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Incidence of maternal near miss among women in labour admitted to hospitals in Ethiopia

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ABSTRACT

Objectives: To assess the incidence of maternal near miss and contributing factors among hospitals in Ethiopia. The study also assessed the ability of hospitals to provide signal functions of emergency obstetric care and its regional distribution.

Design: A national dataset accessed from the Ethiopian Public Health Institute were analysed to assess the incidence of maternal near miss and mortality index among women admitted to hospitals with obstetric complications.

Setting: Maternal health indicators including obstetric complications, maternal deaths and births conducted at all hospitals available in Ethiopia were included.

Measurements: The maternal near miss incidence ratio, which is the number of near miss cases per 1,000 live births, and the mortality index were presented descriptively. Chi-squared test at p value ≤ 0.05 was used to assess the presence of significant regional differences of the provision of signal functions of emergency obstetric care.

Results: In 2015, 78,195 women were admitted to hospitals with both the direct (68,002) and indirect (10,193) causes of maternal mortality. Of women who experienced the direct causes, 435 died which means there were 67,567 maternal near miss cases. In the same year, 323,824 live births were reported in hospitals, making the crude maternal near miss incidence ratio of 20.8% (9.1-38.8%) and mortality index of 0.64% (435/68,002) for the direct causes of maternal mortality. A significant regional variation was observed with regard to incidence of maternal near miss, mortality index and the provision of signal functions of emergency obstetric care. Administration of parenteral antibiotics was the most frequently practiced signal function of emergency obstetric care while blood transfusion was the least provided signal function.

Conclusions: In Ethiopian hospitals, the incidence of maternal near miss was unacceptably high. A significant regional variation was detected with regard to maternal near miss incidence ratio, mortality index and the provision of signal functions of emergency obstetric care. The Ethiopian government needs to work on equitable resource distribution and quality improvement initiatives in order to close the detected regional variations.

Abbreviations: AIDS, Acquired Immunodeficiency Syndrome; APH, Antepartum Haemorrhage; CAFÉ, Computer Assisted Field Editing; CAPI, Computer Assisted Personal Interviewing; CEmOC, Comprehensive Emergency Obstetric Care; EmOC, Emergency Obstetric Care; EPHI, Ethiopian Public Health Institute; HIV, Human Immunodeficiency Virus; HREC, Health Research Ethics Committee; IFSS, Internet File Streaming System; MD, Maternal Death; MI, Mortality Index; MMR, Maternal Mortality Rate; MNM, Maternal Near Miss; MNMIR, Maternal Near Miss Incidence Ratio; PPH, Postpartum Haemorrhage; WHO, World Health Organization; IV, Intravenous; MRP, Manual Removal of Placenta; RRP, Removal of Retained Products; SGD, Sustainable Development Goal; SNNPR, Southern Nations, Nationalities and People Region.

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Implications for practice: The Ethiopian government needs to practice evidence-based maternal health strategies, including capacity building of the regional hospitals in order to improve the distribution of resources and quality of maternal health.

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Background

In developing countries, including Ethiopia, maternal mortality and morbidity continue to be unacceptably high. The risk of maternal death in this region of the world is 1 in 41 live births as opposed to 1 in 3300 live births in developed nations. For every woman who dies, 20 more women experience acute and chronic obstetric complications from the direct causes of maternal mortality (Firoz et al., 2013; WHO, UNICEF et al., 2015).

The high Maternal Mortality Ratio (MMR) in developing countries was recognized and included in the Sustainable Development Goals (SDGs) where target was set to reduce MMR to below 70 per 100,000 live births for all countries by the year 2030 (IAEG 2016). Identifying and targeting the major causes of maternal deaths would contribute to the realization of the SDG's target of reducing maternal mortality. Ethiopia, one of the countries with the highest MMR in the world (Hogan et al., 2010), is hoping to benefit from this global plan.

Maternal near miss (MNM) is a situation where a woman nearly dies from complications of pregnancy, childbirth or within 42 days of termination of the pregnancy, but survives either due to the care she receives or due to chance (Say et al., 2009). In order to eliminate confusions of using different definitions of MNM, the World Health Organization (WHO) developed a set of criteria that are used to precisely define MNM. According to the WHO MNM criteria, a woman who presents with any of the conditions listed in Table 1 that could occur during pregnancy and childbirth but survived the complication is considered as a MNM case (Say et al., 2009).

Although MMR in developing countries remains quite high, investigating MNM has become the best measure of quality of obstetric care (Pattinson and Hall 2003; World Wealth Organization 2004). Studying MNM rather than maternal deaths has further benefits because MNM happens more frequently and has similar causes with maternal deaths (Chhabra 2014; Kalhan et al., 2017). In developing countries, where MMR has shown a declining trend over the last two decades with the advent of different targeted interventions (WHO, UNICEF et al., 2015) and is usually underreported due to high proportion of home delivery (EDHS 2016), studying MNM shows the real figure of the quality of obstetric care. Studying MNM also allows rigorous quantitative analysis of factors leading to maternal mortality (Kasahun and Wako 2018).

The incidence of MNM varies across world regions. It is highly aggregated in middle and low income countries with the highest prevalence among African and Asian countries (Tunçalp et al., 2012). According to the results of a systematic review conducted by the WHO, showed that the prevalence of MNM ranges between 0.80 and 8.23% among studies which used clinical criteria and 0.01–2.99% among studies that used management criteria (Say et al., 2004). A recent systematic review also indicate that in sub-Saharan African countries, the median MNM ratio was 24.2 per 1000 live births (Tura et al., 2019).

In Ethiopia, the MNM incidence ratio (MNMIR) varies among different regions of the country. The few available literature shows that MNMIR was lowest in Addis Ababa, the capital city of the country (8.01 per 1000 live births) (Liyew et al., 2017). While MNMIR was 17 per 1000 live births in the Harari region (Tura et al., 2018), the highest MNMIR (23.3%) was reported in the Amhara region (Abate and Dile, 2015). The underlying causes of the majority of MNM were hypertensive disorders and obstetric haemorrhage. However, studies about MNM are scarce and the available literature are not representative of the country as they were conducted in a small number of health facilities of some regions. The available literature also did not include the case of private hospitals (Liyew et al., 2017; Tura et al., 2018).

Two categories of obstetric services commonly known as 'signal functions of Emergency Obstetric Care (EmOC) have been

Table 1
World health organization maternal near miss definition criteria (Say et al., 2009).

Clinical criteria	Laboratory criteria	Management criteria
✓ Acute cyanosis	✚ Oxygen saturation < 90% for > 60 min	➢ Use of continuous vasoactive drugs
✓ Gasping	✚ pH < 7.1	➢ Intubation and ventilation for > 60 min not related to anaesthesia
✓ Loss of consciousness lasting > 12 h	✚ PaO2/FiO2 < 200mmHg	➢ Hysterectomy following infection or haemorrhage
✓ Loss of consciousness and absence of pulse/heart beat	✚ Lactate > 5	➢ Dialysis for acute renal failure
✓ Respiratory rate > 40 or < 6/min	✚ Creatinine > 300 mmol/l or > 3.5 mg/dl	➢ Transfusion of ≥5 units red cell
✓ Stroke	✚ Acute thrombocytopenia (< 50,000 platelets)	➢ Cardio-pulmonary resuscitation (CPR)
✓ Shock	✚ Bilirubin > 100 mmol/l or > 6.0 mg/dl	
✓ Uncontrollable paralysis	✚ Loss of consciousness and the presence of glucose and ketoacids in urine	
✓ Oliguria non-responsive to fluids or diuretics		
✓ Jaundice in the presence of preeclampsia		
✓ Clotting failure		

recommended as critical lifesaving care for women who experienced obstetric complications. The first category is 'signal functions' of Basic Emergency Obstetric Care (BEmOC) which include administration of parenteral antibiotics, parenteral anticonvulsants, parenteral uterotonics, removal of retained products, manual removal of the placenta and assisted vaginal delivery. The second category is 'signal functions' of Comprehensive Emergency Obstetric Care (CEmOC), which include the provision of caesarean section and blood transfusion in addition to all the signal functions of BEmOC (UNPF 2009).

The government of Ethiopia is striving to reduce MMR through implementation of different targeted interventions. Several actions were taken to improve access and utilization of maternal health services and all maternity health services were made cost free at all public health facilities (Federal Ministry of Health Ethiopia 2015). Despite all of these efforts, the maternal morbidity and mortality remain unacceptably high (EDHS 2016). Therefore, the magnitude and possible causes of MNM need to be well-assessed using representative data. Thus, the main aim of the current study was to assess the incidence of MNM and contributing factors among women in labour who are admitted to hospitals in Ethiopia. The ability of the hospitals in the provision of signal functions of emergency obstetric care and its regional distributions were also accessed.

Methods

Study area and period

Ethiopia is the second most populous country in Africa, after Nigeria. According to the elaboration of the latest United Nations data (2019), the current population of Ethiopia is 112,921,560 as of October 2019 (Worldometers 2019). Currently, the total fertility rate of Ethiopia is 4.6, the contraceptive prevalence rate for currently married women is 36%, and the unmet need for family planning is 22%. The proportion of pregnant women who received antenatal care from a skilled provider was 62% while only 32% of pregnant mothers had at least four antenatal care visits during their pregnancy. Only 17% of women were reported as meeting the Safe Motherhood Programme's recommendation of receiving a postnatal care check within two days of delivery (CSA and ICF 2016).

For this study, we accessed and analysed a national dataset from the Ethiopian Public Health Institute (EPHI). The EPHI is a large public health research institute conducting various researches on several priority public health issues. In 2015, the EPHI conducted a national cross-sectional survey and collected data on maternal and neonatal health indicators from all health facilities found in the country. In the EPHI's survey, all functional health facilities available in Ethiopia including hospitals, health centers and clinics, which had attended births in the last 12 months of the data collection period ($N = 3804$), were included. Although data about maternal and neonatal health indicators were collected from all public and private health facilities, the current analysis was conducted using only hospitals' data. Altogether, there were 293 hospitals in Ethiopia and all of them were included into the current study. Hospitals' maternal data were used in this analysis as women who have experienced obstetric complications are most likely referred to hospitals to receive specialized treatment.

Study participants

Altogether, 293 hospitals (58 private and 235 public hospitals) were included in the national survey conducted by the EPHI. One hundred and sixty primary hospitals, 103 general hospitals and 30 specialized hospitals were included from all regions and city administrations of the country. Data of women who sustained all types of obstetric complications were included in to the current analysis.

Inclusion criteria

The data about type and magnitude of obstetric complications, maternal deaths and all live births conducted in 2015 at all available hospitals were included. Data about maternal health from all public and private hospitals found in Ethiopia were included in the analysis.

Data collection process

During the EPHI survey, several maternal and neonatal health indicators were collected from hospitals during a single facility visit. The data about performance of the Emergency Obstetric and Newborn Care (EmONC) signal functions were retrospectively collected from all hospitals using a standardized questionnaire. The reference period for the data collection was 1st January to 31st December 2015 inclusive and the data were collected from May to December 2016. A standardized tool was used to collect the data from the hospitals' registers and records. The data were collected using Computer Assisted Field Editing (CAFE) and Computer Assisted Personal Interviewing (CAPI). The cleaned data were sent to the central office of EPHI every day using an Internet File Streaming System (IFSS). All data management was done using CSPro 6.1

Table 2
Operational definitions of the technical terms used throughout the paper.

Operational definitions
☑ **Major direct causes of maternal deaths:** in this study, the following were considered as major direct causes of maternal deaths: Antepartum Haemorrhage (APH), Postpartum Haemorrhage (PPH), retained placenta, prolonged/obstructed labour, ruptured uterus, severe eclampsia/preeclampsia, complications of abortion and ectopic pregnancy.
☑ **Indirect causes of maternal deaths:** are potentially lethal complications, which could occur during pregnancy, childbirth and immediate postpartum period but not induced by the pregnancy. These conditions included malaria, anaemia, hepatitis, HIV/AIDS, and other non-specific life-threatening conditions.
☑ **Maternal Near Miss (MNM)**: refers to a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy. It was estimated by subtracting the number of women with life-threatening conditions minus number of women who died of the conditions.
☑ **Maternal death (MD)**: is the death of a woman while pregnant or within 42 days of termination of pregnancy.
☑ **Live birth (LB)**: refers to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life.
☑ **Women with life-threatening conditions (WLTC)**: refers to all women either who qualified as having maternal near miss or who died (WLTC = MNM + MD)
☑ **Maternal Near Miss Incidence Ratio (MNMIR)**: refers to the number of maternal near miss cases per 1000 live births; the numerator being the magnitude of MNM and the denominator is live births conducted at the hospitals.
☑ **Mortality Index (MI)**: refers to the number of maternal deaths divided by the number of women who experienced life-threatening conditions, expressed as percent. The higher the mortality index, the more women with life-threatening conditions die (low quality of care), whereas the lower the index, the fewer women with life-threatening conditions die (better quality of care). [MI = MD/(MNM+MD)] (Say et al., 2009).

data programming software. Although several maternal and neonatal data were collected during the survey, for this paper, we used the data about the number of live births conducted in hospitals, number of women who experienced obstetric complications and number of maternal deaths recorded in hospitals.

Healthcare professionals with at least a bachelor's degree were recruited to conduct data collection. The data collectors were trained on interview techniques, survey tools and field procedures. The survey was conducted under close supervision of the technical working group, which included experts from different partners and professional associations. In addition, regional coordinators supervised the data collection process and conducted spot-checking to ensure the quality of the data. Several terms and phrases used throughout this paper are operational defind hereunder (Table 2).

Data analysis

The data were accessed in IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, N.Y., USA) from the EPHI central server. Then the dataset was exported to Stata version 15 for analysis. Descriptive statistics including means, percentages, frequency tables and ratios were performed to describe facility specific characteristics, and the magnitude of MNM and the MI. The causes of both the direct and indirect MNM and their case fatality rates were also analysed. The ability of hospitals in the provision of the signal functions of EmOC were analysed with due consideration to regions. The MNMIR and MI were presented separately for each region and city administration for the purpose of comparison. A Chi-squared test was performed to examine the presence of significant regional differences of the provision of signal functions of EmOC. Maternal Near Miss Incidence Ratio refers to the total number of MNM per 1000 live births. Mortality index is the ratio of maternal deaths to the total number of women who sustained life-threatening complications. Mortality index indicates the quality of obstetric care, as MI $>$ 1 is interpreted as excess mortality and MI $<$ 1 means fewer deaths than expected (Vandecruysa et al., 2002).

Results

Magnitude of obstetric complications and maternal deaths

In 2015, 78,195 women were admitted to hospitals across Ethiopia due to both the direct and indirect causes of maternal mortality. Slightly more than half, (N = 40,080; 51.3%) of these complications were due to the major direct causes of maternal deaths. The 'other direct causes' including premature rupture of membrane, post-term labour, cord prolapse, breech presentation, and other possible problems that are not considered as a major direct cause of maternal mortality accounted for 27,922 (35.7%) of the complications. The indirect causes of maternal death, which are potentially lethal complications including malaria, anaemia, hepatitis, HIV/AIDS, and other nonspecific life threatening conditions, accounted for 10,193 (13.0%) of the complications. There were 481 maternal deaths recorded in Ethiopian hospitals in the same year. The majority (N = 435) of these deaths were due to direct causes while 46 of the deaths were attributed to indirect causes. Prolonged/obstructed labour (20.3%) was the leading cause of morbidity while hypertensive disorder (25.2%) was the leading cause of mortality (Table 3).

Fig. 1 shows how the provision of EmOC signal functions were distributed among hospitals. Overall, administration of parenteral antibiotics was the most frequently practiced EmOC signal function as it was provided by 282 (96.2%) of the hospitals. Administration of parenteral anticonvulsant (N = 278; 94.8%) was the second most frequently provided signal function. The signal functions of CEmOC were the least provided services as only 189 (64.5%) and 237 (80.8%) of the hospitals provide blood transfusion and caesarean section respectively.

Gambella region has only one hospital and it provided all EmOC signal functions. Harari region (100%) and Addis Ababa city administration (90.9%) were the most frequent providers of caesarean section while Somali (90%) and Oromia (82.2%) regions were the most likely to provide blood transfusion. There were statistically significant regional difference in the provision of parenteral uterotonic (p = 0.012), manual removal of placenta (p = 0.003), removal of retained product (p = 0.007) and blood transfusion (p = 0.001). However, the difference among regions with regard to the provision of the remaining EmOC signal functions was not statistically significant (Table 4).

Maternal near miss indicators

Of the 68,002 women who experienced the direct obstetric complications (40,080 major direct and 27,922 'other direct' complications) 435 died, which means there were 67,567 MNM cases. Overall, 323,824 livebirths were reported in hospitals, making the MNMIR due to direct obstetric causes 20.8%. The highest MNMIR was reported in Benshangul Gumuze (38.8%) and the lowest was observed in Gambella region (9.1%). With regard to MI due to direct obstetric causes, although an acceptable level was observed nationally, significant regional variations were observed and it was highest in Gabella region (3.82%). Excess mortality was observed in Afar, Gambella, Harari and Somali regions as mortality indexes in these regions exceed one (Table 5).

Additionally, of the 10,193 cases of indirect causes of maternal deaths, 46 women died. HIV/AIDS 6249 (61%) was the leading cause of the indirect maternal morbidity while severe anaemia 19 (41%) was the leading indirect cause of maternal death (Fig. 2). The

Table 3
The magnitude of obstetric complications and severe maternal outcomes among hospitals in Ethiopia, 2015.

Complications	Number of women affected N (%)	Maternal Death N (%)
Antepartum Haemorrhage (APH)	4462 (5.70)	23 (4.8)
Postpartum Haemorrhage (PPH)	2811 (3.60)	81 (16.9)
Retained placenta	2201 (2.81)	4 (0.8)
Prolonged/obstructed labour	15,875 (20.30)	25 (5.2)
Rupture of uterus	1516 (1.92)	41 (8.5)
Postpartum sepsis	1460 (1.87)	17 (3.5)
Severe Eclampsia/Preeclampsia	7912 (10.12)	121 (25.2)
Abortion complications	2042 (2.61)	6 (1.3)
Ectopic pregnancy	1801 (2.30)	0 (0.0)
Other direct complications	27,922 (35.71)	117 (24.2)
Indirect causes	10,193 (13.03)	46 (9.6)
Total	78,195	481

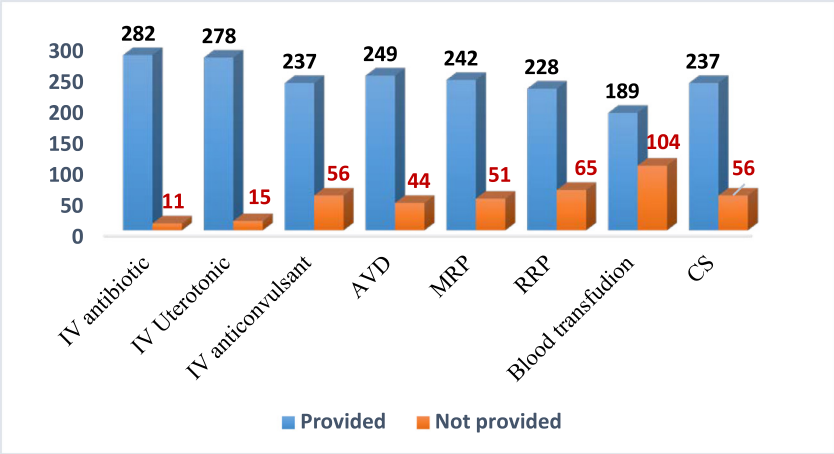

Fig. 1. Distribution of hospitals in Ethiopia by their ability in provision of emergency obstetric care signal functions, 2015.

Table 4
Regional distribution of hospitals in Ethiopia by the provision of EmOC signal functions, 2015.

Interventions	Total hospitals	IV Antibiotic N (%)	IV uterotonic N (%)	IV anticonvulsant N (%)	AVD N (%)	MRP N (%)	RRP N (%)	Blood transfusion N (%)	CS N (%)
AA	33	33 (100)	29 (87.8)	26 (78.7)	23 (69.7)	19 (57.5)	19 (57.5)	24 (72.7)	30 (90.9)
Afar	6	6 (100)	4 (66.7)	5 (83.3)	4 (66.7)	5 (83.3)	5 (83.3)	2 (33.3)	5 (83.3)
Amhara	56	54 (96.4)	52 (96.3)	46 (82.1)	50 (89.3)	48 (85.7)	42 (75)	37 (66.1)	44 (78.5)
BG	3	3 (100)	3 (100)	2 (66.7)	2 (66.7)	2 (66.7)	3 (100)	2 (66.7)	2 (66.7)
DD	6	5 (83.3)	5 (83.3)	3 (50)	4 (66.7)	3 (500	2 (33.3)	4 (66.7)	5 (83.3)
Gambella	1	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	1 (100	1 (100)	1 (100)
Harari	6	6 (100)	6 (100)	3 (50)	6 (100)	4 (66.7)	4 (66.7)	4 (66.7)	6 (100)
Oromia	73	72 (98.6)	73 (100)	64 (87.6)	66 (90.4)	67 (91.7)	66 (90.4)	60 (82.2)	65 (89)
SNNPR	60	54 (90)	56 (93.3)	46 (76.7)	51 (85)	50 (83.3)	46 (76.7)	27 (45)	42 (70)
Somali	10	10 (100)	10 (100)	8 (80)	8 (80)	9 (90)	9 (90)	9 (90)	7 (70)
Tigray	39	38 (97.4)	39 (100)	33 (84.6)	34 (87.2)	34 (87.2)	31 (79.4)	19 (48.7)	30 (76.9)
Total	293	282 (96.2)	278 (94.8)	237 (80.8)	249 (84.9)	242 (82.5)	228 (77.8)	189 (64.5)	237 (80.8)
(X^2 test)	33	$p = 0.232$	$p = 0.012$	$p = 0.32$	$p = 0.17$	$p = 0.003$	$P = 0.007$	$p = 0.001$	$P = 0.206$

IV=Intravenous; AVD=Assisted Vaginal Delivery; MRP=Manual Removal of Placenta; RRP=Removal of Retained Products; CS=Caesarean Section, AA=Addis Ababa, BG=Benishangul Gumuz, DD=Dire Dawa, SNNPR=Sothern Nations, Nationalities and People Region.

Table 5
Regional distributions of incidence of maternal near miss among hospitals in Ethiopia, 2015.

Regions	WLTC (N)		Total number (N) of maternal deaths		Near miss cases (N)		Total livebirths in hospitals (N)	MNMIR/100 Livebirths		MI (%)	
	Direct	Indirect	Direct	Indirect	Direct	Indirect		Direct	Indirect	Direct	Indirect
Addis Ababa	14,453	2698	39	5	14,414	2693	45,049	31.9	5.9	0.27	0.18
Afar	358	187	5	4	353	183	1643	21.4	11.1	1.40	2.18
Amhara	11,263	1687	89	6	11,174	1681	43,899	25.4	3.8	0.79	0.35
Benish. Gumz	1302	268	4	0	1298	268	3338	38.8	8.0	0.31	0
Dire Dawa	1437	133	8	0	1429	133	5330	26.8	2.4	0.55	0
Gambella	157	2	6	0	151	2	1667	9.1	0.1	3.82	0
Harari	1384	112	15	0	1369	112	4823	28.3	2.3	1.10	0
Oromia	17,084	2031	128	14	16,956	114	97,105	17.4	0.1	0.75	12.28
SNNPR	12,942	1179	82	9	12,860	73	68,422	18.8	0.1	0.63	12.32
Somali	1710	548	29	5	1681	24	8181	20.5	0.2	1.69	20.83
Tigray	5912	1348	30	3	5882	27	44,367	13.2	0.06	0.51	11.11
Total	**68,002**	**10,193**	**435**	**46**	**67,567**	**10,147**	**323,824**	**20.8**	**3.1**	**0.64**	**0.45**

MNMIR: Maternal Near Miss Incidence Ratio, WLTC: Women with Life Threatening Complications, MI: Mortality Index.

MNMIR due to the indirect causes of maternal mortality was highest in Afar region (11.1%) followed by Benishangul Gumuz region (8.0%). The mortality index for indirect maternal morbidity was highest in Somali region (20.83%) followed by SNNPR (12.32%) and Oromia (12.28%). However, the national level of mortality index for indirect causes (0.45%) was within the recommended threshold (Table 5).

Discussion

Causes of maternal near miss

In this study, hypertensive disorder of pregnancy was the leading cause of MNM followed by obstetric haemorrhage. The current findings are supported by findings of several studies

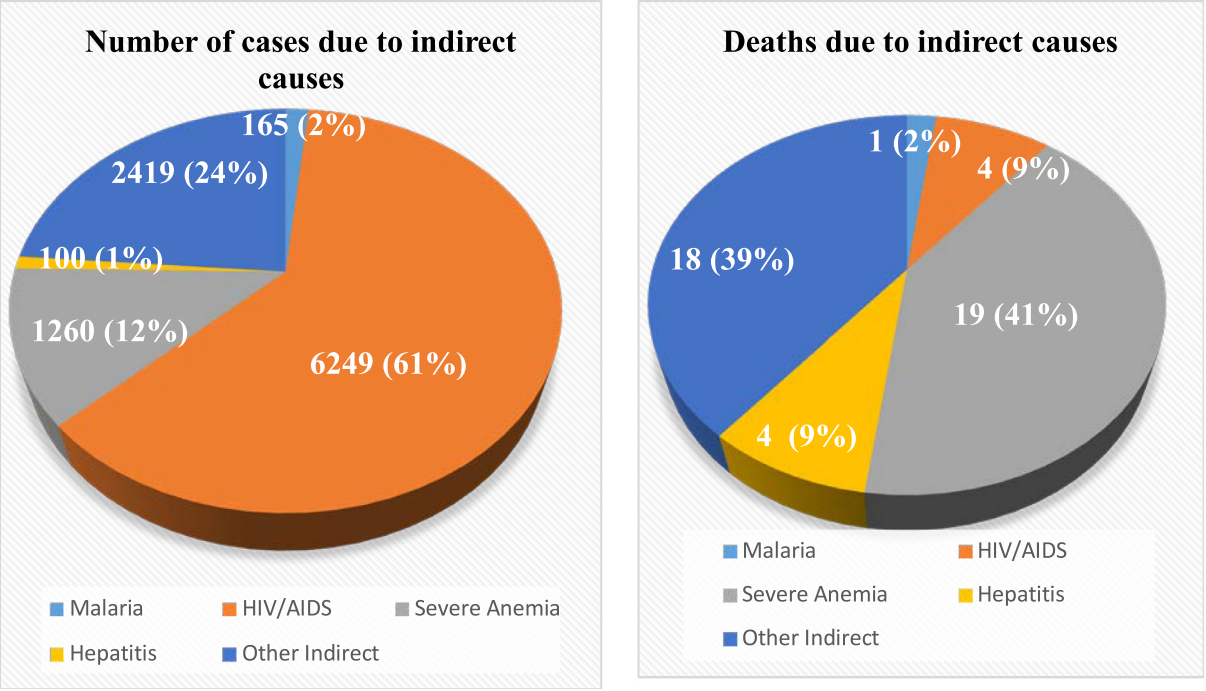

Fig. 2. Morbidity and mortality due to indirect maternal complications among hospitals in Ethiopia, 2015.

conducted in high and middle-income countries (Say et al., 2009; Donati et al., 2012; Ghazal-Aswad et al., 2013) and other African studies (Adeoye et al., 2013; Nelissen et al., 2013; Rulisa et al., 2015) including Ethiopia (Liyew et al., 2017; Tura et al., 2018). For women who experienced hypertension and bleeding, treatment with drugs might not be considered (Getaneh and Kumbi 2010) or there might be delayed initiation of management (Ridge et al., 2010; Jackson et al., 2017). In some conditions, anticonvulsants and antihypertensive drugs might not be available at the health facilities (Gaym et al., 2011) and this challenged initiation of early treatment. It might also be attributed to the fact that, in most developing countries, the prevalence of blood transfusion for women in need is very low (Li et al., 2017).

In the current study, postpartum sepsis was the least registered cause of MNM. This finding is consistent with findings of several studies conducted in multiple African countries where sepsis was reported as the lowest cause of obstetric complications (van den Akker et al. 2011; Adeoye et al., 2013; Nelissen et al., 2013). Reports of a study conducted in Ethiopia also revealed that maternal infection is the lowest among the top four causes of maternal mortality (Berhan and Berhan 2014). This lower rate of postpartum sepsis as a cause of MNM could be explained by the wider coverage of antibiotic administration for the treatment of sepsis (Windsma et al., 2017).

The administration of parenteral antibiotics was the most frequently practiced EmOC signal functions followed by administration of parenteral anticonvulsant. Blood transfusion and caesarean section were the least frequently practiced CEmOC signal functions. Several existing study findings shows that administration of parenteral antibiotic and anticonvulsant were the most frequently practiced EmOC signal functions (Maswanya et al., 2018; Bintabara et al., 2019). The infrequent performance of the CEmOC might be attributed to policy restrictions, lack of trained workforce or lack of medical supplies (Maswanya et al., 2018). This might also be attributed to the shortage of physician in rural and district hospitals. In Ethiopia, staff retention mechanisms was too poor resulted in high staff turnover especially in rural and district facilities (Assefa et al., 2016).

A significant regional difference exists in the provision of EmOC signal functions. A full coverage of EmOC signal functions was observed in Gambella region. This could be due to the availability of a hospital, which facilitated improved investment of resources on the only hospital available in the region. Harari region and Addis Ababa city administration were the most frequent providers of caesarean section. The two regions are urban centers with better health services coverage. It is a usual finding that EmOC facilities in sub-Saharan Africa are concentrated in capitals and urban areas (Banke-Thomas et al., 2019). The presence of regional difference in the provision of EmOC signal functions in our study is supported by previous studies in developing countries (Mony et al., 2013) including Ethiopia (Admasu et al., 2011).

Nearly 13% (10,147/77,714) of the overall MNM cases were accounted to by the indirect causes of maternal deaths. HIV/AIDS is the leading cause of maternal morbidity among the indirect causes of maternal deaths. Anaemia is the leading cause of the indirect maternal death and is the second most frequently observed cause of the indirect MNM. Hepatitis is the least frequent cause of the indirect MNM. Our findings are supported by other previous studies where a high proportion of MNM due to the indirect causes of maternal morbidity was caused by HIV/AIDS and hepatitis was the least frequent observed cases of MNM (Abdella 2010). Reports of several studies showed that anaemia is the most frequent cause of maternal complications (Liyew et al., 2017; Tura et al., 2018). in our study, malaria cases were reduced when compared to previous reports (UNDP 2012), which might be explained by the effectiveness of the preventive health care approach in Ethiopia.

Maternal near miss indicators

The overall national magnitude of MNMIR of the direct causes of maternal deaths among Ethiopian hospitals was 20.8%. Previous studies conducted in selected cities of Ethiopia (Berhane et al., 2012; Liyew et al., 2017; Tura et al., 2018) and other African countries (Nelissen et al., 2013; Tuncalp et al., 2013) revealed a lower rate of MNMIR than the current findings. The observed variation might be explained by disparities in the case definitions and the

study design (Liyew et al., 2017). The current study included all cases of mothers who experienced obstetric complications while all of the previous studies employed some forms of sampling methods, which might have introduced some sorts of sampling errors. Additionally, deliveries can be conducted in lower level health facilities including health centers and clinics that are more proximal to the community while mothers who sustained obstetric complications seek advanced management from hospitals. This might increase the MNM cases in hospitals, which might explain the higher MNMIR in our study, as our study was conducted only in hospitals.

The current study revealed existence of regional variation in MNMIR that ranged from 9.1% in Gambella region to 38.8% in Benshangul Gumuze. Likewise, previous studies conducted in various parts of Ethiopia have reported different MNMIR, 101/1000 live births in Tigray (Berhane et al., 2012), 80/1000 live births in Addis Ababa (Liyew et al., 2017) and 8.01/1000 live births in Harari (Tura et al., 2018). The regional variations in MNMIR might be attributed to variation in the geographical distribution of health infrastructure, magnitude of the catchment population and the urban rural distribution of the hospitals.

Finally, the current study revealed an acceptable national MI of the direct causes of maternal mortality although excess deaths occurred in some regions as MI in these regions exceeds one. Our findings were consistent with findings of previous studies. For example, Tura et al. (2018) found a MI of nearly 0.17 (Tura et al., 2018) while a study in Tanzania reported a mortality index of 0.13 (Nelissen et al., 2013). It should be noted that in most developing countries, the majority of women who sustained obstetric complications arrive at the hospitals after their conditions are advanced, carrying minimal chance to recover (Liyew et al., 2017).

Similarly, the national MI for the indirect causes of maternal mortality was within the acceptable threshold although excess mortalities were observed in Afar, Gambella, Somali and Harari regions. The MI in the first three regions might be high because these regions are pastoral areas where health service coverage is minimal (UNDP 2012). However, MI in Harari region might be high because it is the smallest region and serves as a referral center for several remote regions hence hosting several complicated referral cases.

Strengths and limitations of the study

This study has several strengths. The findings of this study are highly representative and can apply to all regions of Ethiopia as we used national representative dataset. These findings might also apply to other developing countries with similar socioeconomic characteristics. Experts from national and international partners were involved in the data collection and management processes from the commencement to the finalization of the survey. Hence, the analysed dataset were of high quality. This study presented all MNM cases and the EmOC interventions provided for women in order to estimate the quality of obstetric care. Finally, this study utilized data of both public and private hospitals. Hence, the reported MNM indicators represent all types of hospitals irrespective of the managing authority.

However, this study suffered from certain limitations. The WHO recommends a follow-up period of up to 42 days postpartum to define MNM. However, the EPHI conducted a survey by which the maternal health indicator at hospitals were collected during a single hospital visit. This might have resulted in the high incidence of MNM as all women who experienced obstetric complications, irrespective of WHO recommendations were included in the current study. The analysis was done on the hospitals' data by excluding data of the lower level health facilities. In Ethiopia, while there were deliveries conducted at lower health facilities, the majority of mothers who experience obstetric complications seek treatment from hospitals. This might increase the denominator while the numerator remained constant. This might have caused us to overestimate the magnitude of MNMIR. Selection bias might be introduced as we included only hospitals' data by excluding lower level health facilities where several births are attended. Therefore, the findings of this study can only be generalized to hospitals in Ethiopia. Several deaths might not have been reported as many Ethiopian women gave birth at home, which might have affected the magnitude of MI.

Conclusions

The current study revealed a higher MNMIR as compared to most previous studies in African countries including Ethiopia. Obstructed labour was found to be the leading cause of MNM while pregnancy-induced hypertension was the leading cause of maternal deaths. It was demonstrated that the provision of the signal functions of BEmOC was more frequent than the CEmOC. Regional variations exist in the magnitude of MNMIR and MI that might be attributed to the significant difference in the provision of the signal functions of EmOC among regions. However, MI due to both the direct and indirect causes of maternal deaths at the national level appears to be within the acceptable level although higher level of MI were noted in some regions. Therefore, evidence-based maternal health interventions should be designed for management of obstetric complications.

The high incidence of MNM in Ethiopian hospitals might have occurred because of the lower coverage of the signal functions of EmOC; especially of the CEmOC. Admitting the possibility for selection bias, higher MI than the acceptable level in some regions can be considered as an indicator of poor quality of obstetric care at hospitals found in those regions (Say et al., 2009). Therefore, health managers should strengthen evidence-based practice to improve quality of obstetric care at hospitals in regions where MI was higher. While developing strategies for the reduction of MNM, policy makers need to consider equitable distribution of resources in order to close the observed gap of regional variations in the provision of the EmOC signal functions. Further studies with stronger design, which include home deliveries, should be conducted in order to obtain accurate magnitude of MNMIR and MI. Future studies should also include the data of lower level health facilities where the majority of deliveries were conducted.

Ethical approval

The survey was granted ethical approval from the Scientific and Ethical Review Office of the EPHI (approval number: EPHI-6-13-728) on 6 June 2016. Ethical approval for this study was also obtained from the Human Research Ethics Committee (HREC) of The University of Newcastle, Australia (approval number: H-2018-0245) on 15 August 2018. The protocol developed to conduct this analysis had received ethical approval from the Scientific and Ethical Review Office of Ethiopian Public Health Institute before the data were accessed (Protocol number: EPHI-IRB-048-2018) on 25 July 2018.

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Clinical trial registry and registration number

Not applicable.

Declaration of Competing Interest

None declared

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