by a delay in waiting for treatment, which takes more than 30 minutes from the time of admission to assessment and receiving treatment [111]. A similar result was observed in studies done in Ethiopia (Addis Ababa and Tigray) [112, 113], Mozambique [114], Brazil [115], and India [116]. This might be due to the reason for delays such as lack of essential maternal commodities, insufficient training, poor attitudes toward a patient, and poor facility infrastructure related to the operation room and surgical facilities. On the contrary, Ethiopia has designed an alternative strategy to augment the managing capacity of obstetrics emergencies at lower-level health facilities. To this effect, the country has introduced a training program for middle–level health care professionals called the Integrated Emergency Surgical Officers (IESO). Those professionals are trained to handle obstetrics emergencies at lower-level health facilities [117]. In addition, the country has invested resources to upgrade the existing health facilities [118]. However, despite all these efforts, facility-level barriers should still be considered as a milestone to achieve the aspired goal under SDG.

The study has limitations that need to be acknowledged. First, the data used for the analysis was secondary data with single-point time. Thus, only associations were examined, and it was impossible to confirm any causality. Second, all identified, confirmed, and reported maternal death through a weekly reporting system were not reviewed and sent via MDRF to the next level, which might introduce potential bias to the study. Third, nearly all deaths were reported and reviewed from public facilities with limited involvement of private health facilities, and this could affect the representativeness of the study. Fourth, a small number of maternal deaths were captured by the system, which is against national estimates and might compromise the inclusiveness of the study.

Conclusion

Overall, both individual and facility-level variables were significantly associated with postpartum maternal death among reviewed maternal deaths in Ethiopia. Thus, mothers with previous medical history (history of ANC follow up and party), medical cause (obstetrics haemorrhage, HDP, pregnancy-related infection, and non-obstetrics complication), personal factors (poor knowledge of obstetrics complications), and facility-level barriers (shortage of life-saving maternal commodities and delay in receiving treatment) were at increased risk of maternal death after delivery. The study corroborates that handling individual and district-level factors associated with postpartum maternal death through pragmatic policies and programs is essential to reducing maternal death after delivery. Therefore, emphasis should be given to encouraging the utilization of ANC service with more priority to higher parity women, so that they can get information on obstetric complications, birth preparedness, and complication readiness to prevent delay in seeking care, and improve early diagnosis and

treatment of anaemia. Since the two medical causes of death (HDP and obstetrics haemor-rhage) were key determinants for postpartum death in Ethiopia, it is better to enhance the application of innovative technologies, which are suitable for resource constraints settings. Accordingly, innovative services such as utilizing uterine balloon tamponade, improving proteinuria testing, and having better blood pressure measurements are recommended. As for the facility level barriers, further improvement in service delivery at health facilities should be the top priority.

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References

1. World Health Organization. Maternal death surveillance and response: technical guidance information for action to prevent maternal death.

2. World Health Organization. Trends in maternal mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division.

3. Ayele AA, Getaye Tefera Y, East L. Ethiopia's commitment towards achieving sustainable development goal on reduction of maternal mortality: There is a long way to go. Women's Health. 2021 Dec; 17:17455065211067073. https://doi.org/10.1177/17455065211067073 PMID: 34913391

4. Ethiopian minster of health, national reproductive health strategies from 2016–2020, access date 2/6/2022, available at https://tinyurl.com/bdedey22

5. Central Statistical Agency/CSA/Ethiopia and ICF. 2016. Ethiopia Demographic and Health Survey 2016. Addis Ababa, Ethiopia, and Rockville, Maryland, USA: CSA and ICF.

6. Gebremedhin S. Development of a new model for estimating maternal mortality ratio at national and sub-national levels and its application for describing sub-national variations of maternal death in Ethiopia. Plos one. 2018 Aug 6; 13(8):e0201990. https://doi.org/10.1371/journal.pone.0201990 PMID: 30080902

7. Geleto A, Chojenta C, Taddele T, Loxton D. Association between maternal mortality and caesarean section in Ethiopia: a national cross-sectional study. BMC Pregnancy and Childbirth. 2020 Dec; 20 (1):1–1. https://doi.org/10.1186/s12884-020-03276-1 PMID: 33023536

8. Abebe B, Busza J, Hadush A, Usmael A, Zeleke AB, Sita S, et al. 'We identify, discuss, act and promise to prevent similar deaths': a qualitative study of Ethiopia's Maternal Death Surveillance and Response system. BMJ Global health. 2017 Mar 1; 2(2):e000199. https://doi.org/10.1136/bmjgh-2016-000199 PMID: 28589016

9. Hounton S, De Bernis L, Hussein J, Graham WJ, Danel I, Byass P, et al. Towards elimination of maternal deaths: maternal deaths surveillance and response. Reproductive health. 2013 Dec; 10(1):1–8. https://doi.org/10.1186/1742-4755-10-1 PMID: 23279882

10. Hofman JJ, Mohammed H. Experiences with facility-based maternal death reviews in northern Nigeria. International Journal of Gynecology & Obstetrics. 2014 Aug 1; 126(2):111–4. https://doi.org/10.1016/j.ijgo.2014.02.014 PMID: 24834852

11. Mathur A, Awin N, Adisasmita A, Jayaratne K, Francis S, Sharma S, et al. Maternal death review in selected countries of South East Asia Region. BJOG: An International Journal of Obstetrics & Gynaecology. 2014 Sep; 121:67–70. https://doi.org/10.1111/1471-0528.13001 PMID: 25236636

12. Ayele B, Gebretnsae H, Hadgu T, Negash D, G/silassie F, Alemu T, et al. Maternal and perinatal death surveillance, and response in Ethiopia: achievements, challenges, and prospects. PloS one. 2019 Oct 11; 14(10):e0223540. https://doi.org/10.1371/journal.pone.0223540 PMID: 31603937

13. Gurara MK, Van Geertruyden JP, Gutema BT, Draulans V, Jacquemyn Y. Maternity waiting homes as component of birth preparedness and complication readiness for rural women in hard-to-reach areas in Ethiopia. Reproductive health. 2021 Dec; 18(1):1–4.

14. Tiruneh GT, Getu YN, Abdukie MA, Eba GG, Keyes E, Bailey PE. Distribution of maternity waiting homes and their correlation with perinatal mortality and direct obstetric complication rates in Ethiopia. BMC Pregnancy and Childbirth. 2019 Dec; 19(1):1–1.

15. Bekele G, Terefe G, Sinaga M, Belina S. Utilization of non-pneumatic anti-shock garment and associated factors for postpartum hemorrhage management among health care professionals in public hospitals of Jimma zone, south-West Ethiopia, 2019. Reproductive health. 2020 Dec; 17(1):1–0.

16. Desta AA, Berhane M, Woldearegay TW. Utilization Rate and Factors Associated with Non-Utilization of Non-Pneumatic Anti-Shock Garment in the Management of Obstetric Hemorrhage in Public Health Care Facilities of Northern Ethiopia: A Cross-Sectional Study. Int J Womens Health. 2020 Oct 30; 12:943–51. https://doi.org/10.2147/IJWH.S266534 PMID: 33154678

17. Pearson L, Gandhi M, Admasu K. Keyes Eb. International Journal of Gynecology and Obstetrics User fees and maternity services in Ethiopia. BMC pregnancy and childbirth. 2011; 115:310–5.

18. Berhan Y, Berhan A. Review of maternal mortality in Ethiopia: a story of the past 30 years. Ethiopian journal of health sciences. 2014 Sep 12; 24:3–14.

19. Romano M, Cacciatore A, Giordano R, La Rosa B. Postpartum period: three distinct but continuous phases. Journal of prenatal medicine. 2010 Apr; 4(2):22. PMID: 22439056

20. Merdad L, Ali MM. Timing of maternal death: levels, trends, and ecological correlates using sibling data from 34 sub-Saharan African countries. PLoS One. 2018 Jan 17; 13(1):e0189416. https://doi.org/10.1371/journal.pone.0189416 PMID: 29342157

21. Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, Shackelford KA, Steiner C, Heuton KR, et al. Global, regional, and national levels and causes of maternal mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet. 2014 Sep 13; 384(9947):980–1004.

22. Garg BS, Chhabra S, Zothanzami SM. Safe motherhood: social, economic, and medical determinants of maternal mortality. Women and Health Learning Package, The Network: TUFH Women and Health Taskforce. Karachi: The Network. 2006 Sep;1132.

23. Dadi TL, Mihirete KM, Welegebriel TK. Causes and Timing of Maternal Death in Mizan–Tepi University Teaching and Bonga General Hospital from 2011–2015: A Case Control Study and Using Propensity Score Matching Analysis. The Open Public Health Journal. 2017 Jun 30; 10(1).

24. Yaya Y, Eide KT, Norheim OF, Lindtjørn B. Maternal and neonatal mortality in south-west Ethiopia estimates and socio-economic inequality. PloS one. 2014 Apr 30; 9(4):e96294. https://doi.org/10.1371/journal.pone.0096294 PMID: 24787694

25. Ethiopian public health institutes, National Maternal and Perinatal Death Surveillance and Response (MPDSR) System Annual Report 2012 EFY, available from https://tinyurl.com/2p8sbdph

26. Bhutta ZA, Das JK, Bahl R, Lawn JE, Salam RA, Paul VK, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? The Lancet. 2014 Jul 26; 384(9940):347–70.

27. World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience: summary: highlights and key messages from the World Health Organization's 2016 global recommendations for routine antenatal care. World Health Organization; 2018.

28. Ftwi M, Gebretsadik GG, Berhe H, Haftu M, Gebremariam G, Tesfau YB. Coverage of completion of four ANC visits based on recommended time schedule in Northern Ethiopia: a community-based cross-sectional study design. PLoS One. 2020 Aug 18; 15(8):e0236965. https://doi.org/10.1371/journal.pone.0236965 PMID: 32810140

29. Oladapo OT, Tunçalp Ö, Bonet M, Lawrie TA, Portela A, Downe S, et al. WHO model of intrapartum care for a positive childbirth experience: transforming care of women and babies for improved health and wellbeing. Bjog. 2018 Jul; 125(8):918. https://doi.org/10.1111/1471-0528.15237 PMID: 29637727

30. Montufar-Rueda C, Rodriguez L, Jarquin JD, Barboza A, Bustillo MC, Marin F, et al. Severe postpartum hemorrhage from uterine atony: a multicentric study. Journal of pregnancy. 2013 Jan 1; 2013. https://doi.org/10.1155/2013/525914 PMID: 24363935

31. Rocha Filho EA, Costa ML, Cecatti JG, Parpinelli MA, Haddad SM, Sousa MH, et al. Brazilian Network for Surveillance of Severe Maternal Morbidity Study Group. Contribution of antepartum and intrapartum hemorrhage to the burden of maternal near miss and death in a national surveillance study. Acta obstetricia et gynecologica Scandinavica. 2015 Jan; 94(1):50–8.

32. Tunçalp Ö, Were WM, MacLennan C, Oladapo OT, Gülmezoglu AM, Bahl R, et al. Quality of care for pregnant women and newborns—the WHO vision. Bjog. 2015 Jul; 122(8):1045. https://doi.org/10.1111/1471-0528.13451 PMID: 25929823

33. Ehiri J, Alaofè H, Asaolu I, Chebet J, Esu E, Meremikwu M. Emergency transportation interventions for reducing adverse pregnancy outcomes in low-and middle-income countries: a systematic review protocol. Systematic reviews. 2018 Dec; 7(1):1–9.

34. Kansara TN, Shah TM, Lalcheta FR. A study of maternal mortality due to non-obstetric causes. International Journal of Reproduction, Contraception, Obstetrics and Gynecology. 2019 May 1; 8(5):2027–34.

35. Li XF, Fortney JA, Kotelchuck M, Glover LH. The postpartum period: the key to maternal mortality. International Journal of Gynecology & Obstetrics. 1996 Jul 1; 54(1):1–0. https://doi.org/10.1016/0020-7292(96)02667-7 PMID: 8842811

36. Halim A, Biswas A, Abdullah AS, Rahman F. Factors Associated with Maternal Deaths in District and Upazila Hospitals of Bangladesh. Bangladesh Journal of Obstetrics & Gynaecology. 2016; 31(1):16–22.

37. Souza JP, Cecatti JG, Faundes A, Morais SS, Villar J, Carroli G, et al. Maternal near miss and maternal death in the World Health Organization's 2005 global survey on maternal and perinatal health. Bulletin of the World Health Organization. 2010; 88:113–9. https://doi.org/10.2471/BLT.08.057828 PMID: 20428368

38. Adeniran AS, Ocheke AN, Nwachukwu D, Adewole N, Ageda B, Onile T, et al. Nigeria Near-miss and Maternal Death Surveillance Network. Non-obstetric causes of severe maternal complications: a secondary analysis of the Nigeria Near-miss and Maternal Death Survey. BJOG: An International Journal of Obstetrics & Gynaecology. 2019 Jun; 126:41–8.

39. Admasu K, Haile-Mariam A, Bailey P. Indicators for availability, utilization, and quality of emergency obstetric care in Ethiopia, 2008. International Journal of Gynecology & Obstetrics. 2011 Oct; 115 (1):101–5.

40. Knight HE, Self A, Kennedy SH. Why are women dying when they reach hospital on time? A systematic review of the 'third delay'. PloS one. 2013 May 21; 8(5):e63846. https://doi.org/10.1371/journal.pone.0063846 PMID: 23704943

41. Deribe K, Biadgilign S, Amberbir A, Belachew T, Woldemichael K. The road to maternal death in rural southwest Ethiopia. Ethiopian Journal of Health Sciences. 2010; 20(1). https://doi.org/10.4314/ejhs.v20i1.69423 PMID: 22434963

42. Ayalew Tiruneh G, Melkamu Asaye M, Solomon AA, Tiruneh Arega D. Delays during emergency obstetric care and their determinants among mothers who gave birth in South Gondar zone hospitals, Ethiopia. A cross-sectional study designs. Global health action. 2021 Jan 1; 14(1):1953242. https://doi.org/10.1080/16549716.2021.1953242 PMID: 34328059

43. Limenih MA, Belay HG, Tassew HA. Birth preparedness, readiness planning and associated factors among mothers in Farta district, Ethiopia: a cross-sectional study. BMC pregnancy and childbirth. 2019 Dec; 19(1):1–0.

44. Mekonnen W, Gebremariam A. Causes of maternal death in Ethiopia between 1990 and 2016: systematic review with meta-analysis. Ethiopian Journal of Health Development. 2018; 32(4).

45. Tessema GA, Laurence CO, Melaku YA, Misganaw A, Woldie SA, Hiruye A, et al. Trends and causes of maternal mortality in Ethiopia during 1990–2013: findings from the Global Burden of Diseases study 2013. BMC public health. 2017 Dec; 17(1):1–8.

46. Shiferaw MA, Bekele D, Surur F, Dereje B, Tolu LB. Maternal Death Review at a Tertiary Hospital in Ethiopia. Ethiopian Journal of Health Sciences. 2021 Jan 1; 31(1).

47. Negussie D, Mesfin N. Review of maternal death in Jimma University specialized hospital. Ethiopian Journal of Health Sciences. 2009; 19(1).

48. Wanaka S, Hussen S, Alagaw A, Tolosie K, Boti N. Maternal delays for institutional delivery and associated factors among postnatal mothers at public health facilities of Gamo zone, Southern Ethiopia. International Journal of Women's Health. 2020; 12:127. https://doi.org/10.2147/IJWH.S240608 PMID: 32184676

49. Jackson R, Tesfay FH, Gebrehiwot TG, Godefay H. Factors that hinder or enable maternal health strategies to reduce delays in rural and pastoralist areas in Ethiopia. Tropical Medicine & International Health. 2017 Feb; 22(2):148–60. https://doi.org/10.1111/tmi.12818 PMID: 27886436

50. Worldometer, Ethiopian population in 2020, available at https://www.worldometers.info/world-population/ethiopia-population/

51. Central statics agency. Ethiopia—Population and Housing Census 2007 [Internet]. [cited 2022 Feb 6]. Available from https://tinyurl.com/2p8tvpzr

52. Ethiopian Public Health Institute (EPHI) [Ethiopia] and ICF. 2021. Ethiopia Mini Demographic and Health Survey 2019: Final Report. Rockville, Maryland, USA: EPHI and ICF.

53. Ethiopian Public Health Institute. National technical guidance for maternal and perinatal death surveillance and response in Ethiopia—Google Search [Internet]. [cited 2021 Oct 17]. Available from https://tinyurl.com/2p8m4t67

54. World Health Organization. Maternal and perinatal death and surveillance and response: materials to support implementation [Internet]. [cited 2022 Feb 6]. Available from: https://www.who.int/publications-detail-redirect/9789240036666

55. World Health Organization. The WHO application of ICD-10 to deaths during pregnancy, childbirth, and puerperium: ICD-MM. World Health Organization; 2012.

56. Shifti DM, Chojenta C, G. Holliday E, Loxton D. Individual and community level determinants of short birth interval in Ethiopia: a multilevel analysis. PloS one. 2020 Jan 14; 15(1):e0227798. https://doi.org/10.1371/journal.pone.0227798 PMID: 31935262

57. Lemeshow S, Sturdivant RX, Hosmer Jr DW. Applied logistic regression. John Wiley & Sons; 2013 Feb 26.

58. Structural Equation Modeling Reference Manual, Release 17 [Internet]. [cited 2022 Feb 6]. Available from: https://www.stata.com/bookstore/structural-equation-modeling-reference-manual/

59. Merlo J, Chaix B, Ohlsson H, Beckman A, Johnell K, Hjerpe P, et al. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. Journal of Epidemiology & Community Health. 2006 Apr 1; 60 (4):290–7. https://doi.org/10.1136/jech.2004.029454 PMID: 16537344

60. Merlo J. Multilevel analytical approaches in social epidemiology: measures of health variation compared with traditional measures of association. Journal of Epidemiology & Community Health. 2003 Aug 1; 57(8):550–2. https://doi.org/10.1136/jech.57.8.550 PMID: 12883048

61. Raykov T. Intraclass correlation coefficients in hierarchical designs: Evaluation using latent variable modeling. Structural Equation Modeling. 2011 Jan 13; 18(1):73–90.

62. Vrieze SI. Model selection and psychological theory: a discussion of the differences between the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). Psychological methods. 2012 Jun; 17(2):228. https://doi.org/10.1037/a0027127 PMID: 22309957

63. Evjen-Olsen B, Hinderaker SG, Lie RT, Bergsjø P, Gasheka P, Kvåle G. Risk factors for maternal death in the highlands of rural northern Tanzania: a case-control study. BMC Public Health. 2008 Dec; 8(1):1–9. https://doi.org/10.1186/1471-2458-8-52 PMID: 18257937

64. Fawole AO, Shah A, Fabanwo AO, Adegbola O, Adewunmi AA, Eniayewun AB, et al. Predictors of maternal mortality in institutional deliveries in Nigeria. African health sciences. 2012; 12(1):32–40. PMID: 23066417

65. Al Rowaily MA, Alsalem FA, Abolfotouh MA. Cesarean section in a high-parity community in Saudi Arabia: clinical indications and obstetric outcomes. BMC pregnancy and childbirth. 2014 Dec; 14(1):1–0.

66. Sultan S, Ojha J. " Grand multi parity still and obstetric challenge"—a clinical study of grand multi para in a tertiary care center. Journal of Evolution of Medical and Dental Sciences. 2013 Sep 30; 2 (39):7423–31.

67. Sonneveldt E, Plosky WD, Stover J. Linking high parity and maternal and child mortality: what is the impact of lower health services coverage among higher order births?. BMC public health. 2013 Sep; 13(3):1–8. https://doi.org/10.1186/1471-2458-13-S3-S7 PMID: 24564721

68. Ndiaye K, Portillo E, Ouedraogo D, Mobley A, Babalola S. High-risk advanced maternal age and high parity pregnancy: tackling a neglected need through formative research and action. Global Health: Science and Practice. 2018 Jun 27; 6(2):372–83.

69. Saad–Haddad G, DeJong J, Terreri N, Restrepo–Méndez MC, Perin J, Vaz L, et al. Patterns and determinants of antenatal care utilization: analysis of national survey data in seven countdown countries. Journal of global health. 2016 Jun; 6(1). https://doi.org/10.7189/jogh.06.010404 PMID: 27231540

70. Shiferaw K, Mengistie B, Gobena T, Dheresa M, Seme A. Extent of received antenatal care components in Ethiopia: a community-based panel study. International journal of women's health. 2021; 13:803. https://doi.org/10.2147/IJWH.S327750 PMID: 34526826

71. Tsegaye B, Ayalew M. Prevalence and factors associated with antenatal care utilization in Ethiopia: an evidence from demographic health survey 2016. BMC Pregnancy and Childbirth. 2020 Dec; 20(1):1–9. https://doi.org/10.1186/s12884-020-03236-9 PMID: 32917156

72. Tegegne TK, Chojenta C, Getachew T, Smith R, Loxton D. Antenatal care use in Ethiopia: a spatial and multilevel analysis. BMC pregnancy and childbirth. 2019 Dec; 19(1):1–6.

73. Mulat A, Kassa S, Belay G, Emishaw S, Yekoye A, Bayu H, et al., Missed antenatal care follow-up and associated factors in Eastern Zone of Tigray, Northern Ethiopia. African Health Sciences. 2020 Jul 22; 20(2):690–6. https://doi.org/10.4314/ahs.v20i2.20 PMID: 33163033

74. Habitamu D, Goshu YA, Zeleke LB. The magnitude and associated factors of postpartum hemorrhage among mothers who delivered at Debre Tabor general hospital 2018. BMC research notes. 2019 Dec; 12(1):1–6.

75. Amanuel T, Dache A, Dona A. Postpartum Hemorrhage and its Associated Factors Among Women who Gave Birth at Yirgalem General Hospital, Sidama Regional State, Ethiopia. Health Services Research and Managerial Epidemiology. 2021 Nov; 8:23333928211062777. https://doi.org/10.1177/23333928211062777 PMID: 34869791

76. Mesfin S, Dheresa M, Fage SG, Tura AK. Assessment of Postpartum Hemorrhage in a University Hospital in Eastern Ethiopia: A Cross-Sectional Study. International journal of women's health. 2021; 13:663. https://doi.org/10.2147/IJWH.S300143 PMID: 34262356

77. Sotunsa JO, Adeniyi AA, Imaralu JO, Fawole B, Adegbola O, Aimakhu CO, et al. Maternal near-miss and death among women with postpartum haemorrhage: a secondary analysis of the Nigeria Near-miss and Maternal Death Survey. BJOG: An International Journal of Obstetrics & Gynaecology. 2019 Jun; 126:19–25. https://doi.org/10.1111/1471-0528.15624 PMID: 30897283

78. Maswime S, Buchmann E. Causes and avoidable factors in maternal death due to cesarean-related hemorrhage in South Africa. International Journal of Gynecology & Obstetrics. 2016 Sep 1; 134 (3):320–3. https://doi.org/10.1016/j.ijgo.2016.03.013 PMID: 27352737

79. Lancaster L, Barnes RF, Correia M, Luis E, Boaventura I, Silva P, et al. Maternal death and postpartum hemorrhage in sub-Saharan Africa–A pilot study in metropolitan Mozambique. Research and practice in thrombosis and haemostasis. 2020 Mar; 4(3):402–12. https://doi.org/10.1002/rth2.12311 PMID: 32211574

80. Yeshitila YG, Bante A, Aschalew Z, Afework B, Gebeyehu S. Utilization of non-pneumatic anti-shock garment and associated factors for postpartum hemorrhage management among obstetric care providers in public health facilities of southern Ethiopia, 2020. PloS one. 2021 Oct 28; 16(10):e0258784. https://doi.org/10.1371/journal.pone.0258784 PMID: 34710153

81. Spangler SA, Gobezayehu AG, Getachew T, Sibley LM. Interpretation of national policy regarding community-based use of misoprostol for postpartum hemorrhage prevention in Ethiopia: A tale of two regions. Journal of midwifery & women's health. 2014 Jan; 59(s1):S83–90. https://doi.org/10.1111/jmwh.12154 PMID: 24588920

82. Gedefaw G, Demis A, Alemnew B, Wondmieneh A, Getie A, Waltengus F. Prevalence, indications, and outcomes of caesarean section deliveries in Ethiopia: a systematic review and meta-analysis. Patient Safety in Surgery. 2020 Dec; 14(1):1–0.

83. Herrick TM, Harner-Jay CM, Levisay AM, Coffey PS, Free MJ, LaBarre PD. Prioritizing investments in innovations to protect women from the leading causes of maternal death. BMC pregnancy and childbirth. 2014 Dec; 14(1):1–5. https://doi.org/10.1186/1471-2393-14-10 PMID: 24405972

84. Berhan Y, Endeshaw G. Maternal mortality predictors in women with hypertensive disorders of pregnancy: a retrospective cohort study. Ethiopian journal of health sciences. 2015 Feb 10; 25(1):89–98. https://doi.org/10.4314/ejhs.v25i1.12 PMID: 25733789

85. Adamu AN, Okusanya BO, Tukur J, Ashimi AO, Oguntayo OA, Tunau KA, et al. Maternal near-miss and death among women with hypertensive disorders in pregnancy: a secondary analysis of the Nigeria Near-miss and Maternal Death Survey. BJOG: An International Journal of Obstetrics & Gynaecology. 2019 Jun; 126:12–8. https://doi.org/10.1111/1471-0528.15427 PMID: 30270518

86. Keskinkılıç B, Engin-Üstün Y, Sanisoğlu S, Uygur DŞ, Keskin HL, Karaahmetoğlu S, et al. Maternal mortality due to hypertensive disorders in pregnancy, childbirth, and the puerperium between 2012 and 2015 in Turkey: A nation-based study. Journal of the Turkish German Gynecological Association. 2017 Mar; 18(1):20. https://doi.org/10.4274/jtgga.2016.0244 PMID: 28506946

87. Adu-Bonsaffoh K, Obed SA, Seffah JD. Maternal outcomes of hypertensive disorders in pregnancy at Korle Bu Teaching Hospital, Ghana. International Journal of Gynecology & Obstetrics. 2014 Dec 1; 127(3):238–42. https://doi.org/10.1016/j.ijgo.2014.06.010 PMID: 25108587

88. Nakimuli A, Nakubulwa S, Kakaire O, Osinde MO, Mbalinda SN, Kakande N, et al. The burden of maternal morbidity and mortality attributable to hypertensive disorders in pregnancy: a prospective

cohort study from Uganda. BMC pregnancy and childbirth. 2016 Dec; 16(1):1–8. https://doi.org/10.1186/s12884-016-1001-1 PMID: 27492552

89. Ronsmans C, Campbell O. Quantifying the fall in mortality associated with interventions related to hypertensive diseases of pregnancy. BMC public health. 2011 Dec; 11(3):1–1. https://doi.org/10.1186/1471-2458-11-S3-S8 PMID: 21501459

90. Berhe AK, Ilesanmi AO, Aimakhu CO, Bezabih AM. Awareness of pregnancy induced hypertension among pregnant women in Tigray Regional State, Ethiopia. The Pan African Medical Journal. 2020; 35. https://doi.org/10.11604/pamj.2020.35.71.19351 PMID: 32537074

91. Bonet M, Brizuela V, Abalos E, Cuesta C, Baguiya A, Chamillard M, et al. Frequency, and management of maternal infection in health facilities in 52 countries (GLOSS): a 1-week inception cohort study. The Lancet Global Health. 2020 May 1; 8(5):e661–71. https://doi.org/10.1016/S2214-109X(20)30109-1 PMID: 32353314

92. Ngonzi J, Tornes YF, Mukasa PK, Salongo W, Kabakyenga J, Sezalio M, et al. Puerperal sepsis, the leading cause of maternal deaths at a Tertiary University Teaching Hospital in Uganda. BMC pregnancy and childbirth. 2016 Dec; 16(1):1–7.

93. Halder A, Vijayselvi R, Jose R. Changing perspectives of infectious causes of maternal mortality. Journal of the Turkish German Gynecological Association. 2015; 16(4):208. https://doi.org/10.5152/jtgga.2015.0134 PMID: 26692770

94. Berhan Y, Berhan A. Causes of maternal mortality in Ethiopia: a significant decline in abortion related death. Ethiopian journal of health sciences. 2014 Sep 12; 24:15–28. https://doi.org/10.4314/ejhs.v24i0.3s PMID: 25489180

95. Legesse T, Abdulahi M, Dirar A. Trends and causes of maternal mortality in Jimma University specialized hospital, Southwest Ethiopia: a matched case–control study. International journal of women's health. 2017; 9:307. https://doi.org/10.2147/IJWH.S123455 PMID: 28496370

96. Enaruna N, Maduka R. Maternal mortality: A focus on the increasing role of non-obstetric causes at a University Hospital in Benin City, Nigeria. Journal of Medicine and Biomedical Research. 2019; 18 (1):18–29.

97. Young MF. Maternal anaemia and risk of mortality: a call for action. The Lancet Global Health. 2018 May 1; 6(5):e479–80. https://doi.org/10.1016/S2214-109X(18)30185-2 PMID: 29571593

98. Argaw D, Kabthymer RH, Birhane M. Magnitude of anemia and its associated factors among pregnant women attending antenatal care in Southern Ethiopia: a cross-sectional study. Journal of blood medicine. 2020; 11:335. https://doi.org/10.2147/JBM.S264369 PMID: 33117019

99. Gari W, Tsegaye A, Ketema T. Magnitude of anemia and its associated factors among pregnant women attending antenatal care at Najo General Hospital, Northwest Ethiopia. Anemia. 2020 Oct 19; 2020. https://doi.org/10.1155/2020/8851997 PMID: 33133691

100. Azuh DE, Iweala EJ, Adeloye D, Akanbi M, Mordi RC. Factors influencing maternal mortality among rural communities in southwestern Nigeria. International Journal of Women's Health. 2017; 9:179. https://doi.org/10.2147/IJWH.S120184 PMID: 28442936

101. Atuhaire R, Kaberuka W. Factors contributing to maternal mortality in Uganda. African Journal of Economic Review. 2016 May 24; 4(2):43–57.

102. Aden JA, Ahmed HJ, Östergren PO. Causes and contributing factors of maternal mortality in Bosaso District of Somalia. A retrospective study of 30 cases using a Verbal Autopsy approach. Global health action. 2019 Jan 1; 12(1):1672314. https://doi.org/10.1080/16549716.2019.1672314 PMID: 31599213

103. Getachew F, Kassa GM, Ayana M, Amsalu E. Knowledge of direct obstetric causes of maternal mortality and associated factors among reproductive age women in aneded woreda, northwest Ethiopia; a cross-sectional study. The Pan African Medical Journal. 2017; 27. https://doi.org/10.11604/pamj.2017.27.32.10274 PMID: 28761608

104. Pembe AB, Urassa DP, Carlstedt A, Lindmark G, Nyström L, Darj E. Rural Tanzanian women's awareness of danger signs of obstetric complications. BMC pregnancy and childbirth. 2009 Dec; 9(1):1–8. https://doi.org/10.1186/1471-2393-9-12 PMID: 19323836

105. Assefa Y, Gelaw YA, Hill PS, Taye BW, Van Damme W. Community health extension program of Ethiopia, 2003–2018: successes and challenges toward universal coverage for primary healthcare services. Globalization and health. 2019 Dec; 15(1):1–1.

106. Mohammed MM, El Gelany S, Eladwy AR, Ali EI, Gadelrab MT, Ibrahim EM, et al. A ten year analysis of maternal deaths in a tertiary hospital using the three delays model. BMC Pregnancy and Childbirth. 2020 Dec; 20(1):1–8.

107. Nassoro MM, Chetto P, Chiwanga E, Lilungulu A, Bintabara D, Wambura J. Maternal mortality in dodoma regional referral hospital, Tanzania. International Journal of Reproductive Medicine. 2020 Jun 3; 2020.

108. Combs Thorsen V, Sundby J, Malata A. Piecing together the maternal death puzzle through narratives: the three delays model revisited. PloS one. 2012 Dec 19; 7(12):e52090. https://doi.org/10.1371/journal.pone.0052090 PMID: 23284882

109. Gunawardena N, Bishwajit G, Yaya S. Facility-Based maternal death in Western Africa: a systematic review. Frontiers in public health. 2018 Feb 26; 6:48. https://doi.org/10.3389/fpubh.2018.00048 PMID: 29535999

110. Taye Makuria A, Gebremichael D, Demoz H, Hadush A, Abdella Y, Berhane Y, et al. Obstetric hemorrhage, and safe blood for transfusion in Ethiopia: the challenges of bridging the gap. Transfusion. 2017 Oct; 57(10):2526–31. https://doi.org/10.1111/trf.14219 PMID: 28703878

111. Mgawadere F, Unkels R, Kazembe A, van den Broek N. Factors associated with maternal mortality in Malawi: application of the three delays model. BMC pregnancy and childbirth. 2017 Dec; 17(1):1–9.

112. Assefa EM, Berhane Y. Delays in emergency obstetric referrals in Addis Ababa hospitals in Ethiopia: a facility-based, cross-sectional study. BMJ open. 2020 Jun 1; 10(6):e033771. https://doi.org/10.1136/bmjopen-2019-033771 PMID: 32580981

113. Hailu S, Enqueselassie F, Berhane Y. Health facility-based maternal death audit in Tigray, Ethiopia. Ethiopian Journal of Health Development. 2009; 23(2).

114. Chavane LA, Bailey P, Loquiha O, Dgedge M, Aerts M, Temmerman M. Maternal death and delays in accessing emergency obstetric care in Mozambique. BMC Pregnancy and Childbirth. 2018 Dec; 18 (1):1–8.

115. Pacagnella RC, Cecatti JG, Parpinelli MA, Sousa MH, Haddad SM, Costa ML, et al. Delays in receiving obstetric care and poor maternal outcomes: results from a national multicentre cross-sectional study. BMC pregnancy and childbirth. 2014 Dec; 14(1):1–5. https://doi.org/10.1186/1471-2393-14-159 PMID: 24886330

116. Raj SS, Maine D, Sahoo PK, Manthri S, Chauhan K. Meeting the community halfway to reduce maternal deaths? Evidence from a community-based maternal death review in Uttar Pradesh, India. Global Health: Science and Practice. 2013 Mar 1; 1(1):84–96. https://doi.org/10.9745/GHSP-D-12-00049 PMID: 25276519

117. Harrison MS, Kirub E, Liyew T, Teshome B, Jimenez-Zambrano A, Muldrow M, et al. Performance of Integrated Emergency Surgical Officers at Mizan-Tepi University Teaching Hospital, Mizan-Aman, Ethiopia: A Retrospective Cohort Study. Obstetrics and gynecology international. 2021 Jan 5; 2021. https://doi.org/10.1155/2021/8875560 PMID: 33488734

118. Abebe A, Catriona W, Improving health system efficiency [Internet]. [cited 2022 Feb 6]. Available from, https://tinyurl.com/2p8hfr9e