RESEARCH ARTICLE

Area of focus to handle delays related to maternal death in Ethiopia

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Abstract

Background

Maternal delay factors, together with medical factors, have a substantial role in determining maternity outcomes. Although several studies were conducted on delay factors that contribute to maternal death in Ethiopia, the studies were mostly focused either on an individual or at a provincial level factor with a limited number of study participants. In response to this gap, this study is aimed at exploring the magnitude and factors related to delay factors that contribute to maternal death in Ethiopia.

Methods

The study used maternal death surveillance data collected from different regions of Ethiopia, compiled between 2013 and 2021. A total of 4530 maternal deaths were reviewed during the study period. A Multilevel multinomial logistic regression model was applied to examine factors associated with delays related to maternal death. An adjusted relative risk ratio with a 95% confidence interval was stated and variables with p-values less than 0.05 were declared as significant predictors of maternal delay.

Result

Delay three (delay in receiving adequate and appropriate care once reached a health facility) has contributed to 36.3% of maternal deaths followed by delay one (delay in deciding to seek care when experiencing an obstetric emergency) and delay two (delay in reaching to an appropriate obstetric facility) where each of them contributed to 36.1% and 27.6% of maternal deaths respectively. In the multivariate multilevel multinomial model, maternal age, education status, and place of death were among the individual level factors associated with both delay two and delay three. Conversely, marital status and ANC follow-up were associated with delay two alone, while the timing of maternal death was associated with delay three. Residence and type of facility were provincial-level factors linked with both delay two and delay three, while the type of region was related to delay three of maternal death.
Conclusion

Both delay one and three have a major contribution to maternal death in Ethiopia. Individual and provincial level factors played an important role in determining delays related to maternal death. Therefore, it is crucial to account for measures that provide emphasis on the area of raising awareness on the utilization of Antenatal care (ANC) service, improving facility readiness to handle obstetrics emergencies, and narrowing down inequality among regions in service provision.

Introduction

Maternal death is one of the commonly used yardsticks to assess the performance of health systems; it is also an important proxy parameter to measure women’s empowerment and national development [1]. Globally, the burden of maternal death is more prominent in Sub-Saharan African and South Asian countries [2]. Specifically, Sub-Saharan African countries accounted for nearly 67% of global maternal deaths in 2017 [3]. To address these challenges global target was set in 2000, called the millennium development goal (MDG) which lasted fifteen years. To keep the momentum generated by MDG, a new global target was established in 2015 under the sustainable development goals (SDG). The SDG has a target to reduce maternal death to as few as 70 deaths per 100,000 live births by 2030 [4].

Ethiopia is one of the nations that has reduced maternal death remarkably in the last two decades. According to the Ethiopian Demographic and Health Survey (EDHS), there was a substantial decline in the maternal mortality rate, from 871 death per 100,000 live births in 2000 to 412 deaths per 100,000 live births in 2016 [5]. Despite a tangible reduction in the overall maternal mortality rate, the presence of a noticeable regional variation was one of the factors that have hampered the achievement of the target set under the MDGs [6, 7]. To better streamline the information flow on maternal mortality, Ethiopia has established the maternal death surveillance and response system (MDSR) in 2013, which is aimed at monitoring the progress towards the goals of MDG [8].

MDSR is an ongoing system employed for the systematic identification, collection, review, analysis, and interpretation of data related to maternal death [9]. The surveillance system is accompanied by a response component, which is implemented at individual and national levels to avert similar death in the future [10]. Countries like Ethiopia, which have a weak vital registration system in place and a low rate of institutional delivery are recommended to practice a mix of facility-based and community-based reviews of maternal death to ensure the coverage and completeness of the system [11]. Currently, Ethiopia is practicing this mixed method of registering maternal death [12], while its implementation is being challenged by underreporting, limited capacity of the health workforce, and low engagement of the community [13, 14].

MDSR data can guide in identifying the area of interventions to tackle the delay factors related to maternal death and it enables to design individual-level responses at health facility level and programmatic responses at the national and sub-national levels [15, 16]. The three-delay model was developed by Thaddeus and Maine in 1994 to facilitate the identification of indirect factors, from the onset of obstetric complications to the birth of the baby [17, 18]. Delay one is related to delay in deciding to seek care, which is commonly influenced by negative past experiences, late recognition of the problem, and financial problems [19]. Delay two, on the other hand, is related to identifying and reaching care, which is usually determined by
the availability of transport and accessibility of the facility [20–22]. The third delay, i.e., delay three, is related to receiving suboptimal care after reaching a health facility [23], which is usually measured by the availability of trained personnel, essential medical commodities, and initiation of early treatment and follow-up [24].

According to the study by Azmach and Ftalew et al. [25], delay one contributes to 33% of maternal death followed by delay two and delay three, which contributes to 32% and 29% of maternal deaths in Ethiopia respectively. In line with this, per the 2019 annual report of the Ethiopian Ministry of Health, the contribution of delay one is declining over time and the lead is being taken by delay three [12].

Ethiopia has implemented various initiatives to handle delays related to maternal death such as the establishment of maternity waiting rooms in a health facility [26], availing free transport and maternity service [27], and the introduction of health extension and community-based health insurance (CBHI) programs [28, 29]. Moreover, middle-level health cadres (Integrated Emergency Surgical Officers) are being trained to handle obstetric emergencies at a lower level. This is coupled with upgrading the existing health facilities to ensure the provision of comprehensive emergency obstetrics and newborn care (CEmONC) [30, 31]. Despite all this effort, however, the number of maternal deaths remains unacceptably high [32].

Educational status, marital status, ANC service utilization, maternal parity, and place of delivery were individual-level factors that contribute to maternal delay whereas, the type of health facility, residence of the women, and type of region were provincial factors related to maternal delay [33–35]. However, none of the studies had used these factors (i.e., individual, and provincial factors) simultaneously. Furthermore, most of the studies were focused on small and localized areas with a limited study population and descriptive form of analysis. In response to this gap, this study is aimed at determining the magnitude and identifying factors associated with delay factors related to maternal death using multilevel analysis based on the MDSR data.

**Methods and materials**

**Study setting**

Ethiopia has an estimated population of 114,963,588 in 2020, out of which 28,807,161 were women of reproductive age group [36]. Administratively, Ethiopia has nine regions and two city administrations, namely Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations Nationalities and Peoples Region (SNNPR), Gambella, Harari, Addis Ababa city administration and Dire Dawa city administration [37]. The country has a total of 17187 health posts, 3724 health centers, 302 public hospitals, and 5401 private health facilities. The country has 0.44,0.97, 0.8, and 8.4 per 10000 population of medical doctors (including specialists), health officers, midwives, and nurses respectively [38].

**Study design and data collection process**

A secondary data review was conducted on Ethiopian MDSR data gathered and compiled from all regions of the country. The data was collected through the MDSR system, which enforces a mandatory notification, investigation, and verification of maternal deaths across the country. Moreover, the system was accompanied by a review of each notified maternal death to assign the cause and contributing factors related to the death. The review process uses two data sources, namely: facility-based abstraction format (FBAF) for health facility deaths and verbal autopsy (VA) for community deaths. At a health facility level, a maternal death review is conducted based on the abstraction format, by the MDSR committee. After the death review, the final death report is preprepared using the maternal death reporting format (MDRF) by the assigned surveillance focal person. Afterward, the report is sent to the national data hub.
and this national data is used as a data source for this study [39]. A total of 4530 maternal deaths were reviewed from 2013 to 2021 in Ethiopia. The MDSR data is hierarchical i.e., women were nested in reporting facilities and reporting facilities were nested in different zones (provinces) of the country.

**Case definition and inclusion and exclusion criteria**

**Case definition.** Maternal death is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes [39].

**Inclusion criteria.** Women who meet the case definition stated above were included in the study.

**Exclusion criteria.** Women who died due to an accidental or incidental cause during pregnancy or a within 42 days of termination of pregnancy were excluded from the study.

**Study variables**

**Outcome variables.** The delay factor was used as the study’s principal outcome variable. It had three distinct categories; delay one (delay in seeking health care), delay two (delay in reaching a health care facility), and delay three (delay in receiving care at the health facility). The classification was made using 14 variables, which were used to assess the contributing factors to maternal deaths. Delay one was measured using 5 item questionnaires that include 1) visiting a traditional healer or traditional birth attendant first 2) the family having insufficient money 3) lack of awareness of obstetric complications 4) the nearest healthcare facility is more than 5 km away 5) lack of decision to health facility due to perceived poor quality of care at a health facility.

The second delay was assessed using 5 item questions that include 1) the poor road condition and/or terrain 2) long travel time from home to a healthcare facility (more than an hour) 3) the cost of transportation 4) unavailability of transportation 5) unavailability of healthcare facility in the area (takes more than one hour to reach the nearest healthcare facility).

The third delay was also measured using 4 item question that includes: 1) inadequacy of the referral system, (ambulances not available, no fuel, breakdown, and use of public transport) 2) shortage of equipment and supplies 3) delayed management after admission (more than 30 min from the time of arrival to time of assessment or receiving treatment) 4) wrong assessment of risk, wrong diagnosis, and wrong treatment. Three procedures were followed to decide the significant delay factor that contributed to the death of each mother. First, the row sum score of each delay was computed and this was followed by standardization of scores, which rescale the scores to have a mean value of 0 and a standard deviation of 1, to compare the score of each delay based on the value of standard deviation [40]. Finally, the delay with the highest score of standard deviation was selected as the perceptible delay factor that contributes to maternal death.

**Explanatory variables.** Both individual and community (provincial) level variables were included as a predictor in the model. Individual-level variables includes women’s age, educational status, marital status, parity, history of Antenatal Care (ANC) follow-up, place of death, time of death, and cause of death. The medical cause of death was incorporated as individual death after the underlying cause of death was assigned using the International Classification of Diseases -Maternal Mortality (ICD-MM) [41].

Community (provincial) level variables include variables such as residence, type of facility, and type of region. The type of region was classified into three categories (city, agrarian, and pastoralist) based on the cultural and socio-economic backgrounds of the population [42].
Furthermore, the type of facility was codified into classes (primary, secondary, and tertiary facilities) according to their manpower, medical equipment, and service provision [38].

Data management and statistical analysis
The data was exported from Epi -info version 7.2 to Stata version 17 for data cleaning and further analysis. using the cleaned data, both descriptive (count and percentage) and analytical analysis (multilevel multinomial logistic regression) were carried out and reported. Model building. Multilevel multinomial logistics regression was employed to incorporate random and fixed effects into the model. The analysis was performed using Generalized Structural Equation Modelling (with the logit link function) using the “gsem” Stata command [43]. While defining the model, delay one was selected as a reference category of the independent variable. Four consecutive models were fitted to decide on the final model. The first model was a null model (containing only the outcome variable), the second one was model 1 (model fitted using individual-level variables only), the third was model 2(model fitted using provincial-level variables only) and the fourth model was model 3 (fitted using individual and provincial variables). The final best-fitted model was selected based on the value of log-likelihood and Akaike's information criteria (AIC). Both bivariate and multivariate analysis were employed. A P-value of less than 0.20 was used as a cut-off point to retain variables for the final multivariable analysis. Multicollinearity between explanatory variables was checked using the Variance Inflation Factor (VIF). Finally, the adjusted Relative Risk Ratio (RRR) with 95% Confidence Interval (CI) was reported and variables with p- values <0.05, in multivariate analysis, were declared as significant predictors of delay two and delay three.

In the random-effects analysis, to assess the variability of delay two/three between provinces, both Intraclass Correlation Coefficient (ICC) and Proportional change in Variance (PCV) were calculated.

Ethical statement. 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. Since the study used secondary data, other ethical measures were not required.

Result
Selected characteristics of reported facilities
A total of 4530 maternal death were reviewed during the study period. Delay three has contributed to 36.3% of maternal deaths followed by delay one and delay two where each contributed to 36.1% and 27.6% of maternal death, respectively. Among the reported facilities, nearly half of the maternal death (44.3%) contributed by delay one was reported from the primary health care level. Similarly, more than half of maternal death (53.5%) contributed by delay three were reported from tertiary level health care. Region-wise, 42.3% of maternal death in the Afar region was contributed by delay one, whereas 29.8% of maternal deaths in the Amhara region were contributed by delay two. Furthermore, 55.2% of maternal death in the Somali region were contributed by delay three (Table 1).

Sociodemographic characteristics of the deceased women
The proportion of women who died due to the contribution of delay one was higher among women who are in the age group of 10–19 years (42.6%) compared to women who were aged 20–29 years (35.4%). Women who resided in a rural area had a higher proportion of death due to delay three (47.9%) compared to those who resided in an urban area (34.2%). Likewise,
women who lived in cities had a higher proportion of death due to the contribution of delay three (48.0%) compared to those who reside in the pastoralist area (31.3%). In line with this, women who attended secondary education and above had a higher proportion of death due to the influence of delay three (48.5%) compared to women who only attended primary level education (34.4%). Besides, women who died during the antepartum period had a higher proportion of death due to delay two (36.1%) compared to women who died during the postpartum period (26.8%) (Table 2).

The proportion of assigned cause of death for reviewed maternal death

Women who died due to unanticipated complications of management had a higher proportion of death because of delay three (52.3%) compared to women who were deceased due to other causes of death (36.1%). Women who died due to other obstetrics complications had a higher proportion of death because of delay two (39.1%) compared with the remaining cause of death (27.3%). The proportion of delay one was higher among women who died due to abortive
outcomes of pregnancy (43.1%) compared to women who died due to other causes of death (Table 3).

**Multilevel multinomial analysis**

A multilevel multinomial logistic regression analysis was fitted to assess the three-delay factor related to maternal death. In the multivariate multilevel multinomial regression analysis, both individual level and provincial level variables were associated with delay two and delay three.
Factors associated with delay two among reviewed maternal death in Ethiopia.

Women’s age, marital status, educational status, place of death, and history of ANC follow-up were among individual-level factors related to delay two. Residence and type of health facility were provincial level factors associated with delay two. Being in an older age group was associated with a higher risk of facing delay two compared to younger age women. Women who died at home and at a health facility had 69% [RRR = 0.31, 95%CI:(0.24–0.41)] and 30% [RRR = 0.70, 95%CI:(0.55–0.89)] lower risks of encountering delay two, respectively. Women who are married had a 51% [RRR = 1.51, 95%CI: (1.09–2.09)] higher risk of facing up delay two. Women who attend ANC follow-up had a 51% [RRR = 1.51, 95%CI:(1.26–1.81)] higher risk of doing up delay two. Conversely, women who resided in a rural area had a 26% [RRR = 0.74, 95%CI:(0.56–0.97)] lower risk of facing delay two as compared to women who live in an urban area (Table 4).

Factors associated with delay three among reviewed maternal death in Ethiopia.

Women’s age, educational status, place of death, and time of death were among individual-level factors related to delay three. Residence, type of health facility, and region were provincial factors associated with delay three. Women in the age group 20–24 had 41% [RRR = 1.41, 95%
Table 4. Multilevel multinomial logistic regression analysis in assessing the factors associated with delay factor related to maternal death (both delay two and three).

| Variables/Characteristics | Empty model | Model 2b | Model 3c | Model 4d |
|---------------------------|-------------|----------|----------|----------|
|                           | Individual characteristics | Community characteristics | Individual and Community characteristics |
| Delay one (a)             | Delay two | Delay three | Delay two | Delay three | Delay two | Delay three |
| RRR (95%CI)               | RRR (95%CI) | RRR (95%CI) | RRR (95%CI) | RRR (95%CI) | RRR (95%CI) |
| Age group                 |           |           |           |           |           |           |
| 10_19Y                    | 1         | 1         | 1         | 1         | 1         | 1         |
| 20_29Y                    | 1.20(0.86,1.69) | 1.29(0.93,1.78) | 1.19(0.85,1.67) | 1.25(0.90,1.74) |
| 30_39Y                    | 1.31(0.93,1.85) | 1.39(1.00,1.93) | 1.30(0.92,1.84) | 1.41(1.01,1.97) |
| 40-49Y                    | 1.63(1.04,2.55) * | 1.24(0.79,1.96) | 1.62(1.04,2.54) * | 1.29(0.82,2.04) |
| Place of death            |           |           |           |           |           |           |
| On transit (b)            | 1         | 1         | 1         | 1         | 1         | 1         |
| Home                      | 0.31(0.24,0.40) *** | 0.16(0.11,0.22) *** | 0.31(0.24,0.41) *** | 0.17(0.12,0.23) *** |
| Health facility           | 0.76(0.61,0.95) * | 1.65(1.30,2.08) *** | 0.70(0.55,0.89) *** | 1.25(0.98,1.60) |
| Marital status            |           |           |           |           |           |           |
| Unmarried (c)             | 1         | 1         | 1         | 1         | 1         | 1         |
| Married                   | 1.48(1.07,2.05) * | 1.27(0.92,1.74) | 1.51(1.09,2.09) * | 1.26(0.91,1.74) |
| Educational status        |           |           |           |           |           |           |
| Secondary and above (d)   | 1         | 1         | 1         | 1         | 1         | 1         |
| Illiterate                | 0.55(0.38,0.79) *** | 0.50(0.35,0.72) *** | 0.57(0.39,0.82) ** | 0.53(0.37,0.76) ** |
| Primary                   | 0.53(0.39,0.72) *** | 0.47(0.35,0.64) *** | 0.54(0.39,0.73) *** | 0.47(0.35,0.63) *** |
| History of ANC follow-up  |           |           |           |           |           |           |
| No (e)                    | 1         | 1         | 1         | 1         | 1         | 1         |
| Yes                       | 1.59(1.34,1.90) *** | 1.26(1.06,1.50) * | 1.51(1.26,1.81) *** | 1.17(0.98,1.40) |
| Time of death             |           |           |           |           |           |           |
| Antepartum (f)            | 1         | 1         | 1         | 1         | 1         | 1         |
| Intrapartum               | 1.07(0.63,1.83) | 1.92(1.04,8.25) | 1.17(0.68,2.01) | 2.33(1.25,4.32) ** |
| Postpartum                | 1.03(0.61,2.50) | 2.34(1.01,16.44) | 1.09(0.64,1.84) | 2.60(1.42,4.76) ** |
| Type of health facility   |           |           |           |           |           |           |
| Primary health care        | 1         | 1         | 1         | 1         | 1         | 1         |
| Secondary health care      | 1.47(1.19,1.80) *** | 2.63(2.17,3.19) *** | 1.24(0.99,1.56) | 1.66(1.35,2.05) *** |
| Tertiary health care       | 1.67(1.30,2.15) *** | 3.82(3.02,4.83) *** | 1.43(1.09,1.87) ** | 2.41(1.88,3.09) *** |
| Type of region             |           |           |           |           |           |           |
| City administration (g)    | 1         | 1         | 1         | 1         | 1         | 1         |
| Pastoralist region         | 0.76(0.45,1.31) | 0.32(0.31,0.87) * | 0.85(0.50,1.44) | 0.39(0.35,0.99) * |
| Agrarian region            | 0.91(0.58,1.42) | 0.80(0.52,1.22) | 1.01(0.65,1.56) | 0.90(0.59,1.36) |
| Residence                 |           |           |           |           |           |           |
| Urban (h)                 | 1         | 1         | 1         | 1         | 1         | 1         |
| Rural                     | 0.63(0.49,0.82) *** | 0.64(0.50,0.81) *** | 0.74(0.56,0.97) * | 0.71(0.55,0.92) ** |

*P < 0.05, **P < 0.001, ***P < 0.0001, (a) Reference for the dependent variable, (b) Reference for the category of an independent variable

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higher risks of encountering delay three. Women who died at home had an 83% [RRR = 0.17, 95%CI:(0.12–0.23)] lower risk of confronting delay three compared to those who died at a health facility. Women with no education and primary level education had a 47% [RRR = 0.53, 95%CI: (0.37–0.76)] and 53% [RRR = 0.47, 95%CI:(0.35–0.63)] lower risk of facing delay three, respectively. Women who died during intrapartum and postpartum period were associated with 2.33 [RRR = 2.33, 95%CI: (1.25–4.32)] and 2.60 [RRR = 2.66 95%CI: (1.42–4.76)] times higher risk of encountering delay three, respectively as compared to women who died during the antepartum period. Women who were managed in secondary and tertiary level facilities were associated with 1.66 [RRR = 1.66, 95%CI: (1.35–2.05)] and 2.41 [RRR = 2.41, 95%CI: (1.88–3.09)] times higher risk of being challenged by delay three respectively as compared to women who were treated in the primary level of care. Women who live in pastoralist areas had a 41% [RRR = 0.59, 95%CI: (0.35–0.99)] lower risk of confronting delay three as compared to women who live in city administration. Furthermore, women who resided in a rural area had a 29% [RRR = 0.71, 95%CI: (0.55–0.92)] lower risk of facing delay three compared to women who live in an urban area (Table 4).

Random effect analysis. As depicted in Table 5, ICC in the null model revealed that about 7% of the variability in delay factor was attributed to differences between provinces. While the highest PCV in the final model revealed that about 45% of the variability of delay factor was explained by both individual and province-level factors. Overall, model 3 was selected as the best-fitted model, due to its low AIC and high log-likelihood (Table 5).

Discussion

This assessment is the first comprehensive analysis of MDSR data from 2013 to 2021 that focuses specifically on the magnitude and factors related to delays, which contribute to maternal death. Our key finding revealed that delay one and delay three were major contributors to maternal death in Ethiopia; in addition, the delays were influenced by both individual and provincial level factors.

The magnitude of delay one and delay three were comparable with a study conducted in Ethiopia [25]; however, the magnitude of delay one was much lower compared to studies conducted in Addis Ababa [35], Gamo zone [44], and Malawi [45], while the magnitude of delay three was comparable with a hospital-level study conducted in Ethiopia [46]. The disparity in magnitude could be explained by a variety of reasons such as the data sources, the study population, the study area, and the method of analysis employed. Delay one and delay three were responsible for 72% of maternal death in Ethiopia, hence measures targeting both delays should be devised to substantially reduce maternal death.

| Table 5. The random effect model in examining the factors linked to delays relate to maternal death in Ethiopia. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Random effect   | Null model      | Model_1         | Model_2         | Model_3         |
| District level variance (SE) | 0.25(0.07) | 0.15(0.06) | 0.21(0.07) | 0.14(0.05) |
| P_values        | <0.001          | <0.001          | <0.001          | <0.001          |
| ICC (%)         | 7%              | 4.4%            | 6.0%            | 4.0%            |
| Explained variance (PVC) (%) | Reference | 40.0%   | 16.0%   | 45.0%   |
| MOR (95%CI)     | 1.60(1.43,1.86) | 1.44(1.29,1.69) | 1.54(1.37,1.81) | 1.42(1.29,1.64) |
| Model fit statics | Log-likelihood | 4883          | 4602          | 4744          | 4555          |
|                 | AIC             | 9766           | 9218           | 9496           | 9130           |
|                 | BIC             | 9770           | 9230           | 9502           | 9147           |

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The study revealed that the risk of encountering delay two and three was higher in older-aged women compared to younger-age women. This is in line with similar studies done in Nigeria [47], Ghana [48], India [49], and Bangladesh [50]. This could be explained by the high tendency of teenage women (those between 10 to 19 years of age) to hesitate seeking care, due mostly to unwanted and unsupported pregnancy. Those women would prefer home delivery to avoid social exposure making them more vulnerable to delay one as compared to relatively older aged women who had a prior history of giving birth. This has a relationship with the utilization of ANC service, which is commonly influenced by educational status, wealth, and proximity to health facilities [51–53]. Conversely, older women were good at deciding to seek care than younger women and they tend to prefer facility delivery over home delivery. While women encounter numerous challenges hampering them from reaching and receiving care; overall, maternal age is one of the main factors and hence it should be considered in any intervention intended to manage delays related to maternal death.

Place of death, which is believed to be their place of delivery, was negatively associated with delay two and delay three. Women who died at home were less likely to encounter delay two and delay three as compared to women who died during transit. Likewise, women who died at a health facility were less likely to face delay two as compared to women who died during referral. The finding has coherence with studies conducted in Ethiopia (Afar), India, and Nepal [49, 54, 55]. The possible explanation might be due to the expectation that women who deliver at home would fail into the trap of delay in deciding to seek care. Most of the women residing in rural areas would mostly prefer traditional birth attendants due to lack of birth preparedness plans [56–58]. On the other hand, women who died during transit were mostly affected by the unavailability of transportation on their referral from a peripheral health facility [59, 60]. Considering the gap, Ethiopia has established maternity waiting rooms (MWRs), which serve as a waiting area until labor is initiated. The major triggering factors for the establishment of MWRs, among others, were to address barriers to reach to care due to distance, unfavorable seasonal climate, and lack of infrastructure (transportation and effective referral communication) [61]. However, in the Ethiopian context, the utilization of MWRs is affected by the proximity of the mother to a health facility, availability of companion support, and poor awareness about the service [62, 63]. Overall, the finding implied that women who died in different places might encounter varying types of delays based on the delineated circumstance.

This study has demonstrated a statistical significance between marital status and delay two. Married women were more likely to face delay two as compared to unmarried women. This finding was parallel with studies done in Ethiopia (Sidama and Addis Ababa) [64, 65] Nepal [66], Bangladesh [67], India [68] and Myanmar [69]. This might be explained by the positive role husbands play in encouraging women to utilize maternity services. Besides, the husband’s awareness could alert them to take measures timely in addition to availing the necessary resources. This finding implies that male partner involvement could have a positive contribution in reducing the chance of facing delay one, which is a delay in deciding to seek care.

This study has also revealed the association of educational status with delay factors. Women with no education and primary level education were less likely to encounter delay two and three as compared to women who attended school up to secondary and above. Previous studies elsewhere have also demonstrated the correlation between educational status and delay factors related to maternal death [70, 71]. Women’s education enhances health-seeking behavior, and this may lead to early recognition of maternal complications and reduces the risk of facing delay one, which is usually related to delay in deciding to seek care when experiencing an obstetric emergency. Acknowledging the relevance of health education during delivery, Ethiopia initiated a health extension program in 2003 to provide health service and education at a community level, while the implementation and functionality are challenged by the capacity of
health posts and the high turnover rate of health extension workers, it has shown a promising stride [72]. Overall, this finding suggested that women’s education status has a significant role in addressing delays related to maternal death.

The study also revealed that history of ANC follow-up has a connection with the delay factor. Women who attended ANC follow-up have a higher chance of encountering delay two than delay one. This is consistent with study findings from Ethiopia [73], Indonesia, and the Philippines [74]. The plausible reason for this could be the fact that women who attended ANC service are more likely to remain vigilant in identifying and intervening to problems in a timely fashion, which has a significant effect on handling delays related to their health-seeking behavior. However, to better achieve the objectives of the ANC service, it should be augmented by better accessibility and availability of health facilities.

The timing of maternal death was also found to be correlated with delay factor. Women who died during the intrapartum and postpartum period were more likely to face delay three than women who died during the antepartum period. Previous studies elsewhere have also disclosed similar findings, i.e., delay three plays a decisive role in determining the timing of maternal death [75, 76]. This might be directly related to the absence of essential medical commodities, trained health professionals, and well-equipped facilities.

The type of health facility, where the woman visited for an obstetric complication, has also shown an association with delay factors. Women who were treated at a tertiary level facility have a higher chance of facing delay two and delay three compared to other levels of care. Besides, women who were managed in a secondary level facility were more likely to encounter delay three. This finding was congruent with studies done in Uganda [77], Tanzania [78] and India [79, 80]. This could be explained by the poor handling of obstetrics emergencies at lower-level facilities, which in turn, result in overwhelming the managing capacity of the next higher-level facility due to unreasonable referral. Moreover, the presence of poor referral linkage has resulted in a delayed referral and paved the way for multiple referrals, which has a negative consequence on the outcome of the mother. The introduction of mentorship and coaching is one of the new approaches implemented in Sub-Sahara African countries to avert the challenge of poor service provision at lower-level facilities. The mentorship practice allows close observation of lower facilities by availing trained health professionals and equipment to handle obstetrics emergencies [81]. Overall, this finding suggested the need to evaluate the facility-level readiness on a timely basis based on health facilities’ capacity to manage obstetric complications.

The study has identified the presence of regional variation in the delay factors that contributed to maternal death. Women who lived in pastoralist areas have demonstrated a lower risk of facing delay three compared to women who reside in metropolitan cities. Besides women who live in rural areas have shown a lower risk of encountering delays two and three compared with their counterparts who live in urban areas. The finding was comparable with studies done elsewhere [24, 82–84], which revealed the presence of inequality in maternal service utilization based on residence and region. The likely explanation for this could be the fact that women who reside in rural areas and pastoralist regions have limited information on maternity services; in addition, this could also be due to the challenge residents face in accessing health facilities within a reasonable distance and time. The combination of all these factors hinders women from utilizing services and negatively affects their health-seeking behavior. Overall, the finding implies the need for narrowing down the disparity between regions in service availability and utilization.

The study has the following limitations that need to be admitted. First, almost all death review was conducted in public facilities with limited involvement of private facilities, and this could affect the inclusiveness of the study. Secondly, variation among regions in the
implementation of the MDSR system may affect the representativeness of the study. Finally, the available variables in the dataset may not be adequate in explaining factors related to delays.

**Conclusion**

Overall, this study was guided by two research questions, aiming to investigate the magnitude; and factors that determine delays related to maternal death. The study adds knowledge on the impact of delay factors in maternal death in Ethiopia. It also pinpoints a critical area of focus to contend with delay factors at both individual (maternal age, marital status, place of death, timing of death, and education status) and provincial (residence, type region, and facility) levels. With the above-mentioned limitation in mind, some conclusions and recommendations can be drawn from the results obtained. First, improving the health-seeking behavior of the community through various channels such as using media campaigns, frontline health workers (health extension workers), and routine ANC care is crucial. Besides, interventions aimed at improving the engagement of younger-aged women and male companions should be the other front to reduce death contributed by delay one. Second, more emphasis and attention should be given to the crucial time of pregnancy, especially during the intrapartum and postpartum period, by improving the accessibility to maternity service by maximizing the utilization of MWRs to handle maternal death due to delay two. Third, facility-level readiness should be ameliorated in terms of manpower and equipment along with smoothening the referral system among facilities by giving special emphasis on the lower-level facilities to address delay three.

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**References**

1. Miller S, Belizán JM. The true cost of maternal death: individual tragedy impacts family, community, and nations. Reproductive health. 2015 Dec; 12(1):1–4.
2. Vora KS, Saiyed SL, Yasobantu S, Shah SV, Mavalankar DV. Journey to death: Are health systems failing mothers? Indian Journal of Community Medicine: Official Publication of Indian Association of Preventive & Social Medicine. 2018 Jul; 43(3):233. PMID: 30294095
3. World Health Organization. Trends in maternal mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division.
4. McArthur JW, Rasmussen K, Yamey G. How many lives are at stake? Assessing 2030 sustainable development goal trajectories for maternal and child health. Bmj, 2018 Feb 15; 360. https://doi.org/10.1136/bmj.k373 PMID: 29449222
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. Assela Y, Van Damme W, Williams OD, Hill PS. Successes and challenges of the millennium development goals in Ethiopia: lessons for the sustainable development goals. BMJ global health. 2017 Jul 1; 2(2): e000318. https://doi.org/10.1136/bmjgh-2017-000318 PMID: 29081999

8. Tesfay N, Tariku R, Zenebe A, Woldeyohannes F. Critical factors associated with postpartum maternal death in Ethiopia. Plos one. 2022 Jun 24; 17(6):e0270495. https://doi.org/10.1371/journal.pone.0270495 PMID: 35749471

9. Maphosa M, Juru TP, Masuka N, Gombe P, Nebuga P, Tshimanga M. Evaluation of the maternal death surveillance and response system in Hwange District, Zimbabwe. 2017. BMC pregnancy and childbirth. 2019 Dec; 19(1):1–9.

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

11. Moyer CA, Johnson C, Kaselitz E, Aborigo R. Using social autopsy to understand maternal, newborn, and child mortality in low-resource settings: a systematic review of the literature. Global health action. 2017 Jan 1; 10(1):1413917. https://doi.org/10.1080/16549716.2017.1413917 PMID: 29261449

12. Ethiopian public health institutes, National Maternal and Perinatal Death Surveillance and Response (MPDSR) System Annual Report 2012 EFY, https://tinyurl.com/2p8bdph

13. Yigeremu M, Molla M. Underreporting of in-hospital maternal deaths in three hospitals, Addis Ababa, Ethiopia. Ethiopian Medical Journal. 2020 Sep 23; 58.

14. Ayale B, Gebretsnae H, Hadgu T, Negash D, Gsillassie 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

15. Sageer R, Kronguyu E, AdibeimpeWO, Omosehin O, Ogunsola EA, Sanni B. Causes and contributory factors of maternal mortality: evidence from maternal and perinatal death surveillance and response in Ogun state, Southwest Nigeria. BMC pregnancy and childbirth. 2019 Dec; 19(1):1–8.

16. Said A, Malqvist M, Pembe AB, Massawe S, Hansson C. Causes of maternal deaths and delays in care: comparison between routine maternal death surveillance and response system and an obstetrician expert panel in Tanzania. BMC Health Services Research. 2020 Dec; 20(1):1–4.

17. Thaddeus S, Maine D. Too far to walk, maternal mortality in context. Social science & medicine. 1994 Apr 1; 38(8):1091–110. https://doi.org/10.1016/0277-9536(94)90226-7 PMID: 8042057

18. Actis Danna V, Bedwell C, Wakasiaka S, Lavender T. Utility of the three-delays model and its potential for supporting a solution-based approach to accessing intrapartum care in low-and middle-income countries. A qualitative evidence synthesis. Global health action. 2020 Dec 31; 13(1):1819052. https://doi.org/10.1080/16549716.2020.1819052 PMID: 33040697

19. Shah B, Krishnan N, Kodish SR, Yenokyan G, Fatema K, Uddin KB, et al. Applying the Three Delays Model to understand emergency care seeking and delivery in rural Bangladesh: a qualitative study. BMJ open. 2020 Dec 1; 10(12):e042690. https://doi.org/10.1136/bmjopen-2020-042690 PMID: 33061169

20. Thobb VA, Deshpande G, Reddy P. Maternal mortality in Bijapur district. Al Ameen J Med Sci. 2015; 8(2):119–24.

21. Atuoye KN, Dixon J, Rishworth A, Galaa SZ, Boamah SA, Luginaah I. Can she make it? Transportation barriers to accessing maternal and child health care services in rural Ghana. BMC health services research. 2015 Dec; 15(1):1–0. https://doi.org/10.1186/s12913-015-1005-y PMID: 26290436

22. 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

23. Alobo G, Reverzani C, Sarno L, Giordani B, Greco L. Estimating the Risk of Maternal Death at Admission: A Predictive Model from a 5-Year Case Reference Study in Northern Uganda. Obstetrics and Gynecology International. 2022 Mar 17; 2022. https://doi.org/10.1155/2022/4419722 PMID: 35342429

24. Lowe M. Social and cultural barriers to husbands’ involvement in maternal health in rural Gambia. The Pan African medical journal. 2017; 27. https://doi.org/10.11604/pamj.2017.27.255.11378 PMID: 29187924

25. Hadush A, Dagnaw F, Getachew T, Bailey PE, Lawley R, Ruano AL. Triangulating data sources for further learning from and about the MDSR in Ethiopia: a cross-sectional review of facility based maternal...
death data from EmONC assessment and MDSR system. BMC Pregnancy and Childbirth. 2020 Dec; 20(1):1–9.

26. 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.

27. Demissie A, Worku A, Berhane Y. Effect of Implementing a Free Delivery Service Policy on Women’s Utilization of Facility-Based Delivery in Central Ethiopia: An Interrupted Time Series Analysis. Journal of pregnancy. 2020 Dec 21; 2020. https://doi.org/10.1155/2020/8649598 PMID: 33414963

28. Kebede SA, Liyew AM, Tesema GA, Agegnehu CD, Teshale AB, Alem AZ, et al. Spatial distribution and associated factors of health insurance coverage in Ethiopia: further analysis of Ethiopia demographic and health survey, 2016. Archives of Public Health. 2020 Dec; 78(1):1–0. https://doi.org/10.1186/s13690-020-00407-0 PMID: 32190301

29. Fetene N, Linnander E, Fekadu B, Alemu H, Omer H, Canavan M, et al. The Ethiopian health extension program and variation in health systems performance: what matters? PloS one. 2016 May 26; 11(5): e0156438. https://doi.org/10.1371/journal.pone.0156438 PMID: 27227972

30. 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/10.1555/2021/8875560 PMID: 33488734

31. Aelbachew, Abebe & Waddington, Catriona. (2015). Improving health system efficiency: Ethiopia: human resources for health reforms. World Health Organization. https://apps.who.int/iris/handle/10665/187242

32. 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.

33. Teka H, Zelelow YB. A 3 years review of maternal death and associated factors at Ayder comprehensive specialized hospital, Northern Ethiopia. Ethiopian Journal of Reproductive Health. 2018 Dec 25; 10 (3).

34. Yaya Y, Data T, Lindtjørn B. Maternal mortality in rural south Ethiopia: outcomes of community-based birth registration by health extension workers. PloS one. 2015 Mar 23; 10(3):e0119321. https://doi.org/10.1371/journal.pone.0119321 PMID: 25799229

35. Asseta 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

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

37. Ageze L. Health facility governance in the Ethiopian health system. Bethesda: Health Systems. 2012; 20:20.

38. Federal Minister of Health of Ethiopia. Health and Health Related Indicators 2016/2017. 2017 Feb 12 [cited 2022 Mar 1]; http://repository.ifphc.org/xmlui/handle/123456789/395

39. Ethiopian Public Health Institutes. National Maternal and Perinatal Death Surveillance and Response Guidance. 2017 Feb 17 [cited 2022 Mar 2]; http://repository.ifphc.org/xmlui/handle/123456789/374

40. Gökhan AK, Güzeller CO, Eser MT. The effect of the normalization method used in different sample sizes on the success of artificial neural network model. International Journal of Assessment Tools in Education. 2019 Apr; 6(2):170–92.

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

42. Shifti DM, Chojenta C, Holliday EG., 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

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

44. Wanaka S, Husseen S, Alagaw S, 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

45. 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.
46. Worke MD, Enyew HD, Dagnew MM. Magnitude of maternal near misses and the role of delays in Ethiopia: a hospital based cross-sectional study. BMC research notes. 2019 Dec; 12(1):1–6.

47. Ntoimo LF, Okonofua FE, Ogu RN, Galadanci HS, Gana M, Okike ON, et al. Prevalence and risk factors for maternal mortality in referral hospitals in Nigeria: a multicenter study. International journal of women’s health. 2018; 10:69. https://doi.org/10.2147/IJWH.S151784 PMID: 29440934

48. Sumankoro J, Mahama MY, Crockett J, Wang S, Young J. Narratives on why pregnant women delay seeking maternal health care during delivery and obstetric complications in rural Ghana. BMC pregnancy and childbirth. 2019 Dec; 19(1):1–3.

49. Kaur M, Gupta M, Pandara Purayil V, Rana M, Chakrapani V. Contribution of social factors to maternal deaths in urban India: Use of care pathway and delay models. PLoS One. 2018 Oct 9; 13(10): e0203209. https://doi.org/10.1371/journal.pone.0203209 PMID: 30300352

50. Abedini S, Arunachalam D. Maternal autonomy and high-risk pregnancy in Bangladesh: the mediating influences of childbearing practices and antenatal care. BMC Pregnancy and Childbirth. 2020 Dec; 20(1):1–8. https://doi.org/10.1186/s12884-020-03260-9 PMID: 32962637

51. Tsegaye B, Ayalew M. Prevalence and factors associated with antenatal care utilization in Ethiopia: evidence from demographic health survey 2016. BMC Pregnancy and Childbirth. 2020 Dec; 20(1):1–9.

52. Bashar GW. Factors affecting the utilization of a minimum of four antenatal care services in Ethiopia. Obstetrics and Gynecology International. 2019 Aug 14; 2019. https://doi.org/10.1136/bmjopen-2019-031890 PMID: 31485232

53. Okedo-Alex IN, Akamike IC, Ezeanosike OB, Uneke CJ. Determinants of antenatal care utilisation in sub-Saharan Africa: a systematic review. BMJ open. 2019 Oct 1; 9(10): e031890. https://doi.org/10.1136/bmjopen-2019-031890 PMID: 31594900

54. Seward N, Prost A, Copas A, Corbin M, Li L, Colbourn T, et al. Using observational data to estimate the effect of hand washing and clean delivery kit use by birth attendants on maternal deaths after home deliveries in rural Bangladesh, India and Nepal. PloS one. 2015 Aug 21; 10(8): e0136152. https://doi.org/10.1371/journal.pone.0136152 PMID: 26295838

55. Abdella M, Abrah A, Gebre A, Reddy PS. Magnitude and associated factors for home delivery among women who gave birth in last 12 months in Ayssaita, Afar, Ethiopia-2016. A community based cross-sectional study. Glob J Fertil Res. 2017 Aug 31; 2(1):030–9.

56. Berhe R, Nigusie A. Magnitude of home delivery and associated factors among childbearing age mothers in Sherkole District, Benishangul Gumuz regional state-Western-Ethiopia. BMC public health. 2020 Dec; 20(1):1–7.

57. Chernet AG, Dumga KT, Cherie KT. Home delivery practices and associated factors in Ethiopia. Journal of reproduction & infertility. 2019 Apr; 20(2):102. PMID: 31058055

58. Delibo D, Damena M, Gobena T, Balcha B. Status of home delivery and its associated factors among women who gave birth within the last 12 months in east Badawacho District, Hadiya zone, Southern Ethiopia. BioMed Research International. 2020 Aug 19; 2020. https://doi.org/10.1155/2020/4916421 PMID: 32923481

59. Alaofe H, Lott B, Kimaru L, Okusanya B, Okechukwu A, Chebet J, et al. Emergency transportation interventions for reducing adverse pregnancy outcomes in low- and middle-income countries: a systematic review. Annals of global health. 2020; 86(1). https://doi.org/10.5334/aogh.2934 PMID: 33262936

60. Chavane LA, Bailey P, Loquilha 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.

61. Dalla Zuanna T, Fonzo M, Sperotto M, Resti C, Tsegaye A, Azzimonti G, et al. The effectiveness of maternity waiting homes in reducing perinatal mortality: a case–control study in BMJ. BMJ global health. 2021 Apr 1; 6(4):e004140. https://doi.org/10.1136/bmjgh-2020-004140 PMID: 33863756

62. Kurji J, Gebretsadik LA, Wordofa MA, Sudhakar M, Asefa Y, Kiros G, et al. Factors associated with masts028210.

63. Kebede KM, Mihrete KM. Factors influencing women’s access to the maternity waiting home in rural Southwest Ethiopia: a qualitative exploration. BMC Pregnancy and Childbirth. 2020 Dec; 20(1):1–2.

64. Teklesilasie W, Deressa W. Barriers to husband’s involvement in maternal health care in Sidama zone, Southern Ethiopia: a qualitative study. BMC pregnancy and childbirth. 2020 Dec; 20(1):1–8. https://doi.org/10.1186/s12884-019-2697-5 PMID: 31906876

65. Mohammed BH, Johnston JM, Vackova D, Hassen SM, Yi H. The role of male partner in utilization of maternal health care services in Ethiopia: a community-based couple study. BMC pregnancy and childbirth. 2019 Dec; 19(1):1–9.
66. Lewis S, Lee A, Simkhada P. The role of husbands in maternal health and safe childbirth in rural Nepal: a qualitative study. BMC pregnancy and childbirth. 2015 Dec; 15(1):1–0. https://doi.org/10.1186/s12884-015-0599-8 PMID: 26239123

67. Rahman AE, Perkins J, Islam S, Siddique AB, Moinuddin M, Anwar MR, et al. Knowledge and involvement of husbands in maternal and newborn health in rural Bangladesh. BMC pregnancy and childbirth. 2018 Dec; 18(1):1–2.

68. Suryawanshi DS, Rajaseharan D, Venugopal R. Involvement of husband in maternal and child health care in rural field practice area of a tertiary medical college in South India—A mixed method study. Journal of Family Medicine and Primary Care. 2021 Aug; 10(8):2829. https://doi.org/10.4103/jfmpc.jfmpc_2342_20 PMID: 34660413

69. Wai KM, Shibanuma A, Oo NN, Fillman TJ, Saw YM, Jimba M. Are husbands involving in their spouses’ utilization of maternal care services? A cross-sectional study in Yangon, Myanmar. PloS one. 2015 Dec 7; 10(12): e0144135. https://doi.org/10.1371/journal.pone.0144135 PMID: 26641891

70. Daka DW, Woldie M, Ergibia MS, Sori BK, Bayisa DA, Amente AB, et al. Inequities in the uptake of reproductive and maternal health services in the biggest regional state of Ethiopia: too far from “Leaving no one behind”. ClinicoEconomics and outcomes research: CECO. 2020; 12:595.

71. Weitzman A. The effects of women’s education on maternal health: Evidence from Peru. Social science & medicine. 2017 May 1; 180:1–9. https://doi.org/10.1016/j.socscimed.2017.03.004 PMID: 28301806

72. Assela Y, Gelavy 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.

73. Tarekegn SM, Lieberman LS, Giedraitis V. Determinants of maternal health service utilization in Ethiopia: analysis of the 2011 Ethiopian Demographic and Health Survey. BMC pregnancy and childbirth. 2014 Dec; 14(1):1–3. https://doi.org/10.1186/1471-2393-14-161 PMID: 24886529

74. Wulandari RD, Laksono AD, Rohmah N. Urban-rural disparities of antenatal care in Southeast Asia: a case study in the Philippines and Indonesia. BMC Public Health. 2021 Dec; 21(1):1–9.

75. Victoria KM, Patricia MK, Mutinta M, Concepta K, Emmanuel M, Fabian C, et al. Midwives perspectives on risk factors influencing maternal morbidity and mortality rates in Zambia: A case of Lusaka and Mumbwa Districts. International Journal of Nursing and Midwifery. 2020 Apr 30; 12(2):64–70.

76. Sayinzoza F, Bijilmakers L, van Dillen J, Mivumbi V, Ngabo F, van der Velden K. Maternal death audit in Rwanda 2009–2013: a nationwide facility-based retrospective cohort study. BMJ open. 2016 Jan 1; 6(1): e009734. https://doi.org/10.1136/bmjopen-2015-009734 PMID: 26801466

77. Lugobe HM, Boatin AA, Asimwwe F, Karungi C, Kayondo M, Mukiza C, et al. 490 Maternal mortality at a referral hospital in south western Uganda: a 5 year descriptive analysis. American Journal of Obstetrics & Gynecology. 2021 Feb 1; 224(2): S311–2.

78. Herklots T, Van Acht L, Meguid T, Franx A, Jacod B. Severe maternal morbidity in Zanzibar’s referral hospital: Measuring the impact of in-hospital care. PLoS One. 2017 Aug 23; 12(8):e0181470. https://doi.org/10.1371/journal.pone.0181470 PMID: 28832665

79. Horwood G, Opong C, Choudhury SS, Rani A, Nair M. Risk factors for maternal mortality among 1.9 million women in nine empowered action group states in India: secondary analysis of Annual Health Survey data. BMJ open. 2020 Aug 1; 10(8):e038910. https://doi.org/10.1136/bmjopen-2020-038910 PMID: 32819952

80. Raj SS, Manthri S, Sahoo PK. Emergency referral transport for maternal complication: lessons from the community-based maternal death audits in Unnao district, Uttar Pradesh, India. International journal of health policy and management. 2015 Feb; 4(2):99. https://doi.org/10.15171/ijhpm.2015.14 PMID: 25674573

81. Manzi A, Hirschhorn LR, Sherr K, Chirwa C, Baynes C, Awoonor-Williams JK. Mentorship and coaching to support strengthening healthcare systems: lessons learned across the five-population health implementation and training partnership projects in sub-Saharan Africa. BMC health services research. 2017 Dec; 17(3):5–16. https://doi.org/10.1186/s12913-017-2666-7 PMID: 23297323

82. Kaba M, Taye G, Gizaw M, Mitiku I. Maternal health service utilization in urban slums of selected towns in Ethiopia: Qualitative study. Ethiopian Journal of Health Development. 2017; 31(2):96–102.

83. Dewuwa R, Angaw DA, Kassa GM, Dagnew B, Yeshaw Y, Muc He A, et al. Urban-rural disparities in institutional delivery among women in East Africa: A decomposition analysis. PloS one. 2021 Jul 30; 16(7): e0255094. https://doi.org/10.1371/journal.pone.0255094 PMID: 34329310

84. Samuel O, Zewotir T, North D. Decomposing the urban-rural inequalities in the utilization of maternal health care services: evidence from 27 selected countries in Sub-Saharan Africa. Reproductive Health. 2021 Dec; 18(1):1–2.