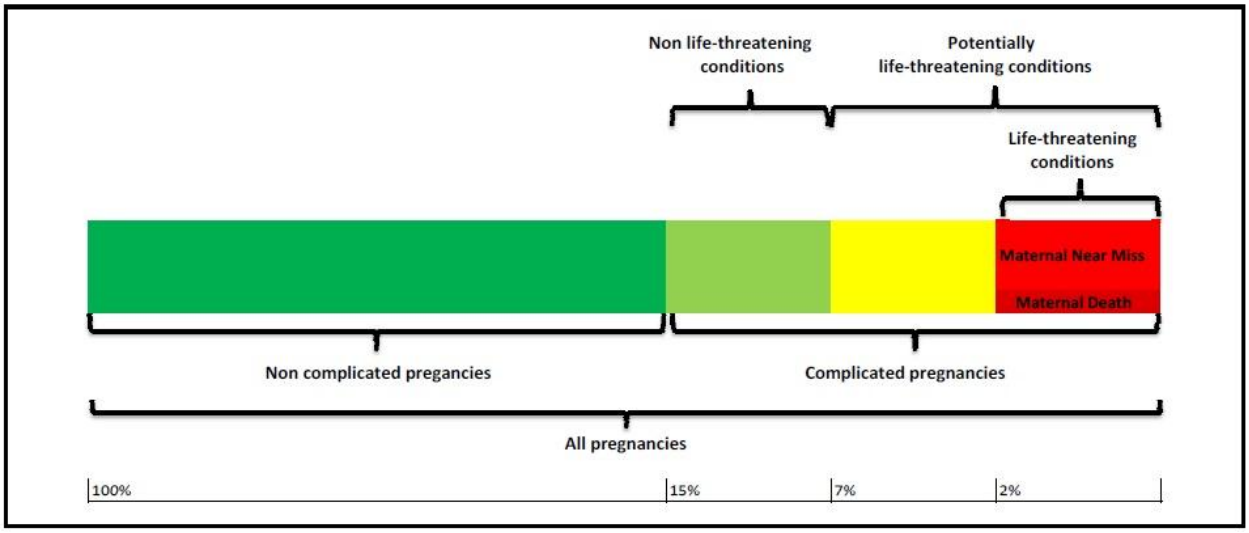
MATERNAL NEAR MISS:

INCIDENCE, CAUSES, FACTORS AND ADVERSE PERINATAL OUTCOMES IN ADDIS ABABA

EWNETU FIRDAWEK



(Adapted from JP Souza, maternal near miss training course in Sexual and Reproductive Health Research, 2011 available at https://www.gfmer.ch/SRH-Course-2011/maternal health/Maternal_near_miss_Souza_2011.htm)

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MATERNAL NEAR MISS:

INCIDENCE, CAUSES, FACTORS AND ADVERSE PERINATAL OUTCOMES IN ADDIS ABABA

A PhD DISSERTATION SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF AAU IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D.) IN PUBLIC HEALTH

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List of Original papers

This dissertation is based on the following three original papers, which are referred to in the text by their Roman numerals.

I. Incidence and causes of maternal near-miss in selected hospitals of Addis Ababa, Ethiopia. PLoS One. 2017;12(6):e0179013. PubMed PMID: 28586355.

II. Distant and proximate factors associated with maternal near-miss: A nested case-control study in selected public hospitals of Addis Ababa, Ethiopia. BMC Women's Health, 2018, 18:28. DOI 10.1186/s12905-018-0519-y.

III. Maternal near-miss and the risk of adverse perinatal outcomes: a prospective cohort study in selected public hospitals of Addis Ababa, Ethiopia. Accepted for publication, BMC pregnancy and Childbirth, 2018 (PRCH-D-17-00376R3).

Abbreviations/Acronyms

AAU	Addis Ababa University
AAAHO	Addis Ababa Administration Health Office
ANC	Antenatal care
AOR	Adjusted odds ratio
Apgar	Activity, Pulse, Grimace, Appearance, Respiration
BEmONC	Basic Emergency Obstetric and Neonatal care.
BMI	Body Mass Index
CEmoNC	Comprehensive Emergency Obstetric and Neonatal Care
CI	Confidence Interval
CSA	Central Statistics Authority
C/S	Caesarian Section
EDHS	Ethiopia Demographic and Health Survey
FMOH	Federal Ministry of Health
HELLP	Hemolysis Elevated Liver enzymes, and Low Platelets
HIV	Human Immunodeficiency Virus
HSDP	Health Sector Development Program
ICU	Intensive Care Unit
KM	Kilometer
LBW	Low Birth Weight
MDGs	Millennium Development Goals

Mg/dl	Milligram per deciliter
MmHg	Millimeter of mercury
Mmol/l	Mili mol per liter
MMR	Maternal Mortality Ratio
MNM	Maternal Near Miss
MNMIR	Maternal Near miss Incidence Ratio
NICU	Neonatal Intensive Care Unit
O_2	Oxygen
OPD	Outpatient Department
OR	Odds Ratio
PAO_2	Partial pressure of Oxygen
PH	Power of Hydrogen
RH	Reproductive Health
SAMM	Severe Acute Maternal Morbidity
SMM	Severe Maternal Morbidity
TB	Tuberculosis
UAE	United Arab Emirates
UK	United Kingdom
UNICEF	United Nations Children's Fund
UNFPA	United Nations Population Fund
USA	United States of America
WHO	World Health Organization

Glossary

Some of the definitions used here are adapted from the World Health Organization (WHO) maternal near-miss approach for maternal health (1).

Admission to intensive care unit: is defined as admission to a unit that provides 24 hours medical supervision and is able to provide mechanical ventilation and continuous vasoactive drug support.

Adverse perinatal outcomes: the presence of either or more of the following: stillbirth, low birth weight, preterm birth, admission to neonatal intensive care unit (ICU) and first minute birth asphyxia in women with and with-out maternal near-miss.

Anemia: is a condition in which the hemoglobin level is less than 6 g/dl.

Apgar score: score ranging from 0–10 based on a newborn's tone, color, respiration, pulse rate, and responsiveness at 1, 5, and 10 minutes.

Birth asphyxia: Apgar score below 7 at1, 5, and 10 minutes of life.

Dystocia: is most frequently used as an equivalent for obstructed labor, but it covers a broad range of conditions, from labor lasting more than 12 hours to uterine rupture, feto-pelvic disproportion or abnormal fetal presentation.

Early neonatal mortality: is defined as the death of the neonate less than 7 days of age.

Eclampsia: generalized fits in a patient without previous history of epilepsy. It includes coma in pre-eclampsia.

Live birth: refers to the birth of an offspring which breathes or shows evidence of life.

Low birth weight: is a new born weight below 2500 g.

Maternal mortality: is 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.

Maternal near-miss: refers to a woman who nearly died, but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy.

Maternal near miss incidence ratio (MNIR): it refers to the number of maternal near-miss cases that happened during the study period per 1000 live births during the same period.

Multiparous women: woman having had at least one previous birth.

Neonatal mortality: is neonatal death of less than 28 days of age.

Nulliparous woman: is a woman who has never given birth previously, or is in her first pregnancy.

Obstructed labor: labor is considered obstructed when the presenting part of the fetus cannot progress into the birth canal, despite strong uterine contractions.

Overweight: is abnormal or excessive fat accumulation that may impair health. A body mass index (BMI) greater than or equal to 25 is considered overweight.

Perinatal mortality: neonatal death of less than seven days of age, and fetal deaths after 28 weeks of gestation. In other words it is the sum of early neonatal death and fetal death after 28 weeks of gestation.

Preterm birth: is a baby born alive before 37 completed weeks of gestation, but after 28 weeks of gestation.

Sustainable Development Goals: specify 17 universal goals, 169 targets, and 230 indicators leading up to 2030, established by the United Nations (UN) General Assembly in September, 2015.

Severe post-partum hemorrhage: bleeding after delivery, with at least one of the following: perceived abnormal bleeding (1000 ml or more) or any bleeding with hypotension or blood transfusion.

Severe pre-eclampsia: persistent systolic blood pressure of 160 mmHg or more or a diastolic blood pressure of 110 mmHg; proteinuria of 5 g or more in 24 hours; oliguria of <400 ml in 24 hours; and HELLP syndrome or pulmonary edema and excludes eclampsia.

Severe systemic infection or sepsis: presence of fever (body temperature >38°C), a confirmed or suspected infection (e.g. chorioamnionitis, septic abortion, endometritis, pneumonia), and at least one of the following: heart rate >90, respiratory rate >20, leukopenia (white blood cells <4000), leukocytosis (white blood cells >12 000).

Stillbirth: is a newborn with no signs of life at or after 28 completed weeks of pregnancy.

Uncomplicated delivery: delivery that happened without any complications.

Uterine rupture: rupture of uterus during labor confirmed by laparotomy.

Underweight: A BMI of lower than 18.5 is considered as underweight.

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Executive Summary

Background: A maternal near-miss event or severe acute maternal morbidity is defined by the World Health Organization as 'a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy'. Since maternal mortality is a rare event in each health facility, it is important to study maternal near-miss as a complement to evaluate and improve the quality of obstetric care. Studies addressing the incidence, causes, factors and adverse perinatal outcomes of maternal near-miss are rare in Ethiopia. Thus, the findings of the current study are important to provide a reliable evidence for policy makers, programmers and health practitioners.

Objectives: The study aimed to assess the incidence, causes, factors and adverse perinatal outcomes of maternal near-miss.

Methods: The study was conducted in five selected public hospitals of Addis Ababa, Ethiopia from May 1, 2015 to April 30, 2016. The hospitals were selected based on the number of deliveries they managed per year. In addition, presence of an Intensive Care Unit, maternity ward, blood transfusion service and availability of cesarean section delivery were considered in the selection of hospitals. A mix of methods was used to address the objectives of the study. A facility-based cross-sectional study was used to determine the incidence and causes of maternal near miss (Objective I). All maternal near-miss cases admitted to the selected hospitals during the study period were prospectively recruited. Maternal near-miss was ascertained using the World Health Organization criteria. A nested case-control design was used for identifying factors associated with maternal near-miss (Objective II). All women who developed maternal near-miss during the study period were included as cases, and those who delivered without any complications within the same day of the near-miss event were enrolled as controls. A total of three controls matched for age and study area were selected for each maternal near-miss case. A prospective cohort study design was used to examine adverse perinatal outcomes of maternal near-miss (Objective III). Women who were admitted to the participating hospitals during the study period and developed maternal near-miss according to the World Health Organization criteria were included as exposed group. Women who delivered without any complications were enrolled as non-exposed group. We followed a total of 828 women admitted for delivery or treatment of pregnancy-related complications along with their singleton newborn babies. The

main outcomes of interest were adverse perinatal outcomes and defined with a composite measure.

Participants were interviewed by well-trained data collectors using pre-tested questionnaire. Medical records were also reviewed to abstract relevant information. In order to review the participants' record, permission was obtained from the participants and administrators of each participating hospital. Univariate analysis was performed to know the underlying and contributing causes of maternal near-miss. The number of maternal near-miss cases over one year per 1000 live births occurring during the same year was calculated to determine the incidence of maternal near-miss. Bivariate and multivariable conditional logistic regressions were performed to identify factors associated with maternal near-miss. Multivariable logistic regressions were also performed to determine the adjusted risk of adverse perinatal outcomes. Stata version 13 was used for the analysis.

Results: During a one-year period, a total of 238 maternal near-miss cases and 29,697 live births were reported in the hospitals included in the study, which produced a total maternal near-miss incidence ratio of 8.01 per 1000 live births (95% CI; 7.06 – 9.09). The underlying causes of the majority of maternal near-miss cases were hypertensive disorders and obstetric hemorrhage. Anemia was the major contributing cause reported for maternal near-miss. Most of the maternal near-miss cases occurred before the women's arrival at the participating hospitals. The main factors associated with maternal near-miss were: history of chronic hypertension (AOR=10.79, 95% CI; 5.15 – 22.64), rural residence (AOR=10.68, 95% CI; 4.60 – 24.78), history of stillbirth (AOR=6.06, 95% CI; 2.09 – 17.49), no antenatal care attendance (AOR=5.58, 95% CI; 1.82 – 17.05) and history of anemia (AOR=5.16, 95% CI; 2.81 – 9.47). After adjusting for potential confounders, women with maternal near-miss condition had more than five-fold increased odds of adverse perinatal outcomes compared to women without maternal near-miss (AOR=5.69: 95% CI; 3.69 – 8.76). Other risk factors that were independently associated with adverse perinatal outcomes included: rural residence (AOR=2.16: 95% CI; 1.03 – 4.53), history of prior stillbirth (AOR=2.39; 95% CI; 1.12 – 5.10) and primary educational level (AOR=1.89: 95% CI; 1.07 – 3.34).

Conclusions and recommendations: The majority of maternal near-miss cases have already occurred on the women's arrival at the participating hospitals, implying the need to focus on existing pre-hospital barriers. However, near-miss cases that develop during hospitalization can

help to measure the quality of obstetric care provided within the health facilities. Efforts made towards improvement in the management of life-threatening obstetric complications could reduce the occurrence of maternal near-miss problems that occur during hospitalization. There is a need for appropriate interventions in order to improve the identified factors of maternal near-miss. The factors can be modified through a better access to medical and maternity care, scaling up of antenatal care in rural areas, improve in infrastructure to fulfill referral chain from primary level to secondary and tertiary health care level, and, health education to pregnant women. Presence of maternal near-miss in women is an independent risk factor for adverse perinatal outcomes. Hence, interventions rendered at improvement in maternal health can lead to an improvement in perinatal outcomes. The follow-up time used by the World Health Organization to define maternal near-miss has duration of 42 days postpartum. However, because of logistic and feasibility concerns, our follow-up time was limited to only the length of the hospital stay. This might have caused us to underestimate the magnitude of maternal near-miss and hindered us not to investigate the occurrence of other events such as maternal deaths occurred after maternal discharge.

Keywords: Maternal near-miss, Incidence, Causes, Factors, Adverse perinatal outcomes, Public Hospitals, Addis Ababa, Ethiopia.

1. Introduction

1.1. Background of the study

The improvement of maternal health has made slow progress in most of the sub-Saharan African countries (2). According to the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), the United Nations Population Fund (UNFPA) and the World Bank (2015) estimate, globally, 303,000 maternal deaths occurred in 2015, with the highest burden being in sub-Saharan African countries (2). Despite the high number of maternal deaths in many of the institutions within these countries, the absolute number for each center classifies these events as rare. Thus, in this situation, severe acute maternal morbidity or maternal near-miss could serve as a surrogate for maternal death to evaluate the quality of obstetric care in particular health institutions (3, 4). A maternal near-miss event or severe acute maternal morbidity is currently defined by the WHO as 'a woman who nearly died, but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy' (1, 5).

Because there were no uniform criteria for the identification of near-miss cases and no standard definition for maternal near-miss until 2009, a heterogeneous estimate of rates was observed in different published literatures around the world. For instance, the rate ranged between 0.14% and 0.75% in some of the high-income countries (6-13), it ranged between 1.5% and 7.7% in some of middle-income countries (14-18), and, in sub-Saharan African countries, it ranged between 2.21% and 12% (19-22). In Ethiopia, the prevalence has reached as high as 9.1% (23).

Worldwide, hypertensive diseases of pregnancy, obstetric hemorrhage, sepsis, anemia and obstructed labor/dystocia have been identified as the major causes of maternal near-miss (8, 14, 24-26).

Different literatures on maternal near-miss around the globe revealed different factors. Advanced maternal age, race, lower socio-economic status, rural residence, less or no antenatal care (ANC) follow-up, multiple pregnancies, nulliparous, multiparous, previous cesarean section delivery, pre-existing medical conditions, overweight and underweight were documented as factors for maternal near-miss (11, 12, 18, 20, 24, 27-30).

Several studies have shown that the presence of maternal near-miss condition in women is strongly associated with the occurrence of adverse perinatal outcomes such as stillbirth, preterm

birth, low birth weight, early neonatal mortality, birth asphyxia, and a possible admission to Neonatal Intensive Care Unit (NICU) (18, 20, 28, 31-33).

1.2. Statement of the problem

In September 2015, the United Nations (UN) General Assembly formally approved a set of 17 Sustainable Development Goals (SDG) as a follow-up to Millennium Development Goals (MDGs). Improving maternal health remains an important topic of SDG, which is to reduce the global Maternal Mortality Ratio (MMR) to less than 70 per 100,000 live births by 2030 (34). Globally, 303,000 maternal deaths occurred in 2015 with sub-Saharan Africa alone accounts for 66% of the deaths (2). The study of maternal mortality is a challenge mainly due to small number of maternal deaths in each health facility. Thus, because maternal mortality is a rare event, and because it follows a similar pathway to maternal near-miss, there is a benefit to include a larger number of cases for analysis, as research related to maternal near-miss is crucial when examining the quality of obstetric care (3-5). Assessing near-miss has an advantage over maternal death as near-misses are more common and statistically robust (3, 4).

In Ethiopia, maternal near-miss complications are common and are estimated to be around 12 times more frequent than maternal deaths (23). Previous studies in Ethiopia have documented a prevalence rate of 101 per 1000 deliveries (a study conducted between January, 2008 to December, 2010) (26), and, 90.79 per 1000 live births, according to a study conducted between May, 2011 and October, 2012 (23). Studies addressing the magnitude of maternal near-miss in Ethiopia failed to utilize the standardized WHO criteria to measure maternal near-miss, and this can lead to an incorrect estimate of the problem. In addition, denominators that were used to calculate the magnitude of maternal near-miss vary from study to study. One of the studies used the total deliveries (26), while the other took the total live births occurred during the study period (23) which provided a heterogeneous estimate. Hence, the first step to design programs that address maternal near-miss in Ethiopia is to accurately measure the problem in a more scientific way.

Review of literatures around the world reported different factors for maternal near-miss. The factors associated with maternal near-miss are not well-studied in Ethiopia. Few previous published studies conducted in the country relied on patient record to assess factors of maternal

near-miss. Hence, these studies might be subjected to information bias due to incompleteness and poor quality of secondary data at the health facility (23, 26). The factors were also identified using a cross-sectional study design which has known limitations of ascertaining cause-effect relationship. Deeper analyses techniques such as conditional logistic regressions were not also shown in these studies (23, 26).

Previous studies have shown that the presence of maternal near-miss condition in women is strongly associated with the occurrence of adverse perinatal outcomes (18, 20, 28, 31-33). Many previous studies on the association between maternal near-miss and adverse perinatal outcomes were either cross-sectional or case-control which are subjected to information bias (18, 33, 35). In addition, majority of the studies used hospital record to abstract potential maternal characteristics, which lead to lack of data on important confounding variables (31, 32). These confounders may be alternative explanations for an observed association between exposure and outcome variables. Thus, it was not clear whether the adverse perinatal outcomes were due to the confounding effect or because of maternal near-miss. In Ethiopia, the perinatal outcomes associated with maternal near-miss condition were also not well-understood.

Therefore, using appropriate criteria to measure maternal near-miss, and the use of proper study methods can help to better understand the incidence, factors and adverse perinatal outcomes of maternal near-miss in Ethiopia.

1.3. Rationale of the study

The current study utilized the recently developed WHO case identification criteria to measure maternal near-miss, which can better estimate the magnitude of the problem in Ethiopia. Magnitude of maternal near-miss is an important indicator of quality of obstetric care (4). Up-to-date information on the causes, factors and adverse perinatal outcomes of maternal near-miss are important to know areas of interventions that help to improve maternal and perinatal health. Nevertheless, studies addressing the incidence, causes, factors and adverse perinatal outcomes of maternal near-miss using a new approach of measurements and proper study methods are rare in Ethiopia. Thus, the findings of the current study are vital to fill the knowledge gap, and it will provide a reliable evidence for policy makers, programmers and health practitioners to bring

about quality of obstetric and newborn care. The study will also serve as baseline for future researchers interested in near-miss studies in Ethiopia.

1.4. Literature review

The aim of the current review was to identify literatures that were conducted across the globe on the magnitude, causes, factors and perinatal outcomes of maternal near-miss. Electronic data bases such as MEDLINE, Google scholar and HINARI were used to retrieve pertinent published materials. Key terms such as "maternal near-miss and magnitude", "maternal near-miss and causes", "maternal near-miss and predictors/factors/determinants", "maternal near-miss and perinatal outcomes", "severe maternal morbidity" and "life threatening maternal complications" were used as search terms. Only those published literatures since 2001 and written in English language were considered. EndNote X6 software was used to cite selected references.

1.4.1 Definitions and identification criteria for maternal near-miss case

Review of literatures revealed that the following four types of approaches were used as identification criteria of maternal near-miss cases. Those include: (i) utilization of disease-based criteria that were used by Fillip et al (36) such as hemorrhage, hypertensive disease of pregnancy, dystocia, infections and anemia, (ii) management-based approaches such as admission to Intensive Care Unit (ICU), blood transfusion or hysterectomy (9, 31, 37, 38), (iii) organ dysfunctions-based such as renal failure (10, 33, 39), and, (iv) the new WHO approach (19, 21, 40).

Definitions of maternal near-miss based on disease-specific entities are generally built around obstetric diagnoses or complications and tend to focus on the major causes of maternal mortality, such as hemorrhage, hypertensive disorders, uterine rapture and sepsis (3). In developing countries, it is possible to get the data on different diagnosis of the complications more easily from hospital registers. However, it is very difficult to develop definitions based on signs and symptoms for all types of complications (3, 36, 41). The definitions will require the consensus of clinicians on criteria of severity, which can be difficult to obtain given the diversity of clinical experience (3, 36, 41). Despite these limitations, disease-specific criteria were used in different literatures to identify maternal near-miss cases.

Management-based criteria, such as hysterectomy or admission to ICU definitions were also used for identification of maternal near-miss in different literatures (9, 16). This definition was most widely used in literatures from developed countries (3). Since only one register is required for data collection, it is simple and easy, but the problem is only life threatening cases are identified from ICUs. Besides, it is that very difficult to define what an ICU constitute and it may vary across hospitals. Some hospitals may not have an ICU even. Because of such variations, comparisons across settings have to be interpreted with caution (3).

Definitions based on organ dysfunctions were also used in different literatures for identification of maternal near-miss cases (17, 18). The organ-based dysfunction is based on the failure of an organ (for example, renal failure or cardiac de-compensation) of women during or within six weeks after pregnancy (3). The disadvantage of organ-based dysfunction criteria is that it cannot be used widely in developing countries since it requires sophisticated technologies to diagnose organ failure which is not usually available in hospitals of developing countries (3).

Because different ways of definitions and identification criteria were used to measure maternal near-miss and no standard definition for maternal near-miss until 2009, there were heterogonous estimate of the prevalence of maternal near-miss across different countries. Hence, in order to let the rates to be comparable over time and across regions, a standard definition and uniform case identification criteria for maternal near-miss was proposed by WHO in 2009 (5). The identification criteria include clinical, laboratory and management-based approaches. The new WHO technical working group on maternal morbidity and mortality classifications also recommends using the total live births during the study period to calculate the maternal near-miss rates (1, 5).

1.4.2. Magnitude of maternal near-miss according to the new WHO criteria

Depending on the new WHO approach, one prospective study conducted in Australia reported an incidence rate of 6 per 1000 live births (13). Using this approach, a study in India, Iraq and Brazil also reported a maternal near-miss prevalence rate of 17.8 per 1000 live births, 5.06 per 1000 live births and 4.4 per 1000 live births respectively (28, 40, 42). In Africa, one prospective facility-based study conducted in Ghana reported an incidence rate of 28.6 cases per 1000 live births (19). Another studies conducted in Rwanda, Uganda and Tanzania reported an incidence

rate of 8 per 1000 live births, 8.42 per 1000 live births and 36 per 1000 live births respectively (43-45).

1.4.3. Causes of maternal near-miss

Hypertensive disorders of pregnancy, obstetric hemorrhage, pregnancy-related infections, obstructed labor/dystocia, and unsafe abortions were reported as underlying (direct) causes of maternal near-miss in various literatures (9, 14, 15, 17, 18, 24, 28, 29, 31, 39, 40, 42, 46-50). However, indirect causes such as anemia, malaria, human immunodeficiency virus (HIV) and tuberculosis (TB) were stated as contributing causes to maternal near-miss (27, 51-56).

Hypertensive disorders of pregnancy

Hypertensive disorders of pregnancy which include eclampsia and pre-eclampsia, are among some of the leading causes of maternal near-miss reported in majority of developed countries (8, 9, 46). For instance, it has been reported as the first leading cause of maternal near-miss in a study conducted at the United Arab Emirates (8). It was also shown to be the second leading cause in two other studies conducted in Italy (9, 46). Prospective studies done in Ireland and the Netherlands also indicated that hypertensive disorders of pregnancy was the second most common cause of maternal near-miss (7, 12).

Hypertensive disorders of pregnancy were also reported as the commonest cause of maternal near-miss in middle-income countries as well. For example, it was stated as the leading cause of maternal near-miss in studies conducted in Brazil, Pakistan, Syria, Bolivia and India (14, 17, 18, 24, 31, 47, 48). Other studies that were conducted in India, Iraq, Pakistan, Brazil, Bolivia, and Indonesia indicated that hypertensive disorders of pregnancy was the second most common cause of maternal near-miss (15, 28, 29, 39, 40, 42, 49).

In Africa, hypertensive disorders of pregnancy were also reported as the commonest cause of maternal near-miss. For instance, studies conducted in Tanzania, Nigeria and Malawi mentioned it as the second leading cause of maternal near-miss (20, 21, 25). In Sudan, it was documented as

the third common cause next to hemorrhage and infection (22). In Ethiopia, hypertensive disorders of pregnancy were reported as the first leading cause of maternal near-miss (23).

Obstetric Hemorrhage

Obstetric hemorrhage was reported as the leading cause of maternal near-miss from studies conducted in many of the developed countries. For example, studies done in Italy, Ireland and the Netherlands ranked hemorrhage as the first cause of maternal near-miss (6, 7, 9, 12, 46). It was also reported as the second leading cause in one study conducted at United Arab Emirates (8). Literatures from some parts of the middle-income countries like India, Iraq, Pakistan, Brazil, Bolivia, and Indonesia identified obstetric hemorrhage as the leading cause of maternal near-miss (15, 24, 28, 29, 39, 40, 42, 49, 50). It was also shown as the second leading cause in studies done in Brazil, Syria, and India (14, 17, 18, 31, 48, 57).

Evidences from some of the African countries documented obstetric hemorrhage as the leading cause of maternal near-miss. For instance, literatures from Tanzania, Nigeria, Malawi and Sudan reported obstetric hemorrhage as the first leading cause of maternal near-miss (20-22, 25). In Ethiopia, it was reported as the second leading cause and responsible for 14.8% of the near-miss cases (23).

Pregnancy-related infections/sepsis

Pregnancy-related infections were the least likely reported cause of maternal near-miss according to studies done in most of the developed countries. However, it was shown to be a cause of maternal near-miss from studies conducted in few low and middle-income countries. In countries like India, Nepal, Brazil and Pakistan it has been reported as the third common cause of maternal near-miss (42, 47, 48, 57, 58). It was also responsible for 3.1% of the causes in Iraq, 2.3%, 2.2% and 3.1% in three studies in Brazil, 2.02% in Bolivia, 2.8% in Syria, 4.2% in Pakistan, and 5.9% in Indonesia (14, 18, 24, 28, 29, 31, 39, 40, 50).

In African countries, pregnancy-related infections were reported as a cause of maternal near-miss as high as 32% of the overall cases in Malawi, 21.5% in Sudan, 18.6% in Nigeria and 4% in Tanzania (20-22, 25).

Obstructed labor/dystocia

Dystocia or obstructed labor that may be associated with or without uterine rapture was also reported as the underlying cause of maternal near-miss in different literatures around the globe (14, 24, 29, 39, 48, 50, 58). Although its contribution to maternal near-miss has not been reported from many of literatures in developed world, in Netherlands, uterine rapture contributed to 8.67% of the overall cause of maternal near-miss (12).

Obstructed labor has been reported as a cause of maternal near-miss in different middle-income countries. For example, it contributed to 14.8% of the causes in Pakistan, 9.5% in India, 6% in Indonesia, 3.8% in Syria, 2.77% in Nepal, and 1.02% and 0.04% in two studies at Bolivia (14, 24, 29, 39, 48, 50, 58).

In African countries, like Nigeria, dystocia was responsible for 23% of the causes of maternal near-miss (20). Obstructed labor accounted for 11%, 7.9%, and 6% of the causes of maternal near-miss in studies conducted in Malawi, Sudan and Tanzania respectively (21, 22, 25). In Ethiopia, obstructed labor or uterine rapture accounted for the third leading underlying cause of maternal near-miss (23).

Unsafe abortions

Unsafe abortions as an underlying cause of maternal near-miss have been mentioned in different literatures. In Indonesia, for instance, unsafe abortions contributed to 16.3% of the overall causes of maternal near-miss (29). In Tanzania, abortion-related complications were found to be one of the leading causes according to a report by Nelissen et.al (21). In Ethiopia, 7.2% of the underlying causes of maternal near-miss were due to unsafe abortions (23).

1.4.4. Factors associated with maternal near-miss

Review of literatures show that a variety of factors, such as socio-economic and demographic characteristics of the women, her obstetric history and reproductive health (RH) characteristics,

pre-existing medical conditions and nutritional status of the women were associated with maternal near-miss (11, 12, 24, 47, 51, 52, 54, 59).

Socio-economic and Demographic characteristics of the women

Advanced maternal age

Being an older woman, that is, age greater than 35, has been mentioned as a risk factor for maternal near-miss in different literatures around the globe. For instance, it was mentioned as one of the main risk factors for maternal near-miss in studies done at high-income countries, such as United States of America (USA), United Kingdom (UK), Canada and the Netherlands (11, 12, 51, 52, 54, 59). It was also reported as the main factor of maternal near-miss in middle-income countries as well. For example, two studies in Brazil, one in eight Latin American countries and another in Bolivia documented advanced maternal age as one of the factors responsible for maternal near-miss (24, 33, 60, 61).

Race/Ethnicity

Evidences from some literatures in UK, USA and the Netherlands show that women of non-white ethnicity were found to be at a greater risk for maternal near-miss (12, 51-54).

Low socio-economic status

When women are poor, they might not get the appropriate care they need or their autonomy of decision to seek care will be denied which leads to poor maternal health outcomes. A study conducted in USA by Creanga et.al. found that maternal near-miss affects more women of low socio-economic status (52). Another study conducted on asylum seekers in Netherlands also documented that unemployment and low socio-economic statuses were factors responsible for maternal near-miss (27).

Educational level

Some literatures also reported an association between women's educational level and maternal near-miss. Women with low level of educational status were at an increased risk for maternal near-miss. For example, evidences from studies in Brazil and Bolivia are suggestive of this (24, 62).

Rural residence

Another risk factor reported of maternal near-miss was place of residence. Studies from Bolivia and Brazil documented that women residing in rural areas were more likely to be affected by maternal near-miss complications compared to women residing in urban areas (24, 63).

Obstetric history and RH characteristics of the women

Less or no antenatal care (ANC) follow-up

Absences of ANC follow-up or less perinatal consultations during the women's gestational period were found to be risk factor for maternal near-miss. For instance, a study conducted in Netherlands found that late gestational booking was found to be associated with maternal near-miss morbidity (27). Lack of ANC follow-up was also reported to be a factor for maternal near-miss in studies conducted at Bolivia and Pakistan (24, 47). Those women having less perinatal consultations were reported to be at greater risk of maternal near-miss in studies done at China and Brazil (61, 64). In Nigeria, it has been documented that ANC follow-up was protective against maternal near-miss (20). In Ethiopia, one study shows that women who did not have ANC follow-up was at an increased risk of developing maternal near-miss (26).

Multiple pregnancies

An association also exists between multiple pregnancies and maternal near-miss. Evidences from developed countries like UK, Ireland, USA, Canada and Netherlands revealed that women having multiple pregnancies were at an increased odds of developing maternal near-miss compared to women with singleton deliveries (12, 51, 54, 56, 59).

Parity extremes

Women at both parity extremes (nulliparous or multiparous) were mentioned to be at a higher risk of developing maternal near-miss. Literatures from some of the countries like USA, Canada and the Netherlands reported that being a nulliparous was one of the factors that were associated with maternal near-miss (12, 54, 59). First time pregnancy was also mentioned as one of the factors of maternal near-miss in Bolivia (24). Higher parity also increased the risk of developing

maternal near-miss as evidenced from studies in USA and Netherlands (27, 54). A study conducted at eight Latin American countries by Souza et.al. is also suggestive of this (33).

Previous caesarean section (CS) delivery

Women who delivered their previous baby by CS were reported to be at an increased risk of developing maternal near-miss compared to women without prior CS. For instance, studies conducted in Netherlands and USA found that presence of prior CS in women was a risk factor for maternal near-miss (12, 27, 65). A similar association between previous CS delivery and maternal near-miss were also documented from studies conducted in Syria and other eight Latin American countries (14, 33).

Pre-existing medical conditions

Women with pre-existing medical conditions, such as chronic hypertension, anemia, maternal cardiac diseases and HIV are at a higher risk of developing maternal near-miss compared to women without any previous medical complications. The presence of previous chronic medical conditions has been mentioned as one of the factors for maternal near-miss in studies done at UK, USA, Ireland and the Netherlands (27, 51-56). Literatures from Brazil and Syria also depict this fact (28, 30, 61).

In some of the middle-income countries, anemia's contribution as a factor for maternal near-miss was reported to be high. For instance, 55% of the associated factors of maternal near-miss was as a result of previous anemia in Iraq, 22% in India, and 21.2% in Pakistan (28, 48, 50). But anemia's contribution as a factor for maternal near-miss was reported to be less in some of the studies conducted at Bolivia and Syria (14, 24, 39). In some of the African countries like, Ghana, presence of previous anemia was the most common factor that contributed to maternal near-miss (19). Anemia also accounted for 14.5% of the causes of maternal near-miss in Nigeria (20), 11.8% in Sudan (22) and 8% in Tanzania (21). Evidence from Nigeria also revealed that women having prior chronic hypertension were at a higher risk of developing maternal near-miss (20).

Nutritional status of the women

Being underweight for the women could lead them for the occurrence of complications during pregnancy or childbirth. Accordingly, finding from one study in Brazil documented underweight

to be as one of the factors responsible for maternal near-miss (30). To the contrary, women who were reported to be overweight were also shown to be at higher risk for the development of maternal near-miss (12, 51, 66).

1.4.5. Adverse perinatal outcomes of maternal near-miss

Review of literatures show that the occurrence of maternal near-miss in women is strongly associated with adverse perinatal outcomes, such as stillbirth, preterm birth, low birth weight, early neonatal death, severe birth asphyxia, and admission to Neonatal Intensive Care Unit (NICU) (18, 20, 28, 31-33).

Stillbirth

A variety of literatures reported that excessively high stillbirth rates were seen among women with maternal near-miss complications compared to women without complications. For instance, a study by Oliveira et.al showed that fetal deaths were higher among women with a maternal near-miss condition than the non near-miss women (32). Similarly, a high rate of stillbirth was documented among women of maternal near-miss in studies conducted in Brazil, Pakistan, Syria and other eight Latin American countries (18, 28, 33, 47). Studies conducted in some of the African countries, like Gambia, Nigeria and Sudan also show a higher risk of stillbirth among women of maternal near-miss compared to women without near-miss conditions (20, 22, 67, 68).

Preterm birth

Available evidences show that preterm births were worst among women of maternal near-miss compared to women without near-miss conditions. For example, a study in Syria showed a higher percentage of preterm birth among women with maternal near-miss events (28). Similarly, a higher rate of prematurity was observed in babies born to women with maternal near-miss case in two studies in Brazil (31, 32).

Low birth weight

Findings from some literatures show that, babies born from woman who developed maternal near-miss complications have had low and very low birth weight compared to women without complications. For instance, studies in Brazil and other eight Latin American countries reported

a low and very low birth weight babies born to women with maternal near-miss (31-33). Additional study from Nigeria documented that babies born from women with maternal near-miss case were found to be of lower birth weight compared to babies born to women without complications (20).

Neonatal mortality

Available evidences depict that there were increased occurrence of neonatal mortality among women who experienced maternal near-miss. For instance, two studies in Brazil documented a higher rate of neonatal mortality among women with maternal near-miss complications (18, 32). Similarly, another study by Souza et.al also reported that there was an increased risk of dying in the first week of life for those babies born to women of maternal near miss cases (33).

Birth (perinatal) asphyxia

Perinatal asphyxia or birth asphyxia, which is the deficiency of oxygen during delivery, could lead to severe hypoxic ischemic organ damage in newborns followed by poor fetal outcomes or severe lifelong pathologies (69). It can be mild or severe depending on the grade of oxygen deficiency that a newborn suffer at delivery and individual reaction developed under asphyxic event. In order to grade the severity of perinatal asphyxia in newborn, Apgar score can be used. It is a quick test performed on a baby at 1, 5 and 10 minutes after birth. The score ranges from 0 to 10. Score below 3 is considered as critically low (which needs immediate resuscitation), 4 – 6, fairly low, and score equal to or above 7 refers to normal state of the newborn (69).

Babies born to women with maternal near-miss case showed a higher risk of developing birth asphyxia in some of the reviewed literatures. For example, severe birth asphyxia was observed among babies born to women of maternal near-miss in one study in Brazil (32). A similar association between presence of maternal near-miss and severe birth asphyxia was also reported in one study in Nigeria (20).

Admission to Neonatal Intensive Care Unit (NICU)

Few available studies show that the occurrence of maternal near-miss among women was associated with admission of the newborn to neonatal ICU. For instance, Souza et.al in their study reported that the chance of admitting babies born from women of maternal near-miss to

neonatal ICU were higher (33). In another study in Brazil, 38.6% of babies born to women experiencing maternal near-miss complications required NICU admissions (31).

As a summery, the current study contributes to the scientific body of knowledge in the following ways. Firstly, the study used a new approach (the WHO criteria) to measure maternal near miss. Secondly, strong research designs including matched nested case-control and prospective cohort were used to study factors and adverse perinatal outcomes of maternal near-miss respectively. The data were also collected prospectively for a long period of time which helped us to obtain an adequate sample size and unbiased estimate of the odds ratio. Additionally, a deeper way of analysis (conditional logistic regression) was conducted for the second objective of the study. Thus, all these approaches used in the current study can meaningfully contribute to the scientific body of knowledge.

1.5. Conceptual framework

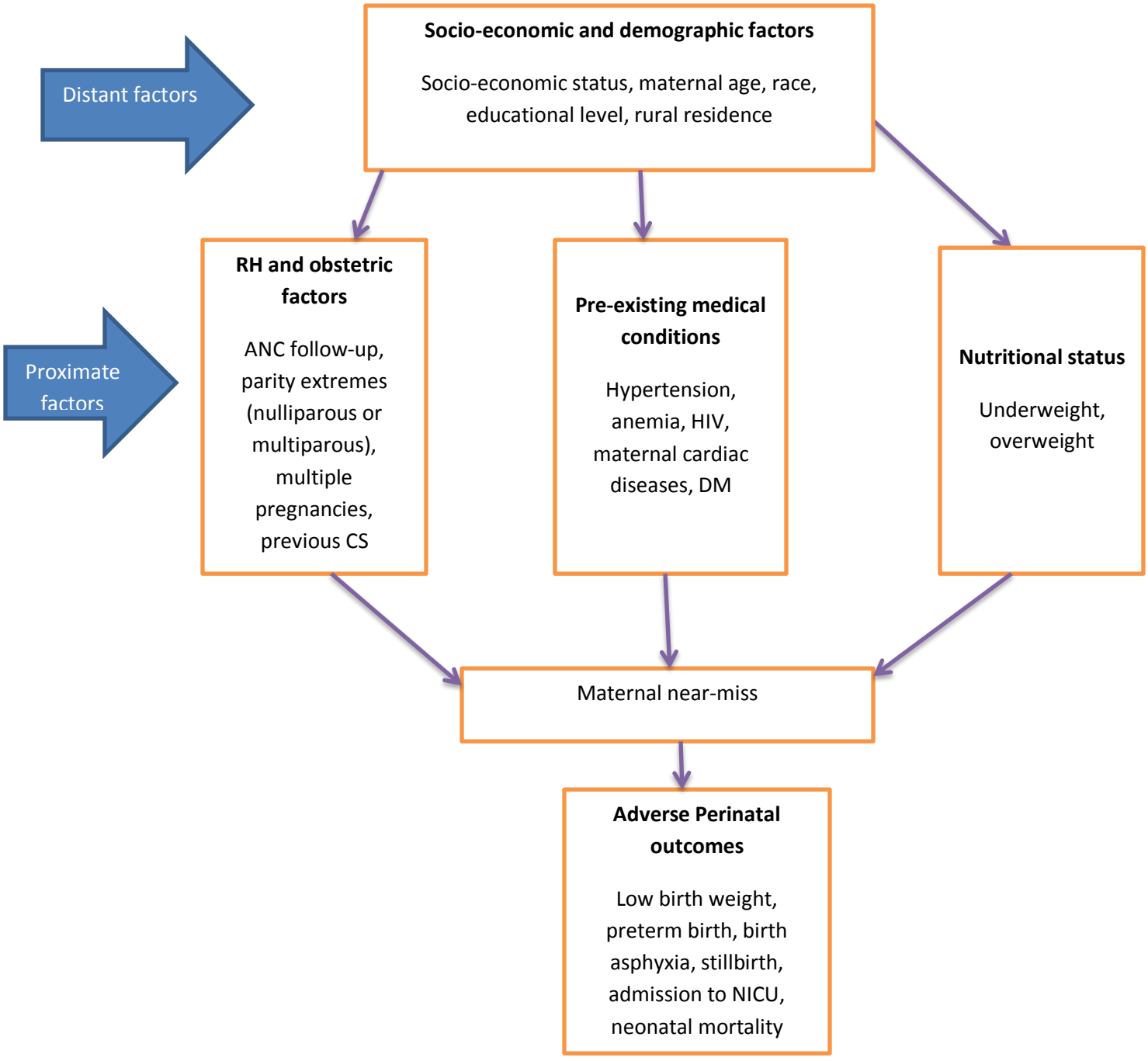

Figure 1 Conceptual framework of maternal near-miss developed based on review of literatures

The above conceptual framework was developed following a thorough review of pertinent literatures across the world. In the literature review, different characteristics were mentioned as factors for maternal near-miss. The factors were classified in to distant and proximate in the conceptual framework. Socio-economic and demographic characteristics were taken as distant factors, while RH and obstetric characteristics, presence of pre-existing medical conditions, and nutritional status of women were taken as proximate factors for the development of maternal near-miss. The conceptual framework also shows the adverse perinatal outcomes to be associated with the presence of maternal near-miss.

2. Research Questions and Objectives

2.1. Research Questions

- What is the magnitude of maternal near-miss in public hospitals of Addis Ababa, Ethiopia?
- What are the causes of maternal near-miss in public hospitals of Addis Ababa, Ethiopia?
- What are the factors associated with maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia?
- What are the adverse perinatal outcomes associated with maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia?

2.2. Research Objectives

General objective

The aim of the study was to assess the incidence, causes, factors and adverse perinatal outcomes of maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia.

Specific objectives

1. To estimate the incidence and identify the causes of maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia **(Paper I).**
2. To identify the factors associated with maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia **(Paper II).**
3. To investigate the effect of maternal near-miss on adverse perinatal outcomes in selected public hospitals of Addis Ababa, Ethiopia (**Paper III**).

3. Methods

3.1. Study setting and period

The study was conducted in five selected public hospitals in Addis Ababa, Ethiopia from May 1, 2015 to April 30, 2016. The hospitals were selected based on the number of deliveries they managed per year. Because most critical maternal cases are referred to a hospital known to provide better care, the presence of an Intensive Care Unit (ICU), maternity ward, blood transfusion service and facilities for caesarean section (CS) were also considered in the selection of hospitals. Hence, Tikur Anbessa, St. Paul's Hospital Millennium Medical College, Zewditu Memorial, Yekatit 12, and Gandhi Memorial Hospitals were selected for the current study. Tikur Anbessa Hospital is the largest referral and teaching hospital in Ethiopia and is operated under the Ministry of Education of Ethiopia. St. Paul's Hospital Millennium Medical College is the largest referral and teaching hospital among those operated under the Federal Ministry of Health. However, the Gandhi Memorial, Yekatit 12 and Zewditu Memorial Hospitals were among the six governmental referral and teaching hospitals that are managed under the Addis Ababa Administrative Health Office. Together, the five hospitals had a total of 29,697 live birth deliveries during the year when this study took place. Apart from Tikur Anbessa Hospital, which received very critical cases from different parts of Ethiopia, the other hospitals are comparable in terms of the patients they receive for care and treatment (Figure 2).

Figure 2 Location map of the study area in Addis Ababa, Ethiopia

SPHMC (St. Paul's Hospital Millennium Medical College), TAH (Tikur Anbessa Hospital), Y12H (Yekatit 12 Hospital), ZMH (Zewditu Memorial Hospital) and GMH (Gandhi Memorial Hospital)

3.2. Study design

A facility-based cross-sectional study design was used to address the first objective of the study. A nested case-control study design, matched for age and study setting was employed to address the second objective. The third objective of the study was addressed using a prospective cohort study design. Participants were followed from admission till discharge.

3.3. Identification of cases and main exposure measure

All women admitted to the participating hospitals during the study period for the treatment of pregnancy-related complications (such as ectopic pregnancy or abortion), having delivered, or within 42 days of termination of pregnancy, and who fulfilled at least one of the conditions stated in the WHO criteria (Annex 1) (1) were included as cases for objectives I and II. Cases were determined based on the WHO criteria after admission. Women who developed maternal

near-miss complications during the third trimester of pregnancy according to the WHO criteria were included as exposed group for the third objective. Depending on when the near-miss occurred, maternal near-miss cases were further categorized into two groups. Women who were assessed as being in critical condition on arrival to a hospital were classified as near-miss before arrival. However, if the near-miss occurred during hospitalization, it was classified as near-miss after arrival.

Exclusion criteria

Any women with maternal near-miss admitted to the participating hospitals for reasons of abortion or ectopic pregnancy were excluded to address the third objective, as those may not result in viable fetus to assess perinatal outcomes. In addition, those women with maternal near-miss who delivered at another facility (outside the included hospitals) and come to the participating hospitals for further follow-up were also excluded from the third objective, as it was difficult to know the perinatal outcomes.

3.4. Selection of controls and non-exposed group

Women who came to the same hospital where the cases happened and having a similar age interval category with that of the cases and delivered without any complications were enrolled as controls for objective II. For each near-miss case that happened in the hospital, three controls that occurred within the same day of the near-miss event were included. Women who come to the same hospital where the exposed group happened and delivered without any complications were enrolled as non-exposed group for the third objective.

3.5. Outcome measure

The outcome of interest for the second objective was maternal near-miss. However, the primary outcome of interest for the third objective was adverse perinatal outcomes, and was categorized as presence or absence of it. Adverse perinatal outcomes were defined with a composite measure based on the presence of either or more of the following: stillbirth, low birth weight, preterm birth, admission to neonatal ICU and first minute birth asphyxia.

3.6. Potential confounders

The following variables were taken as potential confounders and independent variables during analysis of the second and third objectives: (1) socio-economic and demographic characteristics of the women such as age, educational level, marital status, monthly income, (2) reproductive

health and obstetric history of the women, such as ANC status, number of children, history of stillbirth, early marriage, (3) pre-existing medical conditions such as previous chronic hypertensions, previous anemia and history of cardiac problems.

3.7. Sample size determination

The sample size for the first objective was determined by a single population proportion formula by assuming the prevalence of maternal near-miss in Ethiopia to be 9.1% (23). Considering a 1% margin of error, a 95% confidence interval (CI) and a 10% non-response rate, a minimum of 3496 live births were required to address this objective. However, during the year of the study, a larger number of live births than the number required was obtained in the five hospitals (29,697 live births), and we included the entire period of one year to increase the precision of the study, and to have a better estimate of the incidence per year. The sample size for the second objective was estimated using Epi Info 7 software using sample size determination for unmatched case-control studies. The parameters that were used to estimate the sample size were: confidence level of 95%, power of 80%, case-control ratio of 1:3, expected frequency of exposure in control to be 4.11%, and percent exposure among cases, 10.78%. It was estimated from one study in Ethiopia taking no ANC follow-up as one of the main exposure variables for maternal near-miss that provide the maximum sample size (26). Accordingly, that yields a minimum sample size of 166 cases and 497 controls. Adding a 10% non-response rate, the final sample size required for objective II was 183 cases and 547 controls. To increase the power of the study, all cases observed during one year period (collected for objective I), along with the corresponding three controls were included in the study. Summary of sample size calculation for each exposure variable considered for the second objective has been shown in Table 1 below.

Table 1 Summery of sample size calculation for main exposure variables associated with maternal near-miss in one study in Ethiopia (For objective II)

Main exposure variable taken	Prevalence of Exposure in cases (%)	Odds ratio (OR)	Prevalence of exposure in controls (%)	Case to control ratio	Power (%)	Confidence interval (CI) (%)	Cases required (n)	Controls required (n)	Total sample size
Rural residence	39.43	4.57	12.46	1:3	80	95	30	88	118
Parity (>3 delivery)	18.31	3.19	6.55	1:3	80	95	85	255	340
Preterm delivery	17.8	3.28	6.2	1:3	80	95	85	254	339
No ANC follow-up	**10.78**	**2.82**	**4.11**	**1:3**	**80**	**95**	**166**	**497**	**663**

The sample size for the third objective was estimated using Epi Info 7 software using sample size determination for cohort studies. The parameters that were used to estimate the sample size were: confidence level of 95%, power of 80%, exposed to non-exposed ratio of 1:3, expected prevalence of outcome in non-exposed group, 6%, and prevalence of outcome in exposed group to be 22.2%. It was estimated based on one study in Nigeria by taking prevalence of birth asphyxia among exposed and non-exposed women to maternal near-miss (20). Adding a 10% loss rate, the final sample size required for that objective were 55 exposed and 165 non-exposed women; a total of 220 women. The summery of the assumptions used for calculating the sample size for the third objective has been presented in Table 2 below.

Table 2 Summery of sample size calculation for objective III

Main outcome taken	Prevalence of outcome in non-exposed group (%)	Prevalence of outcome in exposed group (%)	Relative risk (RR)	Exposed to non-exposed ratio	Power (%)	CI (%)	Non-Exposed required (n)	Exposed required (n)	Total sample size
Still birth	4.8	28.4	5.92	1:3	80	95	81	27	108
Low birth weight	13.5	44.4	3.29	1:3	80	95	72	24	96
Birth asphyxia	**6**	**22.2**	**3.7**	**1:3**	**80**	**95**	**50**	**150**	**200**

3.8. Data collection

Women who experienced a maternal near-miss event during pregnancy, delivery or the postpartum period were identified prospectively by well-trained midwives and nurses in each hospital. Data relating to the most important variables were abstracted from the medical record of the participants using the WHO data abstraction tool, with some modifications (1). Women with a maternal near-miss condition and those without any complications during delivery were also interviewed using structured, pre-tested questionnaire. The questionnaires were prepared following a thorough review of literatures. Data on the total number of live births occurring over one year for each hospital were extracted from the Health Management Information System (HMIS) report of each hospital. The data were collected from the Delivery Ward, Obstetrics and Gynecology Ward, ICU, and Emergency Gynecology Outpatient Department of each hospital. For each maternal near-miss case, only one underlying cause was identified as per the WHO International Statistical Classification of Diseases and Related Health Problems (ICD-10). According to the ICD-10, the underlying cause is the disease or injury which initiated the sequence of events leading directly to death (70). Because the same classification is used for both maternal death and maternal near-miss (71), the classifications used for maternal near-miss were the same as those listed in the ICD-10 for maternal mortality (72). However, all possible contributing causes were considered. Information regarding whether the near-miss was present before arrival or developed during hospitalization was also collected in order to determine the place where the near-miss occurred.

3.9. Data analysis

The data for the first objective were entered using Epi Info 7 software and analyzed using SPSS version 22 and Open Epi computer software. The total incidence of maternal near-miss in the hospitals included in this study was calculated using the maternal near-miss incidence ratio (MNMIR) formula. This was calculated by dividing the number of maternal near-miss cases during one year by the total number of live births during the same year. The incidence ratio in each hospital was also calculated with a 95% CI. In addition, hospital access indicators, such as the number of women with a maternal near-miss condition before arrival at the hospital, were calculated. Intra-hospital care indicators, such as the number of women with near-miss who developed conditions in the hospital were also calculated. In order to determine the underlying and contributory causes of maternal near-miss, a descriptive frequency for each cause was calculated. The total number and frequency of each cause for all hospitals involved were calculated separately. The causes were categorized into underlying and contributory as per the WHO recommendation (1). A descriptive frequency of the type of organ dysfunction present in maternal near-miss cases was also calculated.

The second objective was analyzed using StataSE version 13.0. The outcome variable of this objective was maternal near-miss. The independent variables which were identified from literatures included: (i) socio-economic and demographic characteristics (educational level, place of residence, ethnicity, religion, marital status, maternal occupation), (ii) reproductive health and obstetric history of the women (antenatal care booking, parity, history of caesarian section delivery, multiple pregnancies, history of abortion, history of stillbirth, early marriage, female genital cutting) and (iii) pre-existing medical conditions (previous hypertension, previous anemia, human immunodeficiency virus (HIV), history of cardiac problems, history of diabetes mellitus (DM)).

Bivariate logistic regression was performed to examine whether there is a significant association between each individual independent variable and maternal near-miss. For each individual variable, the *P*-value, and unadjusted odds ratio (OR) with its 95% confidence interval, and the number and proportion of each variable of case and control were calculated.

Multivariable conditional logistic regression model was used to examine the independent effect of the factors on the occurrence of maternal near-miss. The variables that were mentioned as

factors of maternal near-miss in our literature review were classified as either distant or proximate factors. Socio-economic and demographic variables were taken as distant factors. Whereas, the rest such as, reproductive health and obstetric history of the women, and pre-existing medical conditions were considered as proximate factors. Since distant factors are conceptually related with the proximate factors for the occurrence of maternal near-miss, hierarchical model for the analysis is recommended (73). Based on this hierarchical order, we have developed two models. All socio-economic and demographic variables with $p < 0.2$ in the bivariate logistic regression analysis were fitted with model 1. Those variables that were significant in model 1 ($p < 0.05$) were fitted with model 2. Model 2 contained those significant variables from model 1 and proximate variables. For each model and variables their adjusted OR, its 95% CI and *P*-value were calculated.

The model fitness was estimated using stata's fitstat command. Good fit was indicated by a significance value less than 0.05. Both models which were used to determine the factors associated with maternal near-miss were shown to be significant ($p < 0.001$) which shows the models were best fit.

To see whether there is a statistically significant difference between exposed and non-exposed women with regard to selected categorical variables, chi-square tests were performed. Continuous variables were summarized using the median, and Mann-Whitney U test was used for comparison between groups. The statistical significance was set at $p < 0.05$. In order to know the crude association between maternal near-miss and adverse perinatal outcomes, crude odds ratio (COR) of adverse perinatal outcomes with 95% confidence interval (CI) were calculated among exposed and non-exposed women. In addition, *P*-value and crude odds ratio with 95% CI were calculated for each potential confounding variable to evaluate the crude association between potential risk factors and adverse perinatal outcomes. The number and proportion of the outcome variable with regard to exposure status were also calculated. Those variables with $p < 0.2$ from the bivariate analysis were considered for multivariable binary logistic regression.

Multivariable binary logistic regression analysis was performed to see the effect of maternal near-miss on adverse perinatal outcomes while controlling for potential confounders. Adjusted odds ratio (AOR) with 95% CI was calculated for each independent variable to see the adjusted

association between exposure variables and adverse perinatal outcomes. Since all women were followed for about the same time period, time to event was not considered during the analysis.

Model fitness for the third objective was assessed using Hosmer–Lemeshow goodness-of-fit tests. Poor fit was indicated by a significance value less than 0.05. Because the significance value of the calculated model in the current analysis was greater than 0.05, there was insufficient evidence of poor model fit.

For all the three objectives, data were cleaned before analysis. For objective II and III, we calculated the variance inflation factors (VIF) for each exposure variable to check for the presence of multicollinearity among exposure variables. Possible multicollinearity was suggested if the largest VIF is greater than 10. As all the calculated VIF of each exposure variable in both objectives were less than 10, no possible multicollinearity was observed.

3.10. Data processing and management

The supervisors at all participating hospitals were responsible for checking the completeness of the collected information. The enumerators filled in the date and signed each questionnaire, which was later checked, edited and signed by the supervisors regularly at each hospital. The data that were collected using hard copies were kept in a locked cabinet by each supervisor until gathered by the principal investigator during supervision.

3.11. Data quality assurance

In order to maintain the quality of data, intensive training was given to data collectors and supervisors. All health care workers working in the maternity wards of each participating hospital were also sensitized to the issue so that they would inform the enumerators when they suspected a near-miss case. In addition, inclusion criteria for maternal near-miss were printed and posted on the wall of each ward at all participating hospitals. The data collectors made a daily visit to the Delivery Ward, Obstetrics and Gynecology Ward, ICU, and Emergency Gynecology Outpatient Department to check for potential cases. The data collectors were given training to standardize methods and ensure consistency of data collection. One hospital supervisor, who was responsible for the overall quality of the data, was appointed at each participating hospital. There were frequent supervisions of the included hospitals by the principal

investigator. The questionnaires were first pre-tested in the participating hospitals to verify the appropriateness of the tool. The standardized WHO criteria (1) were used to identify maternal near-miss cases so that there were minimum bias related to measurements. Additionally, we have explicitly defined controls and exposures.

3.12. Operational definitions and measurements

We defined some of the important variables for the three objectives. Maternal near-miss was ascertained using the World Health Organization criteria (1). Educational level was categorized into illiterate (no formal education), primary (grade 1-8), secondary (grade 9-12), and higher education (>12). Antenatal care visit was considered to be present if a woman reported to have ANC during current pregnancy. Monthly income was categorized into the lowest 25 percentile (below 68 USD), between 25 and 75 percentile (68-181 USD), and above 75 percentile (greater than 181 USD). Marriage before age of 18 was considered as early (based on jurisdiction). Pre-existing medical conditions such as chronic hypertension, anemia, HIV, maternal cardiac diseases and DM were considered as present if the women reported their presence before the current pregnancy. Stillbirth was defined as a newborn with no signs of life at or after 28 completed weeks of pregnancy. Low birth weight was defined as a newborn weight below 2500 gram. Preterm birth is a baby born alive before 37 completed weeks of gestation, but after 28 weeks of gestation. Gestational age was determined on the basis of last menstrual period and ultrasound measures were taken when prediction by last menstrual period was not possible. In order to grade the severity of perinatal asphyxia in newborn, Apgar score was used. The score below 7 at the first minute of life were considered as having first minute birth asphyxia.

3.13. Ethical considerations

Acceptable ethical standards were strictly adhered to throughout the study process. The study was first approved by the Institutional Review Board of the College of Health Sciences, Addis Ababa University (Protocol number: 058/14/SPH, Date: January 2015). It was also approved by the Ethical Review Committee of each hospital. Adequate explanation about the purpose of the study and a letter of support were given to all concerned bodies. In order to abstract pertinent information from the participant's record, permission was obtained from the participants and administrators of each hospital. For studies that are not clinical trials that involve invasive procedures, taking verbal consent is the standard requirement of the Institutional Review Board

of Addis Ababa University. Hence, the participants gave verbal consent to be enrolled in the study after they received an adequate explanation of the study aim, benefits and potential harm. Privacy of the participants was maintained throughout the interview process. The anonymity of the participants was respected via the use of codes rather than the name of the participant. The names of the participants were not reported in the findings of the study to ensure confidentiality. The participants received an assurance that participation was voluntary and were informed as if they have full right of withdrawal from the study without affecting the care they were permitted to.

3.14. Summary table of study objectives and methods

The summery of the methods used in the dissertation is shown in Table 3 below.

Table 3 Summery of methods used in the dissertation

Objective	Design	Subjects	Sample size	Data collection	Analysis
To estimate the incidence and identify the causes of maternal near-miss	Cross-sectional	Women admitted for delivery or treatment of pregnancy-related complications, May 1, 2015 to April 30, 2016	238 MNM* cases and 29,697 live births	Review medical record of the participants, HMIS** report	Descriptive statistics
To identify the factors associated with maternal near-miss	Matched nested case-control	MNM cases and control women who delivered without complications	216 maternal near-miss cases and 648 controls	Interview of cases and controls using structured questionnaire, review medical records	Chi-square tests, multivariable conditional logistic regressions, Stata's fitstat command- to assess model fitness, checked multicollinearity using VIF***
To investigate the effect of maternal near-miss on adverse perinatal outcomes	Prospective cohort	Women with and without maternal near-miss along with their singleton newborn babies	207 women with maternal near-miss (exposed women) and 621 corresponding non-exposed women	Review appropriate medical records, interview of exposed and non-exposed women using structured questionnaires	Chi-square tests, Mann-Whitney U test, multivariable logistic regression, model fitness assessed using Hosmer–Lemeshow goodness-of-fit tests, multicollinearity checked by VIF

*MNM represents maternal near-miss cases

** HMIS represents Health Management Information System

*** VIF represents variance inflation factor

4. Results

4.1. Incidence and causes of maternal near-miss

Incidence of maternal near-miss

During the one-year period, a total of 238 maternal near-miss cases and 29,697 live births were reported in all hospitals included in the study, which produced a total maternal near-miss incidence ratio of 8.01 per 1000 live births (95% CI; 7.06 – 9.09).

The highest proportion of cases was reported from Tikur Anbessa hospital (30.7%), followed by St. Paul Millennium Medical College (23.1%), and the lowest proportion was observed at Zewditu Memorial Hospital (Table 4).

Table 1 Incidence of maternal near-miss in five selected public hospitals of Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

Name of Hospital	Near-miss cases *(n)*	Percentage (%)	Total live births in one year	*MNMIR per 1000 live births (95% CI)
Tikur Anbessa	73	30.7	4632	15.8 (12.6 – 19.8)
St. Paul Millennium Medical College	55	23.1	9079	6.06 (4.66 – 7.88)
Gandhi Memorial	39	16.4	7091	5.49 (4.02 – 7.51)
Zewditu Memorial	20	8.4	4610	4.34 (2.81 – 6.69)
Yekatit 12	51	21.4	4285	11.9 (9.06 – 15.61)
Total	238	100	29,697	8.01 (7.06 – 9.09)

*MNMIR represents maternal near-miss incidence ratio.

Characteristics of women with maternal near-miss

The majority (88.2%) of maternal near-miss cases were referred from other health facilities and an ambulance was used by most of the mothers as a means of transport to the study hospitals. A

significant number (68.5%) of maternal near-misses occurred before arrival at the participating hospitals (Table 5).

Table 2 Characteristics of women with maternal near-miss in five selected public hospitals of Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016 (n=238)

Variable	Number	percent
Admission mode		
Self-referred	28	11.8
Referred from other facility	210	88.2
Means of transport used		
Ambulance	181	76.1
Public transport	38	16
Personal vehicle	15	6.3
Others	4	1.7
When did the near-miss occur?		
Before arrival	163	68.5
During hospitalization	75	31.5

Organ dysfunction in maternal near-miss cases

The number of major organ dysfunctions seen in the majority of maternal near-miss cases were Coagulation/Hematological at 114 (47.9%), followed by Neurologic at 97 (40.8%), and Cardiovascular at 96 (40.3%). Hepatic dysfunction was the least-reported organ dysfunction in audited maternal near-miss cases. Around 95 (39.9%) of the cases manifested multiple organ failure (Fig 3).

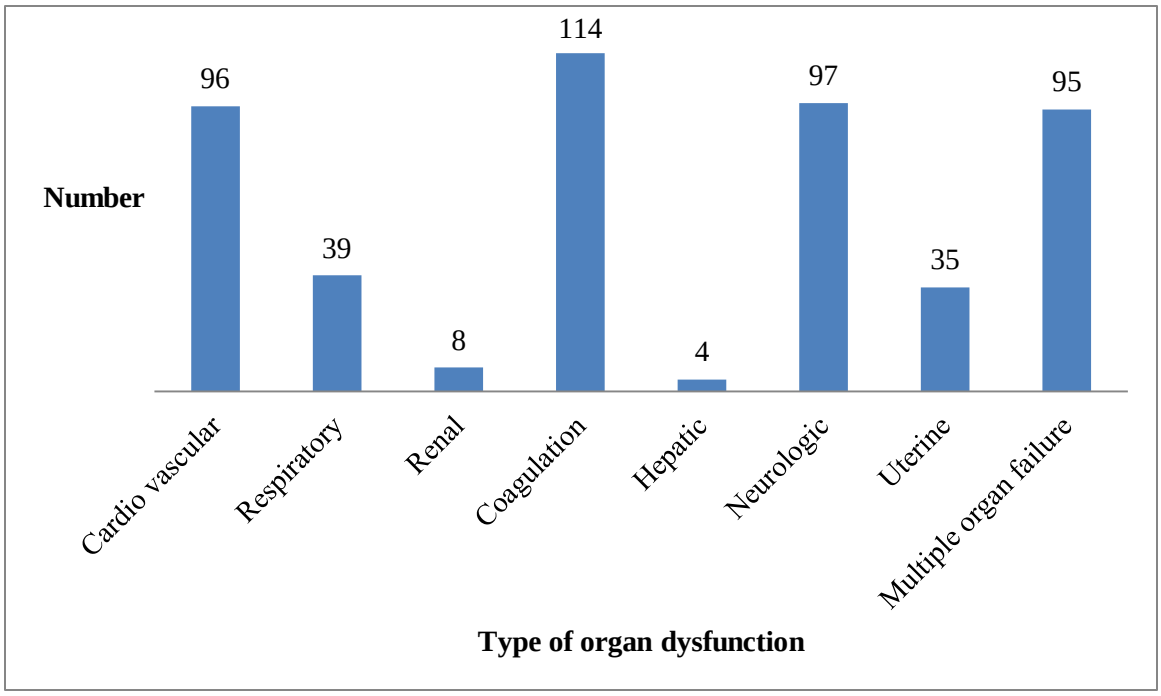

Figure 3 Organ dysfunctions in maternal near-miss cases in five selected public hospitals of Addis Ababa, Ethiopia, May 2015 to April 30, 2016

Underlying and contributory causes of maternal near-miss

The underlying cause for the majority of maternal near-miss cases was hypertensive disorder (53%), followed by obstetric hemorrhage (38%), pregnancy with abortive outcome (4%), and pregnancy-related infections (1%) (Fig 4).

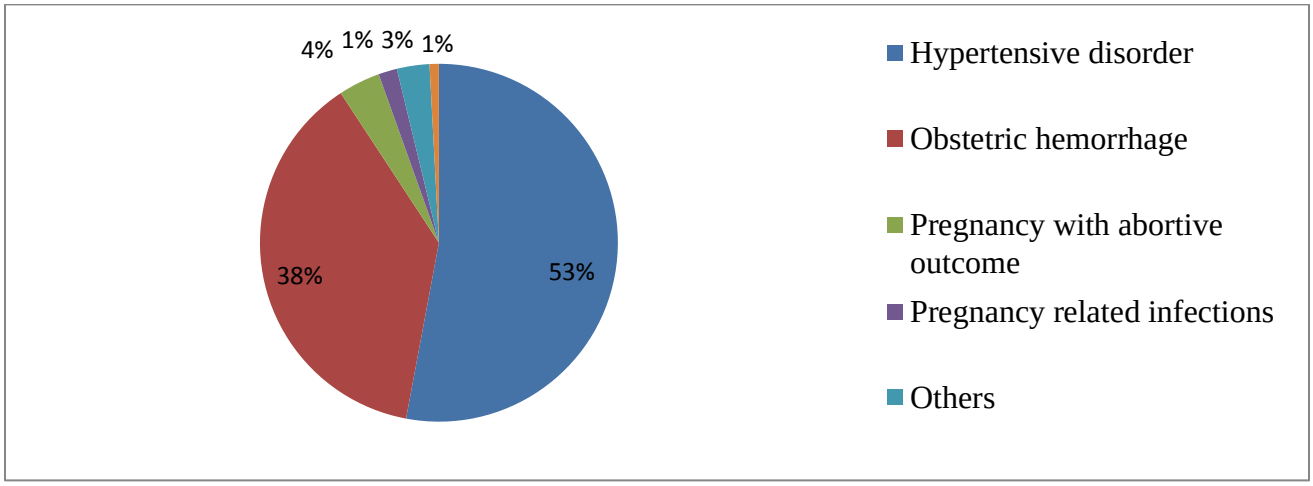

Figure 4 Underlying causes of maternal near-miss in five selected public hospitals, Addis Ababa, Ethiopia May1, 2015 to April 30, 2016 (n=238)

The major contributing causes of maternal near-miss reported were anemia (40%) followed by prolonged/obstructed labor (9%). Around 37% of maternal near-miss cases did not show any form of contributing causes (Fig 5).

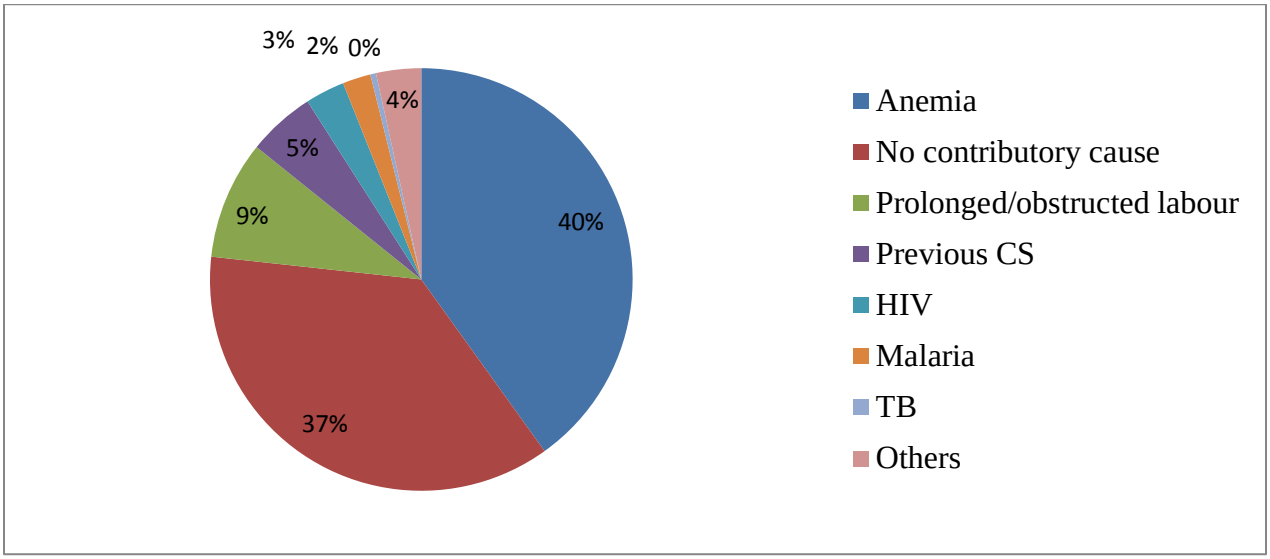

Figure 5 Contributing causes of maternal near-miss in five selected public hospitals, Addis Ababa, Ethiopia May1, 2015 to April 30, 2016 (n=238)

4.2. Risk factors for maternal near-miss

Characteristics of the study participants

Although a total of 238 maternal near-miss cases were reported in all participating hospitals during a year period, we excluded 22 cases because of incomplete data for the nested case-control study. Hence, the study included 216 maternal near-miss cases and 648 corresponding controls.

Women with maternal near-miss tended to be illiterate ($P < 0.001$), never married ($p = 0.011$), reside in rural area ($p < 0.001$), and had a less monthly income ($p < 0.001$) compared to controls (Table 6).

Compared to the control groups, women with maternal near-miss case were more often did not attend ANC, have greater than five children, have a history of stillbirth, and experienced an early marriage, all statistically significant ($p < 0.05$). However, there were no statistically significant

difference between cases and controls with regard to presence of previous caesarean section delivery, history of abortion and undergoing a female genital cutting (FGC) (Table 6).

Cases and controls also differed significantly with regard to the presence of previous medical conditions such as chronic hypertension, anemia, and cardiac problems. However, a significant difference was not observed among the two groups with regard to the presence of HIV and DM (Table 7).

Table 3 Distribution of selected socio-demographic, economic, reproductive health and obstetric characteristics of women with and without maternal near-miss in Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Near-miss (n=216)	**Controls (n=648)**	**COR (95% CI)**	***P*-value**
Characteristics	n (%)	n (%)		
Educational level				
Illiterate	61 (30.0)	75 (11.7)	**3.28 (1.85-5.84)**	< 0.001
Primary	63 (31.0)	214 (33.4)	1.23 (0.70-2.15)	0.470
Secondary	57 (28.1	256 (39.9)	0.91 (0.52 -1.57)	0.724
Higher	22 (10.8)	96 (15)	1.00	
Place of residence				
Urban	159 (73.6)	634 (97.8)	1.00	
Rural	57 (26.4)	14 (2.2)	**13.0 (7.12-23.8)**	< 0.001
Marital status				
Married	200 (92.6)	627 (96.8)	1.00	
Never married	16 (7.4)	21 (3.2)	**2.38 (1.22-4.65**)	0.011
Monthly income				
> 68 USD	81 (37.5)	111 (17.1)	**2.19 (1.43-3.34)**	< 0.001
68 - 181 USD	74 (34.3)	370 (57.1)	**0.54 (0.36-0.79)**	0.002
>181 USD	61 (28.2)	167 (25.8)	1.00	
Received ANC				
Yes	183 (84.7)	638 (98.5)	1.00	
No	33 (15.3)	10 (1.5)	**10.8 (5.16-22.6)**	< 0.001
Number of children				
0-2	171 (79.2)	527 (81.3)	0.99 (0.63-1.56)	0.985
3-4	34 (15.7)	110 (17)	1.00	
>5	11 (5.1)	11 (1.7)	**3.53 (1.34-9.27)**	0.010
Undergone FGC				
Yes	135 (64.6)	383 (59.6)	0.89 (0.59-1.33)	0.225
No	74 (35.4)	260 (40.4)	1.00	
History of stillbirth				
Yes	21 (9.7)	21 (3.2)	**3.45 (1.79-6.68)**	< 0.001
No	195 (90.3)	627 (96.8)	1.00	
Early marriage				
Yes	43 (21.5)	90 (14.5)	**1.97 (1.21-3.19)**	0.006
No	157 (78.5)	532 (85.5)	1.00	

Bold data are those which are significant and their significance is indicated by the P-values expressed at the right end of each ORs

Table 4 Distribution of selected previous medical conditions of cases and controls in Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Near-miss (n=216)	**Controls (n=848)**	**COR (95% CI)**	***p*-value**
Characteristics	**n (%)**	**n (%)**		
Previous hypertension				
Yes	56 (25.9)	16 (2.5)	**13.3 (7.16-24.9)**	< 0.001
No	160 (74.1)	632 (97.5)	1.00	
Previous anemia				
Yes	73 (33.8)	64 (9.9)	**4.66 (3.12-6.95)**	< 0.001
No	143 (66.2)	584 (90.1)	1.00	
History of cardiac problem				
Yes	11 (5.1)	5 (0.8)	**6.6 (2.29-18.9)**	< 0.001
No	205 (94.9)	643 (99.2)	1.00	

Bold data are those which are significant and their significance is indicated by the P-values expressed at the right end of each ORs

Risk factors

In order to know the factors associated with maternal near-miss, two models were used in a multivariable conditional logistic regression analysis. Model one contained five variables which were significant in bivariate analysis (educational level, place of residence, ethnicity, marital status and monthly income). However, the result of the first model showed that only place of residence was found to be associated with maternal near-miss (Table 8).

The second model contained eleven variables, and five variables remained significant. The factors associated with maternal near-miss in the second model were: history of chronic hypertension (AOR=10.80,95% CI; 5.16 – 22.60), rural residence (AOR=10.60,95% CI; 4.59 – 24.46), history of stillbirth (AOR=6.03,95% CI; 2.09 – 17.41), no ANC attendance (AOR=5.58,95% CI; 1.94 – 16.07) and history of anemia (AOR=5.26,95% CI; 2.89 – 9.57) (Table 8). However, the study did not find that FGC was a determinant factor for maternal near-miss.

Table 5 Factors associated with maternal near-miss in model one and two, multivariable conditional logistic regression analysis, Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Model 1		**Model 2**	
	AOR (95% CI)	***p*-value**	**AOR (95% CI)**	***p*-value**
Characteristics				
Place of residence				
Rural	6.86 (3.42-13.76)	< 0.001	**10.60 (4.59-24.46)**	**< 0.001**
Urban	1		1	
Educational level				
Illiterate	1.91 (0.95-3.83)	0.068	-	-
Primary	1.29 (0.68-2.45)	0.429	-	-
Secondary	1.12 (0.62-2.04)	0.699	-	-
Higher	1		-	-
Ethnicity			-	-
Amhara	1		-	-
Oromo	1.32 (0.82-2.13)	0.248	-	-
Gurage	0.66 (0.37-1.21)	0.178	-	-
Tigre	1.01 (0.41-2.47)	0.975	-	-
Silte	0.92 (0.36-2.36)	0.867	-	-
Other	0.86 (0.39-1.89)	0.708	-	-
Marital status			-	-
Married	1		-	-
Never married	1.21 (0.54-2.72)	0.642	-	-
Monthly income			-	-
< 68 USD	1.62 (0.95-2.77)	0.075	-	-
68 - 181 USD	0.65 (0.42-1.02)	0.061	-	-
> 181 USD	1		-	-
Received ANC	-	-		
Yes	-	-	1	
No	-	-	**5.58 (1.94- 16.07)**	**0.001**
Number of children	-	-		
0-2	-	-	2.16 (0.09-5.28)	0.09
3-4	-	-	1	
>5	-	-	4.27 (0.65-27.98)	0.13
History of stillbirth	-	-		
Yes	-	-	**6.03 (2.09- 17.41)**	**0.001**
No	-	-	1	
Early marriage	-	-		
Yes	-	-	1.35 (0.66-2.76)	0.411
No	-	-	**1**	

Previous hypertension	-	-		
Yes	-	-	**10.80 (5.16-22.60)**	**< 0.001**
No	-	-	1	
Previous anemia	-	-		
Yes	-	-	**5.26 (2.89-9.57)**	**< 0.001**
No	-	-	1	
History of cardiac problem	-	-		
Yes	-	-	3.17 (0.59-16.81)	0.175
No	-	-	1	

Bold data are those which are significant and their significance is indicated by the P-values expressed at the right end of each ORs

4.3. Maternal near-miss and the risk of adverse perinatal outcomes

Characteristics of the study participants

A total of 828 women admitted for delivery or treatment of pregnancy-related complications along with their singleton newborn babies were followed. Among those, 207 of them were women with maternal near-miss (exposed women) and the rest 621 were non-exposed women (uncomplicated delivery group).

Women exposed to maternal near-miss tended to be illiterate ($p < 0.001$), unmarried ($p = 0.021$), had less monthly income ($p = 0.003$) and more likely to reside in the rural area ($p < 0.001$) compared to non-exposed women. The two groups did not significantly differ in terms of age ($p = 0.673$), religion ($p = 0.676$) and ethnicity ($p = 0.054$) (Table 9).

Compared to non-exposed women, majority of the exposed women were less likely to receive ANC ($p < 0.001$) and more likely to have had greater than five children ($p = 0.013$), a history of stillbirth ($p < 0.001$) and married early ($p = 0.041$). There were no statistically significant difference among the two groups with regard to the FGC status of the women ($p = 0.201$) (Table 9).

Women with maternal near-miss were more likely to report a previous history of chronic hypertension, anemia and cardiac problems (all $p < 0.001$) (Table 9).

Table 6 Distribution of selected variables among women with near-miss and uncomplicated delivery women in selected public hospitals, Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Near-miss group (n=207)	**Uncomplicated delivery group (n=621)**	***P*-value**
Characteristics	**n (%)**	**n (%)**	
Educational level			
Illiterate	57 (29.2)	75 (12.2)	< **0.001**
Primary	62 (31.8)	201 (32.7)	0.323
Secondary	55 (28.2)	249 (40.5)	0.847
Higher	21 (10.8)	90(14.6)	
Place of residence			
Urban	153 (73.9)	608 (97.9)	
Rural	54 (26.1)	13 (2.1)	< **0.001**
Marital status			
Married	192 (92.8)	600 (96.6)	
Never married	15 (7.2)	21 (3.4)	**0.021**
Monthly income			
> 68 USD	76 (36.7)	108 (17.4)	**0.003**
68 - 181 USD	73 (35.3)	358 (57.6)	**0.002**
>181 USD	58 (28.0)	155 (25.0)	
Received ANC			
Yes	177 (85.5)	611 (98.4)	
No	30 (14.5)	10 (1.6)	< **0.001**
Number of children			
0-2	164 (79.2)	507 (81.6)	0.855
3-4	32 (15.5)	103 (16.6)	
>5	11 (5.3)	11 (1.8)	**0.013**
Undergone FGC			
Yes	129 (64.5)	366 (59.4)	0.201
No	71 (35.5)	250 (40.6)	
History of stillbirth			
Yes	20 (9.7)	20 (3.2)	< **0.001**
No	187 (90.3)	601 (96.8)	
Early marriage			
Yes	41 (21.5)	90 (15.1)	**0.041**
No	150 (78.5)	506 (84.9)	
Previous hypertension			
Yes	54 (26.1)	16 (2.6)	< **0.001**
No	153 (73.9)	605 (97.4)	
Previous anemia			
Yes	70 (33.8)	63 (10.1)	< **0.001**

No	137 (66.2)	558 (89.9)	
History of cardiac problems			
Yes	11 (5.3)	5 (0.8)	**< 0.001**
No	196 (94.7)	616 (99.2)	

***Chi-square test was used to obtain the p-value**

Comparisons of adverse perinatal outcomes among exposed and non-exposed women

Table 10 is about comparison of the adverse perinatal outcomes among exposed and non-exposed women. From a total of 828 cohort of women delivered in the participating hospitals, 36.6% (95% CI: 33.4% – 39.9%) of them ended up in a wide range of adverse perinatal outcomes such as stillbirth, preterm birth, low birth weight infant, birth asphyxia and admission to neonatal ICU. The prevalence of adverse perinatal outcomes was significantly higher among women who were exposed to maternal-near miss compared to the non-exposed women, 72.9% (95% CI: 66.5% – 78.5%) versus 24.5% (95% CI: 21.3% – 28%) respectively, $p < 0.001$). Babies born from women with maternal near-miss were more likely to be stillbirth ($p < 0.001$), preterm ($p < 0.001$), of lower birth weight ($p < 0.001$), admitted to neonatal ICU ($p < 0.001$) and tended to have had a birth asphyxia in the first minute ($p < 0.001$) (Table 10).

A statistically significant difference in hospital stay was also observed between the two groups. Women exposed to maternal near-miss were more likely to have a longer median hospital stay of 6 days compared to non-exposed women with a median hospital stay of 1 day ($p < 0.001$).

Table 7 Prevalence of adverse perinatal outcomes among women with near-miss and uncomplicated delivery women in selected public hospitals, Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Groups				*P-value	COR(95 % CI)
	Uncomplicated delivery (n=621)		Near-miss (n=207)			
Outcome variables	**No**	**%**	**No**	**%**		
Adverse perinatal outcomes	152	24.5	151	72.9	< 0.001	**8.32 (5.82 – 11.89)**
Stillbirth	24	3.9	61	29.5	< 0.001	**10.39 (6.27 – 17.23)**
Preterm birth	48	7.7	84	40.6	< 0.001	**8.15 (5.44 – 12.22)**
Low Birth weight	50	8.1	82	39.6	< 0.001	**7.49 (5.02 – 11.19)**
Asphyxia at 1 min	73	11.8	119	57.5	< 0.001	**10.15 (7.03 – 14.67)**
Admitted to **NICU	52	8.4	61	29.5	< 0.001	**4.57 (3.03 – 6.9)**

***Chi-square test was used to obtain the p-value**

****NICU stands for Neonatal Intensive Care Unit**

Risk factors of adverse perinatal outcomes

After adjustment for potential confounders such as educational level, place of residence, monthly income, ANC status, history of stillbirth, and presence of previous chronic hypertension, anemia, and cardiac problems in a multivariable logistic regression analysis, the association between maternal near-miss and adverse perinatal outcomes remained significant. The odds of developing adverse perinatal outcomes among women with maternal near-miss was more than five times higher than among women with no maternal near-miss (AOR= 5.69: 95% CI; 3.69 – 8.76) (Table 11).

Educational level, place of residence and prior stillbirth delivery also remained independently associated with adverse perinatal outcomes in multivariable logistic regression analysis. The effect of maternal near-miss on adverse perinatal outcome was exacerbated when the women had a primary level of education (AOR=1.89: 95% CI; 1.07 – 3.34), reside in rural area, (AOR=2.16:95% CI; 1.03 – 4.53) and had a history of stillbirth (AOR=2.39; 95% CI; 1.12 – 5.10) (Table 11).

Less monthly income (COR=1.89: 95% CI; 1.26 – 2.82), not receiving ANC (COR=5.66: 95% CI; 2.73 – 11.75), previous history of anemia (COR=2.05: 95% CI; 1.41 – 2.98), prior chronic hypertension (COR=3.49: 95% CI; 2.09 – 5.82) and history of cardiac problems (COR=2.95: 95% CI; 1.06 – 8.21) were positively associated with adverse perinatal outcomes in bivariate analysis, but this association became statistically non-significant after adjustment (Table 11).

Table 8 Maternal near-miss and odds of adverse perinatal outcomes in relation to other confounding variables in selected public hospitals, Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Adverse perinatal outcomes	
	COR (95% CI)	***AOR (95% CI)**
Characteristics		
Maternal near-miss		
Yes	**8.32 (5.82-11.89)**	**5.69 (3.69-8.76)**
No	1	1
Educational level		
Illiterate	**3.11 (1.79-5.04)**	1.56 (0.80-3.04)
Primary	**2.03 (1.24-3.35)**	**1.89 (1.07-3.34)**
Secondary	1.37 (0.83-2.26)	1.45 (0.83-2.52)
Higher	1	1
Place of residence		
Rural	**7.74 (4.21-14.21)**	**2.16 (1.03-4.53)**
Urban	1	1
Monthly income		
<68 USD	**1.89 (1.26- 2.82)**	1.21 (0.73-1.98)
68 to 181 USD	.77 (.55- 1.09)	0.87 (0.58-1.32)
> 181 USD	1	1
Received ANC		
Yes	1	1
No	**5.66 (2.73- 11.75)**	1.86 (0.79-4.41)
History of stillbirth		
Yes	**3.43 (1.76- 6.67)**	**2.39 (1.12-5.10)**
No	1	1
Previous hypertension		
Yes	**3.49 (2.09- 5.82)**	1.24 (0.66-2.32)
No	1	1
Previous anemia		
Yes	**2.05 (1.41- 2.98)**	0.98 (0.61-1.57)
No	1	1
Previous cardiac problems		
Yes	**2.95 (1.06- 8.21)**	1.29 (0.36-4.56)
No	1	1

* Single model was used to produce the AORs.
*Adjusted for the eight variables shown in the table

Bold data are those which are significant

4.4. Summary of main findings of the dissertation

Table 12 below summarizes the major findings of the dissertation.

Table 9 Summary of the findings of the dissertation, Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

Objectives	Major findings
To estimate the incidence and identify the causes of maternal near-miss	• During the one-year period, there were a total of 238 maternal near-miss cases and 29,697 live births in all participating hospitals, which provided a maternal near-miss incidence ratio of 8.01 per 1000 live births (95% CI; 7.06 – 9.09). • The underlying causes of the majority of maternal near-miss cases were hypertensive disorders (53%) and obstetric hemorrhage (38%). • Pregnancy-related infection was the least mentioned cause of maternal near-miss • Anemia was the major contributing cause reported for maternal near-miss (40%). • Most of the maternal near-miss cases (68.5%) occurred before the women's arrival at the participating hospitals. • Major organ dysfunctions seen were, Coagulation/Hematological at 47.9% followed by Neurologic at 40.8%, and Hepatic dysfunction was the least reported organ dysfunction.
To identify the factors associated with maternal near-miss	The main factors associated with maternal near miss were: ✓ History of chronic hypertension (AOR=10.79,95% CI; 5.15-22.64), ✓ Rural residence (AOR=10.68,95% CI;4.60-24.78), ✓ History of stillbirth (AOR=6.06,95% CI;2.09-17.49), ✓ No antenatal care attendance (AOR=5.58,95% CI;1.82-17.05) and ✓ History of anemia (AOR=5.16, 95% CI; 2.81-9.47).
To investigate the effect of maternal near-miss on adverse perinatal outcomes	• The prevalence of adverse perinatal outcomes among women exposed to near-miss was 72.9% (95% CI: 66.5% – 78.5%) versus 24.5% (95% CI: 21.26% – 28.01%) in non-exposed, $p < 0.001$). • Women exposed to maternal near-miss were more likely to have a longer median hospital stay of 6 days compared to non-exposed women with a median hospital stay of 1 day ($p < 0.001$). • Women with maternal near-miss condition had more than five-fold increased risk of adverse perinatal outcomes compared to women without complicated delivery (AOR=5.69: 95% CI; 3.69-8.77). • Other risk factors that were independently associated with adverse perinatal outcomes includes: ✓ Rural residence (AOR=2.16:95% CI; 1.03 – 4.53) ✓ History of prior stillbirth (AOR=2.39; 95% CI; 1.12 – 5.10) ✓ Primary educational level (AOR=1.89: 95% CI; 1.07 – 3.34)

5. Discussions

5.1. Incidence and causes of maternal near-miss

Incidence of maternal near-miss

During the one-year period of the study, the incidence of maternal near-miss was 8.01 per 1000 live births in all participating hospitals. Previous studies in Ethiopia have documented a prevalence rate of 101 per 1000 deliveries (26) and 90.79 per 1000 live births (23). Surprisingly, our finding is considerably lower than that given in previous reports and the observed variation could be a result of disparity in the case definitions used by the researchers, the study design used, and the time at which the study was conducted. We used the newly developed WHO criteria, which are very stringent and would identify only very critical cases. However, previous studies used disease-based criteria, which were less stringent than the WHO criteria for identifying maternal near-miss cases. Thus, had the previous studies employed the WHO criteria, they might have ended up reporting more cases. Data quality issues and the limitations of the secondary data obtained in previous studies might also be an alternative explanation for the observed difference. Nevertheless, when we compare our findings with other studies that used the newly developed WHO criteria, the incidence was lower than some other sub-Saharan African countries such as Ghana and Tanzania (19, 21). However, our results are comparable with studies conducted in Rwanda and Uganda, where they reported an incidence rate of 8 per 1000 live births and 8.42 per 1000 live births, respectively (43, 44).

The majority of maternal near-miss cases have already occurred on the women's arrival at the participating hospitals, a finding which is in line with studies from most developing countries. For example, in Bolivia, Mozambique and Somaliland, 74%, 70.7% and 74.2% of the near-miss cases, respectively, were in a critical state upon arrival at the health facilities, implying the need to focus on existing pre-hospital barriers (39, 74, 75). However, near-miss cases that develop during hospitalization can help to measure the quality of obstetric care provided within the health facilities. In Iran, for example, sub-optimal obstetric care was found in 75% of the near-miss cases (76). The occurrence of maternal near-miss after receiving sub-optimal care following caesarian section has also been reported elsewhere (45). However, it should be noted that quality

of care is not the only possible explanation for near-miss events occurring during hospitalization. Cases that occurred after admission could also be related to the severity of the cases.

Among the five participating hospitals, a higher incidence of maternal near-miss was observed in Tikur Anbesa Hospital (15.76 per 1000 live births). Because that hospital is the major referral hospital in Ethiopia, the possibility of obtaining severely critical cases from different parts of the country and from Addis Ababa is higher.

Causes of maternal near-miss

The leading underlying cause of maternal near-miss in our study was hypertensive disorder (eclampsia and pre-eclampsia), followed by obstetric hemorrhage. This finding is compatible with most studies from high and middle-income countries (8, 9, 46, 77). The study finding was also in line with studies conducted in other African countries (20, 21, 25). A previous study in Ethiopia also reported hypertensive disorder as the primary cause and obstetric hemorrhage as the second leading cause of maternal near-miss (23). High percentages of hypertensive disorder and obstetric hemorrhage might be indicative of some form of delay in managing obstetric complications by the facility staff.

Pregnancy-related infection was the least mentioned cause of maternal near-miss in our study and was also reported to be the least likely cause in most of the studies completed in developed countries. The rate was also much lower as compared to some of the other African countries that had been studied (20-22, 25). The lower percentage of infection as a cause of maternal near-miss could be explained by the presence of early management of the cases with appropriate antibiotics at each health facility.

Anemia was the major contributory cause of maternal near-miss in our study. This finding is also comparable with studies from some middle-income countries such as Iraq, India, and Pakistan (28, 48, 50). This finding was also in line with the studies from some African countries such as Ghana (19). The presence of anemia in women can be attributed to nutritional and iron deficiency during pregnancy. It could also result from the presence of previous malaria. Hence, there is a need to deeply assess the causes of anemia in women with a maternal near-miss case to determine the most appropriate action.

5.2. Factors associated with maternal near-miss

History of chronic hypertension, rural residence, history of stillbirth, no antenatal care attendance and history of anemia were found to be correlated with the occurrence of maternal near-miss.

Among all characteristics, presence of previous chronic hypertension showed the strongest risk factor for the development of maternal near-miss. Women with chronic hypertension are at increased risk for several pregnancy complications which includes: pre-eclampsia, placental abruption, intrauterine growth retardation, CS delivery and preterm delivery (78). The finding was consistent with other studies. A study done at Nigeria reported a seven-fold increased risk of maternal near-miss in women with presence of previous chronic hypertension (20). The observation was also similar to other studies in which the risk of maternal near-miss was higher among women with pre-existing hypertension (41, 61). This indicates that women having a previous chronic hypertension need to be closely monitored and managed during ANC and delivery services in order to avoid the occurrence of severe maternal complications. The information is also important for policy makers to improve access to medical care for pregnant women.

Another strong risk factor for maternal near-miss reported in the current study was place of residence. Accordingly, those women who reside in the rural area have higher odds of developing maternal near-miss. A similar finding was also reported in another study in Ethiopia (26). Studies from Bolivia and Brazil also documented a similar finding (24, 63). Women from rural area might walk longer to access health services. Particularly when maternal complications occurred, her chance of getting appropriate health care on time might be minimized which in turn increase her chance of morbidity. The important implications of this finding is that policy makers need to improve access to maternal health care services to rural part of the country to avoid the occurrence of maternal complications among pregnant women. It will also allow policy makers to improve infrastructure to aid for a quick referral chain from primary level to secondary and tertiary health care level.

Additionally, we found that presence of previous stillbirth in women was an important risk factor for maternal near-miss. After a stillbirth infant, women may experience different psychological as well as relational problems which might in turn increase the risk of maternal complications in subsequent pregnancies. The link between maternal chronic hypertension and

stillbirth may also be an alternative explanation (78). Hence, women who had a stillbirth might have a history of chronic hypertension, and thereby increase the odds of maternal near-miss. Todd et al. in their study on correlates of severe acute maternal morbidity in Kabul also demonstrated that prior stillbirth is a risk factor for maternal near-miss (79). Practical contribution of this finding is that it will allow health care providers to carefully plan and manage women with prior stillbirth to avoid the occurrences of critical maternal morbidity.

The study also showed that the odds of maternal near-miss was higher among those women who failed to attend ANC. Different evidences showed that ANC is effective to identify pre-existing factors that could increase the risk of complications during pregnancy or delivery (80, 81). Protective effect of ANC attendance for maternal near-miss event was also noted in other study too (20). No ANC attendance could also be associated with some of the identified risk factors of maternal near-miss in the current study, such as history of stillbirth and rural residence. However, we have checked the interaction among these variables and no interaction was noted. The massage of this finding highlight that, proper ANC provision to pregnant women can prevent the occurrence of maternal near-miss.

It was also observed that women with a history of anemia have higher odds of maternal near-miss than those without a prior history of anemia. Untreated anemia can lead to post-partum hemorrhage and hypovolemic shock and is a common cause of adverse maternal outcomes (82). The higher risk of maternal near-miss for women with a prior history of anemia has also been identified in previous studies (19, 28). This signifies that improvement in detection and treatment of prior anemia for pregnant women can avert presence of subsequent maternal complications. This risk factor might be modified via appropriate medical and antenatal care for pregnant women. Education of women on importance of nutrition during pregnancy and Iron supplementation for pregnant women during pregnancy might also modify the impact of this risk factor.

Our study did not find that female genital cutting (FGC) was a determinant factor for maternal near-miss events. However, in a WHO multi-center study of female genital cutting, adverse obstetric outcomes were more frequent among cut than uncut women (83). The possible reason for not getting a significant result in our study might be the fact that the study being underpowered for this specific factor. The number of women with FGC was also too small to detect any difference.

5.3. Adverse perinatal outcomes of maternal near-miss

The study showed that the presence of maternal near-miss in women is a risk factor for adverse perinatal outcomes independent of educational level, place of residence, monthly income, ANC follow-up, history of stillbirth, and presence of previous hypertension, anemia and cardiac problems. The observations are consistent with previous studies. Higher risk of adverse perinatal outcomes such as stillbirth, low birth weight, preterm birth, admission to neonatal ICU, birth asphyxia and early neonatal mortality were observed among maternal near-miss women in studies conducted at Nigeria, Brazil and other 8 Latin American countries (20, 32, 33). The Nigeria study used case-control design and higher risk of poor perinatal outcomes such as stillbirth and low birth weight infant were reported among women with maternal near-miss case compared to the control group (20). Unlike the present study, information on potential confounders has been obtained from the medical record in other studies (32, 33). Hence, the previous studies might be subjected to information bias due to incompleteness and poor quality of secondary data at the health facility. A woman under maternal near-miss condition could develop severe conditions which includes eclampsia, anemia, ante-partum hemorrhage and placenta praevia among others. These severe conditions can affect the fetus, for example, via placental insufficiency leading to intrauterine growth restriction (IUGR). Preeclampsia, for instance, is associated with IUGR and prematurity (84). IUGR is associated with distress and asphyxia and is the second cause of perinatal deaths (85, 86). Studies also documented that preterm babies are immature and more likely to be stillbirth, smaller, require an ICU and is a major cause of neonatal mortality (87, 88). Reduction in adverse perinatal outcomes among women might be achieved through provision of proper prenatal care for pregnant women to early diagnose placental insufficiency. The information is also important for health care providers to conduct different tests that detect placental insufficiency. It also highlights the importance of treating the underlying maternal conditions such as high blood pressure and anemia. It further signifies the importance of health education for pregnant women on various issues such as frequent visit and bed rest.

The study also documented that women in rural locations were more likely to experience adverse perinatal outcomes regardless of the near-miss status of the women. In agreement with other studies, the current study found that higher risk of adverse perinatal outcomes were observed among women residing in rural than urban areas (89, 90). Although the data we have

does not permit for a conclusion, one possible explanation for this finding might be the relationship between access to obstetric care and adverse perinatal outcomes. Studies shown that women residing in rural area with no access to obstetric care had to travel longer to get routine antenatal care, a barrier associated with adverse perinatal outcomes (91, 92). For instance, various studies reported that higher number of low birth weight babies were seen in women who had irregular ANC visits compared to women who had regular ANC checkups (93, 94). Lack of proper ANC might lead to undernourishment and less care during pregnancy which could have impact both for the mother and her baby. Rural women are also relatively disadvantaged in terms of their socio-economic status which could possibly increase their risk of adverse perinatal outcomes. For example, rural women tend to have a lower educational level and higher rate of poverty compared to urban women (95).

In this study, women who had prior stillbirth in preceding births were at higher risk of having adverse perinatal outcomes than women without a history of stillbirth. Available evidence suggests that women with stillbirth in their prior pregnancies were at higher risk of adverse perinatal outcomes in subsequent pregnancies (96-101).

Another independent risk factor for adverse perinatal outcomes was level of education. Women who had a primary level of education had a higher risk of having adverse perinatal outcomes than those with a higher level of education. Education enhances the health care seeking behavior of the women so that she can effectively utilize maternal health care services when complications happened (102). Education is also considered as a determinant of health (103). A growing body of literature has revealed that lower levels of maternal education were associated with an increased risk of variety of adverse perinatal outcomes (90, 99, 104-106).

6. Validity and Generalizability

To enhance the internal validity of the current study, we have tried to minimize the role of chance, bias and confounding which could be alternative explanations for the observed association between exposure and an outcome.

Chance may always affect the results observed simply because of random variation from sample to sample. Sample size is one of the major determinants of chance. Hence, the role of chance can be minimized by increasing the sample size. A much larger number of sample sizes than was required were included in the analysis of all the three objectives. Including more than the minimum sample size required has increased the power of the study. In order to see the effect of chance, we also determined the 95% CI as a measure of association between exposure and outcome variables. The confidence interval for most of the variables used in the current study was not wide enough suggesting adequacy of the sample size. Although there is a considerable variation in severity among the perinatal outcomes investigated in our study, we opt to merge these outcomes. This is due to the fact that the sample size was not sufficient to separately investigate the outcomes, thus merging increased the sample size and minimized the role of chance.

The relationship between exposure and outcome may also be impacted by the role of bias. Thus, potential sources of biases were also addressed in all of the three objectives. For instance, to minimize recall bias, we have taken incident rather than prevalent cases. In addition, cases and controls were interviewed when they became healthy near to their discharge time. The use of incident cases was also important to establish temporal sequence between exposure and outcome. To minimize bias related to measurements, the standardized WHO criteria were used to identify maternal near-miss cases. Controls and exposures were also explicitly defined in the method part of this dissertation. Furthermore, adequate training was given to data collectors to obtain data in the same fashion. There was also strict supervision by the principal investigator. Additionally, the questionnaires were pre-tested in the participating hospitals to verify the appropriateness of the tool. Local Amharic language was used during the interview process so that there were easy understanding between the data collectors and the participants. In order to avoid selection bias, matched analysis was done for the matched nested cases-control study (objective II). For objective III, there were no differential losses to follow-up both in exposed and non-exposed

groups. Thus, selection bias was not problematic for this objective. Furthermore, three controls were taken for each case which can minimize the chance for bias.

The role of confounding was also addressed both at the design and analysis stage. Logistic regression is one method for controlling confounding at the analysis stage. Another method of controlling the confound effect is to match on some of the confounders. In the current study, a lot of confounding variables were collected and a multivariable binary logistic regression analysis was used to control the effect of the confounder during analysis. In order to eliminate or control for the confounding effect at the design stage, matching was employed on some of the selected potential confounders such as age and study area.

Concerning generalization, the maternal near-miss women happened in the hospitals of the current study can represent women in the population. This is because most critical maternal cases are referred to referral hospitals to receive a better care. However, normal delivered women taken from the participating hospitals cannot represent women in the population, as majority women in Ethiopia deliver at home (not in a referral hospital) (107). The results of the current study can be generalized to public hospitals in Addis Ababa, beyond those hospitals included in the current study.

7. Strengths and limitations of the study

7.1. Strengths of the study

To our knowledge, this study is the first of its kind in Ethiopia to document the incidence, causes, factors and adverse perinatal outcomes of maternal near-miss using the newly developed WHO case identification criteria. Prospective identification of cases and controls were used for a consecutive period of one year. Identifying the participants prospectively enabled to avoid missing important confounding variables, which is a drawback of most previous country-level retrospective studies. The use of stronger research designs in the current study such as nested case-control and prospective cohort approaches had also the advantage of ascertaining cause-effect relationships than the cross-sectional studies. We also studied a variety of perinatal outcomes such as stillbirth, preterm birth, birth weight, birth asphyxia and admission to neonatal ICU. Additionally, we collected information on a lot of confounding variables for objectives II and III. There was also no loss to follow-up for objective III.

7.2. Limitations of the study

The current study had certain limitations. The follow-up time used by the WHO to define maternal near-miss has duration of 42 days postpartum. However, because of logistic and feasibility concerns, our follow-up time was limited to only the length of the hospital stay. This might have caused us to underestimate the magnitude of maternal near-miss and hindered us not to investigate the occurrence of other events such as maternal deaths occurred after maternal discharge. The study also failed to abstract all maternal near-miss indicators such as the interventions provided for maternal near-miss women, which are important components of quality of care. Poor perinatal outcomes in objective III could be related to poor quality of care around childbirth (108). However, the study did not explore quality of care domains. The study did not also look for some of the important perinatal outcomes such as neonatal mortality among maternal near-miss cases because of feasibility concerns. Although the five minutes Apgar score is more sensitive indicator of birth asphyxia, we have considered the one minute Apgar score in our study. The short and long term maternal consequences of near-miss events were not also addressed in the current study. The other limitation of the study was that the study was carried out only in public health facilities. Hence, it does not represent cases of maternal near-miss that occur in private health facilities. The interviewers were not also blind to the exposure status of

the women and there may be possibility of measurement bias. The other limitation of the study is that it was difficult to identify the causes of maternal near-miss if the women had more than one near-miss conditions.

8. Conclusions

During the one-year period of the study, the incidence of maternal near-miss was 8.01 per 1000 live births (95% CI; 7.06 – 9.09) in all participating hospitals. The majority of maternal near-miss cases have already occurred on the women's arrival at the participating hospitals. The underlying causes of the majority of maternal near-miss cases were hypertensive disorders and obstetric hemorrhage. Pregnancy-related infection was the least mentioned cause of maternal near-miss. Anemia was the major contributing cause reported for maternal near-miss. Major organ dysfunctions seen were Coagulation/Hematological followed by Neurologic. Hepatic dysfunction was the least reported organ dysfunction in women with maternal near-miss.

The study identified that history of chronic hypertension, rural residence, prior stillbirth, no antenatal care attendance and presence of prior anemia were the factors independently associated with the occurrence of maternal near-miss. The study also shown that, women with maternal near-miss complications during pregnancy and delivery were more likely to have adverse perinatal outcomes such as stillbirth, preterm birth, low birth weight infant, birth asphyxia and admission to neonatal ICU than normal delivered women. Rural residence, history of prior stillbirth and primary educational level were the other risk factors that were independently associated with adverse perinatal outcomes.

9. Recommendations

For Policy makers

Policy makers need to design and implement evidence-based interventions to optimize the intra-partum management of life-threatening obstetric complications which could reduce the occurrence of maternal near-miss problems occurring during hospitalization. The study showed that the majority of the near-miss cases happened before the women's arrival at the participating hospitals, which underscores the importance of understanding and eliminating the pre-hospital barriers. Strengthening the available health care system in rural part of the country with focus on maternity services is also a crucial step to avert serious maternal complications. Scaling up of antenatal care in rural areas might have also a role to reduce obstetric risks among pregnant women. An effort to improve in infrastructure could also enhance referral chain from primary level to secondary and tertiary facility level. Interventions aimed at improving better access to medical care for pregnant women with a history of pre-existing medical conditions such as chronic hypertension have a paramount importance. The study also demonstrated that women with maternal near-miss complications during pregnancy and delivery were more likely to have an adverse perinatal outcome. Hence, this suggests that evidence-based interventions rendered at improvements in maternal health can lead to an improvement in perinatal outcome.

For Health Practitioners

Implementations of evidence-based interventions could be used to optimize the intra-partum management of life-threatening obstetric complications. Health care professionals need to carefully plan and manage women with prior medical conditions specifically chronic hypertensions and anemia. In addition, there is a need for counseling a pregnant woman about the risk of chronic hypertensions during routine antenatal care visits. Additionally, education of women on the importance of nutrition during pregnancy and supplementation of iron for pregnant women during ANC visits are important steps to avert critical morbidity experiences related to anemia. Provision of proper antenatal care for pregnant women is important in order to early diagnose placental insufficiency, which may lead to adverse perinatal outcomes.

For Researchers

As majority of the near-misses happened before the women's arrival at the participating hospitals, exploration of these pre-hospital barriers that hindered the women from accessing the health facilities need to be studied preferably using the qualitative approach. Evaluating the underlying causes of anemia among pregnant women who developed maternal near-miss is also mandatory for appropriate action. This study did not look for the short and long term maternal consequences of near-miss events. Hence, this calls for the importance of other big prospective studies to look for these outcomes among maternal near-miss cases. As the current study was limited to public health facilities, future researches conducted at private facilities as well could help to visualize the pattern of maternal near-miss occurring in private facilities. The study failed to explore all maternal near-miss indicators such as the interventions provided for maternal near-miss women, which are important components of quality of care. Hence, we recommend further studies to better understand challenges to quality of care for women and their newborns. In order to study maternal near-miss, a better approach, which is audit by experts or panel committee is also recommended. We also recommend studies to use a five minutes Apgar score for measurement of birth asphyxia.

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12. Appendices

Annex 1: WHO maternal near-miss criteria

Table 10 Identification criteria of maternal near-miss used by the WHO

Dysfunctional system	Clinical criteria	Laboratory markers	Management based proxies
Cardiovascular	shock Cardiac arrest	severe hypo perfusion (lactate >5 m mol/l or >45 mg/dl) severe acidosis (pH <7.1)	Use of continuous vasoactive drugs Cardio pulmonary resuscitation
Respiratory	Acute cyanosis Gasping severe tachypnea (respiratory rate >40 breaths per minute) severe bradypnea (respiratory rate <6 breaths per minute)	severe hypoxemia (O2 saturation <90% for ≥60 minutes or PAO2/FiO2 <200)	Intubation and ventilation not related to anesthesia
Renal	Oliguria non-responsive to fluids or diuretics	severe acute azotemia (creatinine ≥300 µmol/ml or ≥3.5 mg/dl)	dialysis for acute renal failure
Coagulation/hematological	Failure to form clots	severe acute thrombocytopenia (<50 000 platelets/ml)	massive transfusion of blood or red cells (≥5 units)
Hepatic	Jaundice in the presence of pre-eclampsia	severe acute hyperbilirubinemia (bilirubin >100 µmol/l or >6.0 mg/dl)	
Neurological	Prolonged unconsciousness (lasting ≥12 hours)/coma (including metabolic coma), stroke, uncontrollable fits/status epileptics, total paralysis		
Uterine			Uterine hemorrhage or infection leading to hysterectomy

Annex 2: Participant Information Sheet and Consent form English version

Participant information sheet

Title of the project: "Incidence, causes, factors and adverse perinatal outcome of maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia"

Principal Investigator: Ewnetu Firdawek

Supervisors: Prof. Alemayehu Worku ,Prof.Misganaw Fantahun and prof. Birgitta Essén

Coordinating Office: Addis Ababa University, School of Public Health

Introduction: Research related to maternal near-miss is crucial to evaluate and improve quality of obstetric care.

Purpose: The purpose of this study was to assess the incidence, causes, factors and adverse perinatal outcomes of maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia. It is a PhD dissertation conducted for partial fulfillment of Doctor of Philosophy in Public Health at Addis Ababa University.

Procedure and Participation: All women that face maternal near-miss complications as well as those who delivered vaginally without any complications along with their singleton new born babies will be enrolled in this study. We hope the information that you provide will have a paramount importance to bring about quality of care in maternal health. We will ask you questions pertaining to your socio-economic and demographic characteristics, RH and obstetric history, the presence of pre-existing medical conditions, and your nutritional status. The interview will not take more than 30 minutes. We also abstract some of the important information from your medical record.

Confidentiality: All the information that you provide will be kept confidential. We will not write your name in the questionnaire, instead we will use codes. All the information that you provide will not be disclosed to any one individually. It is only the PI that will have access to the data you provide until analyzed.

Benefit: You will not get a direct or immediate benefit from the current research, but in the long run the findings might be used by the policy makers to bring about quality of obstetric care.

Risk: The current research does not bring any physical harm, social discrimination and psychological pain to the participants**.**

Inducement, incentive and Compensation: There is no inducement, incentives or compensations that is given for you while you participate in this study. But we will be much grateful for your participation.

Results Dissemination: The result of the study will be disseminated through publication in scientific journals. In addition, it will also be communicated to the policy makers and other responsible partners working on maternal health through different workshops and conferences.

Right to Refuse or withdraw: You have the full right not to participate or withdraw from the study any time. You have also the right not to answer some of the questions that you do not need to respond. In doing so, you will not be discriminated from any type of care that you might get from this hospital.

Person to Contact: If you have any questions that is not clear about the research you can contact the principal investigator of this research, Ewnetu Firdawek, with cell phone number of 0911 815694. You can also contact the primary supervisor of the research, prof. Alemayehu Worku with cell phone number of +251911 40 56 52.

Informed Consent agreement form (verbal)

I have read/heard when read the information sheet in the language I understand and decided to participate in this study. I am well aware of the general purpose, confidentiality issues, benefits, risks and procedures of the study to the level of my understanding.

Participant code _____

Agreed to participate in the study? 1. Yes 2. No (mark one of them)

If yes continue the interview and data abstraction, if no thank the participant and go to the next respondent.

Data collector

Name ---------- Data-------/-------/---------- sign---------

Supervisor

Name ---------- Data-------/-------/---------- sign---------

Annex 3 Participant Information Sheet and Consent form Amharic version
የምርምር /ጥናት ማብራሪያና የስምምነት መግለጫ ቅጽ በአማርኛ

ሀ/የምርምር /ጥናት ማብራሪያ ቅጽ

የምርምር ፕሮጀክቱ ርዕስ፡ከእርግዝና እና ወሊድ ጋር በተያያዘ በጠና የታመሙ እናቶች እንዲሁም ያለምንም ችግር በወለዱ ሴቶች ላይ በተመረጡ የአዲስ አበባ ሆስፒታሎች የሚካሄድ የዳሰሳ ጥናት

የዋናተመራማሪዉሥም፡እውነቱ ፍርድአወቅ

ተቆጣጣሪዎች፡ፕሮፌሰር አለማየሁ ወርቁ፤ፕሮፌሰር ምስጋናው ፋንታሁን እና ፕሮፌሰር ቢርጊታ ኢስን

አስተባባሪቢሮ፡አዲስ አበባ ዩኒቨርስቲ፤የህብረተሰብ ጤና ት/ት ክፍል

መግቢያ፡በኢትዮጵያ የእናቶች ሞት ቁጥር ከፍተኛውን ደረጃ ይይዛል፡፡ስለዚህ ይህንን ቁጥር ለመቀነስ እንዲሁም በእናቶች ላይ የሚሰጠውን አገልግሎት ለማሻሻል ስለ ዋና ዋና መንስኤዎችና ተያያዥ ጉዳዮች ማጥናት ትክክለኛ ፖሊሲ ለመቅረጽ አስፈላጊ ነው፡፡

የምርምር ፕሮጀክቱ ዓላማ ፡የምርምሩ ዓላማ ከእርግዝና እና ወሊድ ጋር በተያያዘ በጠና የታመሙ እናቶች ብዛት፤መንስኤ እና በሚወልዱት ልጅ ላይ ስለሚያጋጥም ችግር ይሆናል፡፡ ያለ ምንም ችግር የወለዱ እናቶችንም ጠይቀን በወለዱት ልጅ ላይ ያጋጠመ ችግር ካለ ለማወዳደር የጠቅመናል፡፡ጥናቱም የሚካሄደው በአዲስ አበባ ዩኒቨርስቲ የፍልስፍና ዶክትሬት ዲግሪ በህብረተሰብ ጤና አጠባበቅ ለመመረቅ እንደ አንድማሙዋያ ይጠቅማል፡፡

የአሰራር ሂደት፡ በዚህ ሆስፒታል ውስጥ ከወሊድ እና እርግዝና ጋር በተያያዘ በጠና የታመሙ እናቶች በሙሉ በጥናቱ ይሳተፋሉ፡፡ከዚህም ባሻገር የተመረጡ ያለችግር የወለዱ እናቶችም በጥናቱ የሚካተቱ ይሆናል፡፡ የምትሰጡን መረጃዎች በእናቶች ላይ የሚሰጡ የጤና አገልግሎቶችን ያሻሽላል የሚል እምነት አለን፡፡ ከምንጠይቆት ጥያቄዎች መካከል የእርሶን የማህበራዊና ኢኮኖሚያዊ መረጃ፤ ስለ ስነ ተዋልዶ እና ተያያዥ ጉዳዮች ስላሉ ታሪኮችሽ፤ ፤ በፊት ስለነበሩ አጠቃላይ የጤና ችግሮች፤ እና ከምግብ ማነስ እንዲሁም መብዛት ጋር ተያይዘዉ ስለሚከሰቱ ችግሮች ይሆናል፡፡አጠቃላይ ጥያቄዎቹ ከ 30 ደቂቃ በላይ አይወስዱም፡፡አንዳንድ አስፈላጊ መረጃዎችንም ከ ካርዶት ላይ የምንወስድ ይሆናል፡፡

ሚስጥር ስለ መጠበቅ፡ ከዚህ ጥናት የሚገኝ መረጃ በሙሉ በሚስጥራዊነት ይጠበቃል፡፡ለዚህ ጥናት የሚሰበሰበው ዕርስዎን የሚመለከት መረጃ ላይ ስምዎ ሳይሆን በተለየ ኮድ የሚቀመጥ ሲሆን ኮዱ ከዋና ተመራማሪዎች ውጭ ለማንም አይገለጽም፡፡

ጥቅማ ጥቅም፡ በዚህ ጥናት በመሳተፍዎ የተለየ ጥቅም አያገኙም፡፡ነገር ግን የዕርስዎ በጥናቱ መሳተፍ ለፖሊሲ አውጪዎች በእናቶች ላይ የሚሰጡ የጤና አገልግሎቶችን እንዲያሻሽሉ እንደግብአት የሚያገለግል ይሆናል፡፡

ሊከሰቱ የሚችሉ ስጋቶችና ምቾት መጓደሎች፡ በዚህ ጥናት መሳተፍዎ ምንም አይነት የአካል፤ሳይኮሎጂካል ወይም ከማህበራዊ ህይወት መገለልን የሚያስከትል አይደለም፡፡

ማካካሻ፡በዚህ ጥናት በመሳተፍዎ ምንም ዓይነት ማካካሻ አይሰጥዎትም፡፡ነገር ግን በጥናቱ በመሳተፍዎ ምስጋናችን ከፍተኛነው፡፡

የጥናቱን ዉጤት ስለመግለጽ፡ የጥናቱ አጠቃላይ ግኝት በአለም አቀፍ ደረጃ በሚታተሙ የምርምር መጽሄቶች ላይ የሚታተም ይሆናል፡፡ ከዚህም ባሻገር ለፖሊሲ አውጪዎች እንዲሁም ከእናቶች ጤንነት ጋር በተያያዘ ለሚሰሩ ድርጅቶች በሙሉ የጥናቱ ዉጤት በተለያዩ ስብሰባዎች ላይ የሚገለጽላቸው ይሆናል፡፡

በጥናቱ ያለመሳተፍ ወይም ራስን ከጥናቱ የማግለል መብት፡ በጥናቱ ላይ ላለመሳተፍ ከፈለጉ በዚህ ጥናት አለመሳተፍ ወይም በከፊልም ሆነ በሙሉ ጥያቄዎችን አለመመለስ ይችላሉ፡፡ በዚህ ጥናት ባለመሳተፍዎ ወይም በከፊልም ሆነ በሙሉ ጥያቄዎችን ባለመመለስዎ ከሆስፒታሉ የሚያገኙትን የአገልግሎት መብት አይከለከሉም፡፡

ስለ ጥናቱ መረጃ ሲፈልጉ የሚያገኟቸ ውሰዎች፡ ከጥናቱ ጋር በተያያዘ ማንኛዉም ጥያቄ ካለዎት የጥናቱን ዋና ተመራማሪ የሆኑትን አቶ እዉነቱ ፍርድአወቅ በስልክ ቁጥር 0911815694 ማግኘት ይችላሉ፡፡

ለ/የምርምር /ጥናት የስምምነት መግለጫ ቅጽ/የቃል

የጥናቱን ማብራሪያ በሚገባኝ ቁዋንቁአ ሲነበብልኝ የተረዳሁት ስለሆለ በጥናቱ ለመሳተፍ ሙሉ ፍቃደኛ ነኝ፡፡ስለ አጠቃላይ የጥናቱ አላማ፤ ሚስጥር አጠባበቅን በተመለከተ፤ጥቅም እና ጉዳቱ፤እንዲሁም የአሰራር ሂደቱን በደንብ ለመገንዘብ ችያለሁ፡፡

የተሳታፊው ኮድ፤----------

በጥናቱ ለመሳተፍ ፍቃደኛ ኖት

1. አዎ ----------መልሱ አዎ ከሆነ ወደሚቀጥለው ጥያቄ እለፍ/ፊ/
2. የለም ---------- መልሱ የለም ከሆነ አመስግነህ/ሽ/ ጥያቄውን አቋርጥ /ጭ/

ፈቃደኝነት ያረጋገጠው መረጀ ሰብሳቢ

ስም---------- መጠይቁ የተደረገበት ቀን--------/--------/------ፊረማ --------

በተቆጣጣሪው ስለ መረጋገጡ ስም ----------ቀን -------/------/----ፊርማ -------

Annex 4 Study instruments /Quantitative English questionnaires

This form is filled for 1. Near miss women 2. Normal delivered women

Part I. Reporting health facility information and identification of the participant (to be filled from record of the patient and if incomplete ask the patient)			
NO	**Questions**	**Response**	**Skip**
101	Name of health facility		
102	Facility code		
103	Participant Card number		
104	Participant Wereda name		
105	Participant Kebele name		
106	Participant telephone number/cell phone and home/	Cell phone---------- Home----------	
107	Date form filled /DD/MM/YYYY/E.C		
108	Name and sign of data collector	Name ---------- Sign ----------	
109	Date of hospital admission/DD/MM/YYYY/E.C		
110	Admission mode	1. Self-referred 2. Referred from other health facility	If 1 go to Q114
111	If referred name of referring facility		
112	Date of arrival at referring facility/DD/MM/YYYY/E.C		
113	Date of departure from referring facility/DD/MM/YYYY/E.C		
114	Means of transport used	1. Ambulance 2. Public transport 3. Personal vehicle 99. Other specify ---------	
115	This form is filled for	1. Near miss women 2. Normal women	If 2 go to part

			5
116	When did near miss occur?	1. Before arrival at facility 2. During hospitalization	

Part II. Maternal near miss criteria/organ dysfunction criteria/tick on the appropriate

Dysfunctional system	**Clinical criteria**	**Laboratory markers**	**Management based proxies**
Cardiovascular	☐ shock(persistent systolic BP<80mmhg) ☐ Cardiac arrest	☐ severe hypoperfusion (lactate >5 mmol/l or >45 mg/dl) ☐ severe aci-dosis (pH <7.1)	☐ Use of continuous vasoactive drugs ☐ Cardio pulmonary resuscitation
Respiratory	☐ Acute cyanosis ☐ Gasping ☐ severe tachypnea (respiratory rate >40 breaths per minute) ☐ severe bradypnea (respiratory rate <6 breaths per minute)	☐ severe hypoxemia (O2 saturation <90% for ≥60 minutes or PAO2/FiO2 <200)	☐ intubation and ventilation not related to anesthesia
Renal	☐ Oliguria non-responsive to fluids or diuretics	☐ severe acute azotemia (creatinine ≥300 µmol/ml or ≥3.5 mg/dl)	☐ dialysis for acute renal failure

Coagulation/hematological	☐ Failure to form clots(DIC)	☐ severe acute thrombocytopenia (<50 000 platelets/ml)	☐ massive transfusion of blood or red cells (≥5 units)
Hepatic	☐ Jaundice in the presence of pre-eclampsia	☐ severe acute hyperbilirubinemia (bilirubin >100 µmol/l or >6.0 mg/dl)	
Neurological	☐ Prolonged unconsciousness (lasting ≥12 hours)/coma (including metabolic coma) ☐ stroke ☐ uncontrollable fits/status epilepticus ☐ total paralysis		
Uterine			☐ Uterine hemorrhage or infection leading to hysterectomy
Part III. Direct causes of maternal near miss/ to be filled from medical record of patient			

with near-miss			
301	Please tick on the appropriate	☐ Obstetric hemorrhage ☐ Hypertensive disorders/Eclampsia or pre eclampsia/ ☐ Pregnancy with abortive outcome/ abortion or ectopic pregnancy ☐ Pregnancy-related infection ☐ Other obstetric disease or complication---------- ☐ Unknown	
Part IV. Indirect causes of maternal near miss/recorded from medical card or ask patient			
401	Please tick on the appropriate	☐ Anemia ☐ Malaria ☐ HIV ☐ TB ☐ Obstructed/prolonged labor ☐ Previous caesarean section ☐ No indirect cause ☐ Others specify-----	

Part V. Maternal socio-economic and demographic characteristics (to be filled for mothers with near-miss and selected mothers who delivered without complications)			
No	**Questions**	**Responses**	**Skip**
501.	Age in year	----------full years	
502.	Highest educational level	1. Illiterate 2. Only read and write 3. Elementary school(1-6) 4. Seconder/high school completed 5. University/college and above 99. Other specify ------	
503.	Ethnicity	1. Amhara 2. Oromo 3. Gurage 4. Tigre 99. other specify------	
504.	Place of residence	1. Urban 2. Rural	
505.	Religion	1. Christian orthodox 2. Protestant 3. Muslim 4. Catholic 99. Other specify ----------	
506.	Marital status	1. Married 2. Divorced 3. widowed 4. not married 5. separated	
507.	Women's Occupation	1. House wife 2. Government employee	

		3. NGO employee 4. Merchant 5. Student 6. Daily laborer 99. Other specify ----------	
508.	Partners occupation	1. Government employee 2. NGO employee 3. Merchant 4. Daily laborer 99. Other specify----------	
509.	House hold monthly income	----------Ethiopian birr	
	Part VI. RH and obstetric characteristics		
601.	Did you receive ANC during your current pregnancy?	1. Yes 2. No---------Go to Q605	If 2 go to Q 605
602.	If yes place ANC received?	1. In this hospital(study site) 2. Outside study area	
603.	Number of ANC visit?	1. One 2. Two 3. Three 4. Four and above	
604.	Trimester of pregnancy during ANC for last pregnancy?	1. First 2. Second 3. Third 88. Don't know/remember	
605.	Number of living children (today)	----------	
606.	Number of children died (born alive)	----------	
607.	Number of previous total pregnancies	----------	
608.	Do you have a history of still birth?(>28 weeks)	1. Yes 2. No	If 2 go to Q

			610
609.	If yes number of previous still births	----------	
610.	Do you have a history of abortion? (< 28 weeks)	1. Yes 2. No	If 2 go to Q 612
611.	If yes number of previous abortions	----------	
612.	Do you have history of previous caesarean section?	1. Yes 2. No	If 2 go to Q 614
613.	If yes number of previous C/S	----------	
614.	Have you ever undergone FGM?	1. Yes 2. No	
615.	Was there early marriage (before 18 years)?	1. Yes 2. No	
616.	Last Menstrual Period (DD/MM/YYYY)	----------	
617.	Calculated Expected Date of Delivery (DD/MM/YYYY)	----------	
618.	Actual Date of Delivery (DD/MM/YYYY)		
619.	Number of month between end of last pregnancy (delivery or termination) and the current delivery	----------months.	
620.	Current pregnancy (single Vs twin)	1. Single 2. Twin	
621.	At what trimester is she now?	1. One 2. Two	

		3. Three	
622.	Have you taken TT vaccine during pregnancy?	1. Yes 2. No	If 2 go to Q 624
623.	If yes, how many times have you received such injections?	1. Once 2. Two or more	
624.	Intended/actual place of delivery	1. Hospital (study area) 2. Hospital (other than study site) 3. Health center 4. Home 99. other specify----------	
	Part VII. Access to RH services		
	Delay one		
701.	Who is responsible for decision that you should come to the hospital?	1. Self 2. Husband 3. Relatives 4. Friends 99. Other specify ----------	
702.	Was there any delay in making decision to come to hospital?	1. Yes 2. No	If 2 go to Q 704
703.	If yes what was the reason?	1. Underestimated severity of condition. 2. Failure to recognize the problem 3. Bad experience with health system 4. Lack of decision to go to health facility 5. Traditional practices 6. Believed that God was in control	

		99. Others Specify----------	
	Delay 2		
704.	Once you decide to go to hospital did you go straight away?	1. Yes 2. No	If 1 go to Q 706
705.	If no why?	1. Lack of transport 2. lack of money for transport 3. bad road condition 4. no facility within reasonable distance	
706.	Time it takes to reach here?	----------minutes	
707.	How long it takes you reach here?	----------days	
	Delay 3		
708.	Once you reach to the hospital, how long you wait before seen by health professionals?	----------minutes	
709.	Type of problem you face in hospital?	1. Delay in making correct diagnosis 2. No assessment by senior health professionals 3. Lack of supply and equipment 4. Poor monitoring of patient 5. No problem faced	
	Part VIII. Pre-existing medical conditions-before current pregnancy		
801.	Have you had chronic hypertension?	1. Yes 2. No	
802.	Have you had anemia?	1. Yes 2. No	

803.	Have you had HIV?	1. Yes 2. No	
804.	Have you had maternal cardiac disease?	1. Yes 2. No	
805.	Have you had diabetes?	1. Yes 2. No	
806.	Any other health problem specify	----------	
	Part IX. Nutritional status/to be measured by data collector/		
901.	Patients height (m)	----------meter	
902.	Weight at admission (kg)	----------kg	
903.	BMI?	----------	

Perinatal outcomes (to be filled from participant's record)

NB. To be filled from medical record of a women who is in her third trimester (≥ 28 weeks), and for a women who delivered in the participating hospital.

Part X. Perinatal outcomes (should be followed until discharge) / for singleton deliveries			
No	**Questions**	**Response**	**Skip**
1000.	The women is at	1. ≥ 28weeks of gestation and delivered in hospital 2. <28 weeks of gestation or delivered outside study area	If 2 go to Q 1100
1001.	Outcome of current pregnancy	1. Alive at birth 2. Still birth 3. Died at hospital discharge or on 7th day of life in hospital 4. Congenital abnormality 99. other specify----------	

1002.	Gestational age in completed weeks at delivery or abortion	----------weeks	
1003.	Birth weight (g)	----------gram	
1004.	APGAR score at 1st minute	----------	
1005.	APGAR score at 5 minutes	----------	
1006.	APGAR score at 10 minutes	----------	
1007.	Is there any neonatal complications?	1. Yes 2. No	If 2 go to Q 1009
1008.	If yes specify	----------	
1009.	Is there any birth trauma?	1. Yes 2. No	If 2 go to Q 1011
1010.	If yes Specify	----------	
1011.	Baby admitted to special care or ICU?	1. Yes 2. No	If 2 go to Q 1013
1012.	If yes number of days stayed in ICU?	----------days	
1013.	Baby referred to another facility?	1. Yes 2. No	
1014.	Vital status at discharge	1. Alive 2. Dead in the first 24 hours 3. Dead after 24 hours 4. Dead (timing not specified) 88. unknown	
1015.	If dead cause of death	----------	
1016.	Date of discharge, referral or death of the baby	DD/MM/YYYY/E.C --------/----------/---------	

Part XI. Maternal outcomes /filled from medical record of the participants/			
S.n	**Questions**	**Response**	**skip**
1100.	Date of hospital admission of the women	--------/--------/-------- DD / MM /YYYY/	
1101.	Time of hospital admission of women	---------/---------- Hour/ minute	
1102.	Date of delivery or end of pregnancy	---------/----------/---------- DD/ MM/ YYYY	
1103.	Final mode of delivery/end of pregnancy?	1. vaginal delivery 2. caesarian section 3. Instrumental - vacuum/forceps 4. Complete abortion 5. Destructive 88. Other/unknown	
1104.	Vital status of women at discharge?	1. Alive 2. Dead	If 2 go to Q1109
1105.	Date of discharge	---------/----------/-------- DD/MM/YYYY.E.C	
1106.	Time of hospital discharge of women	----------/---------- Hour/ minute	
1107.	Mode of exit?	1. Normal discharge 2. Left against medical advice 3. Referred to other hospital 4. Escaped	If 3 go to Q1111
1108.	Total duration of hospital stay	--------days	
1109.	If dead, date of death of the women	----------/----------/---------- DD/MM/YYYY/E.C	
1110.	If dead time of death	1. Dead on arrival 2. Dead between arrival and admission	

		3. Dead in the first 24 hours 4. Dead after 24 hours	
1111.	If referred referral facility name		
1112.	Reason for referral		

Annex 5: Quantitative Amharic questionnaire for part five only

ክፍል አምስት፤የተጠያቂው አጠቃላይ የማህበራዊና ኢኮኖሚያዊ መረጃ በተመለከተ (በመጠየቅ የሚሞላ)			
ተ.ቁ	**ጥያቄ**	**መልስ**	**እለፍ**
501.	አሁን ዕድሜዎ ስንት ነው ?	----------ሙሉ ዓመት	
502.	የትምህርት ደረጃ	1. ያልተማረ 2.ማንበብና መፃፍ ብቻ 3. አንደኛ ደረጃ(ነ-6) 4.ሁለተኛ ደረጃ ትምህርት ያጠናቀቀ 5. ከፍተኛ ትምህርት /ኮሌጅ/ዩኒቨርስቲ 99. ሌላ ይገለጽ----	
503.	ብሔረሰብ /ጎሣ/	1. አማራ 2. አሮሞ 3. ጉራጌ 4. ትግሬ 99.ሌላ ይገለጽ----------	
504.	የመኖሪያ ቦታ	1. ከተማ 2. ገጠር	
505.	ሃይማኖትዎ ምንድነው?	1. አርቶዶክስ 2. ጴንጤ 3. እስልምና 4. ካቶሊክ 99. ሌላይገለጽ----------	
506.	የጋብቻ ሁኔታ	1. ያገባች 2. የተፋታች 3. ባልየሞተባት 4. ያላገባች 5. ተለያይተው የሚኖሩ	
507.	ሥራ	1. የቤት እመቤት 2. የመንግስት ሰራተኛ	

		3. የ NGO ሰራተኛ 4. ነጋዴ 5. ተማሪ 6. የቀን ሰራተኛ 99. ሌላ ይገለፅ ----------	
508.	የባለቤቶ ስራ(ያገቡ ከሆነ)	1. የመንግስት ሰራተኛ 2. የ NGO ሰራተኛ 3. ነጋዴ 4. የቀን ሰራተኛ 99. ሌላ ይገለፅ ----------	
509.	በአማካኝ የቤተሰብ ገቢ በወር	----------ብር	
ክፍል ስድስት፤ስለ ስነ ተዋልዶ እና ተያያዥ ጉዳዮች ስላሉ ታሪኮች			
601.	ለአሁኑ እርግዝና ለነፍሰ ጡር ምርመራ(ANC)ክትትል ወደ ጤና ድርጅት ይከታተሉ ነበር ?	1. አዎ 2. የለም	2 ከሆነ ወደጥ.ቁ 605 እለፍ
602.	ለነፍሰ ጡር ጤና ክትትል የሄዱ ከሆነ ከየትኛው የጤና ድርጅት ነው ሲከታተሉ የነበረው?	1. በዚህ ሆስፒታል/ጥናቱ በሚካሄድበት 2. በሌላ ጤና ድርጅት	
603.	ለነፍሰ ጡር ጤና ክትትል የሄዱ ከሆነ በአጠቃላይ ስንት ጊዜ ሄደው ነበር?	1. አንድ ግዜ 2. ሁለት ግዜ 3. ሶስት ግዜ 4. ከአራት ጊዜ በላይ	
604.	የነፍሰ ጡር ምርመራ የሚከታተሉ /አዎ/ ከሆነ መልሱ በመጀመሪያ ወደ ጤና ድርጅት የሄዱት በስንተኛው ወር ነበር?	----------ወር ሲሆነኝ 88. አላውቅም/አላስታዉስም	
605.	በህይወት ያሉ ልጆች ብዛት(ያሁኑን ጨምሮ)	----------	
606.	የሞተ ልጅ ካለ ብዛት(በህይወትተወልደው)	----------	
607.	የእርግዝና ቁጥር (Number of previous total pregnancies)?	----------	

608.	ከዚህ በፊት ሞተው የተወለዱ ልጆች አሉሽ (Do you have a history of still birth? (≥28 weeks)	1. አዎ 2. የለም	2 ከሆነ ወደጥያቄ ቁጥር 610 አለፍ
609.	አዎ ከሆነ ሞተው የተወለዱ ብዛት/ቁጥር?	----------	
610.	ከዚህ በፊት የውርጃ ታሪክ አለሽ(Do you have a history of abortion? (< 28 weeks)	1. አዎ 2. የለም	2 ከሆነ ወደ ጥያቄ ቁጥር 612 አለፍ
611.	አዎ ከሆነ የውርጃብዛት?	----------	
612.	ከዚህ በፊት በኦፐራሲዮን/CS/ወልደሽ ታውቂያለሽ?	1. አዎ 2. የለም	2 ከሆነ ወደ ጥያቄ ቁጥር 614 አለፍ
613.	አዎ ከሆነ ምን ያህል ልጅ በኦፐራሲዮን ወልደሻል?	----------	
614.	ተገርዘሻል (Have you ever undergone FGM?)	1. አዎ 2. የለም	
615.	ያለ እድሜሽ ነበር ያገባሽው(ከ18 አመት በታች)?	1. አዎ 2. የለም	
616.	Last Menstrual Period (DD/MM/YYYY)E.C	**----------/----------/----------**	
617.	Calculated Expected Date of Delivery (D/M/Y)E.C	----------	
618.	Actual Date of Delivery/end of pregnancy (D/M/Y)E.C		
619.	በበፊት ልጅሽ /abortion/ ና (የመጨረሻው) በአሁኑ እርግዝና መካከል ምን ያክል የወር ልዩነት አለ?	----------ወር የመጀመሪያዋ ከሆነ ይገለጽ----------	
620.	የአሁኑ እርግዝና መንታ ነው ወይስ አንድ?	1. አንድ 2. መንታ	
621.	የአሁኑ እርግዝና ስንተኛ ሳምንት ወይም ወሩ ነው?	----------ሳምንት ወይም ----------ወር	
622.	በእርግዝና ጊዜ የመንጋጋ ቆልፍ ክትባት(TT) ተከትበሽ ነበር?	1. አዎ 2. የለም	2 ከሆነ ወደ ጥያቄ ቁ 701 አለፍ
623.	አዎ ከሆነ መልስሽ ስንት ግዜ ተከትበሻል?	1. አንዴ 2. ሁለት እና ከዛ በላይ	
ከፍልሰባት፤የስነተዋልዶአገልግሎቶችተደራሽነት			

701.	ሆስፒታል /ጤና ተቐም /መምጣት እንዳለብሽ ከቤት ውስጥ ውሳኔ ሰጪው ማነው?	1. እኔዉ እራሴ 2. ባለቤቴ 3. ዘመድ 4. ጉአደኞቼ 99. ሌላይገለፅ ----------	
702.	ወደ ሆስፒታል መምጣት እንዳለብሽ ዉሳኔ ላይ ዘግይተሽ ነበር?	1. አዎ 2. የለም	2 ከሆነ ወደ ጥያቄ ቁጥር 704 እለፍ
703.	አዎ ከሆነ ምክንያቱ ምን ነበር ? (ምርጫዎቹ አይነበቡም)?	1. የጸና ችግር ይገጥመኛል ብዬ ስላላሰብኩ 2. ችግሩን መረዳት ስላልቻልኩ 3. በጤና ተቁአም ላይ ያለኝ ልምድ ጥሩ ስላልሆነ 4. ወደ ጤና ተቁአም የመምጣት ዉሳኔው የኔ ስላልሆነ 5. ባህሉ ስለማይፈቅድ/በባህላዊ መንገድ መውለድ ስለምፈልግ 6. ፈጣሪ ይጠብቀኛል ብዬ ስለማስብ 99. ሌላ ይገለፅ ----------	
704.	ወደ ሆስፒታል መሄድ እንዳለብሽ ከወሰንሽ በሃላ ወዲያዉ ነው የሄድሽው?	1. አዎ 2. የለም	1 ከሆነ ወደ ጥያቄ ቁጥር 706 እለፍ
705.	የለም ከሆነ ምክንያትሽ ምን ነበር?(ምርጫዎቹ አይነበቡም)?	1. የትራንስፖርት ችግር ስለነበረ 2. የትራንስፖርት ገንዘብ ስላልነበረኝ 3. መንገዱ በጣም አስቸጋሪ ስለነበረ 4. በቅርብ ርቀት ጤና ተቁአም ስላልነበረ 99. ሌላ ይገለፅ ----------	
706.	አዚህ ሆስፒታል ለመድረስ በአጠቃላይ ከቤትሽ ምን የህል ደቂቃ ይወስዳል?	---------- ሰአት ከ---------ደቂቃ	

707.	ሆስፒታል ከደረስሽ ቦሃላ በባለሙያ ለመታየት ምን ያህል ደቂቃ ፈጀብሽ?	----------ሰአት ከ----------ደቂቃ	
708.	ሆስፒታል ላይ የገጠመሽ ችግር ምን አይነት ነዉ? ((ምርጫዎቹ አይነበቡም ፣የመለሰችው ሁሉም ላይ ይከበብ)	1. ትክክለኛውን ምርመራ ለማድረግ መዘግት 2. ልምድ ባለው ባለሙያ አለመታየት 3. አስፈላጊ የሆኑ የሆስፒታ ልእቃዎች አለመሙአላት 4. ደካማ የሆነ ክትትል 5. ምንም ችግር አልገጠመኝም 99. ሌላ ይገለፅ ----------	
ክፍል ሰምንት፤በፊት ስለነበሩ አጠቃላይ የጤና ችግሮች/ከአሁኑ እርግዝና በፊት/			
801.	የደም ግፊት (hypertension) ነበረብሽ?	1. አዎ 2. የለም	
802.	ደም ማነስ (anemia) ነበረብሽ?	1. አዎ 2. የለም	
803.	ኤች አይ ቪ (HIV) አለብሽ?	1. አዎ 2. የለም	
804.	ከልብ ጋር የተያያዘ ችግር (cardiac disease) ነበረብሽ?	1. አዎ 2. የለም	
805.	የስኩአር በሽታ(diabetes)ነበረብሽ?	1. አዎ 2. የለም	
806.	ሌላ የጤና ችግር ካለ ይጠቀስ	----------	
ክፍል ዘጠኝ፡ከምግብ ማነስ እንዲሁም መብዛት ጋርተያይዘዉ ስለሚከሰቱ ችግሮች/በመለካት የሚሞላ/			
901.	የተሳታፊው ቁመት/በሴ.ሜ/	---------ሜትር ከ----------ሴ.ሜ	
902.	የተሳታፊው ክብደት//በኪ..ግ/ at admission	----------ኪ..ግ	

Annex 6: Original papers and manuscripts

Paper-I

PLOS ONE

RESEARCH ARTICLE

Incidence and causes of maternal near-miss in selected hospitals of Addis Ababa, Ethiopia

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Abstract

Background

Because maternal mortality is a rare event, it is important to study maternal near-miss as a complement to evaluate and improve the quality of obstetric care. Thus, the study was conducted with the aim of assessing the incidence and causes of maternal near-miss.

Methods

A facility-based cross-sectional study was conducted in five selected public hospitals of Addis Ababa, Ethiopia from May 1, 2015 to April 30, 2016. All maternal near-miss cases admitted to the selected hospitals during the study period were prospectively recruited. World Health Organization criteria were used to identify maternal near-miss cases. The number of maternal near-miss cases over one year per 1000 live births occurring during the same year was calculated to determine the incidence of maternal near-miss. Underlying and contributing causes of maternal near-miss were documented from each participant's record.

Results

During the one-year period, there were a total of 238 maternal near-miss cases and 29,697 live births in all participating hospitals, which provides a maternal near-miss incidence ratio of 8.01 per 1000 live births. The underlying causes of the majority of maternal near-miss cases were hypertensive disorders and obstetric hemorrhage. Anemia was the major contributing cause reported for maternal near-miss. Most of the maternal near-miss cases occurred before the women's arrival at the participating hospitals.

Conclusion

The study demonstrated a lower maternal near-miss incidence ratio compared to previous country-level studies. The majority of the near-miss cases occurred before the women's arrival at the participating hospitals, which underscores the importance of improving pre-

and interpretation of the data. The finding and conclusion of the study reflect the view of the authors only.

Competing interests: The authors have declared that no competing interests exist.

hospital barriers. Efforts made toward improvement in the management of life-threatening obstetric complications could reduce the occurrence of maternal near-miss problems that occur during hospitalization.

Introduction

The improvement of maternal health has made slow progress in most of the sub-Saharan African countries [1]. According to the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), the United Nations Population Fund (UNFPA) and the World Bank (2014) estimate, globally, 289,000 maternal deaths occurred in 2013, with the highest burden being in sub-Saharan African countries [1]. Despite the high number of maternal deaths in many of the institutions within these countries, the absolute number for each center classifies these events as rare, which leads to a reduced level of power to allow the studies to investigate the potential risk factors. Thus, in this situation, severe acute maternal morbidity or maternal near-miss could serve as a surrogate for maternal death to evaluate the quality of obstetric care in particular health institutions. A maternal near-miss event or severe acute maternal morbidity is currently defined by the WHO as 'a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy' [2–5].

Because there were no uniform criteria for the identification of near-miss cases and no standard definition for maternal near-miss until 2009, a heterogeneous estimate of rates was observed in different published literatures around the world. For instance, the rate ranged between 0.14% and 0.75% in some of the high-income countries [6–13], it ranged between 1.5% and 7.7% in some of middle- income countries [14–18], and, in sub-Saharan African countries, it ranged between 2.21% and 12% [19–22]. In Ethiopia, the prevalence has reached as high as 7.9% [23].

Worldwide, hypertensive diseases of pregnancy, obstetric hemorrhage, sepsis, anemia and obstructed labor/dystocia have been identified as the major causes of maternal near-miss [8,14,24–26].

Ethiopia, as in many developing countries, has a high rate of maternal mortality. According to the 2011 Ethiopian Demographic and Health Survey (EDHS), the maternal mortality ratio (MMR) of the country was 676 per 100,000 live births, and the 2016 EDHS recorded 412 deaths per 100,000 live births [27,28]. An estimated 2.9 million women give birth every year in Ethiopia, and only 26.2% of them deliver in a health facility [28,29]. According to the recent 2016 EDHS report, the percentage of women who received Antenatal care (ANC), delivery care and a postnatal check-up from a skilled provider was 62.4%, 27.7% and 16.5%, respectively [28].

The Federal Ministry of Health of Ethiopia is striving to reduce the rate of maternal mortality of the country. Actions taken so far include organizing and mobilizing the Health Development Army at all levels to promote behavioral change, the distribution of ambulances to all districts of Ethiopia, the provision of free maternity services at different health care levels, the training of human resources and equitable placement of health professionals in health facilities, and the provision of adequate drugs, medical supplies, and equipment [30]. Despite all of these efforts, the maternal mortality rate of the country remains high. Therefore, there is a need to assess the magnitude and possible causes that contribute to maternal mortality. However, because maternal near-miss is a rare event, and because it follows a similar pathway to

maternal deaths, there is a benefit to including a larger number of cases for analysis, as research related to maternal near-miss is crucial when examining the quality of obstetric care [2,4,31]. In Ethiopia, maternal near-miss complications are common and are estimated to be around 12 times more frequent than maternal deaths [23]. However, the incidence and causes of near-miss events are not well documented. Thus, this study aimed to assess the incidence and causes of maternal near-miss.

Methods

Study settings and period

The study was conducted in five selected public hospitals of Addis Ababa, Ethiopia from May 1, 2015 to April 30, 2016. The hospitals were selected based on the number of deliveries they managed per year. Because most critical maternal cases are referred to a hospital known to provide better care, the presence of an Intensive Care Unit (ICU), maternity ward, blood transfusion service and facilities for caesarean section (CS) were also considered in the selection of hospitals. Hence, Tikur Anbessa, St. Paul's Hospital Millennium Medical College, Zewditu Memorial, Yekatit 12, and Gandhi Memorial Hospitals were selected for the current study. Tikur Anbessa Hospital is the largest referral and teaching hospital in Ethiopia and is operated under the Ministry of Education of Ethiopia. St. Paul's Hospital Millennium Medical College is the largest referral and teaching hospital among those operated under the Federal Ministry of Health. However, the Gandhi Memorial, Yekatit 12 and Zewditu Memorial Hospitals were among the six governmental referral and teaching hospitals that are managed under the Addis Ababa Administrative Health Office. Together, the five hospitals were responsible for a total of 29,697 live birth deliveries during the year in which this study took place. Apart from Tikur Anbessa Hospital, which received very critical cases from different part of Ethiopia, the hospitals are comparable in terms of the patients they receive for care and treatment (Fig 1).

Fig 1. Location map of the study area in Addis Ababa, Ethiopia. SPHMC (St. Paul's Hospital Millennium Medical College), TAH (Tikur Anbessa Hospital), Y12H (Yekatit 12 Hospital), ZMH (Zewditu Memorial Hospital) and GMH (Gandhi Memorial Hospital).

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Study design

A facility-based cross-sectional study design was used to address the objective of the current study.

Identification of cases

All women admitted to the participating hospitals during the study period for the treatment of pregnancy-related complications (such as ectopic pregnancy or abortion), having delivered, or within 42 days of termination of pregnancy, and who fulfilled at least one of the conditions stated in the WHO criteria (S1 Table) [5] were included. Depending on when the near-miss occurred, maternal near-miss cases were further categorized into two groups. Women who were assessed as being in critical condition on arrival to a hospital were classified as near-miss before arrival. However, if the near-miss occurred during hospitalization, it was classified as near-miss after arrival.

Sample size determination

The sample size was determined by a single population proportion formula by assuming the prevalence of maternal near-miss in Ethiopia to be 7.9% [23]. Considering a 1% margin of error, a 95% confidence interval (CI) and a 10% non-response rate, a minimum of 2795 live births were calculated to be the appropriate sample size for this study. However, during the year of the study, a 10 times larger number of live births than the number required was obtained in the five hospitals (29,697 live births), and we decided to include the entire period of one year to increase the precision of the study.

Data collection

Women who experienced a maternal near-miss event during pregnancy, delivery or the post-partum period were identified prospectively by well-trained midwives and nurses in each hospital. Data relating to the most important variables were abstracted from the medical record of the participants using the WHO data abstraction tool, with some modifications [5]. The data were collected from the Delivery Ward, Obstetrics and Gynecology Ward, ICU, and Emergency Gynecology Outpatient Department of each hospital. For each maternal near-miss case, only one underlying cause was identified as per the WHO International Statistical Classification of Diseases and Related Health Problems (ICD). According to the ICD, the underlying cause is the disease or injury which initiated the sequence of events leading directly to death [32]. Because the same classification is used for both maternal death and maternal near-miss [33], the classifications used for maternal near-miss were the same as those listed in the ICD for maternal mortality [34]. However, all possible contributing causes were considered. Information regarding whether the near-miss was present before arrival or developed during hospitalization was also collected in order to determine the place where the near-miss occurred. Data on the total number of live births occurring over one year for each hospital were extracted from the Health Management Information System (HMIS) report of each hospital.

Data processing and management

The supervisors in all participating hospitals were responsible for checking the completeness of the information. The enumerators filled in the date and signed each questionnaire, which was later checked, edited and signed by the supervisors regularly at each hospital. The data that were collected using hard copies were kept in a locked cabinet by each supervisor until gathered by the principal investigator during supervision. Following this, the data were entered

into Epi Info 7 software, and transported to SPSS version 20 and Open Epi computer software for final analysis.

Data analysis

The total incidence of maternal near-miss in the hospitals involved in this study was calculated using the maternal near-miss incidence ratio (MNMIR) formula. This was calculated by dividing the number of maternal near-miss cases during one year by the total number of live births during the same year. The incidence ratio in each hospital was also calculated with a 95% CI. In addition, hospital access indicators, such as the number of women with a maternal near-miss condition before arrival at the hospital, were calculated. Intra-hospital care indicators, such as the number of women with near-miss who developed conditions in the hospital, were also calculated. In order to determine the underlying and contributory causes of maternal near-miss, a descriptive frequency for each cause was calculated. The total number and frequency of each cause for all hospitals involved were calculated separately. The causes were categorized into underlying and contributory as per the WHO recommendation [5]. A descriptive frequency of the type of organ dysfunction present in maternal near-miss cases was also calculated.

Data quality assurance

In order to maintain the quality of data, intensive training was given to data collectors and supervisors. All health care workers working in the maternity ward of each participating hospital were also sensitized to the issue so that they would inform the enumerators when they suspected a near-miss case. In addition, inclusion criteria for maternal near-miss were printed and posted on the wall of each ward at all participating hospitals. The data collectors made a daily visit to the Delivery Ward, Obstetrics and Gynecology Ward, ICU, and Emergency Gynecology Outpatient Department to check for potential cases. The data collectors were given training to standardize methods and ensure consistency of data collection. One hospital supervisor, who was responsible for the overall quality of the data, was appointed at each participating hospital. There was frequent supervision of the included hospitals by the principal investigator. The standardized data abstraction form developed by the WHO [5] was used to abstract pertinent information. The questionnaires were also first pre-tested in the participating hospitals to verify the appropriateness of the tool. The standardized WHO criteria were used to identify maternal near-miss cases. Hence, all the above procedures contributed greatly to obtaining quality data.

Ethics statement

Acceptable ethical standards were strictly adhered to throughout the study process. The study was first approved by the Institutional Review Board of the College of Health sciences, Addis Ababa University (Protocol number: 058/14/SPH, Date: January 2015). It was also approved by the Ethical Review Committee of each hospital. Adequate explanation about the purpose of the study and a letter of support was given to all concerned bodies. For studies that are not clinical trials that involve invasive procedures, taking verbal consent is the standard requirement of the Institutional Review Board of Addis Ababa University. Hence, verbal consent was taken to abstract pertinent information from the participant's record. The anonymity of the participants was respected via the use of codes rather than the name of the participant. The names of the participants were not reported in the findings of the study to ensure confidentiality.

Table 1. Incidence of maternal near-miss in five selected public hospitals of Addis Ababa, Ethiopia from May 1, 2015 to April 30, 2016.

Name of Hospital	Near-miss cases *(n)*	Percentage (%)	Total live births in one year	*MNMIR per 1000 live births (95% CI)
Tikur Anbessa	73	30.7	4632	15.8 (12.6–19.8)
St. Paul Millennium Medical College	55	23.1	9079	6.06 (4.66–7.88)
Gandhi Memorial	39	16.4	7091	5.49 (4.02–7.51)
Zewditu Memorial	20	8.4	4610	4.34 (2.81–6.69)
Yekatit 12	51	21.4	4285	11.9 (9.06–15.61)
Total	238	100	29,697	8.01 (7.06–9.09)

* MNMIR represents maternal near-miss incidence ratio

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Results

Incidence of maternal near-miss

During the one-year period, a total of 238 maternal near-miss cases and 29,697 live births were reported in total for all participating hospitals, which produced a total maternal near-miss incidence ratio of 8.01 per 1000 live births (95% CI; 7.06–9.09).

The highest proportion of cases was reported from Tikur Anbessa hospital (30.7%), followed by St. Paul Millennium Medical College (23.1%), and the lowest proportion was observed at Zewditu Memorial Hospital (Table 1).

Characteristics of women with maternal near-miss

The majority (88.2%) of maternal near-miss cases were referred from other health facilities and an ambulance was used by most of the mothers as a means of transport to the study hospitals. A significant number (68.5%) of maternal near-misses occurred before arrival at the participating hospitals (Table 2).

Organ dysfunction in maternal near-miss cases

The number of major organ dysfunctions seen in the majority of maternal near-miss cases were Coagulation/Hematological at 114 (47.9%), followed by Neurologic at 97 (40.8%), and Cardiovascular at 96 (40.3%). Hepatic dysfunction was the least-reported organ dysfunction in

Table 2. Characteristics of women with maternal near-miss in five selected public hospitals of Addis Ababa, Ethiopia from May 1, 2015 to April 30, 2016.

Variable	Number	percent
Admission mode (*n* = 238)		
Self-referred	28	11.8
Referred from other facility	210	88.2
Means of transport used (*n* = 238)		
Ambulance	181	76.1
Public transport	38	16
Personal vehicle	15	6.3
Others	4	1.7
When did the near-miss occur? (*n* = 238)		
Before arrival	163	68.5
During hospitalization	75	31.5

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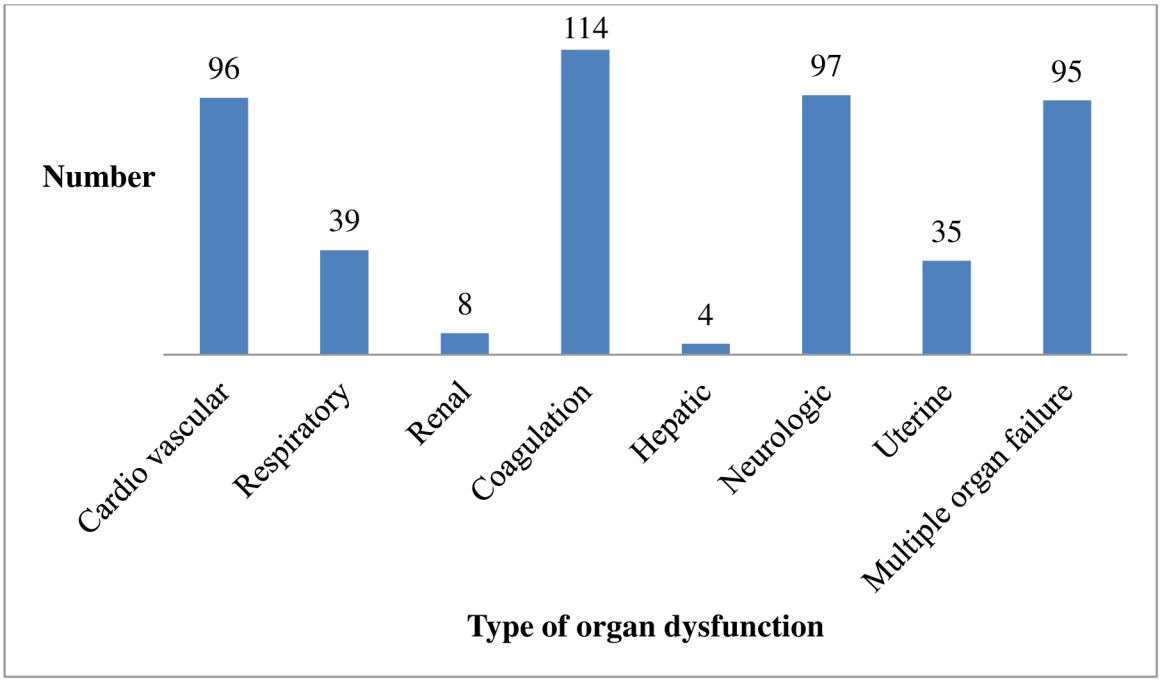

Fig 2. Organ dysfunction in maternal near-miss cases in five selected public hospitals of Addis Ababa, Ethiopia, May 2015 to April 30, 2016.

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audited maternal near-miss cases. Around 95 (39.9%) of the cases manifested multiple organ failure (Fig 2).

Underlying and contributory causes of maternal near-miss

The underlying cause for the majority of maternal near-miss cases was hypertensive disorder (53%), followed by obstetric hemorrhage (38%), pregnancy with abortive outcome (4%), and pregnancy-related infections (1%) (Fig 3).

The major contributing causes of maternal near-miss reported were anemia (40%) followed by prolonged/obstructed labor (9%). Around 37% of maternal near-miss cases did not show any form of contributing causes (Fig 4).

Discussion

Incidence of maternal near-miss

During the one-year period of the study, the incidence of maternal near-miss was 8.01 per 1000 live births in all participating hospitals. Previous studies in Ethiopia have documented a prevalence rate of 101 per 1000 deliveries [26] and 78.9 per 1000 live births [23]. Surprisingly, our finding is considerably lower than that given in previous reports and the observed variation could be a result of disparity in the case definitions used by the researchers, the study design used, and the time at which the study was conducted. We used the newly developed WHO criteria, which are very stringent and would identify only very critical cases. However, previous studies used disease-based criteria, which were less stringent than the WHO criteria for identifying maternal near-miss cases. Thus, had the previous studies employed the WHO criteria, they might have ended up reporting more cases. Data quality issues and the limitations of the secondary data obtained in previous studies might also be an alternative explanation for

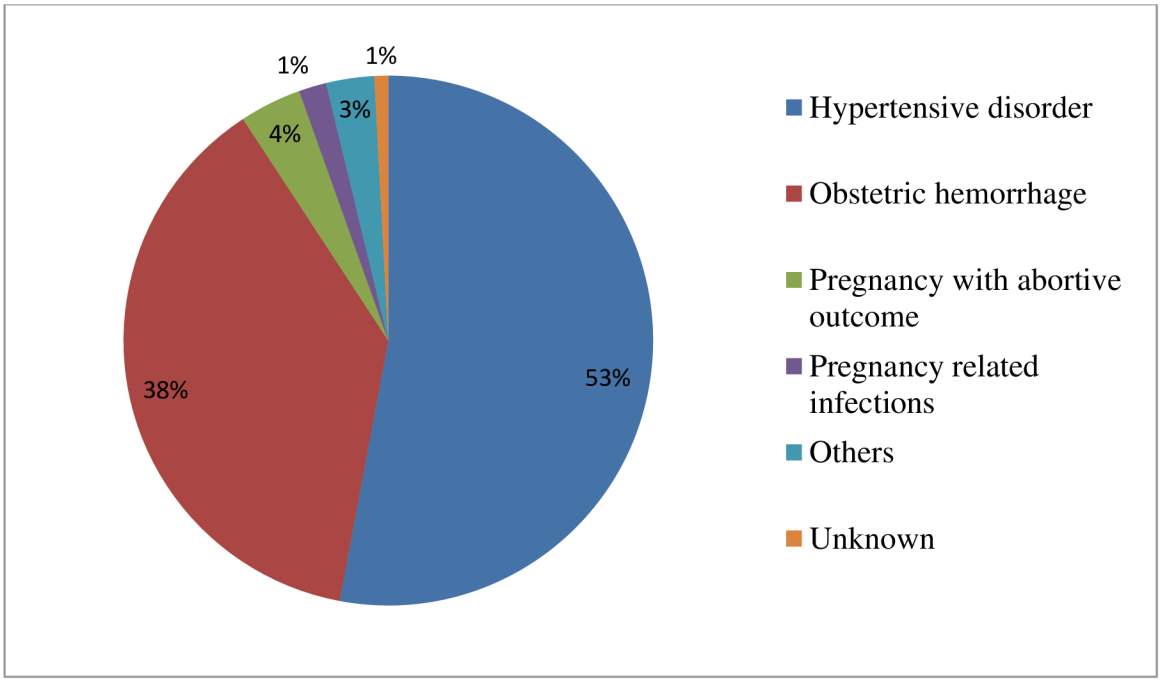

Fig 3. Underlying causes of maternal near-miss in five selected public hospitals, Addis Ababa, Ethiopia May1, 2015 to April 30, 2016.

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the observed difference. Nevertheless, when we compare our findings with other studies that used the newly developed WHO criteria, the incidence was lower than some other sub-Saharan African countries such as Ghana and Tanzania [19,35]. However, our results are comparable

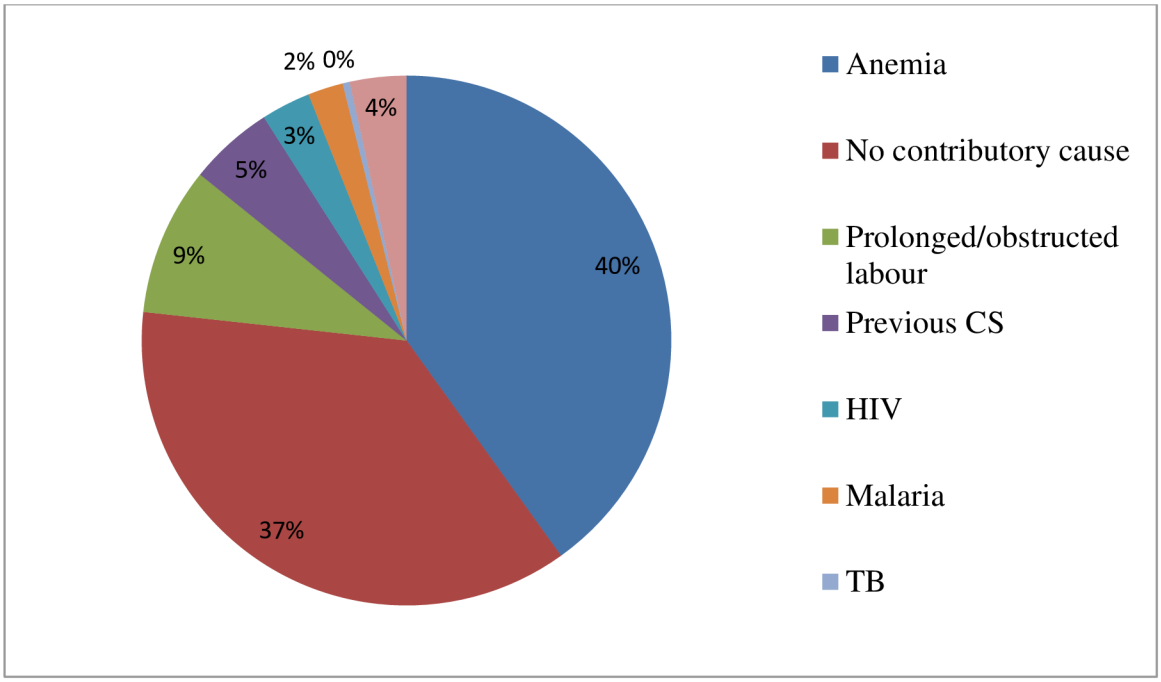

Fig 4. Contributing causes of maternal near-miss in five selected public hospitals, Addis Ababa, Ethiopia May1, 2015 to April 30, 2016.

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with studies conducted in Rwanda and Uganda, where they reported an incidence rate of 8 per 1000 live births and 8.42 per 1000 live births, respectively [36,37].

Among the five participating hospitals, a higher incidence of maternal near-miss was observed in Tikur Anbesa Hospital (15.76 per 1000 live births). Because that hospital is the major referral hospital in Ethiopia, the possibility of obtaining severely critical cases from different parts of the country and from Addis Ababa is higher.

Causes of maternal near miss

The leading underlying cause of maternal near-miss in our study was hypertensive disorder (eclampsia and pre-eclampsia), followed by obstetric hemorrhage. This finding is compatible with most studies from high and middle-income countries [8,9,38,39]. The study finding was also in line with studies conducted in other African countries [20,21,25]. A previous study in Ethiopia also reported hypertensive disorder as the primary cause, and obstetric hemorrhage as the second leading cause of maternal near-miss [23]. High percentages of hypertensive disorder and obstetric hemorrhage might be indicative of some form of delay in managing obstetric complications by the facility staff.

Pregnancy-related infection was the least mentioned cause of maternal near-miss in our study and was also reported to be the least likely cause in most of the studies completed in developed countries. The rate was also much lower as compared to some of the other African countries that had been studied [20–22,25]. The lower percentage of infection as a cause of maternal near-miss could be explained by the presence of early management of the cases with appropriate antibiotics at each health facility.

Anemia was the major contributory cause of maternal near-miss in our study. This finding is also comparable with studies from some middle-income countries such as Iraq, India, and Pakistan [40–42]. This finding was also in line with the studies from some African countries such as Ghana [19]. The presence of anemia in women can be attributed to nutritional and iron deficiency during pregnancy. It could also result from the presence of previous malaria. Hence, there is a need to deeply assess the causes of anemia in women with a maternal near-miss case to determine the most appropriate action.

The majority of maternal near-miss cases have already occurred on the women's arrival at the participating hospitals, a finding which is in line with studies from most developing countries. For example, in Bolivia, Mozambique and Somaliland, 74%, 70.7% and 74.2% of the near-miss cases, respectively, were in a critical state upon arrival at the health facilities, implying the need to focus on existing pre-hospital barriers [43–45]. However, near-miss cases that develop during hospitalization can help to measure the quality of obstetric care provided within the health facilities. In Iran, for example, sub-optimal obstetric care was found in 75% of the near-miss cases [46]. The occurrence of maternal near-miss after receiving sub-optimal care following caesarian section has also been reported elsewhere [47]. However, it should be noted that quality of care is not the only possible explanation for near-miss events occurring during hospitalization. Cases that occurred after admission could also be related to the severity of the cases.

This study has many strengths. The study is the first of its kind in Ethiopia to document the incidence and causes of maternal near-miss using the newly developed WHO case identification criteria. Prospective case identification was used for a consecutive period of one year. Identifying cases prospectively over a longer period of time enabled us to avoid missing important variables, which is a drawback of most previous retrospective studies. Collecting data over a longer period of time can also help to gather a representative sample. In using the WHO criteria, we were able to determine which of the criteria were mainly applicable to the study

hospitals. The use of a standardized WHO data abstraction tool to abstract data was also one of the strengths of the study, which might also have had its own implications for the quality of the study.

However, our study had certain limitations. The follow-up time used by the WHO to define maternal near-miss has a duration of 42 days postpartum. However, because of logistic and feasibility concerns, our follow-up time was limited to only the length of the hospital stay. This might have caused us to underestimate the magnitude of maternal near-miss. The study also failed to abstract all maternal near-miss indicators such as the interventions provided for maternal near-miss women, which are important components of quality of care. The other limitation of the study was that our study was carried out only in public health facilities. Hence, it does not represent cases of maternal near-miss that occur in private health facilities.

Conclusion

The study demonstrated a lower maternal near-miss incidence ratio compared to previous country-level studies. Underlying and contributory causes of maternal near-miss are still prevalent. Evidence-based interventions designed to optimize the intra-partum management of life-threatening obstetric complications, specifically hypertensive disorders and obstetric hemorrhage, could reduce the occurrence of maternal near-miss problems occurring during hospitalization. The majority of the near-miss cases happened before the women's arrival at the participating hospitals, which underscores the importance of eliminating the pre-hospital barriers. Hence, further research is recommended to explore those barriers.

Supporting information

S1 Table. Identification criteria of maternal-near miss as used by the WHO, 2009 and 2011.
(DOCX)

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Author Contributions

Conceptualization: EFL.

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Formal analysis: EFL AWY MFA BE.

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Investigation: EFL AWY.

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Project administration: EFL AWY.

Resources: EFL AWY.

Software: EFL AWY.

Supervision: EFL AW.

Validation: EFL AWY MFA BE.

Visualization: EFL AWY MFA BE.

Writing – original draft: EFL AWY MFA BE.

Writing – review & editing: EFL AWY MFA BE.

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Distant and proximate factors associated with maternal near-miss: a nested case-control study in selected public hospitals of Addis Ababa, Ethiopia

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Abstract

Background: Ethiopia is one of the sub-Saharan Africa countries with the highest maternal mortality. Maternal near-misses are more common than deaths and statistically stronger for a comprehensive analysis of the determinants. The study aimed to identify the factors associated with maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia.

Methods: We conducted a nested case-control study in five selected public hospitals of Addis Ababa, Ethiopia from May 1, 2015 to April 30, 2016. Participants were interviewed by well-trained data collectors using pre-tested questionnaire. Medical records were also reviewed to gather relevant information. World Health Organization criteria were used to identify maternal near-miss cases. A total of three controls matched for age and study area was selected for each maternal near-miss case. Bivariate and multivariable conditional logistic regressions were performed using Stata version 13.0.

Results: A total of 216 maternal near-miss cases and 648 controls were included in the study. The main factors associated with maternal near-miss were: history of chronic hypertension (AOR = 10.80,95% CI; 5.16–22.60), rural residency (AOR = 10.60,95% CI;4.59–24.46), history of stillbirth (AOR = 6.03,95% CI;2.09–17.41), no antenatal care attendance (AOR = 5.58,95% CI;1.94–16.07) and history of anemia (AOR = 5.26,95% CI;2.89–9.57).

Conclusions: There is a need for appropriate interventions in order to improve the identified factors. The factors can be modified through a better access to medical and maternity care, scaling up of antenatal care in rural areas, improve in infrastructure to fulfill referral chain from primary level to secondary and tertiary health care levels, and health education to pregnant women.

Keywords: Maternal near-miss, Risk factors, Nested case-control, Public hospitals, Addis Ababa, Ethiopia

Background

In September 2015, the United Nations (UN) General Assembly formally approved a set of 17 Sustainable Development Goals (SDG) as a follow-up to Millennium Development Goals (MDG). Improving maternal health remains an important topic of SDG which is to reduce the global Maternal Mortality Ratio (MMR) to less than 70 per 100,000 live births by 2030 [1]. According to the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), the United Nations Population Fund (UNFPA), the World Bank Group and the United Nations Population Division (2015) estimate, globally, 303,000 maternal deaths occurred in 2015 with sub-Saharan Africa alone accounts for 66% of the deaths [2].

Ethiopia is one of the sub-Saharan Africa countries with the highest rate of maternal mortality. According to the Ethiopian Demographic and Health Survey (EDHS) report, it was 676 per 100,000 live births in 2011 and the 2016 EDHS documented 412 deaths per 100,000 live

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births [3, 4]. The government of Ethiopia has made different strategies to lower the rate of maternal mortality. For instance, the members of women's association of Ethiopia were trained to address social and structural barriers to sexual, reproductive, maternal and newborn health [5]. In addition to this, there was societal level poverty reduction, hospital level allocation of resources, improving skilled birth attendance and reducing home births [5, 6]. Despite all these efforts, there is no significant decline in maternal mortality in the country, where only 27.7% of women received delivery care from skilled provider [3]. Hence, there is a need to assess the possible factors that contributed to maternal mortality. However, maternal deaths are uncommon per each health facility. Thus, in this situation, studies on maternal near-miss could serve as a proxy for maternal death to evaluate quality of obstetric care in particular health institutions [7, 8]. Assessing near-miss has an advantage over maternal death as near-misses are more common and statistically robust [7, 8]. A maternal near-miss is defined by the WHO as 'a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy' [9].

Different literatures on maternal near-miss around the globe revealed different factors. Advanced maternal age, race, lower socio-economic status, rural residence, less or no antenatal care (ANC) follow-up, multiple pregnancies, nulliparous, multiparous, previous cesarean section delivery, pre-existing medical conditions, overweight and underweight were documented as factors for maternal near-miss [10–18].

The factors associated with maternal near-miss are not well documented in Ethiopia. Few previous published studies conducted in the country relied on patient record to assess predictors of maternal near-miss. Hence, these studies might have limitations of bias due to incompleteness and poor quality of the data at the health facility [19, 20]. However, the current study did not rely on the available hospital secondary data. The aim of this study was to identify the factors associated with maternal near-miss in selected public hospitals of Addis Ababa, Ethiopia.

Methods

Study settings and period

We conducted a study in five selected public hospitals of Addis Ababa, capital of Ethiopia from May 1, 2015 to April 30, 2016. The selection of hospitals was based on the number of deliveries conducted per year. In addition, presence of an Intensive Care Unit (ICU), maternity ward, blood transfusion service and availability of cesarean section (CS) delivery were considered in the selection of hospitals. Accordingly, Tikur Anbessa, St. Paul's Hospital Millennium Medical College, Zewditu Memorial, Yekatit 12 and Gandhi Memorial Hospitals were selected. A total of 29,697 live birth deliveries took place in the participating hospitals during the study period. The details of settings with location map has been described elsewhere [21].

Study design

A nested case-control study design, matched for age and study setting was employed. Age was categorized in five year interval. Participants were followed from admission till discharge.

Inclusion criteria of cases

Women who were admitted to the selected hospitals during the study period for treatment of pregnancy-related complications (irrespective of gestational age), who delivered, or were within 42 days of termination of pregnancy, and fulfilled at least one of the conditions that is indicated in the WHO criteria presented in Table 1 [9] were included as cases.

Exclusion criteria of cases

Those women who have been admitted for reasons not related to pregnancy, delivery or 42 days after termination of pregnancy were excluded.

Selection of controls

Women who came to the same hospital where the cases happened and, having a similar age- interval category with that of the cases and delivered without any complications were enrolled as a control. For each near-miss case, three controls that occurred within the same day of the near-miss event were included.

Sample size determination

The sample size was estimated using Epi Info 7 software using sample size determination for unmatched case-control studies. The parameters that were used to estimate the sample size were: confidence level of 95%, power of 80%, case-control ratio of 1:3, expected frequency of exposure in control to be 4.11%, and percent exposure among cases, 10.78%. It was estimated from one study in Ethiopia taking no ANC follow-up as one of the main exposure variable for maternal near-miss that provide the maximum sample size [20]. Accordingly, these yield a minimum sample size of 166 cases and 497 controls. Adding a 10% non-response rate, the final sample size required for the study was 183 cases and 547 controls. To increase the power of the study, all cases observed during one year period (collected for a different objective to determine the incidence of maternal near-miss, which was described elsewhere) [21], along with the corresponding three controls were included in the study.

Table 1 Identification criteria of maternal near-miss as used by the WHO 2011

Dysfunctional system	Clinical criteria	Laboratory markers	Management based proxies
Cardiovascular	Shock Cardiac arrest	severe hypo perfusion (lactate > 5 m mol/l or > 45 mg/dl) severe acidosis (pH < 7.1)	Use of continuous vasoactive drugs Cardio pulmonary resuscitation
Respiratory	Acute cyanosis Gasping severe tachypnea (respiratory rate > 40 breaths per minute) severe bradypnea (respiratory rate < 6 breaths per minute)	severe hypoxemia (O2 saturation < 90% for ≥60 min or PAO2/FiO2 < 200)	Intubation and ventilation not related to anesthesia
Renal	Oliguria non-responsive to fluids or diuretics	Severe acute azotemia (creatinine ≥300 μmol/ml or ≥3.5 mg/dl)	Dialysis for acute renal failure
Coagulation/hematological	Failure to form clots	severe acute thrombocytopenia (< 50,000 platelets/ml)	Massive transfusion of blood or red cells (≥5 units)
Hepatic	Jaundice in the presence of pre-eclampsia	severe acute hyperbilirubinemia (bilirubin > 100 μmol/l or > 6.0 mg/dl)	
Neurological	Prolonged unconsciousness (lasting ≥12 h)/coma (including metabolic coma), stroke, uncontrollable fits/status epileptics, total paralysis		
Uterine			Uterine hemorrhage or infection leading to hysterectomy

Data collection

Women with a maternal near-miss condition and those without any complications during delivery were interviewed by a well-trained midwives and nurses using structured questionnaire. In addition, medical records were reviewed to gather relevant information. Information on socio-economic and demographic characteristics, reproductive health and obstetric history, and pre-existing medical conditions of the women were obtained from the participant's record. The questionnaires were prepared following a thorough review of literatures. Obstetrics and Gynecology Ward, ICU and Emergency Gynecology Outpatient Department (OPD) of each hospital were visited to collect data. The questionnaires were pre-tested prior to the commencement of data collection to determine the appropriateness of the tool. Data collectors were given a three day training in order ensure consistency of data collection.

Data analysis

The data were entered using Epi Info 7 software and analyzed using Stata version 13.0. The data were cleaned before analysis. The outcome variable of the study was maternal near-miss. The independent variables which were identified from literatures includes: (i) socio-economic and demographic characteristics (educational level, place of residence, ethnicity, religion, marital status, maternal occupation), (ii) reproductive health and obstetric history of the women (antenatal care booking, parity, history of caesarian section delivery, multiple pregnancies, history of abortion, history of stillbirth, early marriage, female genital cutting) and (iii) pre-existing medical conditions (previous hypertension, previous anemia, human immunodeficiency virus (HIV), history of cardiac problems, history of diabetes mellitus (DM)).

Bivariate logistic regression was performed to examine whether there is a significant association between each individual independent variable and maternal near-miss. For each individual variable, the *P*-value, and unadjusted odds ratio (OR) with its 95% confidence interval, and the number and proportion of each variable of case and control were calculated.

Multivariable conditional logistic regression model was used to examine the independent effect of the factors on the occurrence of maternal near-miss. The variables that were mentioned as factors of maternal near-miss in our literature review were classified as either distant or proximate factors. Socio-economic and demographic variables were taken as a distant factors. Whereas, the rest such as, reproductive health and obstetric history of the women and pre-existing medical conditions were considered as proximate factors. Since distant factors are conceptually related with the

proximate factors for the occurrence of maternal near-miss, hierarchical model for the analysis is recommended [22]. Based on this hierarchical order, we have developed two models. All socio-economic and demographic variables with $p < 0.2$ in the bivariate logistic regression analysis were fitted with model 1. Those variables that were significant in model 1 ($p < 0.05$) were fitted with model 2. Model 2 contained those significant variables from model 1 and proximate variables. For each model and variables their adjusted OR, its 95% CI and *P*-value were calculated.

The model fitness was estimated using stata's fitstat command. Good fit was indicated by a significance value less than 0.05. Both models which were used to determine the factors associated with maternal near-miss were shown to be significant ($p < 0.0001$), which shows the models were best fit.

Multicollinearity among independent variables was assessed by calculating variance inflation factors (VIF). No multicollinearity was suggested during the current analysis as all the calculated VIF were less than 10.

We also defined some of the important independent variables. Educational level was categorized into illiterate (no formal education), primary (grade 1–8), secondary (grade 9–12), and higher education (> 12). Antenatal care visit was considered to be present if a woman reported to have ANC during current pregnancy. Monthly income was categorized into the lowest 25 percentile (below 68 USD), between 25 and 75 percentile (68–181 USD), and above 75 percentile (greater than 181 USD). Marriage before age of 18 was considered as early (based on jurisdiction). Pre-existing medical conditions such as chronic hypertension, anemia, HIV, maternal cardiac disease and DM were considered as present if the women reported their presence before the current pregnancy.

Results

Characteristics of the participants

During the one-year period, a total of 238 maternal near-miss cases were reported in all participating hospitals. However, 22 cases were excluded because of incomplete data. Hence, the study included 216 maternal near-miss cases and 648 corresponding controls.

Women with maternal near-miss tended to be illiterate ($P < 0.0001$), never married ($p = 0.011$), reside in rural area ($p < 0.0001$), and had a less monthly income ($p < 0.0001$) compared to controls (Table 2).

Compared to the control groups, women with maternal near-miss case were more often did not attend ANC, have greater than five children, have a history of stillbirth and experienced an early marriage, all statistically significant ($p < 0.05$). However, there were no statistically significant difference between cases and controls with regard to presence of previous caesarean section delivery, history of abortion and undergoing a female genital cutting (Table 2).

Cases and controls also differed significantly with regard to the presence of previous medical conditions such as chronic hypertension, anemia, and cardiac problems. However, a significant difference was not observed among the two groups with regard to the presence of HIV and DM (Table 3).

Determinants of maternal near-miss

In order to know the factors associated with maternal near-miss, two models were used in a multiple conditional logistic regression analysis. Model one contained five variables which were significant in bivariate analysis (educational level, place of residence, ethnicity, marital status and monthly income). However, the result of the first model showed that only place of residence was found to be associated with maternal near-miss (Table 4). The second model contained eleven variables and five variables remained significant. The factors associated with maternal near-miss in the second model were: history of chronic hypertension (AOR = 10.80,95% CI; 5.16–22.60), rural residency (AOR = 10.60,95% CI;4.59–24.46), history of stillbirth (AOR = 6.03,95% CI;2.09–17.41), no ANC attendance (AOR = 5.58,95% CI;1.94–16.07) and history of anemia (AOR = 5.26,95% CI;2.89–9.57) (Table 5). However, the study did not find that female genital cutting was a determinant factor for maternal near-miss.

Discussion

History of chronic hypertension, rural residency, history of stillbirth, no antenatal care attendance and history of anemia were found to be correlated with the occurrence of maternal near-miss.

Among all characteristics, presence of previous chronic hypertension showed the strongest risk factor for the development of maternal near-miss. Women with chronic hypertension are at increased risk for several pregnancy complications which includes: pre-eclampsia, placental abruption, intrauterine growth retardation, CS delivery and pre-term delivery [23]. The finding was consistent with other studies. A study done in Nigeria reported a sevenfold increased risk of maternal near-miss in women with presence of previous chronic hypertension [15]. The observation was also similar to other studies in which the risk of maternal near-miss was higher among women with pre-existing hypertension [24, 25].

Another strong risk factor for maternal near-miss reported in the current study was place of residence. Accordingly, those women who reside in the rural area have higher odds of developing maternal near-miss. A similar finding was also reported in another study in

Table 2 Distribution of selected socio-economic, demographic, reproductive health and obstetric characteristics of women with and without maternal near-miss in Addis Ababa, Ethiopia, 2016

	Near-miss ($n = 216$)	Controls ($n = 648$)	COR (95% CI)	*P*-value
Characteristics	n (%)	n (%)		
Educational level				
Illiterate	61 (30.0)	75 (11.7)	**3.28 (1.85–5.84)**	< 0.0001
Primary	63 (31.0)	214 (33.4)	1.23 (0.70–2.15)	0.470
Secondary	57 (28.1	256 (39.9)	0.91 (0.52–1.57)	0.724
Higher	22 (10.8)	96 (15)	1.00	
Place of residency				
Urban	159 (73.6)	634 (97.8)	1.00	
Rural	57 (26.4)	14 (2.2)	**13.0 (7.12–23.8)**	< 0.0001
Marital status				0.01
Married	200 (92.6)	627 (96.8)	1.00	
Never married	16 (7.4)	21 (3.2)	**2.38 (1.22–4.65**)	0.011
Monthly income				
> 68 USD	81 (37.5)	111 (17.1)	**2.19 (1.43–3.34)**	< 0.0001
68–181 USD	74 (34.3)	370 (57.1)	**0.54 (0.36–0.79)**	0.002
> 181 USD	61 (28.2)	167 (25.8)	1.00	
Received ANC				
Yes	183 (84.7)	638 (98.5)	1.00	
No	33 (15.3)	10 (1.5)	**10.8 (5.16–22.6)**	< 0.0001
Number of children				
0–2	171 (79.2)	527 (81.3)	0.99 (0.63–1.56)	0.985
3–4	34 (15.7)	110 (17)	1.00	
> 5	11 (5.1)	11 (1.7)	**3.53 (1.34–9.27)**	0.010
Undergone FGC				
Yes	135 (64.6)	383 (59.6)	0.89 (0.59–1.33)	0.225
No	74 (35.4)	260 (40.4)	1.00	
History of stillbirth				
Yes	21 (9.7)	21 (3.2)	**3.45 (1.79–6.68)**	< 0.0001
No	195 (90.3)	627 (96.8)	1.00	
Early marriage				
Yes	43 (21.5)	90 (14.5)	**1.97 (1.21–3.19)**	0.006
No	157 (78.5)	532 (85.5)	1.00	

Bold data are those which are significant and their significance is indicated by the *P*-values expressed at the right end of each ORs

Ethiopia [20]. Studies from Bolivia and Brazil also documented a similar finding [12, 26]. Women from rural area might walk longer to access health services. Particularly when maternal complications occurred, her chance of getting appropriate health care on time might be minimized which in turn increase her chance of morbidity.

Additionally, we found that presence of previous stillbirth in women was an important risk factor for maternal near-miss. After a stillbirth infant, women may experience different psychological as well as relational problems which might in turn increase the risk of maternal complications in subsequent pregnancies. The link between maternal chronic hypertension and stillbirth may also be an alternative explanation [23]. Hence, women who had a stillbirth might have a history of chronic hypertension, and thereby increase the odds of maternal near-miss. Todd et al. in their study on correlates of severe acute maternal morbidity in Kabul also demonstrated that prior stillbirth is a risk factor for maternal near-miss [27].

The study also showed that the odds of maternal near-miss was higher among those women who fail to attend ANC. Different evidences showed that ANC is effective to

Table 3 Distribution of selected previous medical conditions of cases and controls in Addis Ababa, Ethiopia, 2016

	Near-miss (n = 216)	Controls (*n* = 848)	COR (95% CI)	*p*-value
Characteristics	n (%)	n (%)		
Previous hypertension				
Yes	56 (25.9)	16 (2.5)	**13.3 (7.16–24.9)**	< 0.0001
No	160 (74.1)	632 (97.5)	1.00	
Previous anemia				
Yes	73 (33.8)	64 (9.9)	**4.66 (3.12–6.95)**	< 0.0001
No	143 (66.2)	584 (90.1)	1.00	
History of cardiac problem				
Yes	11 (5.1)	5 (0.8)	**6.6 (2.29–18.9)**	< 0.0001
No	205 (94.9)	643 (99.2)	1.00	

Bold data are those which are significant and their significance is indicated by the *P*-values expressed at the right end of each ORs

Table 4 Factors associated with maternal near-miss in model one multiple conditional logistic regression analysis, Addis Ababa, Ethiopia, 2016

	Model 1	
	AOR (95% CI)	*p*-value
Characteristics		
Place of residence		
Rural	**6.86 (3.42–13.76)**	**< 0.0001**
Urban	1	
Educational level		
Illiterate	1.91 (0.95–3.83)	0.068
Primary	1.29 (0.68–2.45)	0.429
Secondary	1.12 (0.62–2.04)	0.699
Higher	1.00	
Ethnicity		
Amhara	1.00	
Oromo	1.32 (0.82–2.13)	0.248
Gurage	0.66 (0.37–1.21)	0.178
Tigre	1.01 (0.41–2.47)	0.975
Silte	0.92 (0.36–2.36)	0.867
Other	0.86 (0.39–1.89)	0.708
Marital status		
Married	1.00	
Never married	1.21 (0.54–2.72)	0.642
Monthly income		
< 68 USD	1.62 (0.95–2.77)	0.075
68–181 USD	0.65 (0.42–1.02)	0.061
> 181 USD	1.00	

Bold data are those which are significant and their significance is indicated by the *P*-values expressed at the right end of each ORs

Table 5 Factors associated with maternal near-miss in the last model multiple conditional logistic regression analysis, Addis Ababa, Ethiopia, 2016

	Model 2	
	AOR (95% CI)	*p*-value
Characteristics		
Place of residence		
Rural	**10.60 (4.59–24.46)**	**< 0.0001**
Urban	1	
Received ANC		
Yes	1	
No	**5.58 (1.94–16.07)**	**0.001**
Number of children		
0–2	2.16 (0.09–5.28)	0.09
3–4	1	
> 5	4.27 (0.65–27.98)	0.13
History of still birth		
Yes	**6.03 (2.09–17.41)**	**0.001**
No	1	
Early marriage		
Yes	1.35 (0.66–2.76)	0.411
No	**1**	
Previous hypertension		
Yes	**10.80 (5.16–22.60)**	**< 0.0001**
No	1	
Previous anemia		
Yes	**5.26 (2.89–9.57)**	**< 0.0001**
No	1	
History of cardiac problem		
Yes	3.17 (0.59–16.81)	0.175
No	1	

Bold data are those which are significant and their significance is indicated by the *P*-values expressed at the right end of each ORs

identify pre-existing factors that could increase the risk of complications during pregnancy or delivery [28, 29]. Protective effect of ANC attendance for maternal near-miss event was also noted in other study too [15]. No ANC attendance could also be associated with some of the identified risk factors of maternal near-miss in the current study such as history of stillbirth and rural residency. However, we have checked the interaction among these variables, and no interaction was noted.

It was also observed that women with a history of anemia have higher odds of maternal near-miss than those without a prior history of anemia. Untreated anemia can lead to post-partum hemorrhage and hypovolemic shock and is a common cause of adverse maternal outcomes [30]. The higher risk of maternal near-miss for women with a prior history of anemia has also been identified in previous studies [14, 31].

Our study did not find that female genital cutting (FGC) was a determinant factor for maternal near-miss events. However, in a WHO multi-center study of female genital cutting, adverse obstetric outcomes were more frequent among cut than uncut women [32]. The possible reason for not getting a significant result in our study might be the fact that the study being underpowered for this specific factor.

This study is the first of its kind in Ethiopia to document the factors associated with maternal near-miss using the newly developed WHO case identification criteria. The use of nested case-control study design had also the advantage of ascertaining cause-effect relationship than a cross-sectional study. The cases and controls were also identified and interviewed prospectively, which helped us to avoid missing important confounding variables. To increase the power of the study, all cases observed during one-year period (collected for a different objective to determine the incidence of maternal near-miss) along with the corresponding three controls were included in the study. Potential sources of biases were also addressed in the current study. For instance, to minimize recall bias, we have taken hospital controls. Hence, the controls were more aware of the antecedent exposure so that there were equivalent degree of recall among cases and controls. In addition, cases and controls were interviewed when they became healthy near to their discharge time. To minimize bias related to measurements, the standardized WHO criteria were used to identify maternal near-miss cases. Furthermore, adequate training was given to data collectors, and there were strict supervision.

As the study was restricted only in public hospitals, it does not represent cases of maternal near-miss happened in private health facilities. The puerperium period defined by the WHO to define maternal near-miss lasts for 42 days post-partum. However, we followed the participants only till hospital discharge. Hence, we were unable to investigate the occurrence of other events such as maternal death occurred after maternal discharge. This might also underestimate the number of maternal near-miss cases reported during the study period.

Conclusions

History of chronic hypertension, rural residency, prior stillbirth, no antenatal care attendance and presence of prior anemia were the factors independently associated with the occurrence of maternal near-miss. Interventions aimed at improving better access to medical care for pregnant women with a history of chronic hypertension have a paramount importance. Health care professionals need to carefully plan and manage women with prior chronic hypertension. In addition, there is a need for counseling a pregnant woman about the risk of chronic hypertension during routine antenatal care visit. Strengthening the available health system in rural part of the country with focus on maternity service is also a crucial step to avert serious maternal complications. Scaling up of antenatal care in rural areas might have also a role to reduce obstetric risks among pregnant women. An effort to improve in infrastructure could also enhance referral chain from primary level to secondary and tertiary facility-level. Additionally, education of women on the importance of nutrition during pregnancy and supplementation of iron for pregnant women during ANC visits are important steps to avert critical morbidity experience related to anemia. It is also recommended to evaluate the underlying cause of anemia among pregnant women.

Abbreviations

ANC: antenatal care; AOR: adjusted odds ratio; CI: confidence interval; OR: odds ratio; USD: United States Dollar; VIF: variance inflation factor; WHO: World Health Organization.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

EFL is the primary author, participated in the conceptualization, design, acquisition, analysis and interpretation of the data and drafted the manuscript. AWY was the primary academic advisor, contributed for design,

acquisition, analysis and interpretation of the data and critically revised the manuscript. MFA and BE were co-advisors, contributed for design, acquisition, analysis and interpretation of the data and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The study was approved by the Institutional Review Board of the College of Health Sciences, Addis Ababa University (Protocol number: 058/14/SPH, Date: January 2015). In order to review the participants' record, permission was obtained from the administrators of each participating hospital. For observational studies, taking verbal consent is the standard requirement of the Institutional Review Board of Addis Ababa University. Hence, the participants gave verbal consent to be enrolled in the study after they received an adequate explanation of the study aim, benefits and potential harm. Privacy of the participants was maintained throughout the interview process. The confidentiality of all the information collected was strictly kept. The participants received an assurance that participation was voluntary and were informed as if they have full right of withdrawal from the study without affecting the care they were permitted to. Tikur Anbessa, St. Paul's Hospital Millennium Medical College, Zewditu Memorial, Yekatit 12 and Gandhi Memorial Hospitals were selected for the current study.

Consent for publication

Not applicable for this section.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

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Paper-III

Maternal near-miss and the risk of adverse perinatal outcomes: a prospective cohort study in selected public hospitals of Addis Ababa, Ethiopia

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Abstract

Background: Presence of maternal near-miss conditions in women is strongly associated with the occurrence of adverse perinatal outcomes, but not well-understood in low-income countries. The study aimed to ascertain the effect of maternal near-miss on the risk of adverse perinatal outcomes in Ethiopia.

Methods: A prospective cohort study was conducted in five public hospitals of Addis Ababa, Ethiopia. Women admitted from May 1, 2015 to April 30, 2016 were recruited for the study. We followed a total of 828 women admitted for delivery or treatment of pregnancy-related complications along with their singleton newborn babies. Maternal near-miss was the primary exposure and was ascertained using the World Health Organization criteria. Women who delivered without complications were taken as the non-exposed groups. The main outcome was adverse perinatal outcomes. Data on maternal near-miss and perinatal outcomes were abstracted from medical records of the participants. Exposed and non-exposed women were interviewed by well-trained data collectors to obtain information about potential confounding factors. Logistic regressions were performed using Stata version 13.0 to determine the adjusted odds of adverse perinatal outcomes.

Results: A total of 207 women with maternal near-miss and 621 women with uncomplicated delivery were included in the study. After adjusting for potential confounders, women with maternal near-miss condition had more than five-fold increased odds of adverse perinatal outcomes compared to women who delivered without any complications (AOR=5.69: 95% CI; 3.69 – 8.76). Other risk factors that were independently associated with adverse perinatal outcomes include: rural residence, history of prior stillbirth and primary educational level.

Conclusions: Presence of maternal near-miss in women is an independent risk factor for adverse perinatal outcomes. Hence, interventions rendered at improvement in maternal health of Ethiopia can lead to an improvement in perinatal outcomes.

Keywords: Maternal near-miss, adverse perinatal outcomes, prospective cohort study, public hospitals, Addis Ababa, Ethiopia.

Background

Maternal near-miss is defined by the World Health Organization (WHO) as 'a women who nearly died but survived a complication during pregnancy, childbirth or within 42 days of termination of pregnancy'[1].

Several studies have shown that the presence of maternal near-miss conditions in women is strongly associated with the occurrence of adverse perinatal outcomes such as stillbirth, preterm birth, low birth weight, early neonatal mortality, birth asphyxia, and admission to a Neonatal Intensive Care Unit (NICU) [2-7]. For instance, a study by Souza et al. in their multi- country study in eight Latin American countries highlighted that the occurrence of maternal near-miss in women is associated with low birth weight, stillbirth, admission to neonatal ICU and neonatal mortality [7]. Another study from Brazil reported that fetal and neonatal deaths, low birth weight, severe birth asphyxia and prematurity were higher among women with maternal near-miss compared to women who delivered without complications [4, 6]. Similarly, a study from Nigeria reported a four-fold risk of stillbirth and a three-fold risk of low birth weight infant among women with maternal near-miss conditions compared to women who delivered without complications [5].

Many previous studies on the association between maternal near-miss and adverse perinatal outcomes were either cross-sectional or case-control which are subjected to information bias [2, 5, 7]. Majority of the studies also used hospital records to abstract potential maternal characteristics which leads to lack of data on important confounding variables [4, 6]. These confounders may be alternative explanations for an observed association between exposure and outcome variables. Thus, it was not clear whether the adverse perinatal outcomes were due to

confounding or because of maternal near-miss [4, 6]. Up-to-date information on the effect of maternal near-miss on the risk of adverse perinatal outcomes is important to know the area of interventions that help to improve perinatal health of the country (Ethiopia). Nevertheless, studies that quantify the effect of maternal near-miss on adverse perinatal outcomes are rare in Ethiopia. Hence, the findings of the current study are important to fill the knowledge gap, and it may provide reliable evidence for policy makers, programmers and health practitioners to improve perinatal health of Ethiopia.

Methods

Study settings, design and period

A prospective cohort study was conducted in five public hospitals of Addis Ababa, capital of Ethiopia, from May 1, 2015 to April 30, 2016. The selected hospitals are the major referral hospitals in Ethiopia and provide specialized care both for the mother and neonate. All hospitals have obstetric and neonatal ICU and are responsible for a total of 29,697 live birth deliveries per year. The details of settings with location map have been described elsewhere [8].

Cohort selection, recruitment and exclusions

Women who developed maternal near-miss were the exposure group. Hence, all women admitted for delivery to the participating hospitals during the study period and fulfilled at least one of the WHO criteria were included as exposed group [1]. Women who delivered without any complications were enrolled as non-exposed group. The controls were selected based on the age-interval category and delivered on the same day of the near-miss event. The details of non-exposed (control) selection has been described elsewhere [9]. The study excluded any women

with maternal near-miss that was admitted to the participating hospital for the reason of abortion or ectopic pregnancy as this may not result in viable fetus to assess perinatal outcomes. In addition, those women with maternal near-miss who delivered at another facility (outside the included hospitals) were also excluded as it was difficult to know the perinatal outcomes. We have also excluded women with multiple pregnancies. A total of 31 women were excluded from the study.

Outcome measure

The primary outcome of interest was adverse perinatal outcomes and was categorized as presence or absence of it. Adverse perinatal outcomes were defined as the presence of either of the following: stillbirth, low birth weight, preterm birth, admission to neonatal ICU and first minute birth asphyxia. Stillbirth was defined as a newborn with no signs of life at or after 28 completed weeks of pregnancy. Low birth weight was defined as a newborn weight below 2500 gram. Preterm birth is a baby born alive before 37 completed weeks of gestation but after 28 weeks of gestation. Gestational age was determined on the basis of last menstrual period and ultrasound measures were taken when prediction by last menstrual period was not possible. In order to grade the severity of perinatal asphyxia in newborn, Apgar score was used. The score below 7 at the first minute of life were considered as having first minute birth asphyxia.

Potential confounders

The following variables were taken as potential confounders: (1) socio-economic and demographic characteristics of the women such as age, educational level, marital status, monthly income, (2) reproductive health and obstetric history of the women such as ANC status, number

of children, history of stillbirth, early marriage, (3) pre-existing medical conditions such as previous chronic hypertension, previous anemia and history of cardiac problems. The details of main confounders and their measure have been described elsewhere [9].

Sample size determination

The sample size was estimated using Epi Info 7 software using sample size determination for cohort studies. The parameters that were used to estimate the sample size were: confidence level of 95%, power of 80%, exposed to non-exposed ratio of 1:3, expected prevalence of outcome in non-exposed group 6%, and prevalence of outcome in exposed group to be 22.2%. It was estimated based on one study in Nigeria taking prevalence of birth asphyxia among exposed and non-exposed women to maternal near-miss [5]. Adding a 10% loss rate, the final sample size required for the study were 55 exposed and 165 non-exposed women; a total of 220 women. However, the current study was part of a larger study which required larger sample size. Thus, all available participants were considered in the current analysis to increase the power of the study.

Data collection

Information on still/live birth, birth weight, gestational age, Apgar score at 1st minute and admission to neonatal ICU were extracted from the medical records of both exposed and non-exposed women. The records were made during childbirth by health care professionals working in the delivery ward. At the end of childbirth, well-trained nurses and midwives extracted perinatal information for singleton babies using the data abstraction tool adapted from WHO [1]. Maternal near-miss data were also abstracted from medical record of the participants using the

WHO data abstraction tool [1]. To know other potential confounders of adverse perinatal outcomes, both exposed and non-exposed women were interviewed using pre-tested structured questionnaires. The participants were interviewed when they became healthy near to their discharge time. The details of questionnaire preparation and maternal near-miss assessment were explained elsewhere [8, 9].

Data analysis

The data were entered using Epi Info 7 software and analyzed using Stata version 13.0. Cleaning of the data was performed prior to analysis. To see whether there is a statistically significant difference between exposed and non-exposed women with regard to selected categorical variables, chi-square tests were performed. Continuous variables were summarized using the median and Mann-Whitney U test was used for comparison between groups. The statistical significance was set at $p < 0.05$. In order to know the crude association between maternal near-miss and adverse perinatal outcomes, crude odds ratio (COR) of adverse perinatal outcomes with 95% confidence interval (CI) were calculated among exposed and non-exposed women. In addition, *P*-value and crude odds ratio with 95% CI were calculated for each potential confounding variable to evaluate the crude association between potential risk factors and adverse perinatal outcomes. The number and proportion of the outcome variable with regard to exposure status were also calculated. Those variables with $p < 0.2$ from the bivariate analysis were considered for binary logistic regression.

Logistic regression analysis was performed to see the effect of maternal near-miss on adverse perinatal outcomes while controlling for potential confounders. Adjusted odds ratios (AOR) with

95% CI were calculated for each independent variable to see the adjusted association between exposure variables and adverse perinatal outcomes.

Model fitness was assessed using Hosmer–Lemeshow goodness-of-fit tests. Poor fit was indicated by a significance value less than 0.05. Because the significance value of the calculated model in the current analysis was greater than 0.05, there was insufficient evidence of poor model fit.

To check for the presence of multicollinearity among exposure variables, Stata's estat vif command was used to calculate the variance inflation factors (VIF) for each exposure variable. Possible multicollinearity was suggested if the largest VIF is greater than 10. As all the calculated VIF of each exposure variable in our study was less than 10, no possible multicollinearity was observed.

Results

During the one-year period, a total of 238 women with maternal near-miss were observed in the five participating hospitals. However, 22 of them were at less than 28 weeks of gestation and 9 cases gave birth outside the participating hospitals. Hence, we finally considered and followed 207 women with maternal near-miss (exposed women) and 621 corresponding non-exposed women (uncomplicated delivery group) as a cohort for final analysis.

Women exposed to maternal near-miss tended to be illiterate ($p < 0.001$), unmarried ($p = 0.021$), had less monthly income ($p = 0.003$) and more likely to reside in the rural area ($p <$

0.001) compared to non-exposed women. The two groups did not significantly differ in terms of age ($p = 0.673$), religion ($p = 0.676$) and ethnicity ($p = 0.054$) (Table 1).

Compared to non-exposed women, majority of the exposed women were less likely to receive ANC ($p < 0.001$) and more likely to have had more than five children ($p = 0.013$), a history of stillbirth ($p < 0.001$) and married early ($p = 0.041$). There was no statistically significant difference among the two groups with regard to the female genital cutting (FGC) status of the women ($p = 0.201$) (Table 1).

Women with maternal near-miss were more likely to report a previous history of chronic hypertension and cardiac problems (both $p < 0.001$) (Table 1).

Table 2 is about comparison of the adverse perinatal outcomes among exposed and non-exposed women. From a total of 828 women delivered in the participating hospitals, 36.6% (95% CI:33.4% – 39.9%) of them end up in a wide range of adverse perinatal outcomes such as stillbirth, preterm birth, low birth weight infant, birth asphyxia and admission to neonatal ICU. The prevalence of adverse perinatal outcomes was significantly higher among women who were exposed to maternal-near miss compared to the non-exposed women, 72.9% (95% CI: 66.5% – 78.5%) versus 24.5% (95% CI:21.3% – 28%) respectively, $p < 0.001$. Babies born from women with maternal near-miss were more likely to be stillborn ($p < 0.001$), preterm ($p < 0.001$), of lower birth weight ($p < 0.001$), admitted to neonatal ICU ($p < 0.001$) and tended to have had a birth asphyxia in the first minute ($p < 0.001$) (Table 2).

A statistically significant difference in hospital stay was also observed between the two groups. Women with maternal near-miss were more likely to have a longer median hospital stay of 6 days compared to non-exposed women with a median hospital stay of 1 day ($p < 0.001$).

Risk factors of adverse perinatal outcomes

After adjustment for potential confounders such as educational level, place of residence, monthly income, ANC status, history of stillbirth, and presence of previous chronic hypertension, anemia, and cardiac problems in a logistic regression analysis, the association between maternal near-miss and adverse perinatal outcomes remained significant. The odds of developing adverse perinatal outcomes among women who developed maternal near-miss was more than five times higher than among women with no maternal near-miss (AOR= 5.69: 95% CI;3.69 – 8.76) (Table 3).

Educational level, place of residence and prior stillbirth delivery also remained independently associated with adverse perinatal outcomes in logistic regression analysis. The effect of maternal near-miss on adverse perinatal outcome was exacerbated when the women had a primary level of education (AOR=1.89: 95% CI; 1.07 – 3.34), resided in rural areas, (AOR=2.16: 95% CI; 1.03 – 4.53) and had a history of stillbirth (AOR=2.39; 95% CI; 1.12 – 5.10) (Table 3).

Discussion

The main finding of the study is that the presence of maternal near-miss is a risk factor for adverse perinatal outcomes independent of educational level, place of residence, monthly income, ANC follow-up, history of stillbirth, and presence of previous hypertension, anemia and cardiac problems.

Higher risk of adverse perinatal outcomes such as stillbirth, low birth weight, preterm birth, admission to neonatal ICU, birth asphyxia and early neonatal mortality were also observed among maternal near-miss women in studies conducted in Nigeria, Brazil and other 8 Latin American countries [5-7]. The Nigerian study used case-control design and higher risk of poor perinatal outcomes such as stillbirth and low birth weight infants were reported among women with maternal near-miss compared to the control group [5]. Serious maternal complications generally will lead to interventions which sometimes may also reduce gestational age and thus lead to preterm birth and low birth weight. Unlike the present study, information on potential confounders has been obtained from the medical records in other studies [6, 7]. Hence, the previous studies might be subjected to information bias due to incompleteness and poor quality of secondary data at the health facility. A woman with maternal near-miss could develop severe conditions which include eclampsia, anemia, ante-partum hemorrhage and placenta praevia among others. These severe conditions can affect the fetus, for example, through placental insufficiency leading to intrauterine growth restriction (IUGR). Preeclampsia, for instance, is associated with IUGR and prematurity [10]. IUGR is associated with distress and asphyxia and is the second cause of perinatal deaths [11, 12]. Studies also documented that preterm babies are immature and more likely to be stillbirth, smaller, require an ICU and are a major cause of neonatal mortality [13, 14]. Reduction in adverse perinatal outcomes among pregnant women might be achieved through provision of proper ANC to early diagnose placental insufficiency. The information is also important for health care providers to conduct different tests that detect placental insufficiency. It also highlights the importance of treating the underlying maternal conditions such as high blood pressure and anemia. It further signifies the importance of health education for pregnant women on various issues such as frequent ANC visits and bed rest.

The study also documented that women in rural locations were more likely to experience adverse perinatal outcomes regardless of the near-miss status of the women. This is in agreement with other studies [15, 16]. Studies shown that women residing in rural areas with no access to obstetric care had to travel longer to get routine antenatal care and skilled birth attendance, barriers associated with adverse perinatal outcomes [17, 18]. For instance, various studies reported that higher numbers of low birth weight babies were seen in women who had irregular ANC visits compared to women who had regular ANC checkups [19, 20]. Rural women are also relatively disadvantaged in terms of their socio-economic status which could possibly increase their risk of adverse perinatal outcomes. For example, rural women tend to have a lower educational level and higher rate of poverty compared to urban women [21].

In this study, women who had prior stillbirth in preceding births were at higher risk of having adverse perinatal outcomes than women without a history of stillbirth. Available evidence suggests that women with stillbirth in their prior pregnancy were at higher risk of adverse perinatal outcomes in subsequent pregnancies [22-27]. Another independent risk factor for adverse perinatal outcomes was level of education. Women who had a primary level of education had a higher risk of having adverse perinatal outcomes than those with a higher level of education. Education enhances the health care seeking behavior of the women so that they can effectively utilize maternal health care services when complications happen [28]. A growing body of literature has revealed that lower levels of maternal education were associated with an increased risk of variety of adverse perinatal outcomes [16, 25, 29-31].

The study has several strengths. To our knowledge, this study is the first of its kind in Ethiopia to document the effect of maternal near-miss on adverse perinatal outcomes using a prospective cohort design. The study used the standard WHO criteria to assess maternal near-miss and hence, we ascertained the exposure status. We studied a variety of perinatal outcomes which includes stillbirth, preterm birth, birth weight, birth asphyxia and admission to neonatal ICU. We also collected information on many confounding variables. To see the effect of adverse perinatal outcomes among exposed and non-exposed groups, the effect of other possible determinants of adverse perinatal outcomes were controlled during analysis. Furthermore, adequate training was given to data collectors to obtain data in the same fashion which avoids the presence of bias related to measurements. There was also no loss to follow-up in our study. Although there is a considerable variation in severity among the different perinatal outcomes investigated in our study, we opt to merge these outcomes. This is due to the fact that the sample size was not sufficient to separately investigate the outcomes, thus merging increased the sample size and minimized the role of chance.

Because of logistic and feasibility concerns, the study did not look for some of the important perinatal outcomes such as neonatal mortality among women with maternal near-miss. The short and long term maternal consequences of near-miss events were also not addressed in the current study which calls for the importance of other big studies. Although near-miss includes events within 42 days of termination of pregnancy, we followed women only to the length of hospital stay because of logistic and feasibility concerns. Although the five minutes Apgar score is more sensitive indicator of birth asphyxia, we have considered the one minute Apgar score in our study.

The study was conducted only in public hospitals. Hence, the pattern of adverse perinatal outcomes among the two groups does not represent the larger group in the population. However, the results of the study can be generalized to public hospitals in Addis Ababa, beyond those hospitals included in the current study. Poor perinatal outcomes could be related to poor quality of care around childbirth [32]. However, the study did not explore quality of care domains. Hence, we recommend further studies to better understand challenges to quality of care for women and newborns.

Conclusions

The study demonstrated that women with maternal near-miss complications during pregnancy and delivery were more likely to have adverse perinatal outcomes. Hence, this suggests that evidence-based interventions rendered at improvement in maternal health of Ethiopia can lead to an improvement in perinatal outcome.

List of abbreviations

AOR: adjusted odds ratio; Apgar: activity, pulse, grimace, appearance, and respiration; ANC: antenatal care; CI: confidence interval; COR: crude odds ratio; FGC: female genital cutting; IUGR: intrauterine growth restriction; ICU: intensive care unit; NICU: neonatal intensive care unit; VIF: variance inflation factors; WHO: World Health Organization

Declarations

Ethics approval and consent to participate

The study was first approved by the Institutional Review Board of the College of Health Sciences, Addis Ababa University (Protocol number: 058/14/SPH, Date: January 2015). In order to review the participants' records, permission was obtained from the administrators of each hospital. For observational studies, taking verbal consent is the standard requirement of the Institutional Review Board of Addis Ababa University. Hence, the participants gave verbal consent to be enrolled in the study after they received an adequate explanation of the study aim, benefits and potential harm. Privacy of the participants was maintained throughout the interview process. The confidentiality of all information collected was strictly kept. The participants received an assurance that participation was voluntary and were informed as if they have full right of withdrawal from the study without affecting the care they were permitted to.

Consent for publication

Not applicable for this section.

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

EFL is the primary author, participated in the conceptualization, design, acquisition, analysis and interpretation of the data and drafted the manuscript. AWY was the primary academic advisor, contributed for design, acquisition, analysis and interpretation of the data and critically revised the manuscript. MFA and BE were co-advisors, contributed for design, acquisition, analysis and interpretation of the data and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Tables

Table 1 Distribution of selected variables among women with near-miss and uncomplicated delivery women in selected five public hospitals, Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Near-miss group (n=207)	**Uncomplicated delivery group (n=621)**	***P*-value**
Characteristics	**n (%)**	**n (%)**	
Educational level			
Illiterate	57 (29.2)	75 (12.2)	< **0.001**
Primary	62 (31.8)	201 (32.7)	0.323
Secondary	55 (28.2)	249 (40.5)	0.847
Higher	21 (10.8)	90(14.6)	
Place of residence			
Urban	153 (73.9)	608 (97.9)	
Rural	54 (26.1)	13 (2.1)	< **0.001**
Marital status			
Married	192 (92.8)	600 (96.6)	
Never married	15 (7.2)	21 (3.4)	**0.021**
Monthly income			
> 68 USD	76 (36.7)	108 (17.4)	**0.003**
68 - 181 USD	73 (35.3)	358 (57.6)	**0.002**
>181 USD	58 (28.0)	155 (25.0)	
Received ANC			
Yes	177 (85.5)	611 (98.4)	
No	30 (14.5)	10 (1.6)	**<0.001**
Number of children			
0-2	164 (79.2)	507 (81.6)	0.855
3-4	32 (15.5)	103 (16.6)	
>5	11 (5.3)	11 (1.8)	**0.013**
Undergone FGC			
Yes	129 (64.5)	366 (59.4)	0.201
No	71 (35.5)	250 (40.6)	
History of stillbirth			

Yes	20 (9.7)	20 (3.2)	**<0.001**
No	187 (90.3)	601 (96.8)	
Early marriage			
Yes	41 (21.5)	90 (15.1)	**0.041**
No	150 (78.5)	506 (84.9)	
Previous hypertension			
Yes	54 (26.1)	16 (2.6)	**<0.001**
No	153 (73.9)	605 (97.4)	
Previous anemia			
Yes	70 (33.8)	63 (10.1)	**<0.001**
No	137 (66.2)	558 (89.9)	
History of cardiac problems			
Yes	11 (5.3)	5 (0.8)	**<0.001**
No	196 (94.7)	616 (99.2)	

***Chi-square test was used to obtain the p-value**

Table 2 Prevalence of adverse perinatal outcomes among women with near-miss and uncomplicated delivery women in selected five public hospitals, Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Groups				***P*-value**	**COR (95 % CI)**
	Uncomplicated delivery (n=621)		**Near-miss (n=207)**			
Outcome variables	**No**	**%**	**No**	**%**		
Adverse perinatal outcomes	152	24.5	151	72.9	<0.001	**8.32 (5.82 – 11.89)**
Stillbirth	24	3.9	61	29.5	<0.001	**10.39 (6.27 – 17.23)**
Preterm birth	48	7.7	84	40.6	<0.001	**8.15 (5.44 – 12.22)**
Low Birth weight	50	8.1	82	39.6	<0.001	**7.49 (5.02 – 11.19)**
Asphyxia at 1 min	73	11.8	119	57.5	<0.001	**10.15 (7.03 – 14.67)**
Admitted to **NICU	52	8.4	61	29.5	<0.001	**4.57 (3.03 – 6.9)**

***Chi-square test was used to obtain the p-value**

****NICU stands for Neonatal Intensive Care Unit**

Table 3 Maternal near-miss and odds of adverse perinatal outcomes in relation to other confounding variables in selected five public hospitals, Addis Ababa, Ethiopia, May 1, 2015 to April 30, 2016

	Adverse perinatal outcomes	
	COR (95% CI)	***AOR (95% CI)**
Characteristics		
Maternal near-miss		
Yes	**8.32(5.82-11.89)**	**5.69(3.69-8.76)**
No	1	1
Educational level		
Illiterate	**3.11(1.79-5.04)**	1.56(0.80-3.04)
Primary	**2.03(1.24-3.35)**	**1.89(1.07-3.34)**
Secondary	1.37(0.83-2.26)	1.45(0.83-2.52)
Higher	1	1
Place of residence		
Rural	**7.74(4.21-14.21)**	**2.16(1.03-4.53)**
Urban	1	1
Monthly income		
<68 USD	**1.89(1.26- 2.82)**	1.21(0.73-1.98)
68 to 181 USD	.77(.55- 1.09)	0.87(0.58-1.32)
> 181 USD	1	1
Received ANC		
Yes	1	1
No	**5.66(2.73- 11.75)**	1.86(0.79-4.41)
History of stillbirth		
Yes	**3.43(1.76- 6.67)**	**2.39(1.12-5.10)**
No	1	1
Previous hypertension		

Yes	**3.49(2.09- 5.82)**	1.24(0.66-2.32)
No	1	1
Previous anemia		
Yes	**2.05(1.41- 2.98)**	0.98(0.61-1.57)
No	1	1
Previous cardiac problems		
Yes	**2.95(1.06- 8.21)**	1.29(0.36-4.56)
No	1	1

* Single model was used to produce the AORs.

*Adjusted for the eight variables shown in the table.

Bold data are those which are significant

Declaration

I, the under signed, declared that this is my original work, has never been presented in this or any other University, and that all the resources and materials used for the dissertation, have been fully acknowledged.

Name: _____

Signature: _____

Date: _____

Place: _____

Date of submission: _____

This dissertation has been submitted for examination with my approval as University Supervisor.

Name: _____

Signature: _____

Date: _____