Improving neonatal survival in East Africa Analysis of maternal service utilization, effectiveness of care and risk factors for neonatal mortality in Kenya, Uganda, and Tanzania.

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Improving neonatal survival in East Africa

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Malachi Ochieng Arunda

DOCTORAL DISSERTATION
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Title: Improving neonatal survival in East Africa: analysis of maternal service utilization, effectiveness of care and risk factors for neonatal mortality in Kenya, Uganda, and Tanzania.

Abstract

Despite profound progress made in reducing neonatal mortality, it remains one of the major global health challenges. In 2019, the World Health Organization estimated that 2.4 million neonatal deaths occurred, accounting for over 45 percent of under-5 deaths worldwide. Most of these neonatal mortalities occur in low- and middle-income (LMIC) with East African countries of Kenya, Uganda and Tanzania among countries reporting persistent slow decline in neonatal death rates. The major causes of neonatal deaths include prematurity, infections and birth complications, most of which are preventable. Very limited population-based research has been conducted to examine determinants of continued care utilization from pregnancy to postnatal period, effectiveness of care as well as the impact of leading risk factors for neonatal deaths in Kenya, Uganda and Tanzania. Thus, the aim of this thesis was to examine the determinants of maternal care utilization, effectiveness of care and risk factors for neonatal mortality in Kenya, Tanzania, and Uganda. The findings, of which are contributing to further research around the world and could have significant implications for policy development, prioritization and resource allocations in public health and care systems in the three most populated East African Community countries. We used nationally representative cross-sectional data from the demographic and health surveys in the respective countries. In Study I we found that lack of antenatal (ANC) attendance, unskilled ANC provision and lack of check-ups for pregnancy complications were among the leading indirect risk factors for preventable neonatal mortality in Kenya. Study II concluded that low birthweight contributes a substantial proportion of neonatal deaths in Uganda. Study III reported that the disproportionate access to caesarean delivery has widened along socioeconomic lines in Tanzania and Kenya. Higher risk of caesarean-related deaths exists. Out of the findings of Study IV, we suggested the need for a comprehensive review to develop a toolkit using care utilization information to enable classification of maternal care-seeking behaviour and adopt new strategies to close the care-seeking gaps. Study V found much higher neonatal deaths among married adolescents with unintended pregnancies adolescent-born neonates from unintended pregnancies and proposed strengthening of existing strategies and use of new approaches to reduce adolescent pregnancies and provide focused obstetric care for adolescents. The thesis suggests an array of evidence-based interventions to improve neonatal survival ranging from education and contraceptive use to improved ANC and postnatal care attendance.

Key words

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MADE IN SWEDEN

To my dearest family.

The fruit of the spirit is love, joy, peace, patience, kindness,
generosity, faithfulness, gentleness, and self-control.
Against such things there is no law.
Galatians 5: 22-23

Abbreviations

ANC	Antenatal care
CD	Cesarean delivery
PNC	Postnatal care
DHS	Demographic and Health Survey
LBW	Low birthweight
TT	Tetanus toxoid
LBW	Low birthweight
LMIC	Low - and Middle - income countries
SSA	Sub-Saharan Africa
HIC	High income countries
WHO	World Health Organization
UN	United Nations
UNICEF	United Nations Children´s Fund
UNFPA	United Nations Populations Fund
PMNCH	Partnership for Maternal, Newborn and Child Health

List of publications

This thesis project is based on the following studies:

I. Arunda M, Emmelin A, Asamoah BO. Effectiveness of antenatal care services in reducing neonatal mortality in Kenya: analysis of national survey data. Glob Health Action. 2017;10(1):1328796.

II. Arunda MO, Agardh A, Asamoah BO. Survival of low birthweight neonates in Uganda: analysis of progress between 1995 and 2011. BMC Pregnancy Childbirth. 2018 May 30;18(1):189.

III. Ochieng Arunda M, Agardh A, Asamoah BO. Cesarean delivery and associated socioeconomic factors and neonatal survival outcome in Kenya and Tanzania: analysis of national survey data. Glob Health Action. 2020 Dec 31;13(1):1748403.

IV. Arunda MO, Agardh A, Asamoah BO. Determinants of continued maternal care-seeking during pregnancy, birth and postnatal period and associated neonatal survival outcomes in Kenya and Uganda: analysis of demographic and survey data. *Accepted for publication.*

V. Arunda MO, Agardh A, Asamoah BO. Survival of adolescent-born neonates and the effect of pregnancy intentions and marital status on survival patterns: analysis of cross-sectional surveys in Kenya, Uganda, and Tanzania, 2014–2016. *Manuscript*

Contents

Introduction

Reducing neonatal mortality (newborn death within 28 days after birth) has been a persistent major global challenge and although profound progress has been made (1), it still accounts for about 45 percent of under-5 deaths worldwide(2). In 2019, over 2.4 million neonates died, over 80 percent of whom occurred in sub-Saharan Africa (SSA), and in southern and central Asia (2). The recent United Nations Inter-agency Group for Child Mortality Estimation reported that there was no decline in neonatal mortality rates in 21 out of 48 countries in SSA in about three decades, between 1990 and 2019 (2). The wider disparities in neonatal mortality rates (NMR) across and within regions and countries is a major indication that most of the neonatal deaths are preventable. For instance when comparing sub-Saharan Africa with highest NMR (27 deaths per 1000 live births) and Europe with the lowest NMR (3 deaths per 1000 live births) (2).

Sustainable development Goal (SDG) 3

The SDG 3 that aims to "ensure healthy lives and promote well-being for all at all ages", has its specific target 3.2, "to reduce neonatal deaths to at least as low as 12 deaths per 1000 live births by 2030" (3). A recent study in The Lancet projected that about 60 countries need to expedite their progress in order to meet the SDG 3.2 target (1). To achieve this, target 3.8, that aims "to achieve universal health coverage" (UHC) was also adopted. The UHC intends to achieve universal access to essential health services including maternal and child health care services for at least 1 billion more people every five-years since 2015 leading to 2030. Acknowledging that poverty is a major risk factor for mortality, one of the main focus of UHC is to eliminate out-of-pocket health expenditure that impoverishes many households, particularly in low-and middle-income countries (4, 5). Although the progress of attaining UHC has been hampered by the Covid-19 pandemic since 2020, WHO together with UNICEF, World Bank, Ministries of Health and other global partners continue to work to support attainment of the UHC target (4, 6, 7).

Another strategy that was previously adopted and contributes to the realization of target 3.2 was the *Global strategy for women´s, children´s and adolescents´ health.* This strategy takes a life-course approach and aims among others to end preventable newborn deaths as well as prevent maternal and adolescents' deaths and stillbirths by 2030 (8). The Global strategy emphasizes human rights, equity and universality in its approach and aims to meet the needs of all, including the most vulnerable and marginalized. It highlights the immense returns countries would realize (both in health and economic growth) from investing in women´s, children´s and adolescents´ health in their course of life from birth through childhood to adolescence and adulthood (8).

Global inequalities in maternal and newborn health service utilization

Whereas removal of barriers to maternal care utilization has been a major global priority over the years (9), socioeconomic inequalities that limit access to maternal and newborn health services are still widespread in most low-and middle-income countries (LMIC). A recent systematic review by Ogundele et al. found that the socioeconomic inequalities in reproductive care utilization in sub-Saharan Africa was highest for skilled childbirth but varies in different countries. Nonetheless, progress has also been observed in certain countries. An analysis of trends in usage of ANC and skilled birth attendance among young mothers in Ghana by Asamoah and Agardh, indicated that inequalities related to place of residence and education levels declined overtime between 2003 and 2014 (10). However, wealth-related inequalities in ANC and childbirth service utilization are persistently high in many countries (10-12). The consequences of these inequality are costly to individuals and societies. Estimates from UNFPA indicate that universal access to modern contraceptives, maternal and newborn services would save millions of maternal and neonatal lives and gain billions of monetary benefits to countries (13).

Continuum of care

In 2005, WHO shifted its strategy from addressing maternal and newborn health care separately to advocating for continuum of maternal care approach through achieving universal health coverage (14). The continuum of care would enable equitable and high coverage of maternal and child health care from pregnancy through childbirth to first few weeks after childbirth (14, 15). Given that most neonatal deaths occur within the first 7 days after birth, continuum of care would enable linking of maternal and newborn interventions from pregnancy to postnatal period thus building a strategic interaction to improve access and utilization of health care (16).

Antenatal care attendance

Antenatal care (ANC), referred to as routine care given to pregnant women between conception and onset of labour (17), is one of the leading strategies that is universally recommended to prevent neonatal and maternal morbidities and deaths (18-20) . In high income countries (HIC) such as in Sweden, in 2019, almost all (98%) pregnant women attended about 8–12 ANC bookings with skilled midwives (21, 22). In comparison, a 2018 study in low-and middle-income countries (LMIC), indicated that 90% of pregnant women attended at least 1 ANC visit and in about 55 countries with known statistics, only 44% had 4 or more ANC visits (23). In 2013, early ANC visits (visit during first trimester) was about 48% in LMIC compared to 85% in high income countries (17). These disparities in ANC attendance between HIC and LMIC perhaps explain much of the mortality differences between the regions. Further, many countries with high coverage in sub-Saharan Africa and Southern Asia have poor and low quality of health care(23). Evidence-based findings by WHO show that at population level, the higher the ANC visits, the lower the neonatal mortality rates (18, 19). As such, in 2016 WHO increased the recommended ANC visits in LMIC to at least 8 from previous 4 visits (18).

Health facility birth (skilled birth attendance)

Health facility birth, largely conducted by skilled birth attendants is recommended by WHO for favorable neonatal outcomes (24, 25). WHO defines skilled birth attendance as "care provided to a woman and her newborn during pregnancy, childbirth and immediately after birth by an accredited and competent health care provider who has the necessary equipment and support of a functioning health system, including transport and referral facilities for emergency obstetric care" (24). Utilization of institutional childbirth services range from over 99 % in many high- and upper-middle-income countries to less than 50% in several low-income countries (26, 27). Factors that hinder facility childbirth service utilization in LMIC include socioeconomic factors, women`s lack autonomy in health decision making, longer distance to health facilities, lack of hospital supplies and poor attitudes of health providers among others (28-30)

Whereas a number of population-based studies in LMIC associate facility delivery to positive neonatal outcomes (31), others only agree in part. Instead, the studies indicate that facility births are associated with neonatal protective effects only when mothers experienced obstetric complications (32, 33). Nonetheless, neonatal mortality in LMIC is a complex phenomenon involving several other factors at individual, community and health facility levels associated with delays to seek or receive care (34), which in-turn are a result of socioeconomic inequalities (35) and longer distance to health facilities among other factors (36). Further, inadequate training and lack of emergency facilities in many health institutions as well as poor quality of care and referral systems are also indirect risk factors for neonatal deaths (37-39).

Postnatal care

Postnatal care (PNC) is another key strategy that profoundly contribute to neonatal survival but that is severely underutilized particularly in many LMIC (40). A multi-country study in 36 sub-Saharan Africa countries indicated that PNC utilization between 2008 and 2018 was 52.5%, with Eastern Africa having the lowest PNC attendance of 31.7% (41). More than two-thirds of all neonatal mortalities occur during postnatal, first week after birth (41-43). WHO recommends that for institutional births, mother and newborn(s) be given PNC for at least 24 hours after birth and for home births, the first PNC contact should be within 24 hours (40). Given that about one-third of all newborn deaths occur within a day(2), this recommendation, if adhered to could prevent many newborn deaths. Follow up PNC visits should be after 3 days, implying that most (75%) of the preventable neonatal deaths could be avoided by comprehensive PNC. Other visits are recommended within 7-14 days and 6 weeks after birth (40).

Causes of neonatal mortality

The leading direct (clinical) causes of neonatal deaths are infections such as *sepsis, pneumonia, meningitis, tetanus and diarrhoea,* preterm and intrapartum-related complications such as *birth asphyxia* (43-45). Low birthweight is a major underlying (intermediate) obstetric risk factor for neonatal deaths associated with most of the direct causes of newborn mortality (46). Other non-causal risk factors for neonatal mortality include sociodemographic, maternal and newborn factors that are hypothesized to either hinder care-seeking and/or are indirectly associated with neonatal death or risk factors for neonatal deaths. These include living in rural areas (47), inadequate care utilization (48), low maternal or paternal education(49, 50), poverty (51), single motherhood (52), young maternal age(50), lack of knowledge about neonatal complications (53), and male sex of newborn (50) among others.

Kenya, Uganda, and Tanzania

Kenya, Uganda, and Tanzania have relatively similar demographics. With an estimated total population of over 130 million in 2014-2019 and sex ratio roughly 1.1 (54-56), they constitute the most populated countries among all 6 East Africa Community member states. Fertility rates range from 3.9 in Kenya (57) to 5.4 in Uganda (55). About 23–43 percent of women have their first child before 19 years of age (55, 57, 58). Modern contraceptive use among married women of reproductive age, 15-49 years in 2014-2016 ranged from 32% in Tanzania, 35% in Uganda to 53 % in Kenya (59-61).

Policies and health system challenges in Kenya, Uganda, and Tanzania.

The three countries are in comparable state of maternal and neonatal health situation and are in the pathway towards achieving universal health coverage. Being signatory of the SDGs, Kenya, Uganda, and Tanzania have strengthened their commitment to reduce preventable neonatal and maternal deaths. This is evidenced by the national roadmaps and strategic plans aimed to improve maternal and child care in Uganda (62), Tanzania (63) and Kenya (64, 65). Policy frameworks of the National Health Sector Development Plan, 2015-2020 in Uganda (66), the Kenya Community Health Strategy, 2020-2025 (65) and the Strategic plan to improve maternal, newborn, child and adolescent health in Tanzania, 2016-2020 (63) have all adopted the right based approach to expedite progress towards universal health coverage (UHC) and minimize inequalities and discriminatory practices in access to quality health care including maternity care. Nonetheless, despite the efforts, the health care systems in the three countries are insufficiently funded and have workforce shortages thus affecting access and quality of services. The health expenditures as a percentage of national gross domestic product (GDP) for each of the three east African countries in 2015/2016 and currently is about half (7%) of the Abuja declaration target of 15% (67-71). Free and subsidized maternity and child health care do exist at first level health facilities in Kenya, Uganda, and Tanzania (72-76).

Neonatal mortality in Kenya, Uganda, and Tanzania

The WHO progress report of 2020 indicate that Kenya, Uganda and Tanzania are among 20 countries with the highest neonatal deaths globally (77). The neonatal mortality rates in these three countries ranged from 20–22 deaths per 1000 live births in 2016 (78).The causes of which are similar to those reported globally (79).

Conceptual framework: Determinants of neonatal mortality in Kenya, Uganda, and Tanzania

The conceptual framework of this thesis is adapted from Mosley and Chen´s proximate determinants framework, WHO and UNICEF frameworks for child survival and social determinants of health in low-and middle-income countries. According to Mosley and Chen, given optimal settings, over 97 percent of live-born neonates can be expected to survive (80). The proximal determinants such as maternal age or antenatal care attendance that directly influence the risk of neonatal deaths are based on the premise that (neonatal) survival in any society is dependent on socioeconomic, biological and environmental forces (80). The WHO`s social determinants of health framework for action highlights how social factors at individual or societal levels substantially shape inequitable access to health leading to poor neonatal survival outcomes (81). The UNICEF model links the interrelated underlying risk factors showing how factors at one level impacts other levels leading to the direct causes of neonatal (and maternal) death (82).

The detailed framework can be seen in Figure 1.

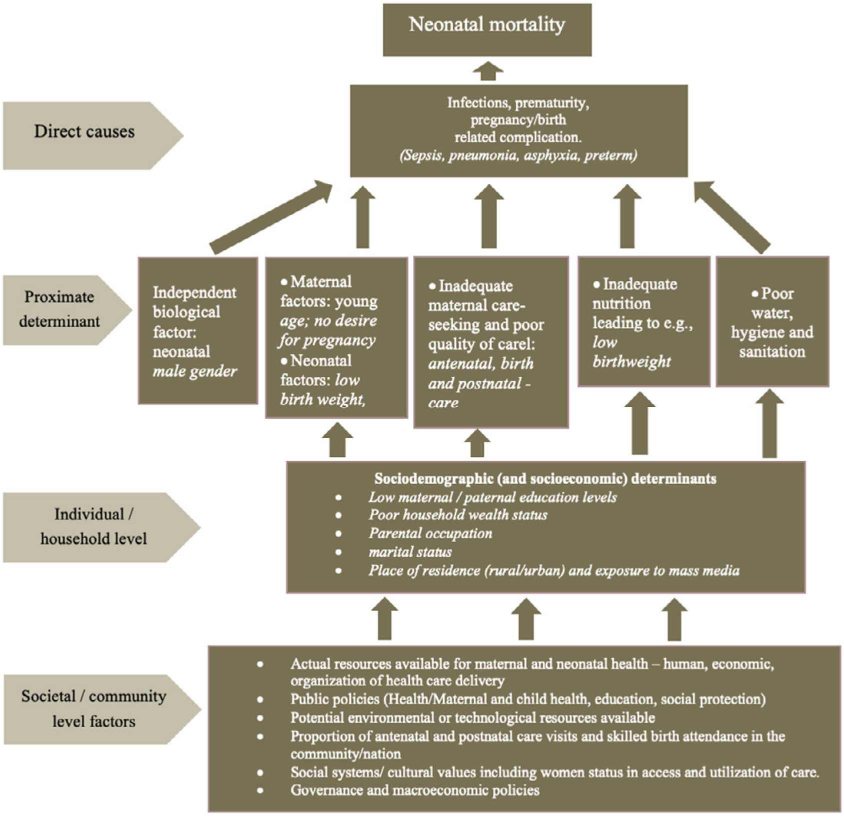


Figure 1: Conceptual framework for direct and indirect risk factors associated with neonatal mortality in Kenya, Uganda, and Tanzania, adapted from Mosley and Chen, WHO, and UNICEF frameworks for child survival and social determinants of health in Low-and middle-income countries.

Analytical model

The analytical model in Figure 2 shows a summary of how individual studies of this thesis project contribute to the whole. It reflects how direct risk factors for neonatal death such as birth-related complications, prematurity and infections are linked to the intermediate and indirect risk factors that form the variable basis for this thesis from pre-pregnancy through childbirth to postnatal period. Study I focus on factors surrounding pregnancy period and neonatal survival outcomes. Study II focuses on a major underlying risk factors associated with postnatal morbidity and mortality. Study III examines factors associated with access to emergency or advance obstetric procedure. Study IV complements all the first three studies by investigating a combination of all the major maternity and newborn care intervention while study V examines a major proximate factor associated with biological and physiological risk factor to neonatal survival.

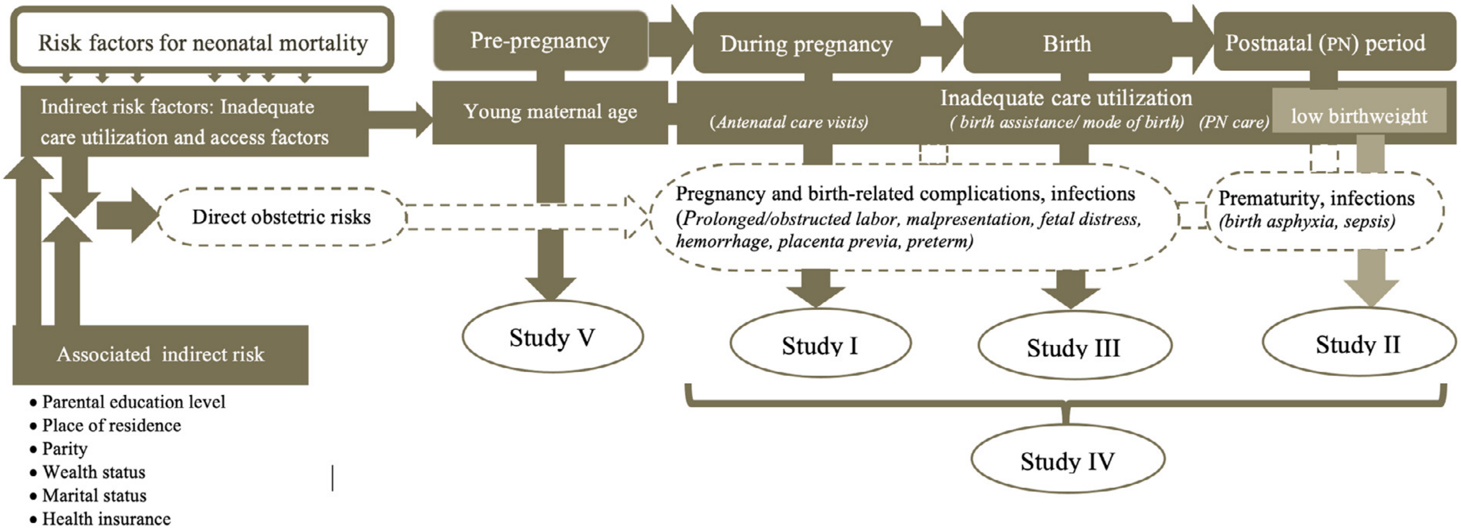


Figure 2: Analytical model showing specific pathways of risk factors for neonatal mortality and care interventions investigated by studies 1-V.

AIM

General aim

To examine determinants of maternal service utilization, effectiveness of care and risk factors for neonatal mortality in Kenya, Tanzania, and Uganda.

Specific aims

To examine the effectiveness of antenatal care services in reducing neonatal mortality in Kenya.

To determine the association between low birthweight and neonatal mortality in Uganda and to estimate the national trends of LBW-attributable neonatal mortality between 1995 and 2011.

To examine the socioeconomic factors associated with cesarean delivery in Kenya and Tanzania and to assess the impact of cesarean delivery on neonatal survival in both countries.

To investigate determinants of continued maternal care-seeking during pregnancy, birth and postnatal and associated neonatal survival outcomes in Kenya and Uganda: analysis of cross-sectional, demographic and health survey data.

To assess survival patterns of neonates born to adolescent mothers and the effect of pregnancy intentions and marital status on newborn survival in Kenya, Uganda, and Tanzania, 2014–2016.

Materials and Methods

Study setting

The five studies in this thesis were conducted in East Africa region, in Kenya, Tanzania, and Uganda. The three countries neighbour each other and have a total population of about 130 million in 2016. Their population growth rates are relatively high. Majority live in rural areas with agriculture as their main source of livelihood. Table 1 provides summary of the specific settings, aim and study populations for each of the five studies.

Data source and study design

All the studies I–V in this thesis obtained data from the Demographic Health Surveys (DHS) program in Kenya, Uganda, and Tanzania. Both household and woman questionnaires were employed to conduct survey interviews across the entire nation in each of the three countries. The surveys were conducted by the respective bureaus of statistics in each country, i.e., Uganda Bureau of Statistics (UBOS), Kenya National Bureau of Statistics (KNBS) and the National Bureau of Statistics (NBS) in Tanzania in collaboration with ministries of health and other partners in each country. In each of the countries, the sampling strategy ensured representative sampling nationally, in rural and urban areas and first administrative unit (and/or geographical areas) such as regions or counties using a two-stage cluster design. In the first part, clusters were selected as primary sampling units from the national census registrations and in the second part samples of households were drawn from each selected sampling unit. In Kenya DHS 2014, 1612 clusters (enumeration areas (EAs)) were selected, and 40,300 households were sample. In TDHS 2015-16, 608 clusters were selected and 13, 376 households sampled. In UDHS 2015-16, 697 EAs and 20, 880 households selected. For Uganda 2011, 2006, 2000-2001 and 1995 surveys, 10,086, 9,864, 8,792, 8,093 households were selected respectively. The response rate based on sampled households was over 95 percent for all the surveys. Eligible women of reproductive ages 15-49 years old were interviewed to obtain information about the background characteristics and a range of maternal health service utilization and childhood (neonatal) mortality. Measurements such as height and weight were also taken.

The Institutional Review Boards for the DHS program and the host countries approved the data collection and the distribution of datasets for public health research upon formal request. We obtained access to the datasets for this thesis project after sending a formal request to DHS secretariat. Further details of DHS methodology and manuals can be obtained from https://dhsprogram.com/methodology/survey-types/DHS-Methodology.cfm .

Table 1 also provides a summary of the inclusion criteria and statistical methods used in this thesis.

Table 1. Summary of the thesis: Aim, study settings and study population, inclusion criteria, study design and statistical methods

Study	Study setting	aim	Study population	Inclusion criteria	Statistical analysis
Study I	Kenya	Examine the effectiveness of ANC services in reducing neonatal mortality in Kenya	Most recent live-born children, dead or alive whose mothers (aged 15–49 years) were eligible for interviews in 2014.	All singleton children born 3-5 years prior to the 2014 survey. Neonatal mortality defined as death of a single liveborn baby within 28 days after birth.	Descriptive statistics, bivariate and binary logistic regression. Population attributable fractions (PAF) were estimated.
Study II	Uganda	Investigate the association between low birthweight and neonatal mortality and to determine the trends of neonatal deaths attributable to low birthweight in Uganda between 1995 and 2011.	Most recent live-born children, dead or alive whose mothers (aged 15–49 years) were eligible for interviews in 1995, 2000-2001, 2006, 2011.	All singleton neonates born 3-5 years prior to the 1995, 2000-2001, 2006, 2011 surveys and had birthweight less or equal to 4000 grams ($\leq 4000g$).	Descriptive statistics, bivariate and binary logistic regression. PAF.
Study III	Tanzania and Kenya	Examine caesarean delivery and its associated socioeconomic patterns and neonatal survival outcomes in Kenya and Tanzania.	Most recent live-born children, dead or alive whose mothers (aged 15–49 years) were eligible for interviews in Kenya in 2014 and Tanzania in 2015-2016.	All singleton neonates born 1-59 months prior to the Kenya 2014 and Tanzania 2015-2016 surveys and were born in health institutions (skilled attendance).	Descriptive statistics, bivariate and binary logistic regression.
Study IV	Uganda and Kenya	To examine how maternal and sociodemographic factors determine continued maternal care-seeking behaviour from pregnancy to postnatal period in Kenya and Uganda and to estimate associated neonatal survival outcomes.	Most recent live-born children, dead or alive whose mothers (aged 15–49 years) were eligible for interviews in Kenya 2014 and Uganda 2015-2016 surveys.	All neonates born 1-59 months prior to the Kenya 2014 and Uganda 2015-2016 surveys.	Descriptive statistics, bivariate and multinomial and binary logistic regression. PAF
Study V	Uganda, Kenya and Tanzania	To assess survival patterns among neonates born to adolescents and the effect of pregnancy intentions and marital status on survival in Kenya, Uganda, and Tanzania.	Most recent live-born children, dead or alive whose mothers (aged 15–49 years) were eligible for interviews in Kenya 2014 and in Uganda and Tanzania 2015-2016 surveys.	All neonates born 1-59 months prior to the Kenya 2014 and Tanzania/Uganda 2015-2016 surveys whose mothers were aged 15–19 years and comparison group, 20–49 years old.	Descriptive statistics, bivariate and survival analysis. PAF

Study variables

Outcome variables

The main dependent variable was neonatal survival outcome which was dichotomized into dead or alive and was examined in all studies I–V. Neonatal death or mortality as the outcome of interest was defined as death of a baby within the first 28 days of life after birth. Other primary outcome variables included low birthweight (Study II), mode of delivery/childbirth (cesarean or caesarean section) (Study III), care-seeking continuum (antenatal care (ANC) attendance and ANC services, facility birth, postnatal care (PNC) attendance (Studies I and IV). Certain outcome variables were also included as independent variables and as secondary objectives in different studies.

Independent variables

The main independent factors constituted sociodemographic, maternal, neonatal, and care-seeking variables that are known or theorized to be associated with neonatal survival or mortality. The categorizations of these variables were guided by previous studies, theories or the DHS methods based on science or common understanding. Different studies classified or regrouped the variables to suit the objectives of the studies. For instance, maternal age was originally grouped as 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49 years old but in this thesis, it was generally reclassified as 15-24, 25-34, and 35-49 years (83, 84) except in study V. Socioeconomic factors such as educational level was reclassified as no education, primary education and secondary or higher (85), wealth status was generally regrouped as poor, middle and rich (85), place of residence was dichotomized into rural and urban (86). Parity (87). Other variables included newborn gender and multiple gestations (88, 89).

Statistical analysis

All the analysis were conducted using Statistical software packages IBM SPSS version 22.0 and 24.0 (IBM, Armonk, New York, USA), Microsoft excel (2017-2021) and Stata versions 12 and 16 (College Station, Texas: Stata Press), at 5% level of significance. To maintain the representativeness of the data during analysis and to adjust for non-response, data sampling weights were applied and adjustment for complex sample design done in all the studies I–V and in all datasets except, Uganda DHS, 1995 data which was not subjected to weighting.

Study I

We used Pearson´s chi square test to examine the distribution of sociodemographic and maternal variables by antenatal care interventions (primary predictor variables), classified as `yes´ if a given service was received and `no´ if not attended/received. The distribution of variables was also examined by neonatal survival outcomes among singleton births and was the dependent variable, dichotomized into died or alive. Both crude and adjusted odds ratios were determined using binary logistic regression analysis to estimate the associations between the inadequate antenatal care services and neonatal death in Kenya, 2014. Crude odds ratios were generated in model 1. Potential confounders were adjusted for using stepwise modelling in models 2, 3 and 4. In model 2, sociodemographic variables such as place of residence, wealth status and maternal factors such as age, parity were adjusted for. Model 3 adjusted for all factors in model 2 plus childbirth related variables while model 4 controlled for all variables in models 2 and 3 in addition to birth weight.

Study II

Descriptive statistics were generated using cross-tabulations. Kaplan-Meier estimator was used to generate survival curves for different birthweight categories in Uganda between 1995 and 2011. Binary logistic regression was used to examine the associations between low birthweight and neonatal death with adjustment for confounders that included sociodemographic and maternal factors, check-up for complications and cesarean delivery.

Study III

The distribution of study variables by mode of delivery and stratified by place of residence (rural and urban) were examined using cross-tabulations. Excel was used to generate graphical display of cesarean delivery rates across various socioeconomic classes in Kenya, 2014 and Tanzania, 2015-2016. Similarly, distribution of study variables by neonatal mortality in Kenya and Tanzania was also assessed. Binomial logistic regression was used to determine the association between socioeconomic variables and cesarean delivery while controlling for other explanatory factors that are potential confounders such as birthweight, multiple gestations, parity, and maternal age. The regression analysis was also used to determine associations between cesarean delivery and neonatal death at 95% confidence interval in Kenya and Tanzania.

Study IV

Microsoft Excel was used to assess the correlations between antenatal care visits and the proportions of health facility births and postnatal care visits in Kenya 2014 and Uganda 2015-2016. Cross-tabulations were used to examine the distribution of sociodemographic, maternal, and paternal variables by 15 different classes (categories) of care-seeking continuum from those mothers who attended all recommended care (*highest* care-seekers) i.e., 4 or more antenatal care, health facility (skilled) childbirth and at least one postnatal attendance within 4 weeks after birth to *lowest* care-seekers i.e., those who received no skilled maternity care. Multinomial logistic regression was used to examine associations between sociodemographic, maternal factors and continuum of care-seeking behaviour in Kenya and Uganda. Further, binary logistic regression was used to determine the associations between selected levels of care-seeking continuum and neonatal mortality in Kenya and Uganda.

Study V

Distribution of variables between adolescent mothers, 15–19 years and mothers 20-29 years old were examined using Pearson´s chi square test at significance level, $\propto$=0.05. Kaplan-Meier´s estimator was used to visualize neonatal survival during 28 days after birth among adolescent, 15-19 years old and mother 20-29 years old in Uganda, Tanzania, and Kenya. The equality of survival curves was assessed using Log-rank method. We employed cox hazard regression models to examine the hazard of death among neonates born to adolescents as compared to those born to women 20-29 years old while controlling for potential confounding variables. Crude and adjusted hazard ratios were determined. Models were used to adjust for various risk factors at different levels. Our analysis was further stratified by marital status and pregnancy intentions both separately and when combined. Furthermore, analysis was stratified by parity. Both the global Schoenfeld test and log-log transformation to the overall function were used to assess the proportional hazard assumptions.

Results

Study I and IV

Study I

Figure 3 below shows that about 95 percent of mothers to singleton neonates in Kenya had at least 1 ANC visit with skilled attendance in 2014 but only about 20% visited within the first 3 months of pregnancy (1st trimester). First ANC visit for majority (67%) of the mothers was between 4 and 6 months of pregnancy (2nd trimester).

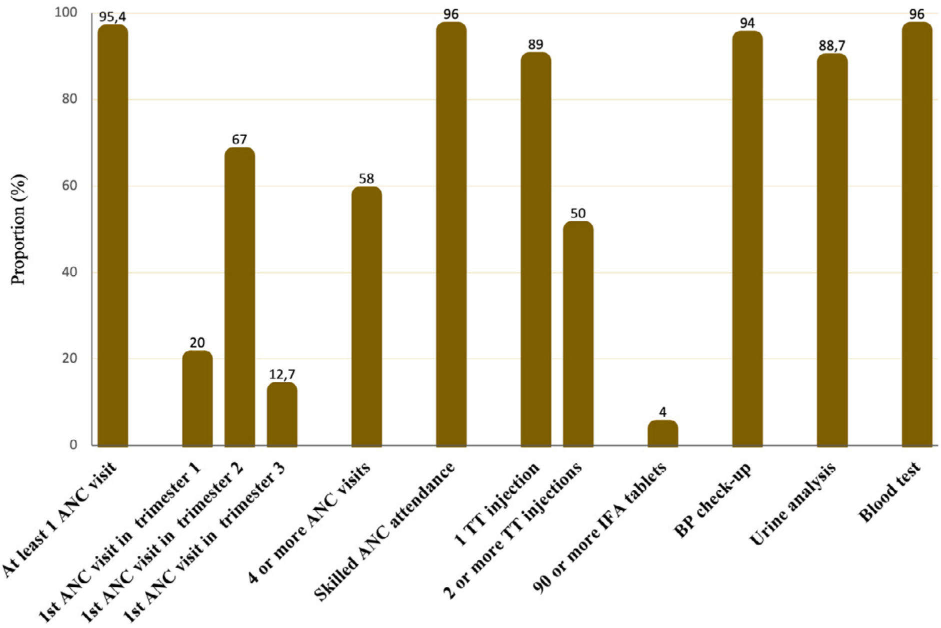


Figure 3. Proportion of antenatal care (ANC) visits and service utilization by pregnant mothers in Kenya using demographic and health survey 2014.

Study IV

Figure 4 below shows that over 95 percent of the mothers had at least 1 ANC visit and 56.7% had 4 or more ANC visits in 2014-2016, with Uganda having slightly more mothers attending recommended number of visits at that time than Kenya. 6 % and 2% had no ANC visits in Kenya and Uganda respectively.

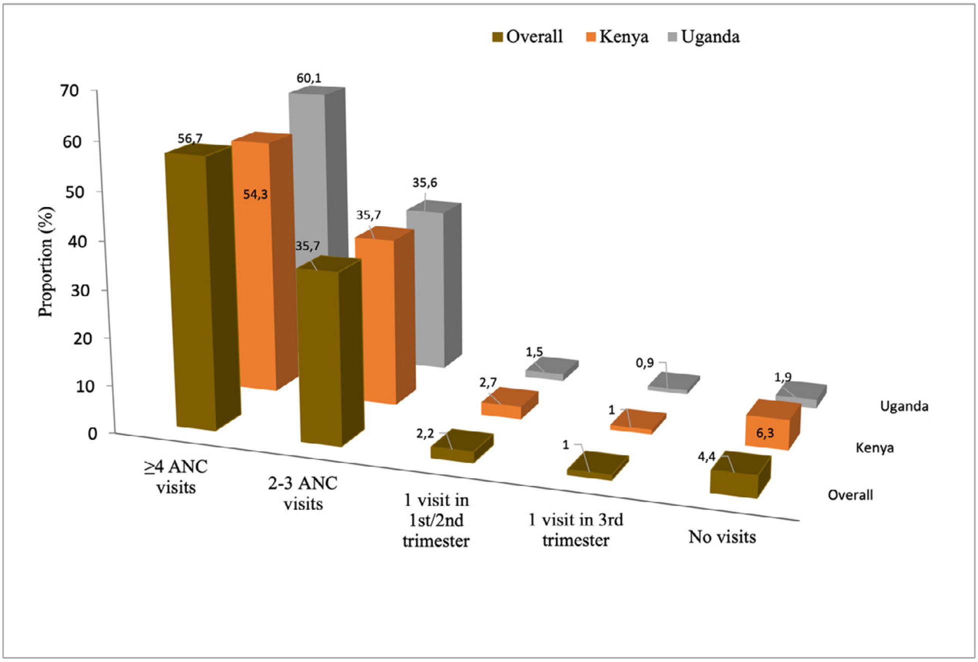


Figure 4. Proportions of antenatal care visits by number of ANC contacts in Kenya and Uganda, using demographic and health survey 2014-2016 data.

Figure 5 below shows a direct linear correlation between the number of ANC visits and proportions of health facility births and postnatal care visits.

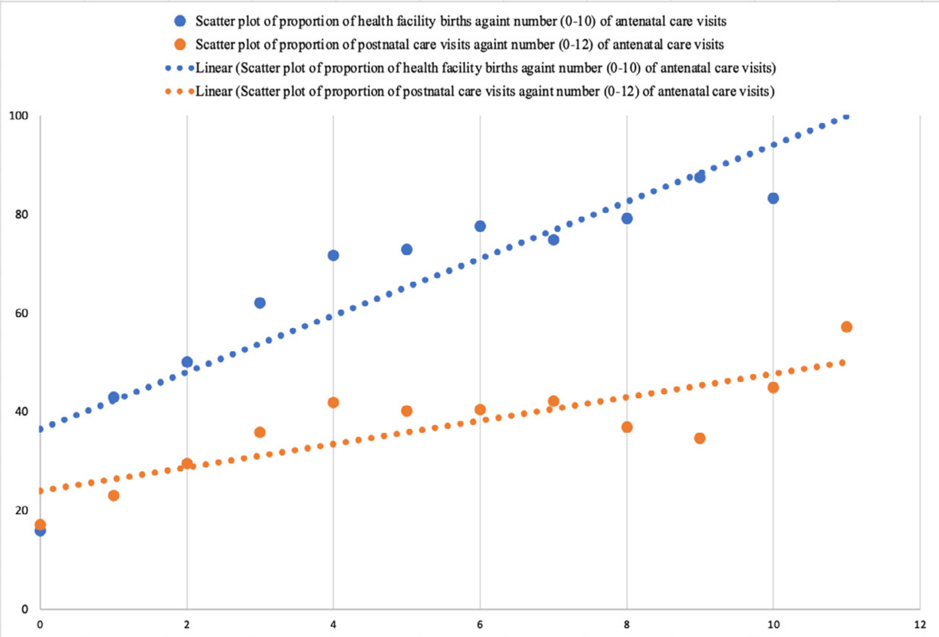


Figure 5. A scatter plot showing correlation between number of antenatal care (ANC) visits and proportions of facility births and postnatal care visits in Kenya and Uganda, using demographic and health survey 2014-2016 data.

Figure 6 is a forest plot showing multinomial regressions for the associations between maternal and socio-demographic factors and different classes of care-seeking continuum during pregnancy, birth and postnatal care in Kenya and Uganda 2014-2016. The figure shows that higher maternal and paternal education versus no formal education, were largely associated with higher care-seeking, except among those who had 1 ANC visit/facility birth or lower. Detailed numbers (not include in the figure) show that the tendency for care-seeking, relative risk ratios RRRs ranged from 2.1– 8.0, (95% confidence intervals [95% CI] 1.1–16.3) for primary or higher parental education compared to no formal education. The higher the education level, the higher the care-seeking tendency. Similarly, exposure to mass media (television/radio) versus no exposure was also largely associated with more continued care-seeking, RRRs ranged from 1.8– 3.2 (95% CI 1.2–5.4). Being told about pregnancy complications generally enhanced care-seeking in Kenya, data for Uganda was not available.

On the contrary, problem with distance to the health facility was generally associated with low care-seeking during pregnancy to postnatal period, RRRs ranged from 0.6 – 0.7 (95% CI 0.5–0.9). Only in a few care-seeking classes was the problem with distance not statistically significant. Similarly, living in rural areas versus urban was also generally associated with lower care-seeking tendencies. Another factor that noticeably hindered care-seeking was when the husband/partner rather than the woman herself made major decisions for maternity care-seeking, this was true in most (9) care-seeking categories, RRRs ranged from 0.5 – 0.7 (95% CI 0.3–0.9).

Other factors such as older maternal age versus young indicated lower associations with care-seeking in all the classes, however the results were not statistically significant, RRRs ranged from 0.4 – 0.9 (95% CI 0.3–1.7). Similarly, having a desire to have a child generally indicated no associations with care-seeking behavior. Being in middle wealth class compared to being poor showed higher care-seeking behavior, but these were only statistically significant in less than half of the care-seeking classes. While among the rich, there was no significant association with care-seeking when compared to the poor, except in one class.

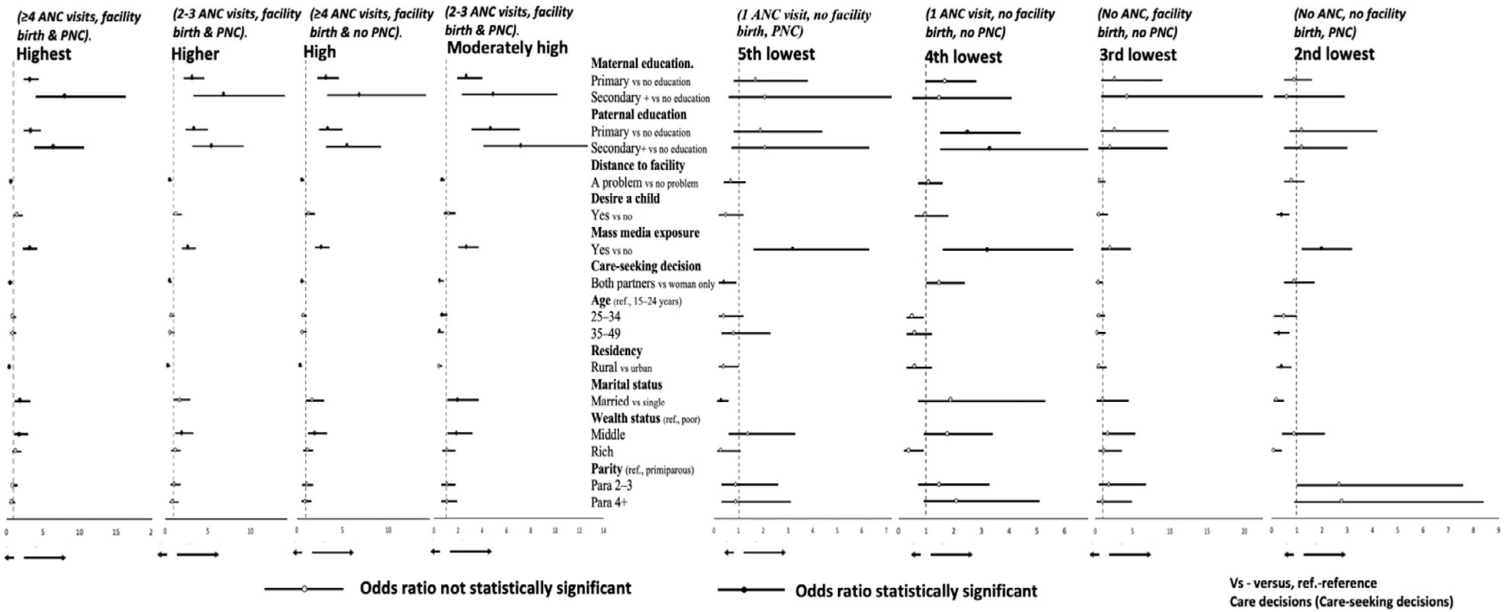


Figure 6: A forest plot showing relative risk ratios (RRR) for the associations between maternal and socio-demographic factors and maternal continuum of care-seeking behaviour in Kenya and Uganda, using demographic and health survey 2014-2016 data

Summary findings for studies I and IV

Figure 7 is also a forest plot showing adjusted odds ratios obtain from findings in study I and study IV.

Study I was conducted in Kenya, 2014. The Figure reveals the associations between lack of or inadequate utilization of antenatal care (ANC) services and neonatal mortality in Kenya. After adjusting for socio-demographic factors, maternal, birth-related factors, and birthweight, the findings showed that no ANC visits (aOR 4.0, 95% CI 1.7 – 9.1) or inadequate (1-3 ANC) visits, (aOR 1.8, 95% CI 1.1–3.0) versus 4 or more ANC visits were associated with neonatal mortality. Similarly, unskilled ANC attendance (aOR 3.0, 95% CI 1.4 – 6.1) versus skilled and no check-up for pregnancy complications compared to check-up, (aOR 2.4, 95% CI 1.4 – 4.0) were all associated with neonatal death. Further, Unskilled (home) birth compared to skilled (health facility) birth was not associated with neonatal death (aOR 0.7, 95% CI 0.6 – 1.5). Having no tetanus toxoid (TT) injection (aOR 2.4, 95% CI 1.1–5.6) compared to having one TT injection was also associated with neonatal mortality. No ANC visit accounted for an estimated 9.1% of neonatal deaths in Kenya. neonatal death,

Study IV was conducted in Kenya, 2014 and Uganda, 2015-2016. In Figure 7 and Table 3, care-seeking continuum of *no ANC visits–no facility births–no PNC (lowest* category*)* and *No ANC–facility birth–no PNC* were significantly associated with neonatal mortality, (aOR 4.2, 95% CI 1.6–10.9 and aOR 4.2, 95% CI 2.3–7.8 respectively) when compared a continuum of 4 or more ANC–facility birth–1 PNC visit within 28 days after birth. For the l*owest* category of care continuum with no care utilization in both countries, the odds of neonatal deaths were higher in Kenya (aOR 6.0, 95% CI 2.6–13.6) compared to that in Uganda (aOR 2.5, 95% CI 1.0–6.5).

Figure 7 shows the summary of findings above for studies I and IV.

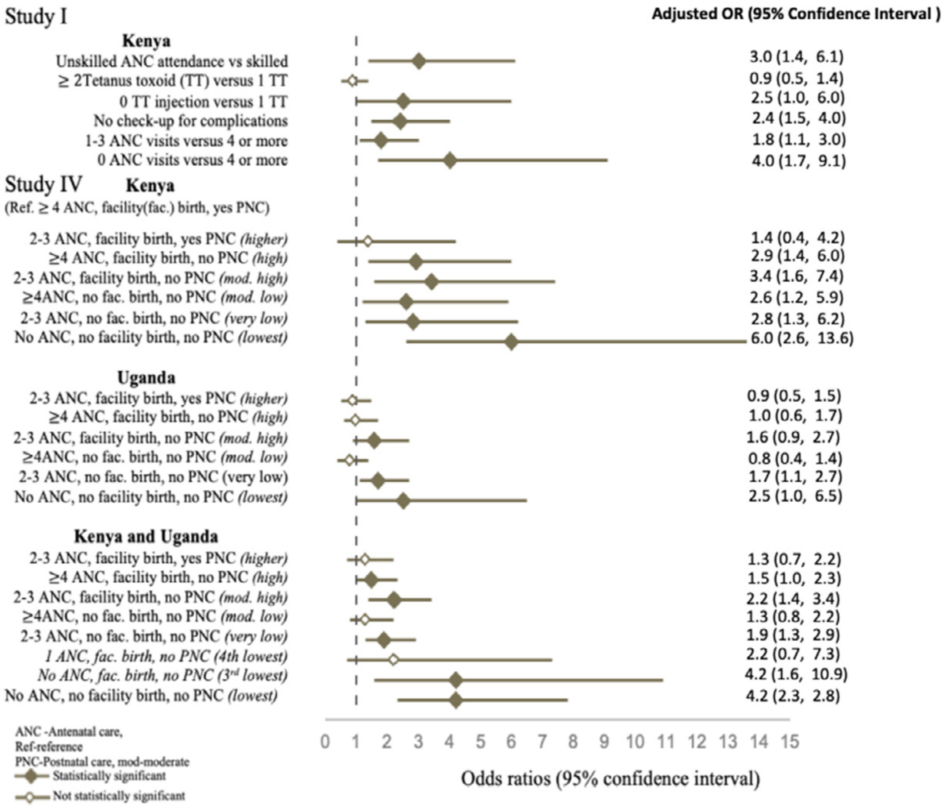


Figure 7. A forest plot summarizing findings from study I and study IV showing associations between the lacking care interventions and neonatal mortality in Kenya 2014 and Uganda 2015-2016.

Table 3 (*Study IV*): Crude and adjusted odds ratios for the association between classes of care-seeking behavior in continuum of care and neonatal mortality in Kenya and Uganda, using demographic and health survey 2014-2016 data.

Classes of care-seeking behaviour	**Overall Crude odds ratio (95% CI) n=22538**	**Overall aOR* (95% CI)**	**Popn. Attr. neonatal mortality risk faction (%)**	**Proportion of the total in Kenya (%) n=12579**	**Kenya only aOR* (95% CI)**	**Popn. Attr. neonatal mortality risk faction**	**Proport-ion of the total in Uganda (%), n=9959**	**Uganda only aOR* (95% CI)**	**Popn. Attr. neonatal mortality risk faction**
Highest *(≥4 ANC* visits*, health facility birth, yes PNC).*	Ref.	Ref.	Ref.	(13.4)	Ref.	Ref.	(33.8)	Ref.	Ref.
Higher *(2-3 ANC visits, Health facility birth, yes PNC). Mis=47*	1.5 (1.0-2.4)	1.3 (0.7-2.2)	–	(6.1)	1.4 (0.4-4.2)	–	(16.3)	0.9 (0.5-1.5)	–
High *(≥4 ANC visits, Health facility birth, no PNC). Mis=72*	1.5 (1.0-2.2)	1.5 (1.0-2.3)		(29.8)	2.9 (1.4-6.0)	19.9%	(15.6)	1.0 (0.6-1.7)	–
Moderately high *(2-3 ANC visits, health facility birth and no PNC). Mis=33*	2.4 (1.6-3.7)	2.2 (1.4-3.4)	9 %	(16.0)	3.4 (1.6-7.4)	14.6%	(8.4)	1.6 (0.9-2.7)	–
Moderately low *(≥4 ANC visits, no facility birth, no PNC). Mis=44*	1.3 (0.8-2.1)	1.3 (0.8-2.2)	–	(14.5)	2.6 (1.2-5.9)	8.6%	(12.4)	0.8 (0.4-1.4)	–
Very low *(2-3 ANC visits, no facility birth, no PNC). Mis=48*	1.9 (1.3-2.8)	1.9 (1.3-2.9)	7%	(14.7)	2.8 (1.3-6.2)	9.3%	(12.0)	1.7 (1.1-2.7)	6.7%
4th lowest *(1 ANC visit, no health facility births, no PNC) Mis=2*	2.2 (0.7-6.7)	2.2 (0.7-7.3)	_	(2.1)	_	–	(1.2)	_	–
3rd lowest *(No ANC, health facility births and no PNC). Mis=2*	7.8 (3.5-17.5)	4.2 (1.6-10.9)	1.9	(0.5)	–	–	(0.4)	–	–
Lowest *(No ANC, no facility births and no PNC.). Mis=17*	4.5 (2.5-7.8)	4.2 (2.3-7.8)	5%	(5.6)	6.0 (2.6-13.6)	10%	(1.5)	2.5 (1.0-6.5)	–

*adjusted/restricted to birthweight ≥2500 g and singleton births. Mis – Missing: Due to non-response, proportionally (relatively random) distributed across all strata. Popn. Attr-Population attributable, Ref-Reference

Figure 8 summarizes findings from studies I and IV. The Figure indicates that lack of or inadequate ANC visits (<4 ANC) accounted for about 28 % of neonatal deaths in Kenya (Study 1). Similarly, neonatal deaths due to lack of PNC visits exceeded 20 % of the total mortalities in Kenya. Overall, from study IV (Figure 8 and Table 3), at least 63% of neonatal deaths in Kenya could be avoided by providing full minimal care of 4 ANC visits, hospital birth and at least 1 PNC. In Uganda, more than 7% of neonatal deaths were associated with 2-3 ANC, no facility birth, and no PNC. For both countries inadequate maternal care utilization is attributable to at least 23 % of neonatal deaths.

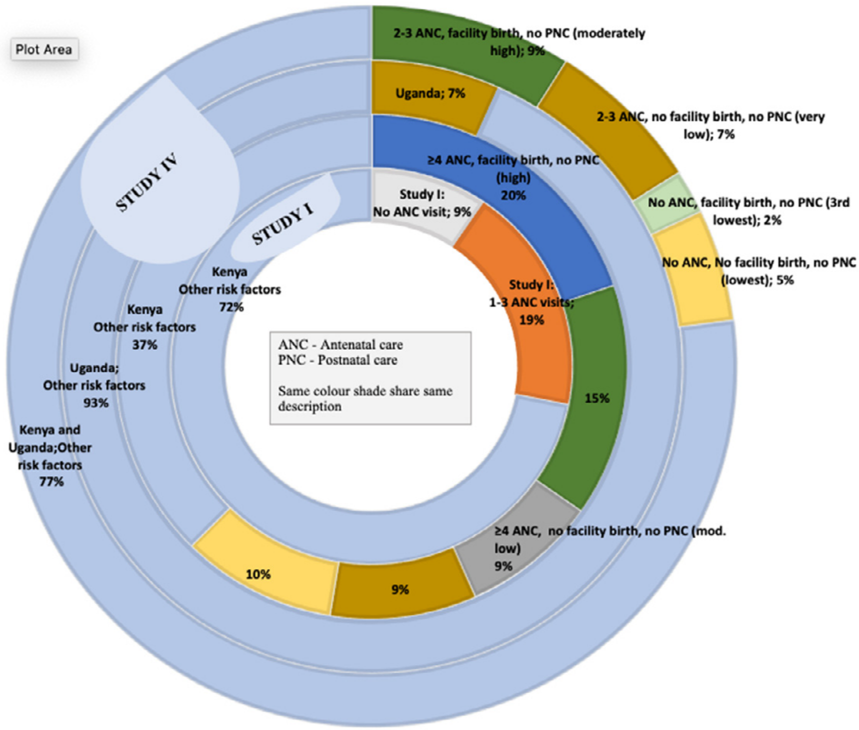


Figure 8: Population attributable neonatal mortality risk fraction for lack of or inadequate interventions in the continuum of care in Kenya and Uganda, 2014-2016.

Study II

Generally, young mothers below 20 years of age were overrepresented among mothers with low birthweight neonates. In Table 4 below, low birthweight (LBW) was associated with neonatal death in all the surveys, 1995-2011 in Uganda. The odds of deaths among low birthweight neonates (versus normal birthweight) declined gradually overtime from 6.2 in 1995 to 3.8 in 2011, although with overlapping confidence intervals. There was a 10% decline in the proportion of neonatal mortalities among low birthweight newborns from 1995 to 2011. In 2011, over 70 percent of neonatal deaths among low birthweight newborns in Uganda could be accounted for their LBW status. However, in the general population, neonatal deaths from LBW declined by half from 1995 to 15.3 % in 2011.

Table 4: Adjusted odds ratios for the association between low birthweight and neonatal mortality in Uganda between 1995–2011 and associated attributable risk fractions.

Adjusted odds ratios (95% Confidence Interval)				
Variable	1995 N=1995	2000-2001 N=1100	2006 N=1519	2011 N=2223
Birthweight				
Low birthweight (<2500 g) (Compared to normal birthweight $\geq 2500\text{g} - 4000\text{g}$)	6.2 (2.3-17.0)[b]	5.3 (1.7–16.1)[b]	4.3 (1.3–14.2)[a]	3.8 (1.3–11.2)[a]
Associated Attributable risk proportion	83.9%	81.1%	76.7%	73.7%
Population attributable mortality risk proportion	33.6%	27.0%	24.0%	15.3%

[a]Adjusted for sociodemographic factors (maternal age, education, parity, marital status, wealth index and place of residence), maternal, pregnancy and birth-related factors

[b]Adjusted for all socio-demographic factors in ([a]) above (except wealth status), maternal, pregnancy and birth-related factors in Table 1. Birth complications were not adjusted for in 1995 findings

Study III

Study III was conducted in Tanzania and Kenya. Findings in Figure 9 indicate that cesarean delivery (CD) was generally higher among mothers in high socioeconomic status, living in urban, than those in low socioeconomic status or in rural areas. CD rates ranged from 5% among the poorer in rural Tanzania to 19% among the richest in Urban Kenya. From 6.8% among mothers with no formal education in rural Kenya to 35% among post-secondary educated mothers in urban Tanzania. From 6.9% among rural domestic workers to 37.5% among urban mothers in managerial positions, in Tanzania. And from 7.5% among mothers without health insurance to 29% among health-insured mothers in Tanzania.

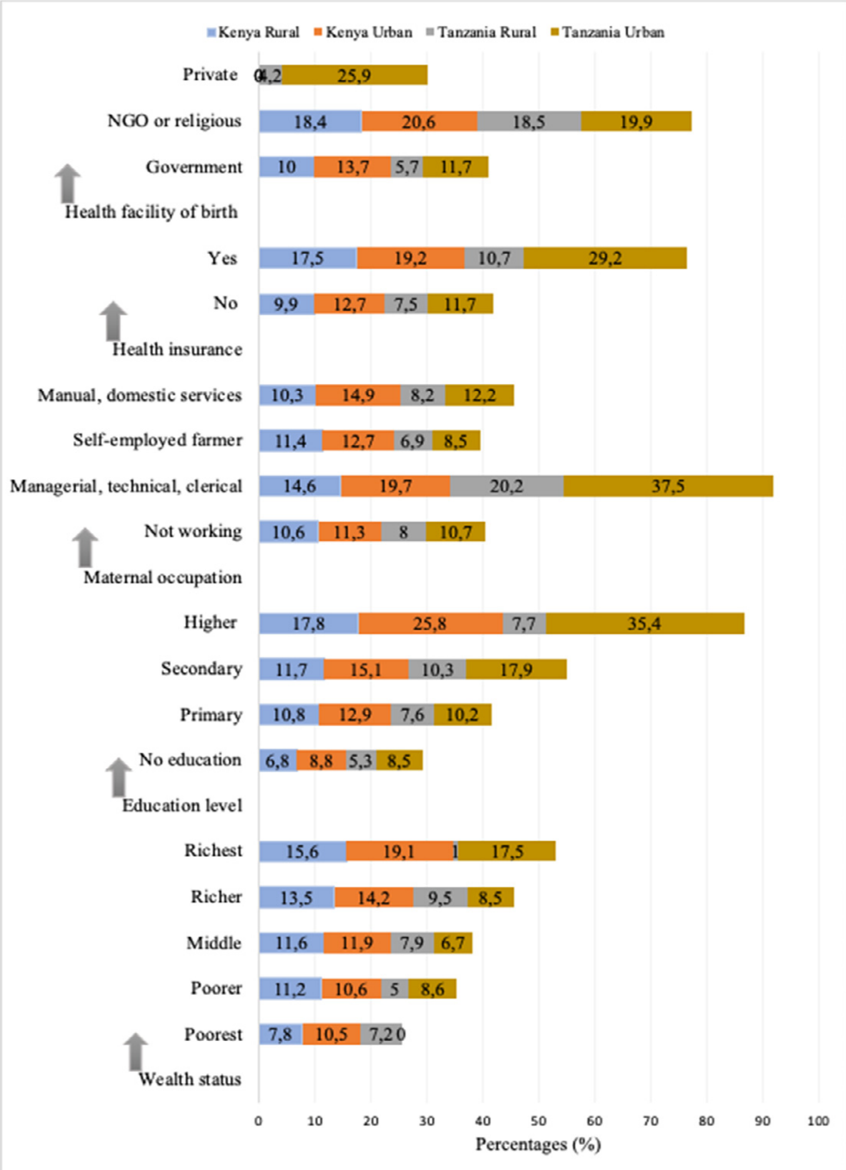


Figure 9. A sample graphical presentation showing cesarean delivery rates by sociodemographic variables and place of residence in 2014-2016, Kenya and Tanzania.

Table 5 presents the odds ratios for the associations between socioeconomic status and CD in Kenya and Uganda. Overall, the richest (aOR 1.4, 95% CI 1.2–1.8), postsecondary educated women (aOR 1.6, 95% CI 1.2–2.0), women managers (aOR 1.7, 95% CI 1.3–2.3) and those health insured (aOR 1.6, 95% CI 1.3–1.9) indicated higher odds of undergoing cesarean birth as compared to middle class, primary educated, unemployed, and uninsured respectively. Country-specific result show that Tanzania generally had higher and significant odds of CD among all the four socioeconomic categories while in Kenya, only mothers with health insurance versus uninsured had statistically significant odds of CD.

With regards to health facility of birth, in comparison to government owned facilities, mission (aOR 2.7, 95% CI 2.1–3.4) and private (aOR 2.2, 95% CI 1.3–3.5) facilities in Tanzania indicated highest odds of cesarean delivery. Similarly, mission facilities in Kenya showed higher odds (aOR 1.5, 95% CI 1.2–1.8) of cesarean birth.

Table 5. Logistic regression analysis showing associations between socioeconomic status and cesarean delivery in Kenya 2014 and Tanzania, 2015-2016.

	Adjusted odds ratios (95% confidence interval)		
Variables	Overall	Kenya	Tanzania
Wealth index	*Reference category* – Middle status of wealth		
Poorest	0.9(0.7–1.2)	0.9 (0.6 –1.2)	0.9(0.6–1.4)
Poor	0.9(0.7–1.2)	0.9(0.7–1.2)	0.6(0.4–1.0)
Rich	1.1(0.9–1.4)	1.1(0.8–1.4)	1.1(0.7–1.4)
Richest	**1.4 (1.2–1.8)**	1.2 (0.9–1.6)	1.6 (1.2–2.2)
Education level	*Reference category* – Primary education		
No education	0.8(0.6–1.0)	0.9(0.6–1.4)	0.8(0.5–1.1)
Secondary education	1.2(1.0–1.4)	1.1(0.8–1.2)	**1.4(1.1–1.8)**
Higher/post-secondary)	**1.6 (1.2–2.0)**	1.4 (1.0–1.8)	**1.6 (1.2–2.0)**
Maternal occupation	*Reference category* – Not working		
Managerial, technical, clerical	**1.7 (1.3–2.2)**	1.3 (0.9–1.7)	**2.9 (1.9–4.3)**
Self-employed farmer	0.9 (0.7–1.1)	1.0 (0.8–1.3)	0.9 (0.7–1.3)
Manual, domestic services	1.0 (0.8–1.2)	1.0(0.8–1.3)	1.1(0.8–1.5)
Health insurance	*Reference category* – No insurance		
Have insurance	**1.6(1.3–1.9)**	**1.4(1.2–1.8)**	**1.8(1.4–2.4)**
Place of residence	*Reference category* – Rural		
Urban	**1.3(1.2–1.5)**	1.2(1.0–1.4)	**1.5(1.2–1.8)**
Health facility of birth	*Reference category* – Government facility		
Mission health facility	**1.9(1.6–2.2)**	**1.5(1.2–1.8)**	**2.7(2.1–3.4)**
Private facility	N/A	N/A	**2.2(1.3–3.5)**
Each socioeconomic factor independently adjusted for maternal age, birthweight, parity, and multiple births.			

In Table 6, cesarean delivery showed significant overall association with neonatal mortality in Kenya and Tanzania after adjusting sociodemographic factors and maternal body mass index (BMI), (aOR 1.7, 95% CI 1.2–2.7). However, further adjusting for birthweight, multiple births in model 2 and additional adjustment for antenatal care visits in model 3, resulted in high but not statistically significant associations aOR 1.6, 95% CI 1.0–2.7 and aOR 1.7, 95% CI 0.9–3.4 respectively.

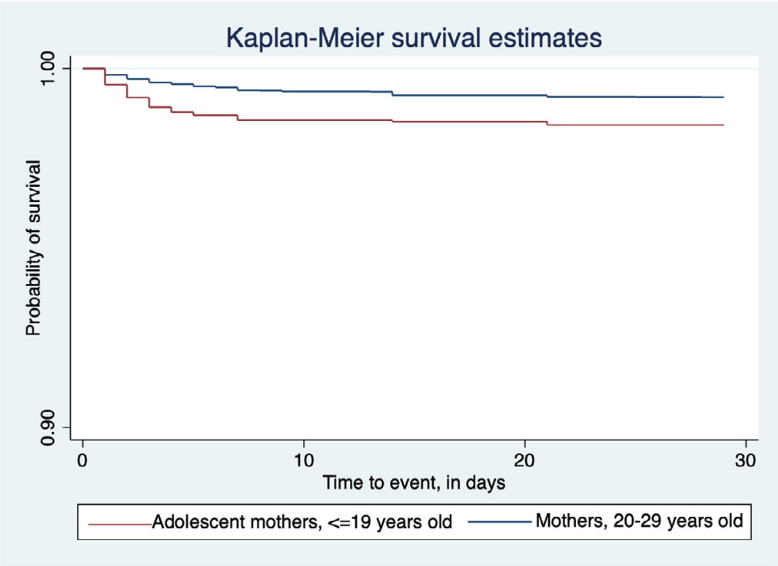
Table 6. Binomial logistic regression analysis (model 1–3) for the associations between cesarean delivery and neonatal death, adjusted odds ratio (aOR) in Kenya 2014 and Tanzania, 2015–2016.

	Model 1 aOR (95% CI)			**Model 2 aOR (95% CI)**			**Model 3 aOR (95% CI)**		
	Overall, N=12,898	Kenya	Tanzania	Overall,	Kenya	Tanzania	Overall,	Kenya	Tanzania
Cesarean section									
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	**1.7 (1.2-2.7)**	1.6 (0.8-3.4)	1.8 (1.0-3.2)	1.6 (1.0-2.7)	1.5 (0.7-3.5)	1.7 (0.9-3.4)	1.6 (0.9-2.6)	1.4 (0.6-3.2)	1.7 (0.6-3.4)

Model 1: Adjusted for maternal factors (maternal age, parity, education level and Base mass index), Model 2: adjusted for Model 1 factors and fetal risk factors (multiple births and birthweight), Model 3: adjusted for Models 1 and 2 factors and number of antenatal care visits.

Study V

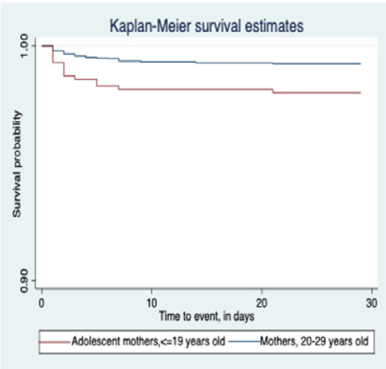
Study V examined neonatal survival patterns among adolescent mothers and the effect of pregnancy intentions and marital status on mortality in Kenya, Uganda, and Tanzania. Figure 10 below is Kaplan-Meier survival curve showing statistically significant difference (log rank test, *P*<0.05) in neonatal survival between babies born to adolescent mothers and those born to mothers 20-29 years of age.



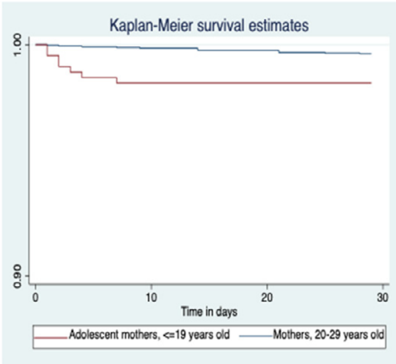
Log rank test, *P* value = 0.0003

Figure 10. Kaplan-Meier survival functions for neonates born to adolescent mothers (15-19 years old) and those born to mothers aged 20-29 years in Kenya, Uganda, and Tanzania, 2014-2016.

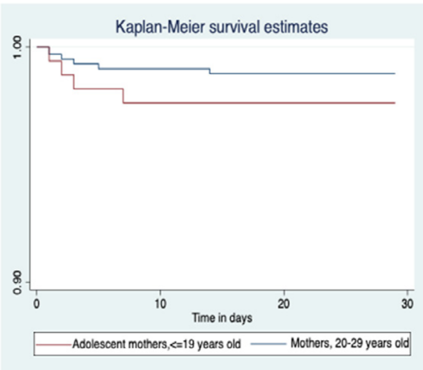
Figure 11 graphically indicates shorter survival time to neonatal deaths among mothers born to adolescents as compared to older mothers, (20-29 years old) among married mothers (a-b) and those unmarried with pregnancy intentions (c) in Kenya, Uganda, and Tanzania, 2014-2016.). There is no observed difference in survival time by maternal age-group among unmarried mothers with no pregnancy intentions (d).



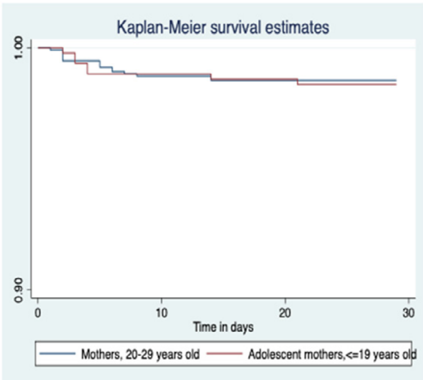
(a) Among married and pregnancy intended



(b) Among married and pregnancy unintended



(c) Among unmarried and pregnancy intended



(d)Among unmarried and pregnancy unintended

Figure 11 a-d. Kaplan-Meier survival curves for neonates born to adolescent mothers, (15-19 years old) versus neonates born to older mothers, (20-29 years old), stratified by marital status and pregnancy intentions in Kenya, Uganda, and Tanzania, 2014-2016.

Adjusted models in Table 7 generally shows that the hazard of neonatal death is about twice higher among neonates born to adolescent mothers than older mothers even after adjusting for other major risk factors.

Table 7: Distribution of study variables by neonatal survival status and cox proportion hazards regression models showing hazard of death for neonates born to adolescents compared to those born to mothers, 20-29 years old in Kenya, Uganda, and Tanzania, 2014-2016.

	Censored	Died		Model 1*(95%CI)	Model 2 (95%CI)	Model 3 (95%CI)
Variables			Unadjusted HR	aHR*	aHR**	aHR**
Maternal age						
[a]Adolescents, ≤19 years	2160(12.2)	59(23.8)	**1.98(1.36-2.87)**	**1.80(1.22-2.63)**	**1.78(1.20-2.64)**	**1.86(1.06-3.29)**
[b]20-29 years	15616(87.8)	189(76.2)	1.00	1.00	1.00	1.00
Marital Status						
Single(unmarried)	3443(19.6)	60(24.7)	**1.57(1.11-2.22)**	1.41 (0.98-2.01)	1.41(0.98-2.02)	—
Married	14159(80.4)	183(75.3)	1.00	1.00	1.00	—
Newborn pregnancy intentions						
Intended	8173(61.0)	126(64.3)	0.85(0.65-1.11)	0.75(0.52-1.10)	0.72(0.49-1.05)	—
Unintended	5231(39.0)	70(35.7)	1.00	1.00	1.00	—
Place of residence						
Rural	12504(70.3)	175(70.6)	0.94(0.67-1.32)		1.01(0.70-1.46)	0.74(0.29-1.85)
Urban	5272(29.7)	73(29.4)	1.00		1.00	1.00
Education level						
No or primary education	12485(70.2)	181(73.0)	1.32(1.00-1.72)	1.15(0.79-1.66)	1.10(0.76-1.60)	0.70(0.42-1.16)
Secondary or higher	5291(29.8)	67(27.0)	1.00	1.00	1.00	1.00

[a]Neonatal mortality rate (NMR)=26.6 per 1000 live births
[b]Neonatal mortality rate (NMR)=12.0 per 1000 live births

LBW – Low birthweight
NBW –Normal birthweight. **CI**-Confidence interval

Model 1. Adjusted for sociodemographic factors, pregnancy intentions and sex of child
Model 2. Adjusted for all model 1 covariates and ANC, PNC, and Place of delivery
Model 3. Adjusted for all covariates in model 1 and model 2 (except marital status and pregnancy intentions) and low birthweight
*Marital status was used to determine HR in all models 1 and 2 in the absence of "Newborn pregnancy intended" variable and newborn pregnancy intended was added to the model in the absence of variable "Marital status" due to collinearity. **Bolded** results are statistically significant (95 % confidence interval (CI)). LBW – low birthweight, NBW

Wealth status						
Poor	8287(46.6)	112(45.2)	0.97(0.70-1.34)	0.75(0.53-1.07)	0.70(0.49-1.00)	0.75(0.43-1.30)
Middle	3236(18.2)	60(24.2)	1.00	1.00	1.00	1.00
Rich	6253(35.2)	76(30.7)				
Sex of newborn						
Male	9084(51.1)	150(60.5)	**0.69(0.49-0.92)**	**0.67(0.49-0.93)**	**0.66(0.48-0.91)**	**0.58(0.34-0.95)**
Female	8692(48.9)	98(39.5)	1.00	1.00	1.00	1.00
ANC visits						
<4	7770 (43.9)	138(55.7)	**1.45(1.06-1.97)**		**1.40(1.02-1.93)**	**1.73(1.08-2.77)**
≥4	9945(56.1)	110(44.4)	1.00		1.00	1.00
Place of delivery						
Home	5512(31.0)	69(28.0)	0.94(0.67-1.32)		1.01(0.70-1.46)	0.74(0.29-1.85)
Health facility	12251(69.0)	177(72.0)	1.00		1.00	1.00
PNC visit within 28 days after birth						
Yes	4424(26.0)	29(11.7)	**1.76(1.16-2.66)**		**1.69(1.11-2.56)**	**2.78(1.49-5.20)**
No	12595(74.0)	219(88.3)	1.00		1.00	1.00
Low birthweight						
Yes	1989(12.7)	62 (29.7)	**3.57(2.49-5.14)**			**4.43(2.76-7.11)**
No	13685(87.3)	147(70.3)	1.00			
Parity						
Primiparous	11273 (63.5)	92(37.3)				
Multiparous	6495(36.6)	155 (62.7)				

[a]Neonatal mortality rate (NMR)=26.6 per 1000 live births
[b]Neonatal mortality rate (NMR)=12.0 per 1000 live births

LBW – Low birthweight
NBW –Normal birthweight. **CI**-Confidence interval

Model 1. Adjusted for sociodemographic factors, pregnancy intentions and sex of child
Model 2. Adjusted for all model 1 covariates and ANC, PNC, and Place of delivery
Model 3. Adjusted for all covariates in model 1 and model 2 (except marital status and pregnancy intentions) and low birthweight
*Marital status was used to determine HR in all models 1 and 2 in the absence of “Newborn pregnancy intended” variable and newborn pregnancy intended was added to the model in the absence of variable “Marital status” due to collinearity
Bolded results are statistically significant (95 % confidence interval (CI)). LBW – low birthweight, NBW

In Table 8, we observe that when stratified by marital status and pregnancy intentions, the hazard of neonatal death among married adolescent mothers (15-19 years old) compared to married older mothers, 20-29 years old increases about 3 times among those with pregnancy intentions and 4 times among those with unintended pregnancies. Further, when considering only first-time mothers, the hazard of neonatal death among married adolescent mothers increased 4-6 times higher compared to their older counterparts, with unintended pregnancies registering highest hazard of neonatal death. There were no reliable mortality numbers for viable analysis in certain strata among the unmarried and multiparous mothers.

Table 8. Adjusted hazard ratios (aHR)* for neonatal mortality among adolescent mothers compared to mothers, 20-29 years old in Kenya, Uganda, and Tanzania, 2014-2016, stratified by marital status and †pregnancy intentions, both overall and among primi-and multi-parous mothers.

Overall				
Variable	**Model 1, AHR**	**Model 2, AHR**	**Model 3, AHR****	**Model 4, AHR****
Adolescent mothers,15-19 years	2.86 (1.55-5.26)	4.08 (1.62-10.31)	1.89 (0.59-6.08)	1.13 (0.46-2.80)
Mothers,20-29 years old	1.00	1.00	1.00	1.00
Among primiparous only (First time mothers)				
Adolescent mothers,15-19 years	4.32 (1.41-13.27)	6.48 (1.37-30.71)	–	1.56 (0.39-6.09)
Mothers, 20-29 years old	1.00	1.00	–	1.00
Among multiparous only (Given birth to at least once previously)				
Adolescent mothers, ≤ 19 years	1.84 (0.89-3.80)	2.43 (0.75-7.98)	–	0.63 (0.19-2.11)
Mothers,20-29 years old	1.00	1.00	–	1.00

Model 1- Among married mothers and newborn from intended pregnancy
Model 2- Among married mothers and newborn from unintended pregnancy
Model 3- Among unmarried mothers and newborn from intended pregnancy
Model 4- Among unmarried mothers and newborn was unintended pregnancy

*Adjusted for sociodemographic factors and maternal care variables (antenatal and postnatal attendance and place of delivery)

†Whether or not the neonate pregnancy was intended. Birth weight was not adjusted for due to insufficient data in the various strata.

** Insufficient mortality data among unmarried (single) mothers with intended pregnancies hindered plausible analysis

Discussion

The general objective of this thesis was to examine determinants of maternal service utilization, effectiveness of care and risk factors for neonatal mortality in Kenya, Tanzania, and Uganda. Overall results indicate that inadequate utilization of care, low birthweight, and young maternal age (adolescents) are leading indirect or intermediate risk factors that contribute substantial proportion of neonatal deaths in Kenya, Uganda, and Tanzania. Various sociodemographic and maternal factors play significant role in determining utilization of care services during pregnancy, childbirth, and postnatal period, indicating unequal access to care. Further, there exists disproportionate utilization of emergency or planned cesarean delivery (CD) along socioeconomic divide and type of health facility. However, despite more access to emergency obstetric procedure such as CD among higher socioeconomic class, there was no clear indication of improved neonatal survival outcomes at population level among these mothers.

Dominant among the factors that determine maternal care utilization is parental education, the higher the level of education of one or both parents the greater the tendency to utilize obstetric services in almost all care-seeking classes. Several studies agree with these findings (90, 91). Also, consistent with other findings (92-94), access to mass media (radio/television) and being told about maternity-related complications also play a significant positive role towards maternal care-seeking tendency. On the contrary, maternal care-seeking was relatively hindered when a husband/partner was a major decision maker for maternity care-seeking versus when a woman makes that decision herself. Similar findings have also been reported by other studies (95, 96). Perhaps future research could investigate the mean time (in days) between asking for husband/partners support for care-seeking and the actual going to the health facility to seek care compared to when a woman makes decisions herself. This could reveal specific details to the general household delays highlighted by Waiswa et al. in East Africa (97). Similarly, problems with (longer) distances to the health facilities and associated rural residency were also found to be deterring factors to utilization of care.

Despite introduction of free or subsidized maternal and child health care policies in Kenya, Uganda and Tanzania that aim to eliminate all or part of catastrophic out-of-pocket expenditure (63, 98, 99), wide disparities in utilization of care across socioeconomic groupings still exist. From our results, these disparities seem to emanate from a complex interaction of factors ranging from individual, household, and societal level factors highlighted by the conceptual framework in this thesis, derived from Mosley and Chen, WHO and UNICEF frameworks (80-82). For instance, at individual level, lack of knowledge about the need to seek maternity care impeded care utilization among mothers with low education and lack of access to mass media or have not been told about maternity complications. From societal perspective, majority of women in these countries live in rural areas as also reflected by our studies and are largely self-employed, subsistence farmers or are in agricultural labour employment (57, 58, 100, 101). Thus, most of the women have lower financial income to meet their maternity needs such as transportation to the health facilities and other minor hospital charges thus less likely to afford to freely seek care. The situation is aggravated by gender inequalities that disfavour a spectrum of socioeconomic aspects among women such as land ownership in rural areas. In this thesis, about 80 percent of women were married, implying most of them can obtain financial support from their spouses. At household level, this financial dependency can also hinder prompt care-seeking as previously discussed. On the contrary, those unmarried or without recognizable partners have financial constraints to seek care leading to poor care utilization and this is reflected in our results (Paper IV).

Studies in LMIC agree that improving household socioeconomic status will improve care utilization (102-104). Societal factors related to gender inequities and inequalities that are unsupportive of women to freely determine when to seek care still exist, for instance unpaid daily roles of ´stay-home´ mothers who take care of their families and are regarded as playing a less important role due to no financial gains as compared to a formally employed husband/partner. This financial dependency on the husband/partner to seek care can to some extent be deterring factor (100, 104), although other factors such as education have a more profound impact.

Although this thesis could not examine the quality of maternal or newborn care, care-seeking at minimal levels (modified recommendations prior to 2016) of 4 or more ANC, skilled (facility) birth and at least one PNC with 28 days postpartum can be highly effective in reducing neonatal deaths in Kenya, Uganda, and Tanzania. This is particularly evident in this thesis with ANC and PNC utilization and findings from other studies concur (19, 20, 105, 106). Sufficient data from Kenya DHS enabled plausible analysis in Study IV that revealed that about 63 % of neonatal deaths would be avoided if mothers attend full (recommended) continuum of care from ANC to at least one PNC. Findings from *The Lancet series* and UN agencies also showed comparable estimate of 67 % of neonatal deaths in sub-Saharan Africa that could be prevented with high continuum of care coverage (14, 107). Further, Darmstadt et al. also estimated, that low to moderate PNC utilization would avert 17– 29 % of neonatal deaths in 75 countries across the world of which more than 50% were from Africa. This figure is also comparable to 20 % estimate obtained from lack of at least 1 PNC visit within 28 days in Kenya.

Furthermore, study I that examined neonatal survival outcomes between facility and home birth did not find any statistically significant differences in survival or mortality. However, in Study IV it was evident that ANC is positively correlated with facility births and PNC, implying that facility births could still enhance utilization of PNC services. A cluster-randomized controlled trial in *The Lancet* also found no survival benefits of facility births as compared to home births. However, the study recommended facility births only when emergency obstetric or newborn services are available in a facility (33). However, contrary to our study I findings on facility births, a systematic review by Tura et al. indicated greater neonatal survival outcomes among facility births compared to home births (31).

Adolescent maternal age is a well-known risk factor for neonatal (and maternal) mortality (108, 109) and this thesis (Study V) findings confirmed that in East Africa. However, we further considered how marital status and pregnancy intentions affect neonatal survival in the age-group, 15-19 years. The results indicate 3-4 times higher hazard of neonatal death among married adolescent mothers compared to their corresponding older counterparts aged 20-29 years old. Findings from Singh et al. are consistent with these results (110). Lack of sufficient data hindered further analysis among the unmarried women. However, studies suggest that abortions are common in East Africa among unmarried adolescents and young women and that could have affected reporting and data availability (111, 112). Future studies could explore more.

The hazard of death was much higher (4-6 times) among primiparous (nulliparous) married adolescent mothers versus their corresponding older counterparts aged 20-29 years. Generally, neonates born to adolescent mothers with unintended pregnancies had much higher death hazard when compared with those of similar mothers of older age 20-29, than when adolescent with intended pregnancies were compared with corresponding older mothers. However, the findings were not statistically significant among multiparous married women irrespective of pregnancy intentions. Similar findings were recently reported by Zhang et al. (87, 113). Another study by Klerman made parity comparisons between adolescent mothers and found worse neonatal outcomes among multiparous adolescent mothers compared to primiparous adolescents (114). However, when he compared first and second births of the same adolescent mothers, the first birth had worse neonatal outcomes (114). Nonetheless, the difference in neonatal mortality by parity among adolescents could be further investigated to understand the mechanisms leading to these differences. Again, lack of sufficient data in mortality strata could not allow for more reasonable analysis among multiparous unmarried adolescents in our study.

Methodological consideration

General

The nationally representative data of the DHS for Kenya, Uganda, and Tanzania allowed for valid statistical investigations with several stratifications and the findings are generalizable across similar settings. The data collection also captured neonatal births and deaths that may have not been recorded in health facility birth or death registries. Nevertheless, further stratifications would have been desirable to unearth more findings, for instance, in study V where analysis were limited to mainly married adolescents and mothers 20-29 years old. Similarly, certain country specific stratification was not possible for Uganda and Tanzania due to relatively lower numbers compared to Kenya.

Because of the retrospective nature of the cross-sectional data collection, we cannot ascertain that all recall bias were eliminated, particularly when more detailed information such as birthweight were asked during verbal interviews and when perhaps the mother had no birth information card to remember. This could have affected mothers that gave birth much earlier prior to the data collection period and consequently could have lowered the accuracy of our findings. Further, a study by Biks et al. reported that home births and neonatal deaths had less likelihood of being weighed at birth (115). We however, minimized the recall bias through using data of most recent births and neonatal death occurrences from most recent pregnancies, all of which are significant events not easily forgotten by mothers or carers. A recent randomized study by Akuze et al. compared two DHS questionnaire modules across different surveillance sites including Uganda, found no difference in reporting of neonatal deaths (116), indicating minimal recall bias, no interviewer and social desirability biases.

It was not possible to determine the quality of maternity care that was rendered to the mothers or neonates or lack of hospital supplies. However, proxy indicators such as skilled ANC attendance could be regarded to render the required standard of care. Moreover, the studies could not capture other internal facility factors hypothesized by other studies to deter maternal care-seeking such as mistreatment and abuse of mothers during childbirth by health personnel (117-119) and absence of facility staff (120).

Non-response led to few missing data across variables in all the three countries. In Uganda in particular, data collection in older surveys such as 1995 were affected by civil and military conflict in northern Uganda that led to compensation by data being sampled/collected in other areas instead. Also, the 1995 data was not weighted and that could have rendered it less representative. However, an investigation of the missingness of data in all most recent year surveys in all the three countries indicated random distribution between rural and urban and across key variables in all the studies in this thesis.

General implications for public health policy and future research

Policies intended to improve maternal care utilization could consider routine group maternal education for mothers seeking ANC to enlighten them about pregnancy, birth and perinatal complications and highlight neonatal death statistics and importance of completing the care-continuum including PNC. For the long term, social and educational policies could include focus geared towards improving knowledge about safe maternity care and rights from lower primary education for both boys and girls to adult education, this could easily be integrated in biology or health science curricula. Additionally, over 4 years after WHO updated its ANC recommendations to 8 visits in 2016, over 90 percent of countries in SSA are still non-adherent (121). Public health campaigns could promote this and ANC guidelines in Kenya, Uganda and Tanzania ought to not only be updated but also implemented in health facilities countrywide. This could bring a significant improvement in neonatal survival outcomes.

Our findings indicated wider socioeconomic disparities in utilization of care implying that the current free or subsidized maternity policies have not achieved their intended goals. Advocating for “absolutely” free maternal and newborn care could be considered in Kenya, Uganda, and Tanzania. In turn this will also lead to promotion of intervention to prevent unwanted pregnancies through use of contraceptives and eliminating child marriages to alleviate health systems from unnecessary financial burdens resulting from providing free maternal health care for the many unintended adolescent pregnancies.

Beyond the current social and educational policies aimed at preventing adolescent pregnancies, there could be continuous evaluation research of the impact of such policies to improve their effectiveness. Additionally, given the high population of young people in these countries, there could be a sustained national crisis-level intervention to prevent adolescent pregnancies. Implying that even in vulnerable situations such as covid-19 pandemic lockdowns, keeping adolescents free from pregnancies could be among the highest national priorities. For the long term, access to quality education for all and tertiary skills could be improved beyond the current state, and this could be legally binding for parents with primary level children in East Africa. Return on investments that spotlights earnings that can be realized through prevention of adolescent pregnancies for instance the “Girls not bride” campaigns (122) across SSA could be highlighted to give impetus to political support and policy implementations.

Conclusion and recommendations

Inadequate care utilization, low birthweight, and adolescent maternal age are major risk factors to neonatal deaths in Kenya, Uganda, and Tanzania. Further research to understand the broader spectrum of factors influencing maternal care-seeking behaviour is necessary. Understanding which maternal and newborn care policies have been fully implemented in East African countries and which ones exist only in print, including the 8 ANC visit recommendations (121) is vital to closing the implementation gaps.

The many strategies aimed at reducing adolescent pregnancies have not achieved any improvements in Kenya, Uganda, and Tanzania. For instance, the 2020 revised guidelines for prevention and management of teenage pregnancy in school settings in Uganda outlines previous 9 separate policy frameworks since 1995 aimed at preventing adolescent pregnancies (123). The report acknowledges that teenage pregnancy rates has persistently remained high and continue to contribute to both low birthweight and neonatal (and maternal) deaths in East Africa. Given our finds that maternal education plays a key role in prevention strategy, perhaps new strategies such as integrating reproductive education in primary and secondary school curricula would be a result-oriented strategy to eliminate adolescent pregnancies. Harnessing political support through highlighting research findings to parliamentarians such as the very high neonatal deaths among unintended adolescent pregnancies in this study, could help to mobilize resources needed to propel tangible preventive strategies such contraceptive awareness and education. These strategies have proved efficacies in contributing to efforts in HIC to reduce adolescent pregnancies and consequent neonatal deaths (124).

Achieving SDG 3.2 target for neonatal survival in Kenya, Uganda and Tanzania will necessitate adopting new and innovative strategies to improve care utilization. One such approach would be to adopt an evidence-based brief set of standard questions with an overall score scale, that can be used during the first ANC visit to determine care-seeking tendencies of a mother and use that information to close the care-seeking gaps where most needed. Using existing structures such as community health workers or village health teams and perhaps mobile health (mHealth) strategy to send reminder messages to pregnant mothers to seek care ought to be explored.

Given our findings of 63% avoidable neonatal deaths in Kenya, it can be noted that even with the current state of quality of maternal health care in Kenya, and perhaps in Uganda and Tanzania too, improving and sustaining care-seeking among expectant mothers in East Africa to a minimum of at least 4 ANC, facility birth and at least 1 PNC could help to achieve SDG 3.2 that aims to reduce neonatal deaths to as low as 12 deaths per 1000 live births much earlier before 2030.

Sammanfattning på svenska

I denna avhandling, med titeln *"Förbättring av neonatal överlevnad i Östafrika: analys av mödravårdsanvändning, vårdeffektivitet och riskfaktorer för neonatal dödlighet i Kenya, Uganda och Tanzania"*, undersöker vi ledande riskfaktorer och interventioner som påverkar neonatal överlevnad i de tre mest befolkade länderna i East Africa Community (EAC). Kenya, Uganda och Tanzania är tre afrikanska länderna söder om Sahara som har registrerat en mycket långsam nedgång av neonatal dödlighet. Detta beror delvis på brist på forskning för att informera evidensbaserad policyformulering och implementering, samt resursfördelning. Detta forskningsprojekt bidrar delvis redan till att fylla luckorna i evidensbasen för att möjliggöra förverkligandet av Sustainable Development Goals (SDG) 3, mål 3.2 som syftar till att avsevärt minska neonatal dödlighet till 12 dödsfall per 1000 levande födda innan slutet av 2030.

FN noterar att vissa länder i Afrika söder om Sahara fortfarande använder föråldrade riktlinjer som hindrar tillhandahållande av livräddande hälso-och sjukvård. Under 2019 dog över 2,4 miljoner nyfödda (neonatala) barn, vilket motsvarar nästan hälften av alla dödsfall under 5 år. Över 80 procent av dödligheten inträffar i låg- och medelinkomstländer. Vissa låg inkomstländer, som Rwanda och Malawi, uppnådde millennieutvecklingsmål (MDG) 4 2015, medan Kenya, Uganda och Tanzania fortfarande är bland de länder som bidrar mest flest neonatala dödsfall i Afrika trots att de har relativt bättre ekonomi. MDG 4 syftade till att minska barns dödsfall med två tredjedelar mellan 1990 och 2015.

De största (direkta) riskfaktorerna för neonatala dödsfall är infektioner, förlossningskomplikationer och för tidig födsel. De flesta av riskfaktorerna kan förebyggas med insatser utanför intensivvården. Födslar utanför vårdinrättningar (hemma) är vanliga i många länder i Afrika söder om Sahara vilket gör att ett antal sjukhusbaserade studier är mindre representativa för befolkningen. Vidare gör bristen på födelse-och dödsdata för nyfödda det svårt att bedriva forskning för att informera evidensbaserad policy. Likt många andra afrikanska länder söder om Sahara finns det mycket begränsade befolkningsbaserade studier i Östafrika. Detta projekt använder nationellt representativa data från *Demographic and Health Survey* (DHS) för att ge en djupare förståelse av faktorer som påverkar neonatal överlevnad i Östafrika. Projektet genererar också rekommendationer för att stödja beslutsfattare i att vägleda mödra-och barnhälsointerventioner för ökad överlevnad hos nyfödda.

Projektet består av 5 individuella studier som kompletterar varandra: Studie I, II, III, IV och V. Data från DHS användes i alla studier. Fördelarna med att använda denna typ av data är att det är nationellt representativt, det vill säga, att data samlades in över hela landet. Insamlade data fångade även de många neonatala födslar och dödsfall som inte registrerades officiellt, eftersom de inträffade utanför vårdinrättningarna. Dataanalysen omfattade binomial och multinomial logistikregression samt överlevnadsanalysmetoder.

I studie I, med titeln, ”*Effektivitet av mödravård för att förbygga neonatal dödlighet i Kenya: analys av nationella enkätdata”*, undersökte vi hur besök hos barnmorskor, olika vårdinsatser, och kontroll för graviditetskomplikationer bidrar till neonatal överlevnad i Kenya. Resultaten indikerar att brist på, eller färre besök hos, barnmorskor bidrog till ungefär 28 % av neonatala dödsfall i Kenya 2014, och att mödravård med okvalificerad personal indirekt orsakade 9% av neonatala dödsfall.

Syftet med studie II, med titeln ”*Överlevnad hos nyfödda med låg födelsevikt i Uganda: analys av framsteg mellan 1995 och 2011”,* var att undersöka sambandet mellan låg födelsevikt (LFV) (bebisar som väger mindre än 2500 gram vid födseln) och neonatal dödlighet, och att fastställa trenderna för neonatala dödsfall på grund av låg födelsevikt i Uganda mellan 1995 och 2011. Resultaten visade att låg födelsevikt är en stor underliggande riskfaktor för neonatala dödsfall. Jämfört med normal födelsevikt (2500–4000 gram) var risken (oddsen) för neonatal dödlighet i Uganda 6 gånger högre för barn med LFV 1995, och denna risk minskade gradvis till cirka 4 gånger högre år 2011. Över 70% av LFB nyfödda dog i Uganda i 2011, en minskning med ungefär hälften sedan 1995.

Studie III, med titeln ”*Kejsarsnittsförlossningar och associerade socioekonomiska faktorer och neonatala överlevnadsutfall i Kenya och Tanzania: analys av nationella enkätdata”*, undersökte hur kejsarsnitt och associerade socioekonomiska faktorer påverkar överlevnad bland nyfödda barn i Kenya och Tanzania. Resultaten tyder på att användandet av kejsarsnitt var mycket högre bland mödrar från rikare hushåll, med mer utbildning, samt bland mödrar i högre anställningsspositioner. Dessutom var kejsarsnittsförlossningarna högre bland de som födde barn på missionärbaserade sjukhus jämfört med statliga sjukhus i Kenya och Tanzania. Vi fann också betydande samband mellan kejsarsnitt och neonatala dödsfall. Ytterligare forskning behövs för att stärka dessa resultat.

Syftet med studie IV, med titeln *”Bestämningsfaktorer för fortsatt mödravårdsanvändande under graviditet, födsel och postnatalt och associerad neonatala överlevnadsutfall i Kenya och Uganda: analys av demografisk-och undersökningsdata”*, var att undersöka hur socioekonomiska faktorer påverkar mödrars vårdsökande från graviditet till födsel och till den postnatala perioden, och dess samband med neonatal överlevnad i Kenya och Uganda. Detta är ett område som tidigare sällan studerats i låginkomstländer. Resultaten av studien visar att Kenya kunde 63 % av all neonatala dödsfall ha förhindrats om alla gravida mödrar hade besökt kvalificerad personal minst 4 gånger, hade sin förlossning på sjukhuset, och besökte postnatalvården minst en gång tidigt efter förlossning. Resultaten visar också att både i Kenya och i Uganda så var det bara ungefär hälften (56%) av gravida som besökte mödravården 4 eller fler gånger, och mycket färre hade 1 postnatalvårdsbesök. Tendensen att söka vård ökar som mest bland mödrar där någon av föräldrarna hade högre utbildning. Tillgången till media, så som radio och TV, ökade också mödrars vårdsökande. Längre avstånd till vårdinrättningar minskade vårdsökandet. Vidare så visade resultaten att mödrar som var mer beroende av sin man i beslutstagande kring när de bör söka mödravård var mindre benägna att söka vård, än de som bestämde själva.

Studie V, med titeln ”*Överlevnad bland nyfödda med tonårsmödrar och effekterna av graviditetsintention och civilstatus på nyföddas överlevnad: analys av en tvärsnittsundersökning i Kenya, Uganda och Tanzania, 2014 – 2016*” undersökte effekterna av graviditetsintention och civilstatus på överlevnadsmönstret bland nyfödda med mödrar i tonåren i Kenya, Uganda och Tanzania. Överlevnadstiden hos nyfödda med mödrar i tonåren var ungefär två gånger så kort i jämförelse med äldre mödrar, i åldrarna 20–29. Bland gifta tonåringar med oplanerad graviditet så var risken för neonatala dödsfall inom en kort period efter födsel 3–4 gånger högre. Bland förstagångsmödrar i tonåren med oplanerad graviditet så var risken för neonatala dödsfall 6 gånger högre.

Resultaten visar att brist på, eller otillräckligt mödravårdsanvändande, låg födelsevikt och ung ålder är bland de främsta riskfaktorerna och bidrar till en hög andel av neonatala dödsfall i Kenya, Uganda och Tanzania. Implementering av, och förstärkning till, existerande rekommendationer så som den nya 8 ANC rekommendationen från WHO kan bidra till ökad neonatal överlevnad. Nya strategier för att främja vårdsökande bland mödrar i Kenya, Uganda och Tanzania måste undersökas för att nå drastiska förändringar som i sin tur kan bidra till att nå Sustainable Development Goal 3.2 som syftar till att avsevärt minska neonatal dödlighet till 12 dödsfall per 1000 levande födda innan slutet.

Summary in Swahili

Katika mradi huu kwa kichwa, *"Uporeshaji wa maisha ya watoto wachanga Afrika Mashariki: utafiti kuhusu utumiaji wa huduma za akina mama, ufanisi wa huduma za afya na sababu hatari zinazoletea vifo vya watoto wachanga nchini Kenya, Uganda na Tanzania."* Tunachunguza vitu vinavyoongoza kuhatarisha maisha ya watoto wachanga (chini ya umri wa siku 28), na suluhisho za kipekee zinazoletea watoto hao wachanga kunusurika katika nchi tatu zenye watu wengi sana katika jumuiya ya Afrika Mashariki (EAC). Kenya, Uganda na Tanzania ni miongoni mwa nchi zilizoko Kusini mwa Jangwa la Sahara ambazo zimepungua polepole sana viwango vya vifo vya watoto wachanga ndani ya siku 28 baada ya kuzaliwa. Hii kwa kiasi fulani ni kwa sababu ya ukosefu wa utafiti wa kufahamisha uundaji na utekelezaji wa sera unaozingatia ushahidi na ugawaji wa rasilimali. Mradi huu wa utafiti, kwa kiasi, tayari unachangia kujaza mapengo yanayohitaji ushahidi mathubuti kuwezesha utimilifu wa Lengo la Maendeleo Endelevu (SDG) 3, lengo 3.2 ambalo linalenga kupunguza kwa kiasi kikubwa viwango vya vifo vya watoto wachanga (chini ya umri wa mwezi mmoja) hadi vifo 12 kwa watoto 1000 wanaozaliwa wakiwa hai ifikapo mwaka 2030.

Umoja wa mataifa ulibainisha kua baadhi ya nchi za Africa kusini mwa Jangwa la Sahara bado zinatumia sera ambazo hazina uwezo na ambazo mwongozo wao ni wa kitambo sana unaozuia utoaji wa huduma bora zinazookoa maisha. Mnamo mwaka 2019, zaidi ya watoto milioni 2.4 chini ya umri wa mwezi mmoja walikufa, ambayo ni takribani asilimia 47 ya vifo vya watoto chini ya miaka 5. Zaidi ya asilimia 80 ya vifo vya watoto hawa hutokea kwenye nchi zenye mapato ya chini na ya katikati. Hata hivyo, baadhi ya nchi zenye pato la chini kama Rwanda na Malawi zilikia Malengo ya Maendeleo Milenia (MDG) 4 mnamo mwaka 2015 huku Kenya, Uganda na Tanzania zikabaki kati ya nchi zinazochangia vifo vingi sana vya watoto wachanga Afrika licha ya kuwa na uchumi mzuri kiasi kuliko Rwanda na Malawi.

Sababu kuu za hatari zinayosababisha vifo vya watoto wachanga hujumuisha; kuzaliwa kwa watoto mapema kabla ya wakati, maambukizi, na matatizo ya kujifungua, ambayo mengi yanazuilika kwa uingiliaji wa huduma zisizo za wagongjwa mahututi. Wamama kujifungua wakiwa nyumbani pasipo kutembelea vituo vya afya vinaenea kwa wingi katika nchi nyingi za Afrika kusini mwa Jangwa la Sahara. Wao huchukua sehemu kubwa ya mafunzo ya kiafya kuwakilisha idadi ya watu.Zaidi ya hayo,upungufu wa rekodi za usajili hospitalini pamoja na upungufu wa ukaguzi wa kitaifa kuonyesha miezi kabla na baada ya kuzaliwa kwa mtoto, na tena rekodi ya vifo vya watoto wachanga hufanya vigumu sana kufanya utafiti na kuzua sera halisi. Ukizingatia nchi nyingi za Afrika Kusini mwa Jangwa la Sahara, utafiti kuhusu idadi ya watu, hupatikana kwa nadra sana katika Afrika Mashariki. Mradi huu kwa sasa hutumia hesabu za kitaifa za idadi ya watu na utafiti wa kiafya (DHS) kutoa ufahamu wa kindani kuhusu sababu zinazoamua hatima ya watoto wachanga Afrika Mashariki. Mradi huu pia huzalisha mapendekezo ya kusaidia juhudi za watunga sera kuongoza afya ya mama na mtoto kwa matokeo bora ya watoto wachanga.

Mradi huu wa utafiti hunajumuisha tafiti tano za kibinafsi ambayo yanapongezana: Masomo I, II, III, IV na V. Tulitumia data ya uchunguzi kutoka kwa tafiti za idadi ya watu na afya (DHS). Kutumia aina hii ya data kulikuwa na faida kwa kuwa ilikuwa uwakilishi wa kitaifa. kwa mfano,habari inakusanywa kutoka sehemu yote ya nchi. Data iliyokusanywa ilinasa hata vifo vingi vya watoto wachanga na vifo ambavyo havijasajiliwa katika sajili za kuzaliwa au vifo kwa sababu vilitokea nje ya vituo vya afya.

Kwa uchanganuzi wa data, tulitumia njia ya uchambuzi wa data inayoitwa ”logistic regression”, ”multinomial logistic regression” na pia ”survival analysis” kwa lugha ya kingereza.

Katika utafiti wa 1, kwa kichwa: “*Ufanisi wa huduma za utunzaji katika ujauzito katika kupunguza vifo vya watoto wachanga nchini Kenya: uchambuzi wa data ya uchunguzi wa kitaifa”.* Tunachunguza mama wajawazito akienda kuhudumiwa katika kituo cha afya (yani, antenatal care), na huduma mbalimbali kama, utunzaji wa ujauzito wenye ujuzi, kupata sindano ya Pepopunda,na kuangalia matatizo ya mimba ili kusaidia kupunguza vifo vya watoto wachanga. Matokeo yanaonyesha kuwa,mama mjamzito anapokosa kutembelea vituo vya huduma za afya, au bila kabisa kupata huduma za kutosha inaletea vifo vya watoto wachanga asilimia 28 nchini Kenya katika mwaka wa 2014 na kwa kutopata ujuzi kutokana na huduma za kiafya, imeletea vifo vya watoto wachanga asilimia 9.

Katika utafiti wa II, kwa kichwa: *“Maisha ya watoto wanaozaliwa wakiwa na kipimo cha uzito mdogo nchini Uganda: Utafiti wa maendeleo haya ulifanyika kati ya mwaka wa 1995 na 2011”*. Lengo hasa lilikuwa kutathmini uhusiano kati ya watoto waliozaliwa na uzito ulio chini ya gramu 2500, na vifo vya watoto wachanga, na kuamua ni mwenendo au kiwango gani kilicholetea vifo vya watoto hao waliozaliwa na uzito wa chini miaka hiyo (1995-2011).

Matokea yalionyesha kuwa uzito wa kiwango cha chini kwa watoto wanaozaliwa ni sababu kuu ya hatari inayolete vifo vya watoto wachanga. Tukilinganisha na watoto wa kawaida wanaopima kati ya gramu 2500 na 4000 baada ya kuzaliwa,uwezekano wa vifo vya watoto wanaokufa wakiwa wachanga nchini Uganda ni mara 6 zaidi ya wale watoto wachanga waliopima uzito wa chini mnamo mwaka wa 1995. Hii hatari iliendelea kupungua taratibu hadi mara 4 zaidi ilipofikia mwaka wa 2011.

Zaidi ya asilimia 70 ya watoto wanaozaliwa wakipima uzito wa chini walikufa nchini Uganda mnamo mwaka wa 2011. Katika nchi nzima ya Uganda, hii iliweza kuchangia takribani asilimia 15 ya watoto waliokufa wakiwa wachanga katika mwaka wa 2011 wachache kwa takribani nusu tangu mwaka wa 1995.

Katika somo la III, lenye kichwa: *"Kujifungua kwa upasuaji na sababu zinazohusiana za kijamii na kiuchumi na matokeo ya maisha ya watoto wachanga nchini Kenya na Tanzania: uchambuzi wa data ya uchunguzi wa kitaifa".* Lengo Lake ni kuchunguza sababu za kijamii na za kiuchumi zinazosababisha kujifungua kwa njia ya oparesheni nchini Kenya na Tanzania ili kutathmini athari za Maisha baada ya kuzaliwa kwa mtoto. Matokeo yanayoonyesha kuwa utumiaji wa huduma ya upasuaji ulikua wa juu zaidi miongoni kwa wamama wajawazito kutoka familia tajiri, wenye elimu ya juu na wale walio na vyeo vya juu kazini. Pia waliojifungua kwa upasuaji walikuwa juu zaidi kati ya wale waliojifungulia katika hospitali ya misheni ikilinganishwa na hospitali za serikali nchini Kenya na Tanzania. Pia tulipata uhusiano mkubwa kati ya kujifungua kwa upasuaji na vifo vya watoto wachanga. Hata hivyo utafiti zaidi unahitajika ili kutoa ushahidi zaidi.

Katika utafiti wa IV, kwa kichwa; "*Viamuzi vya kuendelea kutafuta huduma ya uzazi wakati wa ujauzito, kujifungua na baada ya kuzaa na matokeo yanayohusiana na maisha ya watoto wachanga: uchambuzi wa data ya uchunguzi wa kitaifa".* Hii ni sehemu ambayo ilikuwa na masomo machache sana ya hapo awali katika nchi za kipato cha chini na kati. Utafiti huo ulilenga kuchunguza sababu zinazoathiri wamama kuendelea kutafuta huduma kutoka kwa ujauzito hadi kuzaliwa kwa mtoto nchini Kenya na Uganda. Tuligundua kwamba nchini Kenya hasa watu asilimia 62 wanaotokana na vifo vya watoto wachanga (neonates) wanaweza kingwa iwapo wanawake wajawazito afadhali hutembelea vituo vya huduma za afya mara nne kabla ya kujifungua, hujifungulia hospitalini na kwa uchache sana hutembelea vituo vya huduma za afya mara moja baada ya kujifungua.

Matokeo yanaonyesha kuwa Kenya na Uganda nusu pekee (asilimia 56) ya wanawake wajawazito walitembelea mara nne au zaidi vituo vya huduma za afya, na wachache sana walivitembelea vituo hivyo kupokea huduma. Mazoea ya kutembelea vituo vya huduma za afya iliongezeka kwa wazazi walioelimika sana. Pia kufikia vyombo vya habari vikiwemo redio na runinga, huongeza hamu na haja ya wanawake wajawazito kutembelea vituo vya afya kupokea huduma. Hali kadhalika, baadhi ya wanawake ambao walitegemea waume zao kufanya maamuzi ya lini watatafuta huduma ya uzazi walikuwa na mwelekeo mdogo wa kutafuta matunzo ikilinganishwa na wale ambao wangeweza kuamua wao wenyewe.

Masomo ya (V) kwa kichwa, "*Kua hai kwa watoto wachanga chini ya mwezi mmoja wanaozaliwa na wanawake vijana na athari za nia la kupata mimba pamoja na viwango vya hali ya maisha ya ndoa nchini Kenya, Uganda na Tanzania".* Kua hai kwa watoto wachanga wanaozaliwa kimakusudi na wamama vijana ulikuwa mara dufu kwa ufupi ukilinganisha na wamama wakomavu wa umri kati ya miaka 20-29.

Kati ya wanawake vijana walio katika ndoa ambao hawakusudia kupata mimba, hatari ya kufa kwa watoto wachanga muda mfupi baada ya kuzaliwa ulikuwa takribani mara 3-4 zaidi.

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References

1. Hug L, Alexander M, You D, Alkema L. National, regional, and global levels and trends in neonatal mortality between 1990 and 2017, with scenario-based projections to 2030: a systematic analysis. Lancet Glob Health. 2019;7(6):e710-e20.
2. United Nations Inter-agency Group for Child Mortality Estimation. Levels and Trends in Child Mortality. 2020.
3. United Nations Children´s Fund (UNICEF). UNICEF and the Sustainable Development Goals 2021 [Available from: https://www.unicef.org/sdgs#sdg3.
4. The World Bank. Tracking Universal Health Coverage: 2017 Global Monitoring Report. 2017.
5. World Health Organization. Universal health coverage: Primary health care towards universal health coverage. 2019.
6. United Nations Children´s Fund (UNICEF). The UNICEF Health Systems Strengthening Approach. York HSPDN; 2016.
7. UNICEF. Accelerating progress towards universal coverage for women and children in South Asia, East Asia and The Pacific: Thematic paper: . 2009.
8. World Health Organization. THE GLOBAL STRATEGY FOR WOMEN'S, CHILDREN'S AND ADOLESCENTS' HEALTH (2016-2030). 2015.
9. World Health Organization. Primary Health Care on the Road to Universal Health Coverage: 2019 Global Monitoring report. . Executive summary. Geneva: World Health Organization; 2019; 2019.
10. Asamoah BO, Agardh A. Inequality trends in maternal health services for young Ghanaian women with childbirth history between 2003 and 2014. BMJ Open. 2017;7(2):e011663.
11. Bintabara D. Addressing the huge poor-rich gap of inequalities in accessing safe childbirth care: A first step to achieving universal maternal health coverage in Tanzania. PLoS One. 2021;16(2):e0246995.
12. Novignon J, Ofori B, Tabiri KG, Pulok MH. Socioeconomic inequalities in maternal health care utilization in Ghana. Int J Equity Health. 2019;18(1):141.
13. UNFPA GI. The costs And benefits of investing in family planning and maternal and newborn health. 2009.
14. PMNCH. Opportunities for Africa's Newborns: practical data, policy and programmatic support for newborn care in Africa. . Cape Town, South Africa:: PMNCH, Save the Children, UNFPA, UNICEF, USAID, WHO; 2007.
15. Kerber KJ, de Graft-Johnson JE, Bhutta ZA, Okong P, Starrs A, Lawn JE. Continuum of care for maternal, newborn, and child health: from slogan to service delivery. Lancet. 2007;370(9595):1358-69.

16. World Health Organization. Make every mother and child count. . Geneva, Switzerland; 2005.; 2005.
17. Moller AB, Petzold M, Chou D, Say L. Early antenatal care visit: a systematic analysis of regional and global levels and trends of coverage from 1990 to 2013. Lancet Glob Health. 2017;5(10):e977-e83.
18. World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience. 2016.
19. Tunçalp Ö, Pena-Rosas JP, Lawrie T, Bucagu M, Oladapo OT, Portela A, et al. WHO recommendations on antenatal care for a positive pregnancy experience-going beyond survival. Bjog. 2017;124(6):860-2.
20. Doku DT, Neupane S. Survival analysis of the association between antenatal care attendance and neonatal mortality in 57 low- and middle-income countries. Int J Epidemiol. 2017;46(5):1668-77.
21. Skane R. Basprogram för graviditet och eftervård i Region Skåne, 2014–2023 (Base programme for pregnancy and postnatal in Skane region. In: Skåne R, editor. 2014.
22. Graviditetsregistret (Pregnancy registry). Graviditetsregistrets Årsrapport 2019 2019.
23. Arsenault C, Jordan K, Lee D, Dinsa G, Manzi F, Marchant T, et al. Equity in antenatal care quality: an analysis of 91 national household surveys. Lancet Glob Health. 2018;6(11):e1186-e95.
24. World Health Organization. Making pregnancy safer: the critical role o the skilled attendant: A joint statement by WHO, ICM and FIGO. 2004.
25. World Health Organization. Every Newborn: An action plan to end preventable deaths. 2014.
26. Hasan MM, Magalhaes RJS, Fatima Y, Ahmed S, Mamun AA. Levels, Trends, and Inequalities in Using Institutional Delivery Services in Low- and Middle-Income Countries: A Stratified Analysis by Facility Type. Glob Health Sci Pract. 2021;9(1):78-88.
27. World Health Organization E. Place of birth in Europe. 2015.
28. Karanja S, Gichuki R, Igunza P, Muhula S, Ofware P, Lesiamon J, et al. Factors influencing deliveries at health facilities in a rural Maasai Community in Magadi sub-County, Kenya. BMC Pregnancy Childbirth. 2018;18(1):5.
29. Bohren MA, Hunter EC, Munthe-Kaas HM, Souza JP, Vogel JP, Gülmezoglu AM. Facilitators and barriers to facility-based delivery in low- and middle-income countries: a qualitative evidence synthesis. Reprod Health. 2014;11(1):71.
30. Bohren MA, Vogel JP, Hunter EC, Lutsiv O, Makh SK, Souza JP, et al. The Mistreatment of Women during Childbirth in Health Facilities Globally: A Mixed-Methods Systematic Review. PLoS Med. 2015;12(6):e1001847; discussion e.
31. Tura G, Fantahun M, Worku A. The effect of health facility delivery on neonatal mortality: systematic review and meta-analysis. BMC Pregnancy Childbirth. 2013;13:18.
32. Altman R, Sidney K, De Costa A, Vora K, Salazar M. Is Institutional Delivery Protective Against Neonatal Mortality Among Poor or Tribal Women? A Cohort Study From Gujarat, India. Matern Child Health J. 2017;21(5):1065-72.

33. Gabrysch S, Nesbitt RC, Schoeps A, Hurt L, Soremekun S, Edmond K, et al. Does facility birth reduce maternal and perinatal mortality in Brong Ahafo, Ghana? A secondary analysis using data on 119 244 pregnancies from two cluster-randomised controlled trials. Lancet Glob Health. 2019;7(8):e1074-e87.
34. Mgawadere F, Unkels R, Kazembe A, van den Broek N. Factors associated with maternal mortality in Malawi: application of the three delays model. BMC Pregnancy Childbirth. 2017;17(1):219.
35. Doctor HV, Nkhana-Salimu S, Abdulsalam-Anibilowo M. Health facility delivery in sub-Saharan Africa: successes, challenges, and implications for the 2030 development agenda. BMC Public Health. 2018;18(1):765.
36. Yaya S, Bishwajit G, Uthman OA, Amouzou A. Why some women fail to give birth at health facilities: A comparative study between Ethiopia and Nigeria. PLoS One. 2018;13(5):e0196896.
37. Harahap NC, Handayani PW, Hidayanto AN. Barriers and technologies of maternal and neonatal referral system in developing countries: A narrative review. Informatics in Medicine Unlocked. 2019;15:100184.
38. UNICEF. Ending preventable newborn deaths and stillbirths by 2030. 2020.
39. Sobhy S, Arroyo-Manzano D, Murugesu N, Karthikeyan G, Kumar V, Kaur I, et al. Maternal and perinatal mortality and complications associated with caesarean section in low-income and middle-income countries: a systematic review and meta-analysis. Lancet. 2019;393(10184):1973-82.
40. World Health Organization. WHO recommendations on postnatal care of the mother and newborn. Geneva, Switzerland: World health Organization. 2014.
41. Tessema ZT, Yazachew L, Tesema GA, Teshale AB. Determinants of postnatal care utilization in sub-Saharan Africa: a meta and multilevel analysis of data from 36 sub-Saharan countries. Ital J Pediatr. 2020;46(1):175.
42. Lawn JE, Blencowe H, Oza S, You D, Lee AC, Waiswa P, et al. Every Newborn: progress, priorities, and potential beyond survival. Lancet. 2014;384(9938):189-205.
43. Sankar MJ, Natarajan CK, Das RR, Agarwal R, Chandrasekaran A, Paul VK. When do newborns die? A systematic review of timing of overall and cause-specific neonatal deaths in developing countries. Journal of Perinatology. 2016;36:S1 - S11.
44. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals. Lancet. 2016;388(10063):3027-35.
45. Bassani DG, Kumar R, Awasthi S, Morris SK, Paul VK, Shet A, et al. Causes of neonatal and child mortality in India: a nationally representative mortality survey. Lancet. 2010;376(9755):1853-60.
46. Olack B, Santos N, Inziani M, Moshi V, Oyoo P, Nalwa G, et al. Causes of preterm and low birth weight neonatal mortality in a rural community in Kenya: evidence from verbal and social autopsy. BMC Pregnancy Childbirth. 2021;21(1):536.
47. Kananura RM, Tetui M, Mutebi A, Bua JN, Waiswa P, Kiwanuka SN, et al. The neonatal mortality and its determinants in rural communities of Eastern Uganda. Reprod Health. 2016;13:13.

48. Gray RH, Ferraz EM, Amorim MS, de Melo LF. Levels and determinants of early neonatal mortality in Natal, northeastern Brazil: results of a surveillance and case-control study. Int J Epidemiol. 1991;20(2):467-73.
49. Kamal SMM. Maternal Education as a Determinant of Neonatal Mortality in Bangladesh. Journal of Health Management. 2012;14(3):269-81.
50. Mekonnen Y, Tensou B, Telake DS, Degefie T, Bekele A. Neonatal mortality in Ethiopia: trends and determinants. BMC Public Health. 2013;13:483.
51. Mohamoud YA, Kirby RS, Ehrenthal DB. Poverty, urban-rural classification and term infant mortality: a population-based multilevel analysis. BMC Pregnancy Childbirth. 2019;19(1):40.
52. Izugbara C. Single motherhood and neonatal and infant mortality in Sierra Leone, Burkina Faso and Burundi. Public Health. 2016;135:122-30.
53. Abdullah A, Hort K, Butu Y, Simpson L. Risk factors associated with neonatal deaths: a matched case-control study in Indonesia. Glob Health Action. 2016;9:30445.
54. Kenya National Bureau of Statistics. 2019 Kenya Population and housing census. 2019.
55. Council NP. State of Uganda Populatin Report 2017. 2017.
56. National Bureau of Statistics Tanzania. 2012 Population and Housing Census 2012.
57. National Bureau of Statistics-Kenya and ICF International. 2014 Kenya Demographic and Health Survey. Key Findings. . 2015.
58. National Bureau of Statistics (NBS). 2015-16 TDHS-MIS Key Findings. Rockville, Maryland, USA. 2016.
59. Kenya National Bureau of Statistics and ICF. 2015. Kenya Demographic and Health Survey 2014. 2015.
60. Uganda Bureau of Statistics (UBOS) and ICF 2018. Uganda Demographic and Health Survey 2016. Kampala,

. In: Uganda and Rockville M, USA: UBOS and ICF., editor. 2018.
61. National Bureau of Statistics (NBS) and ICF 2016. Tanzania Demographic and Health Survey and Malaria Indicator Survey. Dar es Salaam, Tanzania, and Rockville, Maryland, USA:: MoHCDGEC, MoH, NBS, OCGS, and ICF; 2016.
62. Republic of Uganda. Roadmap for Acceleratingthe Reduction of Maternal and Neonatal Mortality and Morbidity in Uganda. 2007-2015.
63. Welfare MoHaS. The National Road Map Strategic Plan to Improve Reproductive, Maternal, Newborn, Child & Adolescent Health in Tanzania (2016 - 2020). 2015.
64. Republic of Kenya. National Road Map: For accelerating the attainment of the MDGs related maternal adn newborn health in Kenya. 2010.
65. Ministry of Health. Kenya Community Health Strategy 2020-2025. 2020.
66. Republic of Uganda U. The status of integration of human rights-based approach in health care delivery in uganda: case study of selected northern and central regions' health service points.. 2016.
67. The World Bank. Current health expenditure 2021 [Available from: https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS?locations=TZ-KE-UG.

68. The republic of Uganda Ministry of Health. National health expenditure Uganda.; 2017.
69. Republic of Kenya. National and county health budget analysis FY 2016/17. 2018.
70. World Health Organization. The Abuja Declaration: Ten Years On. 2011.
71. UNICEF. Health budget brief 2018, Tanzania. 2018.
72. Kenya National Commission on Human rights. Implementing free maternal health care in Kenya. 2013. 2013.
73. Ministry of health. Situation analysis of newborn health in Uganda: current status and opportunities to improve care and survival. Kampala: Government of Uganda. . In: Save the Children U, WHO. 2008., editor. 2008.
74. Odokonyero T MF AA, et al. . Universal health coverage in Uganda: The critical health infrastructure, healthcare coverage and equity. 2017.
75. Ministry of Health and Social Welfare (Tanzania). National Health Policy. Dar es Salaam: Ministry of Health and Social Welfare; 2003.
76. Shija AE, Msovela J, Mboera LE. Maternal health in fifty years of Tanzania independence: Challenges and opportunities of reducing maternal mortality. Tanzan J Health Res. 2011;13(5 Suppl 1):352-64.
77. World Health Organization. Reaching the every newborn national 2020 milestones. 2020.
78. The World Bank. Open Data, indicators, neonatal (per 1000 live births)-Kenya, Uganda, Tanzania. 1994–2019. 2021. 2021 [Available from: https://data.worldbank.org/indicator/SH.DYN.NMRT?end=2019&locations=KE-UG-TZ&start=2000.
79. Mangu CD, Rumisha SF, Lyimo EP, Mremi IR, Massawe IS, Bwana VM, et al. Trends, patterns and cause-specific neonatal mortality in Tanzania: a hospital-based retrospective survey. International Health. 2020;13(4):334-43.
80. Mosley WH, Chen LC. An analytical framework for the study of child survival in developing countries. 1984. Bull World Health Organ. 2003;81(2):140-5.
81. World Health Organization. A Conceptual Framework for Action on the Social Determinants of Health: Social determinants of health discussion paper 2. . 2020.
82. United Nations Children´s Fund (UNICEF). The State of the World's Children 2009: Maternal and newborn health. 2009.
83. Leader J, Bajwa A, Lanes A, Hua X, Rennicks White R, Rybak N, et al. The Effect of Very Advanced Maternal Age on Maternal and Neonatal Outcomes: A Systematic Review. J Obstet Gynaecol Can. 2018;40(9):1208-18.
84. Cunnington AJ. What's so bad about teenage pregnancy? J Fam Plann Reprod Health Care. 2001;27(1):36-41.
85. Adedokun ST, Yaya S. Factors influencing mothers' health care seeking behaviour for their children: evidence from 31 countries in sub-Saharan Africa. BMC Health Serv Res. 2020;20(1):842.
86. Asamoah BO, Agardh A, Cromley EK. Spatial analysis of skilled birth attendant utilization in Ghana. Glob J Health Sci. 2014;6(4):117-27.

87. Kozuki N, Lee AC, Silveira MF, Sania A, Vogel JP, Adair L, et al. The associations of parity and maternal age with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. BMC Public Health. 2013;13 Suppl 3(Suppl 3):S2.
88. Veloso FCS, Kassar LML, Oliveira MJC, Lima THB, Bueno NB, Gurgel RQ, et al. Analysis of neonatal mortality risk factors in Brazil: a systematic review and meta-analysis of observational studies. J Pediatr (Rio J). 2019;95(5):519-30.
89. Aghai ZH, Goudar SS, Patel A, Saleem S, Dhaded SM, Kavi A, et al. Gender variations in neonatal and early infant mortality in India and Pakistan: a secondary analysis from the Global Network Maternal Newborn Health Registry. Reprod Health. 2020;17(Suppl 3):178.
90. Sacks E, Mehrtash H, Bohren M, Balde MD, Vogel JP, Adu-Bonsaffoh K, et al. The first 2 h after birth: prevalence and factors associated with neonatal care practices from a multicountry, facility-based, observational study. Lancet Glob Health. 2021;9(1):e72-e80.
91. Balaj M, York HW, Sripada K, Besnier E, Vonen HD, Aravkin A, et al. Parental education and inequalities in child mortality: a global systematic review and meta-analysis. Lancet. 2021;398(10300):608-20.
92. Acharya D, Khanal V, Singh JK, Adhikari M, Gautam S. Impact of mass media on the utilization of antenatal care services among women of rural community in Nepal. BMC Res Notes. 2015;8:345.
93. Fatema K, Lariscy JT. Mass media exposure and maternal healthcare utilization in South Asia. SSM Popul Health. 2020;11:100614.
94. Zamawe COF, Banda M, Dube AN. The impact of a community driven mass media campaign on the utilisation of maternal health care services in rural Malawi. BMC Pregnancy Childbirth. 2016;16:21.
95. Somé DT, Sombié I, Meda N. How decision for seeking maternal care is made--a qualitative study in two rural medical districts of Burkina Faso. Reprod Health. 2013;10:8.
96. Morgan R, Tetui M, Muhumuza Kananura R, Ekirapa-Kiracho E, George AS. Gender dynamics affecting maternal health and health care access and use in Uganda. Health Policy and Planning. 2017;32(suppl_5):v13-v21.
97. Waiswa P, Kallander K, Peterson S, Tomson G, Pariyo GW. Using the three delays model to understand why newborn babies die in eastern Uganda. Trop Med Int Health. 2010;15(8):964-72.
98. Kenya National Commission on Human Rights (KNCHR). Implementing Free Maternal Health Care in Kenya. 2013.
99. World Health Organization. The elimination of user fees in Uganda: impact on utilization and catastrophic health expenditures 2005.
100. Food and Agricultural Organization (FAO). Gender Inequalities in Rural Employment in Tanzania Mainland - An Overview. 2014.
101. Food and Agricultural Organization. Gender and adaptation planning in the agricultural sector: the case of Uganda. 2017.
102. Sui Y, Ahuru RR, Huang K, Anser MK, Osabohien R. Household Socioeconomic Status and Antenatal Care Utilization Among Women in the Reproductive-Age. Front Public Health. 2021;9:724337.

103. Benova L, Campbell OM, Sholkamy H, Ploubidis GB. Socio-economic factors associated with maternal health-seeking behaviours among women from poor households in rural Egypt. Int J Equity Health. 2014;13:111.
104. Dahab R, Sakellariou D. Barriers to Accessing Maternal Care in Low Income Countries in Africa: A Systematic Review. Int J Environ Res Public Health. 2020;17(12).
105. Singh K, Brodish P, Haney E. Postnatal care by provider type and neonatal death in sub-Saharan Africa: a multilevel analysis. BMC Public Health. 2014;14:941.
106. Tiruneh GT, Shiferaw CB, Worku A. Effectiveness and cost-effectiveness of home-based postpartum care on neonatal mortality and exclusive breastfeeding practice in low-and-middle-income countries: a systematic review and meta-analysis. BMC Pregnancy Childbirth. 2019;19(1):507.
107. Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L. Evidence-based, cost-effective interventions: how many newborn babies can we save? Lancet. 2005;365(9463):977-88.
108. Marvin-Dowle K, Soltani H. A comparison of neonatal outcomes between adolescent and adult mothers in developed countries: A systematic review and meta-analysis. European Journal of Obstetrics & Gynecology and Reproductive Biology: X. 2020;6:100109.
109. Neal S, Channon AA, Chintsanya J. The impact of young maternal age at birth on neonatal mortality: Evidence from 45 low and middle income countries. PLoS One. 2018;13(5):e0195731.
110. Singh A, Singh A, Mahapatra B. The consequences of unintended pregnancy for maternal and child health in rural India: evidence from prospective data. Matern Child Health J. 2013;17(3):493-500.
111. Ushie BA, Izugbara CO, Mutua MM, Kabiru CW. Timing of abortion among adolescent and young women presenting for post-abortion care in Kenya: a cross-sectional analysis of nationally-representative data. BMC Womens Health. 2018;18(1):41.
112. Sully EA, Atuyambe L, Bukenya J, Whitehead HS, Blades N, Bankole A. Estimating abortion incidence among adolescents and differences in postabortion care by age: a cross-sectional study of postabortion care patients in Uganda. Contraception. 2018;98(6):510-6.
113. Zhang T, Wang H, Wang X, Yang Y, Zhang Y, Tang Z, et al. The adverse maternal and perinatal outcomes of adolescent pregnancy: a cross sectional study in Hebei, China. BMC Pregnancy Childbirth. 2020;20(1):339.
114. Klerman LV. Risk of poor pregnancy outcomes: is it higher among multiparous teenage mothers? J Adolesc Health. 2006;38(6):761-4.
115. Biks GA, Blencowe H, Hardy VP, Geremew BM, Angaw DA, Wagnew A, et al. Birthweight data completeness and quality in population-based surveys: EN-INDEPTH study. Popul Health Metr. 2021;19(Suppl 1):17.
116. Akuze J, Blencowe H, Waiswa P, Baschieri A, Gordeev VS, Kwesiga D, et al. Randomised comparison of two household survey modules for measuring stillbirths and neonatal deaths in five countries: the Every Newborn-INDEPTH study. Lancet Glob Health. 2020;8(4):e555-e66.

117. Balde MD, Bangoura A, Diallo BA, Sall O, Balde H, Niakate AS, et al. A qualitative study of women's and health providers' attitudes and acceptability of mistreatment during childbirth in health facilities in Guinea. Reprod Health. 2017;14(1):4.
118. Bohren MA, Mehrtash H, Fawole B, Maung TM, Balde MD, Maya E, et al. How women are treated during facility-based childbirth in four countries: a cross-sectional study with labour observations and community-based surveys. Lancet. 2019;394(10210):1750-63.
119. McMahon SA, George AS, Chebet JJ, Mosha IH, Mpembeni RN, Winch PJ. Experiences of and responses to disrespectful maternity care and abuse during childbirth; a qualitative study with women and men in Morogoro Region, Tanzania. BMC Pregnancy Childbirth. 2014;14:268.
120. Kisiangani I, Elmi M, Bakibinga P, Mohamed SF, Kisia L, Kibe PM, et al. Persistent barriers to the use of maternal, newborn and child health services in Garissa sub-county, Kenya: a qualitative study. BMC Pregnancy Childbirth. 2020;20(1):277.
121. Odusina EK, Ahinkorah BO, Ameyaw EK, Seidu AA, Budu E, Zegeye B, et al. Noncompliance with the WHO's Recommended Eight Antenatal Care Visits among Pregnant Women in Sub-Saharan Africa: A Multilevel Analysis. Biomed Res Int. 2021;2021:6696829.
122. Girls not brides 2019. Child marriage prevalence rate 2019 [Available from: https://atlas.girlsnotbrides.org/map/.
123. (Uganda) MoEaS. Revised guidelines for the prevention and management of teenage pregnancy in school settings in Uganda. . 2020.
124. Baxter AJ, Dundas R, Popham F, Craig P. How effective was England's teenage pregnancy strategy? A comparative analysis of high-income countries. Soc Sci Med. 2021;270:113685.

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Effectiveness of antenatal care services in reducing neonatal mortality in Kenya: analysis of national survey data

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ABSTRACT

Background: Although global neonatal mortality declined by about 40 percent from 1990 to 2013, it still accounted for about 2.6 million deaths globally and constituted 42 percent of global under-five deaths. Most of these deaths occur in developing countries. Antenatal care (ANC) is a globally recommended strategy used to prevent neonatal deaths. In Kenya, over 90 percent of pregnant women attend at least one ANC visit during pregnancy. However, Kenya is currently among the 10 countries that contribute the most neonatal deaths globally.
Objective: The aim of this study is to examine the effectiveness of ANC services in reducing neonatal mortality in Kenya.
Methods: We used binary logistic regression to analyse cross-sectional data from the 2014 Kenya Demographic and Health Survey to investigate the effectiveness of ANC services in reducing neonatal mortality in Kenya. We determined the population attributable neonatal mortality fraction for the lack of selected antenatal interventions.
Results: The highest odds of neonatal mortality were among neonates whose mothers did not attend any ANC visit (adjusted odds ratio [aOR] 4.0, 95% confidence interval [CI] 1.7–9.1) and whose mothers lacked skilled ANC attendance during pregnancy (aOR 3.0, 95% CI 1.4–6.1). Lack of tetanus injection relative to one tetanus injection was significantly associated with neonatal mortality (aOR 2.5, 95% CI 1.0–6.0). About 38 percent of all neonatal deaths in Kenya were attributable to lack of check-ups for pregnancy complications.
Conclusions: Lack of check-ups for pregnancy complications, unskilled ANC provision and lack of tetanus injection were associated with neonatal mortality in Kenya. Integrating community ANC outreach programmes in the national policy strategy and training geared towards early detection of complications can have positive implications for neonatal survival.

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Background

Antenatal care (ANC) is one of the key strategies recommended to reduce the risk of neonatal mortality in any community irrespective of socio-demographic background [1–4]. Although global neonatal mortality (deaths before 28 days of age) declined by 40 percent from 1990 to 2013 [5,6], it still accounted for about 2.6 million deaths globally and constituted 42 percent of global under-five mortality (deaths before 5 years of age) [7]. Over 99 percent of neonatal mortalities occur in low- and middle-income countries [8]. While the absolute numbers of under-five deaths have declined, the proportion of deaths occurring in the neonatal period has risen and this is because of the slower declining rates of neonatal mortalities [9]. From 1990 to 2013, the neonatal proportion of under-five mortality increased from 37 to 44 percent [5]. Reducing global under-five mortality is thus largely dependent on a reduction in neonatal deaths [3]. In sub-Saharan Africa (SSA), high numbers of neonatal deaths are sustained by the high fertility rate of about 5.1 births per woman [10].

In many SSA countries, the leading risk factors for neonatal deaths include preterm births, birth complications, infections such as tetanus, sepsis and pneumonia [1,11,12]. All these risk factors can be minimized or prevented through ANC interventions. The World Health Organization (WHO) recommendation for effective ANC services, specific to low-income countries, is four or more ANC visits [13]. The recommendation requires each of the first two ANC visits to take place in the first two trimesters and the last two visits should take place in the last trimester [13]. Each visit is required to focus on a given ANC service package as outlined in the WHO guidelines [13]. Overall, the main services include screening for complications, health education for healthy lifestyle, 2 tetanus toxoid (TT) injections and 90 iron/folic acid (IFA) tablets [13]. Several countries have adopted these recommendations and the coverage of at least one ANC visit has been high.

However, while the decline in neonatal mortality rate (NMR) has progressed moderately fast in some low-income countries, in others, the decline has been

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slow [9,14]. For instance, the NMR in Rwanda and Cambodia declined from 42 to 19 and 35 to 15 (per 1000 live births) between 2000 and 2015 respectively, while in Kenya the NMR declined from 29 to 22 during the same period [14].

Kenya is among the 10 countries that contribute the most neonatal deaths globally [15]. In addition to the WHO recommendations, the Kenyan government introduced free maternal health services that included antenatal and delivery care in first-level government health facilities from June 2013 [16].

Like in many other SSA countries, estimating the impact of ANC in improving neonatal or birth outcomes in Kenya has been difficult [17]. Most studies have focused on the effectiveness of coverage and implementation of ANC services [18–21] but there exists no thorough standardized system to evaluate the interventions in terms of neonatal survival. A number of community and health facility-based studies in SSA have investigated the effectiveness of various components of ANC interventions in reducing neonatal mortality [22,23]. However, these studies have been limited to the fraction of births that are registered in the health facilities and neonatal deaths that are inadequately reported and are therefore less representative of the entire population. A few similar population-based or nationally representative studies have also been conducted in some SSA countries [20,21,24,25]. In 2011, McCurdy et al. [26] conducted an aggregate-level study in the region, which involved 17 least developed SSA countries, excluding Kenya [26]. The study generally found that ANC from a skilled provider was associated with decreased risk of neonatal mortality. The study also identified that the most effective ANC interventions included TT injection, and weight and blood pressure (BP) measurements [26]. However, with the very wide disparities in NMRs among the countries observed in the study and the wider differences in the years of surveys for the various countries included (between 2003 and 2009), country-specific analysis would provide more comprehensive and reliable findings at the country level.

The aim of this study is to examine the effectiveness of ANC services in reducing neonatal mortality in Kenya. The findings will highlight the impact of ANC interventions, with implications to improve health workers' operations, cost-effectiveness and to accelerate the reduction of neonatal deaths.

Methods

Study settings

The Kenyan population was estimated to be 47.8 million in 2015 [27] and about 75 percent live in the rural areas [28]. With the fertility rate at 4.1 and sex ratio of 1:1, an estimated 22,000 births occur every day [27]. Like many SSA countries, agriculture is the main economic activity [29]. In June 2013, the Kenyan government introduced free maternal and child health services in all first-level public health facilities and this resulted in an increase in the number of pregnant women using ANC services and about an 18 percent increase (from 44 percent in 2009 to 62 percent in 2014) in skilled attendance during delivery at the health facilities [30]. The main challenges affecting maternal and child health care in Kenya are severe in rural areas and include inadequately skilled health providers, distance to the health facilities (in rural areas), burden of HIV/AIDS, and insufficient facilities, equipment and supplies[16,31].

Study design and data source

We obtained cross-sectional survey data from the 2014 Kenya Demographic and Health Survey (DHS). The DHS randomly samples data across the entire country and in all the counties. The 2014 Kenya DHS used a sampling frame generated from the National Sample Survey and Evaluation Programme (NASSEP V) and therefore the data-sets are nationally representative [32]. The survey used household and individual (mothers) questionnaires to collect information on mortality, ANC, family planning, reproduction and sociodemographic characteristics [32]. In this study, only the most recent singleton children, born 1–59 months (~5 years) prior to the 2014 survey, were included in the study. This improved the accuracy of verbal interview since the respondents (mothers) could easily recall the most recent birth occurrences or readily provide the ANC card for reference, thus strengthening the internal and external validity of this study. Further, singleton selection eliminated any confounding effect of multiple births that are prone to mortality due to biological factors other than inadequate ANC. A total of 14,190 cases were included in the study. The participants remained anonymous. The mothers were asked a series of structured, direct, probing and follow-up questions on reproduction and various ANC services they had received or not received. The responses were filtered and coded into two or more categories [33]. The DHS methodology toolkit and field manuals are available for further details on data sampling and collection methods [34,35].

Study variables

Outcome variables

Neonatal mortality: This was defined as the death of a baby before reaching 28 days (one month) of age. This variable was dichotomized into yes (for neonates who died within a month) and no (were alive for the first month of life).

Primary predictor variables

ANC visits: This meant the number of times an expectant mother visited a skilled provider for check-ups and pregnancy-related advice during pregnancy until the delivery of the baby. It was classified into no visit, 1–3 visits and 4 or more visits.

TT injection: TT vaccination protects the mother and the baby against tetanus, a deadly infection caused by *Clostridium tetani* bacteria which enter the body through skin cuts and wounds such as those during delivery or cutting of the umbilical cord [36,37]. In this study, we examined the effectiveness of no tetanus injection and two or more tetanus injections relative to one in preventing neonatal deaths.

IFA: Intake of IFA supplements is recommended to lower the risk of preterm birth, low birth weight, anemia and subsequently neonatal mortality [38]. In the present study, we compared the effect of 90 or more IFA tablets, as recommended by the WHO, and less than 90 in improving neonatal survival.

ANC assistance: Skilled assistance included ANC attendance conducted by doctors, nurses, clinical or medical officers while unskilled assistance included those done by traditional birth attendants (TBA), nursing aids, community health workers (CHW), relatives, friends and others. This classification was similar to that of birth attendance.

Other ANC services examined in this study include urine analysis [39], checking of BP [40], screening of weight, blood tests and check-ups for pregnancy complication.

Socio-demographic, maternal and birth-related variables

These comprised independent variables that are theorized to be non-causal risk factors to neonatal mortality. Some variables are also associated with lack of or inadequate ANC and are included in this study as confounding variables. They include place of residence (rural), birth attendance, cesarean birth [41], parity [42,43], advanced maternal age [42], low birth weight [43,44], poverty (low wealth) [45], low education level [46] and single motherhood [47]. The wealth status classification of the DHS is based on a composite measure of a household's cumulative living standard measured in terms of household assets such as cars, bicycles, type of water and sanitation facility used and housing construction materials [48]. The wealth index is computed based on the asset index of socioeconomic status [48]. It also takes into account the rural and urban settings. A statistical procedure known as principal components analysis is then used to categorize individual households on a continuous scale of relative wealth [48]. In this study, single women included those who were never married, widowed, divorced or separated and not living together while married women were those who were married or living together at the time of neonatal death. Similarly, education level of less than 9 years was primary level and 9 years or more was secondary or higher level while no formal education was referred to as no education. Descriptions and classifications of the study variables are detailed in Box 1.

Box 1. Summary of variables

Variable category	Variable	Categorization
Outcome variable	Neonatal mortality	Yes (Died within 1 month) No (Was alive for the first month of life)
Predictor variables	ANC visits	No visit 1–3 ANC visits 4 or more (≥ 4) ANC visits
	ANC attendance	Unskilled attendant Skilled attendant
	Timing of 1^{st} ANC visit	1^{st} trimester 2^{nd} trimester 3^{rd} trimester
	Tetanus toxoid (TT) injection(s)	No injection 1 TT injection 2 or more (≥ 2) TT injections
	Iron/folic acid (IFA)	0 to < 90 tablets 90 or more (≥ 90) tablets
	Birth attendance	Unskilled attendant Skilled attendant
	Weight screened, BP checked, analysis of blood/urine done	Yes and no
Socio-demographic/maternal/birth-related variables	Maternal age	15–24, 25–34 and 35–49
	Low birth weight (LBW)	Yes (< 2500 g) No (≥ 2500 g)
	Cesarean birth	Yes or no
	Parity	Nulliparous, para 1–3 and para 4+
	Marital status	Single and married
	Maternal education level	No or primary education Secondary or higher
	Wealth index	Poor, middle and rich
	Place of residence	Rural and urban

Parity refers to the number of times a woman has given birth to a fetus of 24 or more weeks gestation age, irrespective of whether the child is dead or alive [42]. *LBW* is birth weight less than 2500 grams [49].

Statistical methods

Pearson's chi-square test of independence was employed to examine the distribution of ANC interventions and neonatal survival status. Binary logistic regression was used to determine both the crude and adjusted odds ratios (cOR and aOR, respectively) for the associations between lack of or inadequate ANC services and neonatal mortality. Statistical significance was established at 95 percent confidence intervals (95% CI). Data sampling weights were applied and the complexity of the DHS sampling design was taken into account in order to improve the representativeness of the data. To eliminate the effect of potential confounding, stepwise regression modeling was used. All the socio-demographic variables, maternal and birth-related variables were considered as potential confounders in this study. Possible associations between each of the predictor variables, each of the other independent variables and the outcome variable (neonatal mortality) were assessed by observing the *p*-values. Only predictor variables that indicated possible associations (p-value < 0.05) with the dependent variable (neonatal mortality) were subjected to further analysis. All the other predictor variables were excluded from further analysis. Crude odds ratios were generated in model 1. In model 2, adjusted odds ratios for the associations between lack of or inadequate ANC interventions and neonatal mortality were determined after controlling for maternal background variables (socio-demographic). In model 3, in addition to the confounding variables in model 2, the model adjusted for birth-related variables (skilled birth attendance and cesarean birth). Model 4 adjusted for all the confounding variables in models 2 and 3 plus LBW. All the socio-demographic, maternal and birth-related variables were also adjusted for each other in each of the models where they were included in the analysis. We used the statistical software package IBM SPSS version 22.0 (IBM, Armonk, New York, USA) for analysis and Microsoft Excel to graphically summarize the effectiveness of ANC interventions in reducing neonatal mortality.

Estimation of population attributable risk fraction of selected ANC interventions

The population attributable neonatal mortality risk fraction (PAR) for lack of or inadequate ANC services was computed as the fraction of neonatal deaths that could have been prevented if the given ANC service had been provided. The PAR was determined using the formula,

$Pe * \left(\frac{OR-1}{OR}\right) * 100$, where OR is the odds ratio, adjusted for all the confounding variables in the study in the logistic regression analysis, and *Pe* is the proportion of deaths that lacked the given ANC service, thus exposed.

Results

Table 1 shows the distribution of maternal background characteristics by ANC services and birth attendance. Over 95 percent of all the pregnant women in Kenya aged 15–49 had at least one ANC visit during the 1–59 months (~5 years) prior to the 2014 survey. About 89 percent had at least one TT injection. About 20 percent of the women had their first ANC visit in the first trimester and over 63 percent of all the mothers in the survey had skilled birth attendance for their most recently born child.

Table 2 shows the distribution (including *p*-values) of all the study variables by neonatal survival status and NMR. The NMR was four times higher among those who did not attend any ANC visit relative to those who had four or more visits. About 67% of all the expectant mothers in the survey had their first ANC visit in the second trimester and more than half of all the women had four or more ANC visits during pregnancy. The NMR was about 3.5 times higher among neonates whose mothers had unskilled ANC attendance relative to those whose mothers had skilled ANC attendance. Similarly, mothers who did not receive any pregnancy complication check-up had a 2.5 times higher NMR compared to those who received a check-up. The NMR was twice higher among neonates whose mothers had no TT injection as compared to those who had one TT injection. Although the NMRs were comparatively higher among neonates whose mothers had no or fewer than 90 IFA tablets, no BP check and no blood tests or urine analysis, there was no statistically significant associations ($p > 0.05$) detected between the lack of these ANC interventions and neonatal mortality.

Table 3 presents the binary logistic regression analyses (crude and adjusted odds ratios) for the associations between lack of or inadequate ANC services and neonatal mortality. Overall, after controlling for the effect of maternal background characteristics and birth-related factors including LBW (Model 4), the odds of neonatal death were four times higher among neonates whose mothers had no ANC visit relative to those whose mothers had four or more (aOR 4.0, 95% CI 1.7–9.1). The neonates whose mothers had 1–3 ANC visits had about twice higher odds of deaths compared to those whose mothers had four or more ANC visits. Similarly, the odds of neonatal mortality were significantly higher among neonates whose mothers had no TT injection as compared to those whose mothers had only one TT injection (aOR 2.5, 95% CI 1.0–6.0). There was no statistically significant difference in the odds of neonatal mortality between mothers who received two or more TT injections and those who received one TT injection (aOR 0.9, 95% CI 0.5–1.4). Neonates whose mothers had unskilled ANC attendance had three times higher odds of mortality relative to those whose mothers had skilled ANC attendance (aOR 3.0, 95% CI 1.4–6.1). Lack of check-up for complications during pregnancy was associated with neonatal mortality (aOR 2.4, 95% CI 1.5–4.0). There was no statistically significant difference between neonatal survival rates when comparing skilled or unskilled birth attendance.

Figure 1 summarizes model 4's results. It indicates that inadequate or lack of ANC visits, unskilled ANC attendance, no TT injection and lack of check-up for complications were associated with neonatal mortality

Table 1. Distribution of maternal background characteristics, by antenatal care (ANC) services and birth attendance.

	At least 1 ANC visit, N = 14,144			At least 1 TT, N = 6703			Given/bought 90 or more IFA, N = 13,912			1st ANC visit in 1st trimester, N = 13,595			Skilled birth assistance, N = 14,189		
Variables	Yes (%)	No (%)	χ^2 p	Yes (%)	No (%)	χ^2 p	Yes (%)	No (%)	χ^2 p	Yes (%)	No (%)	χ^2 p	Yes (%)	No (%)	χ^2 p
Education level															
No education	84.5	15.5	< 0.01	76.6	23.4	< 0.01	1.8	98.2	< 0.01	15.4	84.6	< 0.01	28.8	71.2	< 0.01
Primary	96.3	3.7	< 0.01	89.2	10.8	< 0.01	3.3	96.7	< 0.01	16.8	83.2	< 0.01	59.7	40.3	< 0.01
Secondary/higher	98.8	1.2		94.6	5.4		4.4	95.6		27.4	72.6		86.8	13.2	
Marital status															
Single	94.3	5.7	< 0.01	90.0	10.0	> 0.05	2.9	97.1	< 0.05	19.6	80.4	> 0.05	69.0	31.0	< 0.01
Married	96.4	3.6		89.8	10.2		3.7	96.3		20.6	79.4		65.7	34.3	
Place of residence															
Rural	94.7	5.3	< 0.01	87.9	12.1	< 0.01	2.9	97.1	< 0.01	17.1	82.9	< 0.01	55.1	44.9	< 0.01
Urban	98.1	1.9		93.0	7.0		4.6	95.4		26.0	74.0		84.3	15.7	
Wealth index															
Poor	92.7	7.3	< 0.01	85.9	14.1	< 0.01	2.9	97.1	< 0.01	15.7	84.3	< 0.01	43.7	56.3	< 0.01
Middle	97.5	2.5	< 0.01	89.2	10.8	< 0.01	2.8	97.2	< 0.01	17.3	82.7	< 0.01	65.6	34.4	< 0.01
Rich	98.5	1.5		93.9	6.1		4.5	95.5		26.3	73.7		88.1	11.9	
Parity															
Nulliparous	97.4	2.6		94.6	5.4		3.4	96.6		26.4	73.6		84.6	15.4	
Para 1–3	97.0	3.0	< 0.05	92.9	7.1	< 0.05	4.0	96.0	> 0.05	19.9	80.1	< 0.01	67.9	32.1	< 0.01
Para 4+	93.1	6.9	< 0.01	81.6	18.4	< 0.01	2.5	97.5	> 0.05	15.1	84.9	< 0.01	42.1	57.9	< 0.01
Maternal age															
15–24	96.2	3.8	0.6	92.8	7.2	< 0.01	3.3	96.7	> 0.05	19.8	80.2	0.001	62.2	36.8	< 0.01
25–34	96.5	3.5		90.7	9.3		3.7	96.3		22.1	77.9		60.5	39.5	
35–49	94.4	5.6	< 0.01	83.6	16.4	< 0.01	3.4	96.6	> 0.05	18.0	82.0	< 0.01	51.5	48.5	< 0.01
Average (%)	**95.4**	**4.6**		**89.1**	**10.9**		**3.4**	**96.6**		**20.2**	**79.8**		**63.5**	**36.5**	

Notes: χ^2 p – *p*-value from chi-square test. TT – tetanus toxoid injection. IFA – iron folic/acid. < 90 IFA includes those who had zero.

Table 2. Distribution of all the study variables by neonatal survival status in Kenya, neonatal mortality rates (NMR) and *p*-values.

	Neonatal survival status (percent)			
Variables	Died (N = 191)	Alive (N = 13,997)	NMR (per 1000 live births)	*p*-value
ANC visits				
No visit	24 (12.6)	539 (3.9)	42.6	< 0.01
1–3 visits	80 (41.9)	5340 (38.2)	14.8	< 0.05
4 or more visits	87 (45.5)	8074 (57.9)	10.7	
First ANC visit				
1st trimester	31 (18.6)	2766 (20.6)	11.1	
2nd trimester	118 (70.7)	8959 (66.7)	13.0	> 0.05
3rd trimester	18 (10.8)	1704 (12.7)	10.5	> 0.05
ANC attendant				
Unskilled	26 (13.6)	555 (4.0)	44.8	< 0.001
Skilled	165 (86.4)	13,442 (96.0)	12.1	
TT				
No TT injection	15 (18.1)	665 (10.0)	22.0	< 0.01
1 TT injection	29 (31.2)	2739 (39.3)	10.5	
≥ 2 TT injections	36 (48.4)	3405 (48.6)	13.1	> 0.05
Bought/given IFA				
0 to < 90 IFA	182 (96.3)	13,237 (96.5)	13.6	> 0.05
90 or more	7 (3.7)	485 (3.5)	14.2	
BP checked				
No	6 (8.0)	390 (6.1)	16.2	> 0.05
Yes	69 (92.0)	6047 (93.9)	11.3	
Urine analysis				
No	11 (14.7)	723 (11.2)	15.0	> 0.05
Yes	64 (85.3)	5711 (88.8)	11.0	
Blood tests				
No	4 (5.3)	257 (4.0)	16.3	> 0.05
Yes	71 (94.7)	6179 (96.0)	11.4	
Complications check				
No	49 (65.3)	2668 (41.5)	18.0	< 0.001
Yes	26 (34.7)	3765 (58.5)	6.9	
Birth attendant				
Unskilled	70 (36.5)	4704 (33.6)	14.7	> 0.05
Skilled	122 (63.5)	9293 (66.4)	13.0	
Cesarean birth				
Yes	28 (14.7)	1300 (9.3)	21.1	< 0.05
No	163 (85.3)	12,691 (90.7)	12.7	
Place of delivery				
Health facility	117 (64.6)	8224 (63.9)	14.0	
Home/other places	64 (35.4)	4649 (36.1)	13.6	> 0.05
Sex of the child				
Male	94%	7152	13.0	> 0.05
Female	97%	6845	14.0	
Parity				
Para 1–3	83 (43.2)	7305 (52.2)	11.5	> 0.05
Para 4+	63 (32.8)	3129 (22.4)	19.5	> 0.05
Nulliparous	46 (24.0)	3563 (25.5)	11.7	
Low birth weight				
Yes (< 2500 g)	7 (8.3)	293 (4.4)	23.3	> 0.05
No (≥ 2500 g)	77 (91.7)	6370 (95.6)	11.9	
Maternal age[1]				
15–24	51 (26.7)	4192 (29.9)	12.0	> 0.05
25–34	80 (41.9)	6977 (49.8)	11.3	
35–49	60 (31.4)	2828 (20.2)	20.8	< 0.001
Education level				
No education	25 (13.1)	1366 (9.8)	18.0	< 0.01
Primary	119 (62.3)	7607 (54.3)	15.4	< 0.01
Secondary or higher	47 (24.6)	5025 (34.9)	9.3	
Marital status				
Single	34 (17.7)	2594 (18.5)	12.9	> 0.05
Married	158 (82.3)	11,404 (81.5)	13.7	
Place of residence				
Rural	114 (59.7)	8613 (61.5)	13.1	> 0.05
Urban	77 (40.3)	5384 (38.5)	14.1	
Wealth index				
Poor	89 (46.6)	5554 (39.7)	15.8	< 0.05
Middle	38 (19.9)	2557 (18.3)	14.6	> 0.05
Rich	64 (33.5)	5886 (42.1)	10.8	
Sex of the child				
Male	94 (49.2)	7152 (51.1)	13.0	> 0.05
Female	97 (50.8)	6845 (48.9)	13.9	

Sample neonatal mortality rate (NMR) = 1 3.5.
NMR was calculated as $\left(\frac{\text{Number of live-born deaths before 1 month of age}}{\text{Total number of live-born deaths before 1 month of age}} \text{x}1000\right)$.

Table 3. Binary logistic regression analysis (models 1–4) showing the associations between antenatal care (ANC) interventions and neonatal mortality in Kenya, crude odds ratios (cOR) and adjusted odds ratios (aOR) with 95 percent confidence intervals (CI).

		Model 1		Model 2		Model 3		Model 4	
Variables /variable classifications	Categories	cOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)	aOR	(95% CI)
ANC visits	0 visits	4.2	(2.7–6.7)	3.9	(2.3–6.3)	4.4	(2.5–7.6)	4.0	(1.7–9.1)
	1–3 visit(s)	1.4	(1.0–1.9)	1.3	(1.0–1.8)	1.4	(1.0–1.9)	1.8	(1.1–3.0)
	4 or more	1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0	Ref.
ANC assistance	Unskilled	3.8	(2.5–5.8)	3.4	(2.1–5.3)	3.7	(2.4–5.9)	3.0	(1.4–6.1)
	Skilled	1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0	Ref.
TT injection	0 TT	2.4	(1.1–5.6)	2.4	(1.0–5.7)	2.3	(1.0–5.5)	2.5	(1.0–6.0)
	1 TT	1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0	Ref.
	2 or more	0.9	(0.5–1.4)	0.9	(0.6–1.5)	0.9	(0.6–1.5)	0.9	(0.5–1.4)
Complications check	Yes	1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0	Ref.
	No	2.7	(1.7–4.3)	2.4	(1.5–3.9)	2.4	(1.5–4.1)	2.4	(1.5–4.0)
Maternal age	15–24	1.1	(0.8–1.5)	1.0	(0.7–1.5)	1.2	(0.6–2.4)	0.9	(0.5–1.8)
	25–34	1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0	Ref.
	35–49	1.8	(1.3–2.6)	1.7	(0.9–3.3)	1.5	(1.1–2.3)	2.1	(1.2–3.7)
Education level	No education	1.4	(1.1–1.8)	1.9	(1.3–2.9)	2.1	(0.9–4.5)	2.4	(0.8–6.6)
	Primary	1.6	(1.2–2.4)	1.2	(1.0–2.4)	1.3	(1.0–2.4)	1.2	(0.7–2.1)
	Secondary	1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0	Ref.
Parity	Nulliparous	1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0	Ref.
	Para 1–3	0.9	(0.6–1.3)	1.2	(0.7–2.1)	1.0	(0.5–2.0)	0.8	(0.3–2.5)
	Para 4+	1.6	(1.1–2.3)	1.4	(0.9–2.3)	1.2	(0.7–2.0)	1.5	(0.4–6.2)
Place of residence	Rural	1.1	(0.8–1.4)	1.2	(0.9–2.0)	1.5	(1.1–2.2)	1.4	(0.9–2.5)
	Urban	1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0	Ref.
Wealth index	Poor	1.2	(0.9–1.7)	1.2	(0.8–2.1)	1.3	(1.0–1.9)	1.8	(1.0–3.6)
	Middle	1.4	(0.9–2.0)	1.3	(0.8–2.3)	1.3	(0.9–2.1)	1.6	(1.0–3.5)
	Rich		1.0	Ref.	1.0	Ref.	1.0	Ref.	1.0
Cesarean birth	Yes	1.7	(1.1–2.5)			1.6	(1.1-3.4)	1.4	(0.7–3.0)
	No	1.0	Ref.			1.0	Ref.	1.0	Ref.
Birth assistance	Unskilled	0.9	(0.7–1.2)			1.2	(0.7–2.1)	0.7	(0.6–1.5)
	Skilled	1.0	Ref.			1.0	Ref.	1.0	Ref.
Low birth weight	Yes (< 2500 g)	1.9	(0.8–4.2)					2.0	(0.9–4.5)
	No (≥ 2500 g)	1.0	Ref.					1.0	Ref.

Notes: Ref. – reference. **Model 1**: shows crude odds ratios. **Model 2**: Adjusted for maternal and socio-demographic variables. **Model 3**: Adjusted for maternal/socio-demographic variables plus birth-related variables (cesarean and skilled birth attendance). **Model 4**: Adjusted for maternal/socio-demographic variables, birth-related variables plus low birth weight. Variables in each model were mutually adjusted for each other.

in Kenya. Figure 2 is a graph showing that about 38 percent of neonatal deaths that occurred within the 5 years prior to the 2014 DHS survey in Kenya could have been prevented if the mothers had had check-ups for pregnancy complications. Further, about 9.5 and 18.6 percent of the neonatal deaths during the same period were attributable to lack of ANC visits and inadequate ANC visits, respectively. The figure shows that about 10 percent of neonatal mortalities in Kenya could be attributable to lack of a single TT injection. Unskilled ANC assistance could account for 9 percent of neonatal deaths.

Discussion

The present study is perhaps the first of its kind to be conducted in Kenya at national level and after the introduction of free maternal and child health care services in mid-2013 in all the first-level public health facilities [16]. Overall, our findings suggest that lack of skilled ANC attendance and no or inadequate ANC visits were the key ANC factors associated with neonatal mortality. ANC visits to a health facility provide the basis for other ANC services.

The results also indicate that a single TT injection to all pregnant women in Kenya could prevent about 10 percent of neonatal deaths in Kenya. Similar studies in Ghana and India and an aggregate-level study in other sub-Saharan countries reported similar findings [1,25,26]. The findings also indicate that availing of check-ups for complications during pregnancy could avert about 38 percent of neonatal deaths in Kenya. Slightly lower estimates were observed in a hospital-based prospective cohort study (2015) conducted in neighboring Uganda that attributed 17.2 percent of neonatal deaths to obstetric complications [49]. One might argue that Uganda has had free maternal health care services in first-level health facilities (following the abolition of user fees) since 2001 [50], long before Kenya followed suit [16], and that could explain the difference in the attributable mortality fractions since more Ugandan women had free access to ANC services.

Our findings have key implications for maternal health care operations in Kenya because they not only validate most of the WHO recommendations [13], but also imply that new strategies such as outreach programmes (such as community or home visits) by skilled nurses to administer ANC services such as check-ups and one TT injection could effectively and significantly reduce neonatal mortalities. This is particularly plausible due to the fact that the

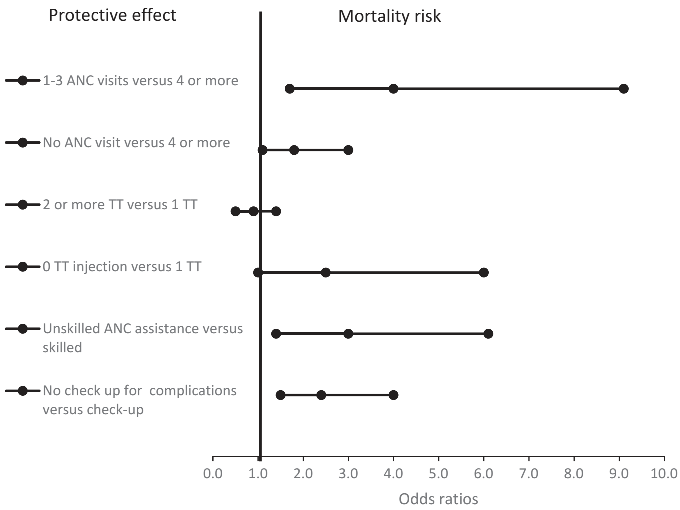

Figure 1. Graphical representation of model 4's results showing adjusted odds ratios for the associations between ANC interventions and neonatal mortality.

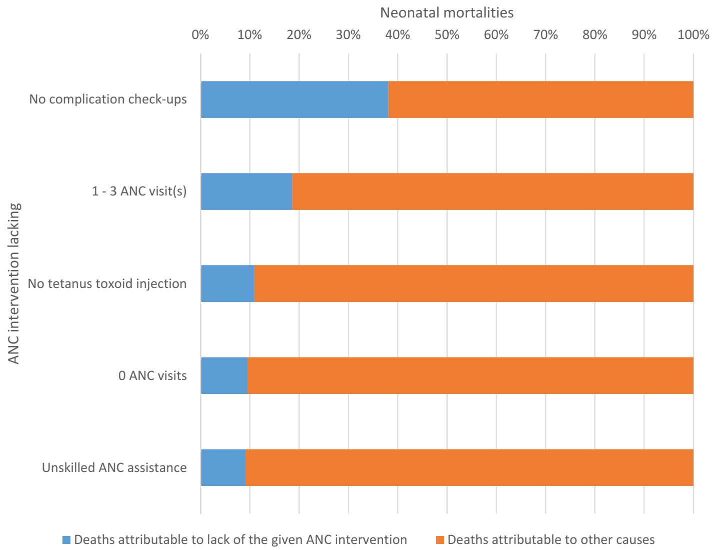

Figure 2. Population attributable neonatal mortality risk fraction for lack of or inadequate ANC interventions.

NMR among ANC non-attendees was 42.6 per 1000 live births, 4 times higher than among mothers who attended ≥ 4 or more times.

In Figure 2, it appears as if insufficient ANC visits (1–3 ANC visits) accounted for double (18.6 percent) the percentage of neonatal deaths accounted for by zero ANC visits (9.1 percent). This is sufficiently true due to the very few mothers (5 percent) that are in the category of zero ANC visits compared to the many mothers (38 percent) in the 1–3 ANC visits category. It is also most probable that the 5 percent did not seek any ANC because they felt they had no pregnancy complications or symptoms of complications.

Our findings could not explain why two or more TT injections relative to one TT injection did not provide any additional protection to the neonates as shown by the crude and adjusted odds ratios that are not statistically significant. However, a study in India indicated that one and two TT injections equally (equal OR) reduced the risk of neonatal mortality [51]. Given the state of low-resourced settings in SSA, the results reflect that comprehensive population coverage with a single TT injection during the antenatal period could generate a much greater national progress in reducing neonatal deaths in Kenya. However, further research is needed to explore the impact of two TT injections in reducing neonatal deaths in Kenya.

Contrary to our findings, studies have hypothesized the protective effect of consuming ≥ 90 IFA tablets towards newborn survival [1]. Investigating the effectiveness of IFA in a cross-sectional study has key limitations in that iron and folate can easily be obtained in mothers' daily diets. Further, it is very difficult for the majority of the less educated, rural women to recall the quantity of IFA they bought or the actual number of tablets taken in their last pregnancy. In this study, less than 5 percent took the recommended 90 or more IFA tablets. This study therefore recommends further research on the effectiveness of IFA with a more localized approach linked to maternity hospitals with close follow-up within the counties. This will provide a stronger evidence basis on which appropriate policy adjustments can be implemented.

We note that it is mainly through ANC visits to the health facilities that the ANC services are administered to the women. In addition to the community outreach proposed in this study, we also advocate for further training and appraisal of less skilled health workers such as nursing aids and clinical officers, and refresher training for doctors and nurses. The focus of this training ought to be tailored towards early detection of pregnancy complications and provision of the most effective care to the highest possible numbers, by, for instance, one TT injection instead of two for each expectant mother. Modification of the WHO guidelines can also be done using the best practice approaches to ensure the maximum possible service provision during the fewest visits possible for an expectant mother. For instance, multiple interventions could be combined. Further research on the impact of continued care from antenatal to delivery to the postnatal period by skilled providers could provide a holistic and effective approach towards reducing neonatal deaths and subsequently under-five deaths in the post-Millennium Development Goals (MDG) era.

Methodological considerations

Due to the introduction of county governments in Kenya, the 2014 DHS data collection and sample size was increased to almost three times more than the previous DHS samples. This provided our study with a comparatively higher statistical power than previous DHS-based studies in Kenya, thus increasing the validity of the results in this study. A key limitation of our study data is that recall bias might not have been completely eliminated. This is especially true for the mothers who gave birth to their last born earlier in the five-year period prior to the survey. Mortalities may have been underestimated due to under-reported deaths.

This study does not confirm the causal association between lack of or inadequate ANC services and neonatal mortality. This is because we could not ascertain the actual cause(s) of deaths among the neonates.

Although this study briefly mentioned the WHO's recommendations regarding the quality and timing of ANC visits, our data provided only the reported quantity as narrated by the respondents. It is possible that some complex measures of the ANC package such as the BP check or urine or blood analysis results can be misunderstood and misreported by many, especially uneducated mothers. Further, reporting of the IFA tablets intake is likely to be less accurate, so we suggest a follow-up study that can monitor the actual intake or non-intake of the tablets and compare this with the neonatal outcomes.

Conclusion

Lack of check-ups for complications during pregnancy, insufficient ANC visits, lack of skilled ANC provision and lack of tetanus injection were associated with the risk of neonatal mortality in Kenya. New strategies such as community ANC outreach programmes could supplement the regular ANC visits. Further, training of health workers with a focus on early detection of pregnancy complications and administration of at least one TT injection to all expectant mothers can have quick and significant positive implications towards neonatal survival in resource-limited Kenya.

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Author contribution

MA conceptualised the research, drafted the design, acquired the data-set, conducted analysis, interpretation and developed the first version of the manuscript, AE and BOA involved in development of the structure, design and critical review of the manuscript. The authors read and approved the final version of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethics and consent

DHS data collection and storage ensured that all participants remained anonymous and all identifiers were removed. Therefore, confidentiality was guaranteed. Datasets are publicly accessible on request and permission to access, download and store the data-sets for this study was obtained in February 2016 from ORC Macro Inc.

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Paper context

Inadequate antenatal care is a major reason for the slow decline of neonatal mortality in Kenya. The Division of Reproductive Health (DRH) is currently implementing the Vision 2030 which aims to lower the number of neonatal deaths. However, there is no comprehensive standardized system to evaluate the antenatal care interventions in terms of neonatal survival. We hope our study will provide a basis for continuous countrywide research and contribute to policy developments aimed to improve neonatal survival.

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References

[1] Singh A, Pallikadavath S, Ram F, et al. Do antenatal care interventions improve neonatal survival in India? Health Policy Plan. 2014;29:842–848.
[2] Garrido GG. The impact of adequate prenatal care in a developing country: testing "the WHO recommendations. Los Angeles: California Center for Population Research; 2009.
[3] MP L-Q, Owoo NS. Examining the influence of antenatal care visits and skilled delivery on neonatal deaths in Ghana. Appl Health Econ Health Policy. 2014;12:511–522.
[4] Wehby GL, Murray JC, Castilla EE, et al. Prenatal care effectiveness and utilization in Brazil. Health Policy Plan. 2009;24:175–188.
[5] Oestergaard MZ, Yoshida S, Mahanani WR, et al. Neonatal mortality levels for 193 countries in 2009 withTrends since 1990: a systematic analysis of progress, projections, and priorities. PLoS Med. 2011;8.
[6] UNICEF. UNICEF Data: monitoring the situation of children and women. Child mortality estimates. Neonatal mortality rates [homepage on the internet]. 2013c [Updated 2014 Sep 16; cited 2014 Sep 28]. Available from: http://data.unicef.org/child-mortality/neonatal
[7] Wang H, Liddell CA, Coates MM, et al. Global, regional, and national levels of neonatal, infant, and under-5 mortality during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384:957–979.
[8] Shiffman J. Issue attention in global health: the case of newborn survival. Lancet. 2010;375:2045–2049.
[9] United Nations Children´s Fund. Level & Trends in Child Mortality: report 2013. In: Estimates developed by the UN inter-agency Group for Child Mortality Estimation. New York: United Nations Children´s Fund; 2013.
[10] Casterline J, Bongaarts J. Fertility transition: is sub-Saharan Africa different? Popul Dev Rev. 2013;38:153–168.
[11] Liu L, Cousens S, Perin J, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;379:2151–2161.
[12] Institute of medicine committee on improving birth O. In: Bale JR, Stoll BJ, Lucas AO, editors. Improving birth outcomes: meeting the challenge in the developing world. Washington (DC): National Academies Press (US); 2003.
[13] Lincetto O, Mothebesoane-Anoh S, Gomez P, et al. Antenatal care. In: Lawn J, Kerber K, editors. Opportunities for Africa's newborns: practical data, policy, and programmatic support for newborn care in Africa. Cape Town: Partnership for Maternal, Newborn and Child Health; 2006. p. 51–62.
[14] The World Bank. Mortality rate, neonatal (per 1,000 live births). C2015 [updated 2015; cited 2015] Available from: http://data.worldbank.org/indicator/SH.DYN.NMRT
[15] Oza S, Cousens SN, Lawn JE. Estimation of daily risk of neonatal death, including the day of birth, in 186 countries in 2013: a vital-registration and modelling-based study. Lancet Glob Health. 2014;2:e635–44.
[16] Bourbonnais N. Implementing free maternal health care in Kenya; Challenges, Strategies And Recommendations. Nairobi: Kenya National Commission on Human Rights; 2013.
[17] Garrido GG. The impact of adequate prenatal care in a developing country: testing the WHO recommendations. Los Angeles: Calif Cent Popul Res. 2009. Retrieved from: http://escholarship.org/uc/item/1c86q94h.
[18] Tann CJ, Kizza M, Morison L, et al. Use of antenatal services and delivery care in Entebbe, Uganda: a community survey. BMC Pregnancy Childbirth. 2007;7:23.
[19] Van Eijk AM, Bles HM, Odhiambo F, et al. Use of antenatal services and delivery care among women in rural western Kenya: a community based survey. Reprod Health. 2006;3:2.
[20] Kyei NN, Chansa C, Gabrysch S. Quality of antenatal care in Zambia: a national assessment. BMC Pregnancy Childbirth. 2012;12:151.
[21] Fagbamigbe AF, Idemudia ES. Assessment of quality of antenatal care services in Nigeria: evidence from a population-based survey. Reprod Health. 2015;12:88.
[22] Brown CA, Sohani SB, Khan K, et al. Antenatal care and perinatal outcomes in Kwale district, Kenya. BMC Pregnancy Childbirth. 2008;8:2.
[23] Kiwuwa MS, Mufubenga P. Use of antenatal care, maternity services, intermittent presumptive treatment and insecticide treated bed nets by pregnant women in Luwero district, Uganda. Malar J. 2008;7:44.
[24] Ochako R, Gichuhi W. Pregnancy wantedness, frequency and timing of antenatal care visit among women of childbearing age in Kenya. Reprod Health. 2016;13:51.
[25] Lambon-Quayefio MP, Owoo NS. Examining the influence of antenatal care visits and skilled delivery

on neonatal deaths in Ghana. Appl Health Econ Health Policy. 2014;12:511–522.

[26] McCurdy RJ, Kjerulff KH, Zhu J. Prenatal care associated with reduction of neonatal mortality in Sub-Saharan Africa: evidence from Demographic and Health Surveys. Acta Obstet Gynecol Scand. 2011;90:779–790.

[27] World Population Review]. Kenya Population 2015; [updated 2015 Nov 24; cited 2016 Apr]. Available from: http://worldpopulationreview.com/countries/kenya-population/

[28] The World Bank. Rural population (percentage of total population); C2015 [cited 2016 Apr]. Available from: http://data.worldbank.org/indicator/SP.RUR.TOTL

[29] Ministry of state for devolution and planning, Kenya; United Nations Development Fund. Kenya human development report: climate change and human Development: harnessing emerging opportunities. Nairobi: United Nations Development Programme; 2013.

[30] Countdown to 2015; Maternal, Newborn and Child. Country profile. c2014 [updated 2015; cited 2016 Apr 2]. Available from: http://www.countdown2015mnch.org/country-profiles

[31] Wilson Center. Maternal health challenges in Kenya 2011 report: what new research evidence shows. 2011. Available from: https://www.wilsoncenter.org/event/maternal-health-challenges-kenya-what-new-research-evidence-shows [cited July 2016]

[32] Kenya National Bureau of Statistics (KNBS), Ministry of Health, National AIDS Control Council, Kenya Medical Research institute, National Council for Population and Development and ICF international. Kenya demographic and health survey 2014. Nairobi: KNBS and ICF International, Inc; 2015.

[33] ICF International. Demographic and Health Survey Methodology. In: Questionnaires: household, Woman's, and Man's. MEASURE DHS. Calverton (MD): ICF International; 2012.

[34] MEASURE DHS. Guide to demographic and health survey statistics: methodology for the Measure DHS phase III project, implemented from 2008–2013. Calverton, MD: MEASURE DHS; 2006.

[35] ICF International. Demographic and health survey *sampling and household listing manual*. In: MEASURE DHS. Calverton (MD): ICF International; 2012.

[36] Demicheli V, Barale A, Rivetti A. Vaccines for women for preventing neonatal tetanus. Cochrane Database Syst Rev. 2015;7:Cd002959.

[37] World Health Organization. Maternal immunization against tetanus: integrated management of pregnancy and childbirth. Geneva: World Health Organization; 2006.

[38] Zeng L, Dibley MJ, Ceng Y, et al. Impact of micronutrient supplementation during pregnancy on birth weight, duration of getation, and perinatal mortality in rural western China: double blind cluster randomised controlled trial. BMJ. 2008;337:a2001.

[39] Schlembach D. [Urine analysis in pregnancy]. Therapeutische Umschau Revue Therapeutique. 2006;63:585–589.

[40] Kattah GA, Garovic DV. The management of Hypertension in Pregnancy. Adv Chronic Kidney Dis. 2013 May;20:229–239.

[41] Signore C, Klebanoff M. Neonatal morbidity and mortality after elective cesarean delivery. Clin Perinatol. 2008;35:361–371.

[42] Kozuki N, Lee A, Silveira MF, et al. The associations of parity and maternal age with small- for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. BMC Pub Heal. 2013;13:S2.

[43] Restrepo-Mendez MC, Lawlor DA, Horta BL, et al. The association of maternal age with birthweight and gestational age: a cross-cohort comparison. Paediatr Perinat Epidemiol. 2015;29:31–40.

[44] Feresu SA, Harlow SD, Woelk GB. Risk factors for low birthweight in zimbabwean women: a secondary data analysis. PLoS One. 2015;10:e0129705.

[45] McKinnon B, Harper S, Kaufman JS, et al. Socioeconomic inequality in neonatal mortality in countries of low and middle income: a multicountry analysis. Lancet Global Health. 2014;2:e165–73.

[46] Mekonnen Y, Tensou B, Telake DS, et al. Neonatal mortality in Ethiopia: trends and determinants. BMC Public Health. 2013;13:483.

[47] Izugbara C. Single motherhood and neonatal and infant mortality in Sierra Leone, Burkina Faso and Burundi. Public Health. 2016;135:122–130.

[48] Rutstein SO, Johnson K. The DHS wealth index. In: DHS comparative reports no. 6. Calverton (MD): ORC Macro; 2004.

[49] Nakimuli A, Mbalinda SN, Nabirye RC, et al. Still births, neonatal deaths and neonatal near miss cases attributable to severe obstetric complications: a prospective cohort study in two referral hospitals in Uganda. BMC Pediatr. 2015;15:44.

[50] Xu K, Evans DB, Kadama P, et al. Understanding the impact of eliminating user fees: utilization and catastrophic health expenditures in Uganda. Soc Sci Med. 2006;62:866–876.

[51] Singh A, Pallikadavath S, Ogollah R, et al. Maternal tetanus toxoid vaccination and neonatal mortality in rural north India. PLoS One. 2012;7:e48891.

Study II

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RESEARCH ARTICLE Open Access

Survival of low birthweight neonates in Uganda: analysis of progress between 1995 and 2011

Malachi Ochieng Arunda*, Anette Agardh and Benedict Oppong Asamoah

Abstract

Background: Although low birthweight (LBW) babies represent only 15.5% of global births, it is the leading underlying cause of deaths among newborns in countries where neonatal mortality rates are high. In Uganda, like many other sub-Saharan African countries, the progress of reducing neonatal mortality has been slow and the contribution of low birthweight to neonatal deaths over time is unclear. The aim of this study is to investigate the association between low birthweight and neonatal mortality and to determine the trends of neonatal deaths attributable to low birthweight in Uganda between 1995 and 2011.

Methods: Cross-sectional survey datasets from Uganda Demographic and Health Surveys between 1995 and 2011 were analyzed using binary logistic regression with 95% confidence interval (CI) and Kaplan-Meier survival analysis to examine associations and trends of neonatal mortalities with respect to LBW. A total of 5973 singleton last-born live births with measured birthweights were included in the study.

Results: The odds of mortality among low birthweight neonates relative to normal birthweight babies were; in 1995, 6.2 (95% CI 2.3 –17.0), in 2000–2001, 5.3 (95% CI 1.7 –16.1), in 2006, 4.3 (95% CI 1.3 – 14.2) and in 2011, 3.8 (95% CI 1.3 – 11.2). The proportion of neonatal deaths attributable to LBW in the entire population declined by more than half, from 33.6% in 1995 to 15.3% in 2011. Neonatal mortality among LBW newborns also declined from 83.8% to 73.7% during the same period.

Conclusion: Low birthweight contributes to a substantial proportion of neonatal deaths in Uganda. Although significant progress has been made to reduce newborn deaths, about three-quarters of all LBW neonates died in the neonatal period by 2011. This implies that the health system has been inadequate in its efforts to save LBW babies. A holistic strategy of community level interventions such as improved nutrition for pregnant mothers, prevention of teenage pregnancies, use of mosquito nets during pregnancy, antenatal care for all, adequate skilled care during birth to prevent birth asphyxia among LBW babies, and enhanced quality of postnatal care among others could effectively reduce the mortality numbers.

Keywords: Low birthweight, Attributable neonatal mortality, Logistic regression, Kaplan-Meier survival analysis, Cross-sectional

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Background

About 20 million low birthweight (LBW) babies are born every year, representing 15.5% of all births globally [1]. Over 95% of all LBW cases occur in low-income countries [1]. Of recent, Lawn et al. and the World Health Organization (WHO) estimated that LBW contributes to 60–80% of all neonatal deaths (death within 28 days after birth) worldwide [2, 3]. However, wider disparities in estimates exist between countries. India, a low-to-middle income country, contributes about 40% of global burden of LBW babies [4], and in 2013, 48% of all neonatal deaths in India were attributed to LBW and preterm birth [5]. In comparison to Sweden, a high-income country where neonatal mortality is very low (1.5 per 1000 live births in 2014) [6], LBW babies constituted only 3.2% of national live birth in 2014, and barely 4.3% of all neonatal deaths in 2014 were LBW cases [6]. WHO defines LBW as birthweight of less than 2500 g [1]. LBW is mainly a result of preterm births and restricted fetal growth (resulting in small for gestational age (SGA) babies) or both [1]. The main risk factors leading to LBW include young mothers/short stature of the mother [7], multiple births [8], poor nutrition before conception and during pregnancy (poverty) [9], smoking [10], maternal HIV positivity, and malaria during pregnancy [11, 12].

In sub-Saharan Africa (SSA), the general rate of decline in neonatal mortality (NM) has been slow compared to infant or under-five mortality [13] and more than half of all births do not take place in health facilities [14]. An individual participant level meta-analysis study in four district projects within East Africa (EA) in 2012 estimated that 52% of all neonatal deaths in Kenya, Uganda, and Tanzania were attributable to preterm birth or small for gestational age, of which 99% were LBW babies [15]. Several neonatal and infant mortality studies in SSA fall short of determining the contribution of LBW to neonatal deaths. Whereas LBW is the underlying cause of majority of neonatal deaths, most studies have focused on other leading direct causes of neonatal deaths such as birth asphyxia, infections, and preterm birth [16–18]. Another 5-year health facility-based study in Ghana estimated that LBW was a sole contributor of 50% of neonatal deaths in the facility between 2008 and 2012 [19]. While LBW can be a result of preterm birth, it is also a notable fetal risk factor for birth asphyxia and infections such as sepsis [17, 18].

In Uganda, like in many SSA settings, apart from health system limitations such as inadequate resources, paucity of data in hospital registries makes it difficult to determine the prevalence of LBW and associated mortality trends [20, 21]. The 2008 situation analysis report indicated that neonatal deaths were not registered in Uganda; no countrywide perinatal audit exists [20]. The 2006 retrospective demographic survey in Uganda estimated that 60% of newborn deaths occurred at home [22]. The Uganda roadmap for reducing neonatal mortality 2007–2015 fell short of incorporating LBW among the causes of neonatal deaths [21], possibly due to challenges in determining LBW-attributable deaths. No studies that determined the national trends of LBW-attributable neonatal mortality in Uganda were identified by our literature search, despite being a key indicator of population and reproductive health in a country [2]. However, in order for Uganda to achieve the global Sustainable Development Goal (SDG) target 3.2 that aims to drastically reduce neonatal mortality by 2030 [23], the contribution of LBW towards neonatal mortality can no longer remain unclear. Although LBW is estimated to contribute about 80% of neonatal deaths in SSA [3], efforts to reduce neonatal mortality from the inception of the Millennium Development Goals (MDGs) in 1990 to its end in 2015 in Uganda have never been evaluated in terms of reduction of LBW-attributable deaths. Further, there are no national representative studies that have examined the contribution of LBW toward the overall neonatal mortality in Uganda. This present study thus aims to determine both the association between LBW and neonatal mortality in Uganda and to estimate the national trends of LBW-attributable neonatal mortality between 1995 and 2011. This period covered the entire MDG period except for the last 4 years to 2015.

Methods

Study setting and maternal health situation

With an annual population growth rate of about 3.2 and an overall fertility rate of 5.6, Uganda's population rose from about 17 million in the 1990s to about 34 million in 2011 [24]. The sex ratio is 1:1 and the adolescence fertility rate was about 131 per 1000 births in 2010 [25]. Over 77% of the population live in rural areas. The national poverty levels notably reduced from 38.8% in 2002–2003 to about 20% in 2012–2013 [26]. However, poverty levels differ significantly by region and sub-regions. For instance, while incidence of poverty in the northern region in 2013 was 44%, it was only 5.1% in the central region [26]. In March 2001, Uganda abolished user fees in first level government health facilities and this included maternal health services [27]. The proportion of four or more antenatal care visits was still less than 50% by 2011 [28]. Incrementally, by 2011 about 57% of total births took place in health facilities and the proportion of births that received post-natal care increased from less than 10% in 1995 to 26% in 2006 and to 32% in 2011 [28, 29].

Study design and data source

We obtained secondary data from repeated cross-sectional surveys by the Demographic and Health Survey (DHS) program. The datasets are independent and nationally representative. We used four datasets from the Uganda DHS birth recodes for the years 1995, 2000–2001, 2006, and 2011. A total of 5973 singleton last-born live births with birthweight measures were included in the study. This consisted of 1160 children in 1995 representing 25% of all the last-born live births in the data sample for that year and 1100 children for the year 2000–2001 representing 30% of all the last-born live births in the sample for that year. Similarly, 1514 (35%) children were included for the year 2006 and 2199 (50%) for the year 2011. We targeted and utilized the birth recode information for the last-born live births born within the 5-year period prior to each of the surveys. The Demographic and Health Survey (DHS) program employs standardized questionnaires and protocols that ensure that the participants remain anonymous [30, 31]. The DHS data collection procedure involves stratified two-stage cluster sampling and collection of data countrywide using updated lists of enumeration areas for each of the surveys to avoid overlap and improve national representativeness of the data [32]. Further information on data sampling and collection criteria are detailed in the DHS field manuals and methodology toolkits [30–32].

Variables

Outcome variable

Neonatal mortality This referred to death of newborn within 28 days after birth. It was dichotomized into yes (died) or no (alive).

Predictor variable

Low birthweight The variable low birthweight (LBW) was the predictor variable. Birthweight records were obtained from the child's health card or from the mother's verbal report of measured weight at birth. Birthweight was dichotomized into LBW (< 2500 g) or normal birthweight (NBW) ≥ 2500 g. Macrosomia (> 4000 g) [33] was eliminated in the univariate and logistic regression analyses involving birthweights. The higher neonatal mortality risks of macrosomia relative to NBW [34] would reduce the accuracy of our findings if they are included among NBW numbers. At the hospital, newborns are weighed and their birthweights recorded on the child's health card and is communicated. In contrast, for births outside the health facility such as home births, birthweight is likely to be estimated by observing the birth size of body parts, the accuracy of which is questionable. To improve the accuracy of reported birthweight, whether recall or from the health card, only hospital births were included in the study for the years 2000–2001, 2006, and 2011. For the 1995 dataset, however, we also included the very few home birth cases in our sample in order to improve the statistical power of our analyses. Records of the size of the babies registered as small or average among others were excluded from the study to minimize errors of misclassification due to the unreliable subjective nature of the categorization criteria [35]. From the study's selected samples, 72% of the 1160 selected sample in 1995 had birthweight from mothers' recall and the rest were from health cards. Similarly, in 2000, 79% of the 1100 selected sample were from recall. In 2006, 73.5% of the total 1514 were recall birthweights and in 2011, 67% of the total 2199 were recall birthweights.

Preterm birth, LBW and birth asphyxia are highly correlated and it is difficult to determine their independent contributions towards neonatal deaths. These three, together with infections, contribute to 80% of neonatal mortality as the highest cause of neonatal mortality, with LBW being the underlying factor [36].

Maternal and socio-demographic variables

In this study, independent variables that are known to be direct and indirect risk factors for neonatal mortality and LBW such as 'young' maternal age (7) and poor nutrition (resulting from poverty and low or no education (9) were investigated. Wealth status was determined as a composite cumulative living standard measured in terms of household asset inventory. These were investigated in the univariate analysis to determine their distribution and possible associations with birthweight and neonatal survival categories. Smoking was not examined due to lack of data. Figure 1 below shows a conceptual visualization of LBW as an overriding cause of the majority of neonatal deaths.

Below (Table 1) is a summary of outcome and predictor variables and the covariates that influence the occurrence of low birthweight and the survival of neonates.

Data analysis

We used analytical software IBM SPSS version 24 and MS excel for analyses. Pearson's chi square test of independence and association was used to examine the distribution of variables according to birthweight and neonatal mortality for each survey. Survival plots of the birthweight categories were generated using Kaplan-Meier's estimator. Binomial logistic regression analysis was used to determine the odds ratios for the association between LBW and neonatal mortality after adjusting for socio-demographic and maternal factors, cesarean births and check-ups for pregnancy complications. The analysis was conducted at 5% significant level. In order to improve the validity of the results, the national representativeness of the data and to adjust for non-response, the complexity of DHS sampling design was taken into account, and data sampling weights were applied to datasets for the years

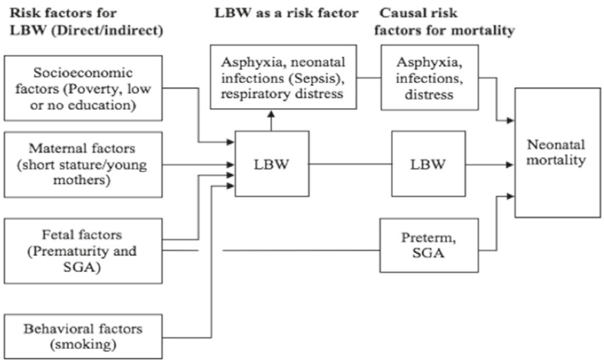

Fig. 1 Conceptual visualization of potential risk factors leading to LBW and neonatal mortality. LBW – Low birthweight, SGA – Small for gestation age

Table 1 Summary of variables

Variables	Categories	Descriptions
Outcome variable		
Neonatal mortality	Yes (Dead)	Died within age ≤ 1 month
	No (Alive)	Alive at age ≥ 1 month
Predictor variable		
Low birthweight	Yes	< 2500 g
	No	≥ 2500 g ≤ 4000 g
Maternal and socio-economic variables		
Maternal age	< 20 years	
	20–34 years	
	35–49 years	
Wealth status	Poor	
	Middle/rich	
Maternal education	No education	No formal education
	Primary	< 9 years of education
	Secondary/higher	≥9 years of education
Parity	Primiparous	First ever birth
	Para 2–3	2–3 children
	Para 4+	4 or more children
Marital status	Single	Never married, widowed, separated/divorce at delivery time, not living with the spouse
	Married	Married or cohabiting
Place of residence	Rural	
	Urban	
Cesarean birth	No	
	Yes	
Check-up for pregnancy complications	No	
	Yes	

2000–2001, 2006, and 2011. However, the 1995 dataset was not subjected to weighting due to the need to maintain the statistical power of the data for that year, the implication of which is a very minimal difference. A total of 5973 last-born live births with birthweights were included in the analyses.

Estimation of LBW-attributable mortality risk fraction among LBW neonates and in the population

The LBW-attributable neonatal mortality risk fraction (AF) and population-attributable mortality risk fraction (PAF) were computed as proportion of prevalent deaths that could be avoided if LBW was prevented or the death of LBW babies was eliminated. These were calculated manually using eqs. (1) and (2) below.

$$\mathrm{AF} = \left(\frac{OR{-}1}{OR}\right) * 100, \tag{1}$$

The population attributable mortality risk fraction PAF, expressed as a percentage (%) was computed using the eq. (2).

$$\mathrm{PAF} = \mathrm{P_e}{}^{*}\mathrm{AF} = \mathrm{P_e} * \left(\frac{OR{-}1}{OR}\right) * 100, \tag{2}$$

OR is the odds ratio generated from binary logistic regression analysis and *Pe* is the proportion of deaths that have the exposure.

Results

Table 2 shows birthweight and maternal and socio-demographic characteristics of last-born live births by neonatal survival status in Uganda. Overall, the average proportion of neonatal deaths among LBW babies between 1995 and 2011 was about 3.5% while the average proportion of neonatal deaths among normal weight babies (≥2500 g ≤ 4000 g) during the same period was less than 1 %. Cesarean birth was associated with neonatal mortality only in the year 2000–2001 ($p < 0.05$).

Table 3 shows the distribution of the study variables by birthweight. Statistical significantly higher proportions ($p < 0.05$) of mothers with no formal education had LBW babies in almost all the years except 2011. Similarly, maternal age < 20 years of age was associated with having higher proportions of LBW babies as shown in the 1995 and 2006 findings ($p < 0.01$).

In all surveys, LBW was significantly associated with neonatal mortality as shown in Table 4 below. The adjusted odds ratio (AOR) for the years in question were as follows: in 1995, 6.2 (95% CI (2.3 – 17.0), in 2000–2001, 5.3 (95% CI 1.7 – 16.1), in 2006, 4.3 (1.3 – 14.2), and in 2011, 3.8 (95% CI 1.3 – 11.2). The 1995 and 2000–2001 data were not adjusted for wealth status due to large amounts of missing data. Birth complications were also not adjusted for in 1995 due to absence of data.

Figure 2 below shows the relationship between birthweight and time-to-death among neonatal mortality cases, combining all the study years. In conjunction with the survival table (not included in the paper), we observed that over 85% of all neonatal deaths in our study sample occurred in the first week of life. About 95% of all the LBW (< 2500 g) neonatal deaths occurred within the first week of life. In comparison, about 82% of deaths among neonates with NBW (2500 g ≤ 4000 g) took place within in the first weeks. The rest died later, in the second, third, and fourth weeks. The figure also shows an inverse proportionality relationship between weight and survival. With the exception of an outlier, the neonates with higher birthweights tended to survive longer, i.e. beyond the first week.

The LBW-attributable neonatal mortality in Uganda declined by more than half, from 33.6% (%) in 1995 to 15.3% in 2011 as shown in Table 5 below. Similarly, LBW-attributable neonatal mortality among LBW babies also declined by 10.2% from 83.9% to 73.7% in the same period.

Figure 3 shows a non-uniform but continuous decline of LBW-attributable neonatal mortality in Uganda between 1995 and 2011.

Discussion

Overall, the odds of neonatal mortality among LBW babies as compared to normal birthweight were reduced by a third, from about 6 times higher in 1995 to 3.8 times higher in 2011. The LBW-attributable neonatal mortality in the population declined by more than half, from 33.6% in 1995 to 15% in 2011. This present study is the first of its kind in Uganda and perhaps the whole of east Africa that examines the trends of LBW-attributable mortality over the years. The study reinforces the very few LBW-related studies in Uganda and east Africa by providing new peer-reviewed findings on the contribution of LBW towards neonatal mortality countrywide over a period of over 15 years. The study findings might be useful for auditing the causes of neonatal deaths, and for evaluation, future health planning and policy making aimed at improving neonatal survival. The WHO emphasizes that auditing the causes of neonatal deaths is paramount for effective monitoring and improving mother and child health care [37].

The 3.8 times higher odds of deaths among LBW neonates in 2011 in the present study is consistent with the findings of a related study conducted by Kananura et al. in eastern Uganda in 2012–2013 that indicated a 3.51 mortality odds ratio [36]. Comparable findings were also obtained in a follow-up study in western Uganda, completed in 2006 but analyzed by Marchant et al. in 2012

Table 2 Distribution of birthweight, maternal and sociodemographic characteristics by neonatal survival status in Uganda, 1995–2011

Variables	1995			2000–2001			2006			2011		
	Survival, $N = 1160$			Survival, $N = 1100$			Survival, $N = 1514$			Survival, $N = (2199)$		
	Died n (%)	Lived n (%)	*P* value	Died n (%)	Lived n (%)	*P* value	Died n (%)	Lived n (%)	*P* value	Died n (%)	Lived n (%)	*P* value
Birthweight												
< 2500 g	4 (3.3)	118 (96.7)	< 0.01	5 (4.6)	104 (95.4)	< 0.01	5 (2.8)	175 (97.2)	< 0.05	7 (2.9)	234 (97.1)	< 0.05
≥ 2500 g	6 (0.6)	1032 (99.4)		10 (1.0)	981 (99.0)		11 (0.8)	1323 (99.2)		22 (1.1)	1936 (98.9)	
Maternal age												
< 20	1 (0.6)	155 (99.4)	> 0.05	1 (0.9)	111 (99.1)	> 0.05	2 (1.4)	138 (98.6)	> 0.05	2 (1.3)	154 (98.7)	> 0.05
20–34	6 (0.7)	855 (99.3)		12 (1.4)	825 (98.6)		11 (1.0)	1105 (99.0)		15 (1.0)	1496 (99.0)	
35–49	3 (2.1)	140 (97.9)		3 (2.0)	148 (98.0)		2 (0.8)	254 (99.2)		7 (1.6)	427 (98.4)	
Wealth index	$n = 392$[b]			$n = 424$[b]								
Poor	1 (0.7)	137 (99.3)	> 0.05	1 (0.5)	187 (99.5)	> 0.05	4 (0.9)	442 (99.1)	> 0.05	7 (1.1)	652 (98.9)	> 0.05
Middle / Rich	4 (1.6)	250 (98.4)		3 (1.3)	233 (98.7)		11 (1.0)	1056 (99.0)		17 (1.1)	1426 (98.9)	
Maternal education												
No education	2 (1.5)	132 (98.5)	> 0.05	2 (1.6)	124 (98.4)	> 0.05	3 (1.6)	179 (98.4)	> 0.05	2 (1.2)	171 (98.8)	> 0.05
Primary	6 (0.9)	653 (99.1)		8 (1.6)	605 (98.4)		7 (0.8)	857 (99.2)		12 (1.0)	1149 (99.0)	
Secondary higher	2 (0.5)	365 (99.5)		5 (1.4)	356 (98.6)		5 (1.1)	462 (98.9)		11 (1.4)	757 (98.6)	
Parity												
Primiparous	3 (1.0)	296 (99.0)	> 0.05	4 (1.4)	278 (98.6)	> 0.05	6 (1.7)	356 (98.3)	< 0.05	3 (0.7)	424 (99.3)	> 0.05
Para 2–3	3 (0.6)	532 (99.4)		5 (1.0)	483 (99.0)		7 (1.1)	622 (98.9)		11 (1.2)	945 (98.8)	
Para 4+	4 (1.2)	322 (98.8)		6 (1.8)	323 (98.2)		2 (0.4)	520 (99.6)		10 (1.4)	709 (98.6)	
Marital status												
Single	1 (0.5)	199 (99.5)	> 0.05	2 (1.0)	198 (99.0)	> 0.05	2 (0.7)	277 (99.3)	> 0.05	3 (0.8)	354 (99.2)	> 0.05
Married	9 (0.9)	951 (99.1)		14 (1.6)	887 (98.4)		13 (1.1)	1221 (98.9)		22 (1.3)	1722 (98.7)	
Residence												
Rural	5 (1.0)	517 (99.0)	> 0.05	11 (1.5)	737 (98.5)	> 0.05	10 (0.9)	1051 (99.1)	> 0.05	17 (1.1)	1493 (98.9)	> 0.05
Urban	5 (0.8)	633 (99.2)		4 (1.1)	348 (98.9)		5 (1.1)	447 (98.9)		7 (1.2)	584 (98.8)	
Delivery mode												
Cesarean	1 (1.4)	71 (98.6)	> 0.05	4 (4.4)	87 (95.6)	< 0.05	1(0.8)	122 (98.2)	> 0.05	5(2.1)	230 (97.9)	> 0.05
Normal	9 (0.8)	1079 (99.2)		12 (1.2)	995 (98.8)		14 (1.0)	1372 (99.0)		24 (1.2)	1940 (98.8)	
Check-up[a]												
No	No data			11 (1.5)	742 (98.5)	> 0.05	6 (0.7)	866 (99.3)	> 0.05	13 (1.5)	843 (98.5)	> 0.05
Yes				4(1.2)	332 (98.2)		9 (1.4)	613 (98.6)		14 (1.1)	1261 (98.9)	

P values were generated from Chi square analysis. Statistical significance ($p < 0.05$, two-sided)
[a]complications
[b]The separate totals(n) for wealth index in 1995 and 2000 shows a deviation from the total (N) due to missing data

[15]. This study estimated the odds of neonatal mortality among LBW newborns relative to NBW newborns at 3.45 [15]. Our findings of 15.3% LBW-attributable neonatal mortality in 2011 in the population are comparable to the findings of a situation analysis study conducted by the Ministry of Health (MoH) in Uganda in 2008 [38]. The MoH study combined both quantitative and qualitative methods and collected data from 10 districts covering the four conventional regions (Central, Eastern, Western and Northern) in Uganda. In this MoH study, the health personnel interviewed about perinatal outcomes in the health units indicated that LBW contributed to 16% of the total newborn deaths [38]. However, the study also acknowledged the underreporting of LBW as a cause of death due to overlaps with infections and breathing difficulties [38].

The results indicated a significantly higher proportion of deaths among LBW babies and this corroborates with findings of other studies [2, 3] that show higher mortalities among LBW newborns relative to their NBW counterparts.

Table 3 Univariate analysis of maternal and sociodemographic characteristics of neonates by birthweight in Uganda, 1995–2011

Variables	1995, *N* = 1160			2000–2001, *N* = 1100			2006, *N* = 1514			2011, *N* = 2199		
	LBW (%)	NBW (%)	*P* value	LBW	NBW	*P* value	LBW	NBW	*P* value	LBW	NBW	*P* value
Maternal age												
< 20	26(16.7)	130(83.3)	< 0.01	15(13.4)	97(86.6)	> 0.05	27(19.1)	114(80.9)	< 0.01	20(12.7)	137(87.3)	> 0.05
20–34	81(9.4)	780(90.6)		77(9.2)	761(90.8)		112(10.0)	1004(90.0)		174(11.5)	1337(88.5)	
35–49	15(10.5)	128(89.5)		17(11.2)	135(88.8)		41(16.0)	216(84.0)		39(9.0)	395(91.0)	
Wealth	*n* = 392			*n* = 424[a]								
Poor	15(10.9)	123(89.1)	> 0.05	19(10.1)	169(89.9)	> 0.05	61(13.7)	385(86.3)	> 0.05	72(10.9)	587(89.1)	> 0.05
Middle/rich	26(10.2)	228(89.8)		25(10.6)	211(89.4)		118(11.1)	949(88.9)		161(11.2)	1282(88.8)	
Education level												
No education	24(17.9)	110(82.1)	< 0.01	21(16.7)	105(83.3)	< 0.01	29(15.9)	153(84.1)	< 0.05	27(15.6)	146(84.4)	> 0.05
Primary	67(10.2)	592(89.8)		60(9.8)	555(90.2)		101(11.7)	763(88.3)		121(10.4)	1040(89.6)	
Secondary	31(8.4)	336(91.6)		28(7.8)	332(92.2)		49(10.5)	418(89.5)		85(11.1)	684(88.9)	
Parity												
Primiparous	45(15.1)	254(84.9)	< 0.01	27(9.6)	255(90.4)	> 0.05	50(13.8)	312(86.2)	> 0.05	58(13.6)	368(86.4)	> 0.05
Para 2–3	48(9.0)	487(91.0)		51(10.5)	437(89.5)		69(11.0)	560(89.0)		98(10.3)	858(89.7)	
Para 4+	29(8.9)	297(91.1)		31(9.4)	300(90.6)		60(11.5)	462(88.5)		77(10.7)	643(89.3)	
Place of residence												
Rural	67(12.8)	455(87.2)	< 0.05	76(10.1)	674(89.9)	> 0.05	134(12.6)	928(87.4)	> 0.05	167(11.1)	1343(88.9)	> 0.05
Urban	55(8.6)	583(91.4)		33(9.4)	319(90.6)		46(10.2)	406(89.8)		66(11.1)	526 (88.9)	
Marital status												
Single	25(12.5)	175(87.5)	> 0.05	29(14.5)	171(85.5)	< 0.05	39(13.9)	241(86.1)	> 0.05	36(10.1)	321(89.9)	> 0.05
Married	97(10.1)	863(89.9)		80(8.9)	821(91.1)		141(11.4)	1093(88.6)		197(11.3)	1547(88.7)	
Cesarean												
Yes	4(5.6)	68(94.4)	> 0.05	11(11.8)	82(88.2)	> 0.05	24(19.7)	98(80.3)	< 0.01	29(12.3)	206(87.7)	> 0.05
No	118(10.8)	970(89.2)		99(9.8)	909(9.2)		154(11.1)	1232(88.9)		212(10.8)	1752(89.2)	
Check-up												
No	No data			72(9.5)	683(90.5)	> 0.05	105(12.0)	767(88.0)	> 0.05	87(10.2)	769(89.8)	> 0.05
Yes				34(10.1)	302(89.9)		73(11.8)	1315(88.1)		143(11.2)	1132(88.8)	

LBW refers to low birthweight (< 2500 g), NBW refers to normal birthweight (≥2500 g – 4000 g). *P* values were obtained from chi square test
[a]The separate totals (n) for wealth index in 1995 and 2000 shows a deviation from the total (N) due to missing data

Although cesarean births have been associated with mortality as also shown by the findings ($p < 0.05$) for the year 2000–2001 in Table 2, in 2006 and 2011 however, the findings ($p > 0.05$) indicated improvements in obstetric services that has enabled the survival of many cesarean birth babies.

Figure 2 showed that about 85% of neonatal deaths occurred in the first week after birth. This is close to the estimate of a recent MoH report on maternal, perinatal and child death review that indicated about 75% neonatal deaths in the first week [39]. The inverse proportional

Table 4 Logistic regression analysis showing association between low birthweight and neonatal mortality in Uganda, 1995 – 2011

Variable	Adjusted odds ratios (95% confidence interval)			
	1995	2000–2001	2006	2011
	N = 1160	*N* = 1100	*N* = 1519	*N* = 2223
Birthweight				
Low birthweight	6.2 (2.3 – 17.0)[b]	5.3 (1.7 – 16.1)[b]	4.3 (1.3 – 14.2)[a]	3.8 (1.3 – 11.2)[a]
Normal birthweight	1.0	1.0	1.0	1.0

LBW refers to low birthweight < 2500 g, NBW refers to normal birthweight (≥2500 g – 4000 g)
[a]Adjusted for all socio-demographic, maternal, pregnancy and birth related factors in Table 1
[b] Adjusted for all socio-demographic (except wealth status), maternal, pregnancy and birth related factors in the study (Table 1). Complications were not adjusted for in 1995

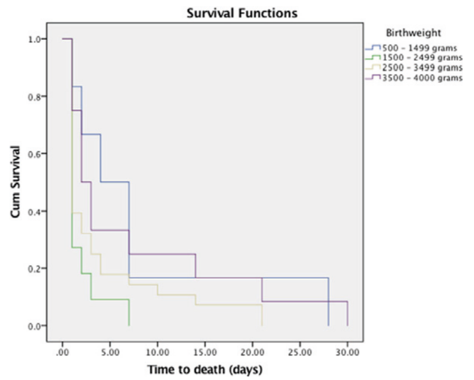

Fig. 2 Kaplan-Meier survival curves by birthweight for neonates in Uganda between 1995 and 2011. Cum - cumulative

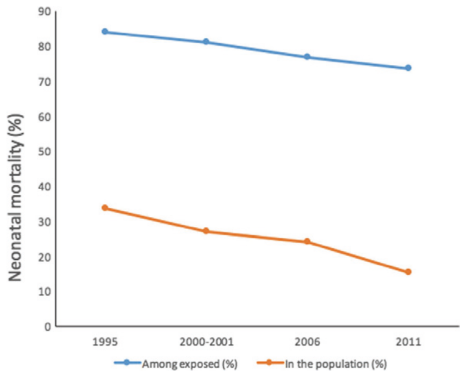

Fig. 3 Graphical representation of low birthweight-attributable neonatal mortality trends in Uganda between 1995 and 2011

relationship indicated by the trends of birthweight versus time-to-death among neonatal deaths in Fig. 2 concurs with findings from a hospital-based study in Dhaka, Bangladesh [40]. The findings in Fig. 2 also implied that the risk of neonatal death is inversely proportional to birthweight and are in agreement with several other studies [40–43]. However, our data on age at death (days) appeared to have been aggregated in terms of 7 days (weekly) and not the actual mortality days. This slightly compromised the accuracy of the Kaplan Meier's survival curve in our study in terms of days of survival.

According to a facility-based study by Hedstrom et al. in central Uganda that admitted neonates born between December 2005 and September 2008, 89% of neonatal deaths among LBW neonates weighing under 1000 g could be attributable to LBW [43]. Another study by Marchant et al. [15] that utilized data collected in 2006 in western Uganda also estimated a 71% LBW-attributable neonatal mortality among LBW neonates. Both of these findings are comparable with the LBW-attributable mortality estimates among LBW babies in the whole country in this present study.

Table 5 Low birthweight-attributable neonatal mortality risk proportions in Uganda between 1995 and 2011

	Year of survey	Attributable risk fraction (%)
Among LBW neonates (AF)	1995	83.9
	2000–2001	81.1
	2006	76.7
	2011	73.7
In the entire population (PAF)	1995	33.6
	2000–2001	27.0
	2006	24.0
	2011	15.3

LBW low birthweight, *AF* Attributable Fraction, *PAF* Population Attributable Fraction

Neonatal mortality accounts for about 40% of global under-five mortality [44]. In Uganda, in recent years, it was estimated that about 45,000 neonates die every year [20]. By extension of our findings, this corresponds to approximately 7000 (15.3%) neonatal deaths attributable to LBW in 2011. Although our findings could be a slight underestimation given the many unrecorded births (about 45% in 2011) [43] and unregistered neonatal deaths, they provide comparable national estimates that can be used for advocacy and countrywide public health planning to reduce LBW-attributable neonatal deaths. For instance, the successful Kangaroo Mother Care project for premature and LBW newborns initiated by Uganda Newborn Study project (UNEST) in 2007–2011 in Iganga and Mayuge district [45] could be implemented countrywide.

The greatest national decline of LBW-attributable mortality estimated in 2011 in our study is a notable finding that could be attributed to the efforts of the inter-agency national Newborn Steering Committee (NSC) [46]. The NSC, which was initiated in 2006, ensured rapid policy adaptation and implementations both at the health facility and community levels in the few years to 2011 [46]. It was mandated by the MoH to spearhead comprehensive service delivery and community-and health facility-based training [46, 47]. Our findings thus reveal that the policy changes and its implementation may have had a profound positive impact on the survival of LBW newborns during this period. The findings indicate that it is possible to eliminate unnecessary neonatal deaths due to LBW and make significant contributions towards achieving the SDG 3.2 target that aims to lower neonatal death rate to 12 per 1000 live births by 2030 [23]. Further, both the present study findings and the NSC initiative could be of keen interest to similar countries (with high neonatal mortalities) for policy making and study replications with the aim of improving LBW neonatal survival, for instance, in the Philippines, where the decline of neonatal deaths has stagnated [48].

Also, the Uganda Newborn Study (UNEST) Project partly contributed to the decline in mortality of LBW and preterm newborns in parts of eastern Uganda and consequently contributed to the overall national decline during this period [45].

The survival analysis indicated that the rate of decline in LBW-attributable mortality in the 5-year periods increased from 6.6% between 1995 and 2000–2001 to 8.7% between 2006 and 2011 in the population (Table 5). However, between the two periods, there was a significant deceleration in the decline to 3.0% between 2000 and 2001 and 2006 (Fig. 3 and Table 5). This could potentially be due to the 20% decline in the use of family planning methods among < 20 years old sexually active girls during this period as noted by the analytical overview of the Ugandan child report [49]. This could have led to increased teenage pregnancies. LBW are common among teenage mothers (< 20 years) [7] and the mortality among babies born to younger mothers in Uganda was also notably high between 1995 and 2005 [22]. Nevertheless, our findings in Table 2 did not show any significant higher mortality numbers among the < 20 years old mothers, perhaps because of the few number of births in this age-group in our sample selection. However, statistically reasonable numbers in 2006 showed a significant association between primipara mothers (most of whom were younger mothers (Table 3)) and neonatal mortality. A study conducted by Andualem et al. in western Uganda between 2005 and 2008 revealed that over 82% of female students had unmet sexual/reproductive health counseling needs [50]. Lack of knowledge about the signs of pregnancy complications has been linked to birth unpreparedness in Uganda [51], a consequent risk factor for neonatal deaths, including LBW deaths. A comparative development study by Kevin Croke [52] also highlighted the decline in the health system gains in Uganda between 2001 and 2006 due to political shocks related to removal of presidential term limits. Financing of the health care system was negatively affected. This could partly account for the rise in LBW-neonatal deaths during this period. The specialized care of LBW babies requires extra financing compared to NBW. The direct impact of the decline in health system gains on survival of LBW detected by the present study is consistent with WHO/UNICEF observations that survival of LBW neonates, a high-risk infant group, is among the most sensitive indicators to assess the progress of maternal and child health status in a country [2].

There was no statistically significant association between place of residence, maternal education, marital status, wealth status, maternal age, and neonatal mortality, *($P > 0.05$)* (Table 2). Although studies vary in their findings concerning the association between these socio-demographic and maternal factors (including parity) and neonatal mortality [53], many study findings have indicated an association between single motherhood [54], teenage maternal age [55–57], lack of education [56], rural residence [57] and neonatal mortality. A systematic review of 17 studies up to the year 2013 in SSA [55] indicated that socio-demographic and maternal risk factors are much more prevalent among teenage mothers as compared to adult mothers [55]. With the decentralized system in Uganda, further analytical research at the districts or regional levels on the effect of socio-demographic factors on birthweight and neonatal deaths would provide more robust findings for monitoring, policy making and interventions. However, at the national level, comprehensive measurement and recording of birthweight need to be made possible, irrespective of whether a child is born at home or at the hospital. As a national policy driven initiative, the provision of weighing scales to health volunteers and midwives at the community level, even on a shared basis based on proximity and locality, is feasible and could be very effective for monitoring neonatal health countrywide. Apart from improving accuracy on birthweight data collection, the availability of weighing scales could also be a profound campaign tool for lowering LBW incidences by highlighting preventive measures. Affordable and easy to maintain mechanical weighing scales have previously been used at the community level in over 400 villages in western Kenya [58]. Although it was on a small scale, the initiative was profoundly successful, as shown by an increase in the birthweight measurements of newborns of about 54%, from 43% to 97% [58]. The current study could thus give the impetus to communities and local organizations to take initiatives and improve the survival of LBW neonates. Further, as LBW is an underlying cause of 60–80% of all neonatal deaths globally (2,3) and about 15% of neonatal deaths in Uganda (present study 2011 findings), continuous data collection on birthweights that supports research, monitoring, and strategic preventive interventions could be a formidable approach to curbing neonatal deaths and overall health systems strengthening both globally and in Uganda.

Although our study largely indicated no significant associations between cesarean birth, pregnancy complications and neonatal mortality for most of the years, a number of studies have found associations between cesarean births [57, 59], pregnancy complications [59] and neonatal deaths. There were inconsistencies in our findings with regard to the significant associations between socio-demographic factors and LBW across all the study years *(p < or > 0.05)* (Table 3). However, there were higher proportions of LBW babies among teenage and uneducated mothers in all the survey years. Teenage pregnancy was associated with LBW only in 1995 and 2006. These findings corroborate study findings elsewhere in rural India [60] and in several SSA countries [7, 61] that strongly indicate that young maternal age is associated with LBW. A study in Brazil, however, found an association between teenage pregnancy and LBW only when marital partners (an economic factor) were lacking [62].

Methodological considerations

The random sampling of data across the entire country and the standardized nature of data collection method of the DHS strengthen the external validity of our study and enable global comparability among countries. Weighting the data for the years 2000, 2006 and 2011enabled us to adjust for disproportionate sampling and non-response. This improved the national representativeness and validity of the study estimates. The 1995 dataset was not weighted and the results for that year are slightly less representative. However, the results are still valid, due to the fact that there was only a small difference when weighted and unweighted results of all the other years were compared. The national representativeness of the 1995 data was only dependent on the random sampling across the entire country and the standardized nature of DHS data collection for its reliability.

The repeated findings of significant associations between LBW and neonatal mortality across all surveys confirm the existing evidence of association and the internal validity of this present study. Nonetheless, our study could not confirm the causal association because the exact causes of newborn deaths were not ascertained medically. The in-depth use of the nationally representative DHS datasets in this study has revealed the need to improve data collection techniques and to include other similarly important variables such as diagnostic causes of death among individual children, for example, birth asphyxia.

Another limitation of our study was that although hospital births recorded and/or communicated birthweights, over 65% were from mothers` recall and the rest from the health card, and we cannot therefore completely dismiss the possibility of recall bias. This also applies to the 1995 data that included both hospital and home births. Nevertheless, child birth is a significant event in a mother's life and with our study selection of the most recent birth experience, there is a very high possibility that the mothers recalled correct birthweights. Moreover, for the years 2000 to 2011, birthweight data concerned solely information regarding hospital born babies because these were measured birthweights and not estimated weights as in-home births, where birthweights are mainly estimated based on the physical size of the body parts such as foot length, chest or head [63]. A study in Uganda compared the accuracy of a proxy measure of LBW by midwives in a hospital-based setting showed an accuracy of over 80%. However, the study also noted the limitation that the findings may not reflect the actual situation in the communities where less skilled community volunteers assist in most births, and their estimates of cut-offs are prone to bias [63]. Elimination of macrosomic newborns improved the validity of our findings.

Although the 1995 data included both home and hospital births, which undermined the consistency of the study methodology across years, preliminary analysis indicated that among the selected sample of newborns with birthweight measures in 1995, only 3.5% of the births were home births (or perhaps on the way to the hospital). The 1995 data thus has a reasonable degree of consistency with other survey years. However, the selection of only hospital births in other survey years improved the quality and validity of the findings for those years.

The recording of neonatal survival data from day 0 to 30 by the DHS allowed us to clearly categorize our outcome variable and investigate risk factors across all the survey years with consistency. Given the large number of home births (about 50%) in all the surveys, both the LBW and neonatal deaths were likely underreported.

The birthweight data are prone to rounding-off or aggregation into 500 g-weight intervals which could have slightly compromised the accuracy of Kaplan-Meier's survival analysis in this study. This aggregation of data was observed in a study by Channon et al. [64]. However, the fact that over 90% of LBW neonatal deaths in our study occurred in the first week is quite consistent with global WHO findings that 75% of neonatal deaths occur in the first week [65], given the high-risk group of LBW in a low-income country.

Conclusion

Low birthweight is associated with neonatal mortality and contributes to a substantial proportion of neonatal deaths in Uganda. Although significant progress has been made to reduce newborn deaths attributed to LBW, by 2011, about 74% of all LBW neonates died in the neonatal period. This implies that the health system in place has been inadequate to meet the challenge of ensuring LBW survival. There is also profound need to strengthen both birth and neonatal death registration irrespective of whether the infants are born at home or at the health centers. The decentralized health system in Uganda can enable community health workers (CHW) and the village health teams (VHT) in liaison with the sub-counties and the districts to close the existing gaps concerning neonatal birth and death audits. This will enable robust and continuous research and monitoring of the progress of LBW neonatal survival. Our study presents national estimates of risks and mortality trends that provide national basis for continual evaluation and policy recommendations to prevent LBW and minimize risks of neonatal deaths. A holistic approach to reduce the incidence of preventable LBW babies could be fostered to reduce these mortality rates. Viable fronts that could be strengthened include sexual education in schools to prevent teenage pregnancies, complementing nutritional diet of pregnant mothers, HIV testing, ensuring that all pregnant mothers use mosquito nets, training of health workers, and promoting antenatal care visits and hospital births. Enhancing the quality of postnatal care could also reduce mortality incidence of LBW newborns.

Abbreviations
AF: Attributable fraction; AOR: Adjusted odds ratio; CHW: Community health workers; DHS: Demographic and health survey; EA: East Africa; LBW: Low birthweight; MDG: Millennium development goals; MoH: Ministry of Health; NBW: Normal birthweight; NSC: Newborn Steering Committee; PAF: Population attributable fraction; SDG: Sustainable development goal; SGA: Small for gestational age; SSA: Sub-Saharan Africa; UNAP: Uganda nutrition action plan; UNEST: Uganda newborn study; VHT: Village health teams

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Availability of data and materials
Authorization to use the secondary, unrestricted Uganda DHS data was obtained from MEASURE DHS after a requisition was made through their webpage by registration, selection of country and submission of a brief description of the study. The DHS program is authorized by the country, Uganda to distribute data for research aimed at improving public health. Procedures and questions for standard DHS surveys have been approved by both ICF Institutional Review board and the review board in the host country Uganda. Both of which ensure that DHS complies with the protection of the dignity and rights of human participants and the norms of the country.

Authors' contributions
MOA Conceptualized the research study, developed the study design, acquired data, analyzed and drafted the manuscript. AA Contributed to the interpretation of data and to the writing of the manuscript. BOA Involved in developing the study design, interpretation and contributed to the writing of the manuscript. MOA, AA, BOA Read and approved the final draft of the manuscript.

Ethics approval and consent to participate
Approval for utilization of Uganda DHS data for this study was obtained from ICF Macro Int. Data was accessible from: https://dhsprogram.com/Data/. Uganda National guidelines for secondary (third party) research that use unrestricted, publicly available and unlinked data that does not identify individuals or communities are exempted from ethical approval requirement. During data collection process by the primary data collector, ICF Macro Int, a written informed consent was sought for each willing participant by MEASURE DHS before data collection commenced. The statement of consent emphasize to the participant that they are at liberty to terminate or decline to respond at any stage of the interview process. Those unwilling were excluded from the study. The participants remained anonymous and the DHS approved procedures ensure that future identification of any individual participant or community is practically impossible. These measures are thus in adherence with both the international guidelines for epidemiological studies of the Council of International Organizations of Medical Sciences (CIOMS) and the Uganda National guidelines for research involving human subjects. Further, the measures abide by the United States Department of Health and Human Services regulations for the protection of human subjects.

Competing interests
The authors declare that they have no competing interests.

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References

1. United Nations Children's Fund and World Health Organization. Low birthweight: country, regional and global estimates. New York: UNICEF; 2004.
2. World Health Organization. Care of the preterm and/or low-birth-weight newborn. [Updated 2017]. Available from: http://www.who.int/maternal_child_adolescent/newborns/prematurity/en/. Accessed July 2017.
3. Lawn J, Blencowe H, Oza S, You D, Lee A, Waiswa P, et al. Every newborn: progress, priorities, and potential beyond survival. Lancet. 2014;384(9938):189–205.
4. Ministry of Health and Family Welfare (India). India Newborn Action Plan: Government of India. New Delhi: 2014.
5. Office of the Registrar General and Census Commissioner (India). Causes of death in India 2010–2013 [data table online]. c2010–2013. Available from: http://www.censusindia.gov.in/2011-common/Sample_Registration_System.html. Accessed 11 Nov 2016.
6. Official Statistics of Sweden. Statistics – Health and Medical Care (Sweden), 2015. Pregnancies, Deliveries and Newborn Infants. The Swedish Medical Birth Register 1973–2014 Assisted Reproduction, treatment 1991–2013.
7. Chibwesha C, Zanolini A, Smid M, Vwalika B, Phiri Kasaro M, Mwanahamuntu M, et al. Predictors and outcomes of low birth weight in Lusaka, Zambia. Int J Gynecol Obstet. 2016;134(3):309–14.
8. Nkyekyer K. Twin and singleton births in Ghana — a case-control study. Twin Res. 2002;5(04):265–9.
9. Kayode G, Amoakoh-Coleman M, Agyepong I, Ansah E, Grobbee D, Klipstein-Grobusch K. Contextual risk factors for low birth weight: a multilevel analysis. PLoS One. 2014;9(10):e109333.
10. Juárez S, Merlo J. Revisiting the effect of maternal smoking during pregnancy on offspring birthweight: a quasi-experimental sibling analysis in Sweden. PLoS One. 2013;8(4):e61734.
11. Xiao P, Zhou Y, Chen Y, Yang M, Song X, Shi Y, et al. Association between maternal HIV infection and low birth weight and prematurity: a meta-analysis of cohort studies. BMC Pregnancy Childbirth. 2016;16:243. https://doi.org/10.1186/s12884-016-1044-3.
12. Guyatt H, Snow R. Impact of malaria during pregnancy on low birth weight in sub-Saharan Africa. Clin Microbiol Rev. 2004;17(4):760–9.
13. Registrar General of India and the Centre for Global Health Research. Causes of Death Statistics 2010-2013. [Updated 2015]. Available from: http://www.cghr.org/2015/12/causes-of-death-in-india-2010-2013/.
14. Lawn JE, Cousens SN, Wilczynska K. Estimating the causes of four million neonatal deaths in the year 2000: statistical annex—the world health report 2005. Geneva: World Health Organization; 2005.
15. Marchant T, Willey B, Katz J, Clarke S, Kariuki S, Ft K, et al. Neonatal mortality risk associated with preterm birth in East Africa, adjusted by weight for gestational age: individual participant level meta-analysis. PLoS Med. 2012; 9(8):e1001292.
16. Welaga P, Moyer C, Aborigo R, Adongo P, Williams J, Hodgson A, et al. Why are babies dying in the first month after birth? A 7-year study of neonatal mortality in northern Ghana. PLoS One. 2013;8(3):e58924.
17. Aslam H, Saleem S, Afzal R, Iqbal U, Saleem S, Shaikh M, et al. Risk factors of birth asphyxia. Ital J Pediatr. 2014;40:94. https://doi.org/10.1186/s13052-014-0094-2.
18. Shah G, Budhathoki S, Das B, Mandal R. Risk factors in early neonatal sepsis. Kathmandu Univ Med J (KUMJ). 2006;4(2):187–91.
19. Siakwa M, Kpikpitse D, Laryea T, Ankobil A, Dare S, Ebu N. A Five-year neonatal mortality trend in a Ghanaian teaching hospital after the implementation of strategies to achieve the millennium development goal. Int J Pediatrics Child Health. 2014;2(1):043–9.

20. Ministry of Health. Situation analysis of newborn health in Uganda: current status and opportunities to improve care and survival. Kampala: government of Uganda. Save the children, UNICEF, WHO; 2008.
21. The Republic of Uganda: Roadmap for Accelerating the Reduction of Maternal and Neonatal Mortality and Morbidity in Uganda: Government of Uganda; 2007–2015.
22. Uganda Bureau of Statistics (UBOS) and Macro International Inc. Uganda Demographic and Health Survey 2006. Calverton: UBOS and Macro International Inc.; 2007.
23. Sustainable development goals - United Nations. United Nations Sustainable Development. 2016. Available from: http://www.un.org/sustainabledevelopment/sustainable-development-goals/. Accessed 01 Dec 2016.
24. World Population Review. Uganda Population 2016. [Updated 2016]. Available from: http://worldpopulationreview.com. Accessed 20 Nov 2016.
25. The World Bank. World Development Indicators (WDI). [Updated 2016]. Available from: http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators. Accessed 21 Nov 2016.
26. Uganda Bureau of Statistics (UBOS) (Uganda), Republic of Uganda; 2014. Statistical Abstract.
27. Xu K, Evans DB, Kadama P, Nabyonga J, Ogwal PO, Nabukhonzo P, et al. Understanding the impact of eliminating user fees: utilization and catastrophic health expenditures in Uganda. Soc Sci Med. 2006;62(4):866–76.
28. Uganda Bureau of Statistics (UBOS) and ICF International Inc. 2012. Uganda Demographic and Health Survey 2011. Kampala: UBOS and Calverton: ICF International Inc.
29. Statistics Department/Uganda and Macro International. Uganda Demographic and Health Survey, 1995. Calverton: Statistics Department/Uganda and Macro International; 1996.
30. Measure DHS. Guide to demographic and health survey statistics: methodology for the measure DHS phase III project, implemented from 2008–2013. 2006.
31. ICF International. MEASURE DHS Biomarker Field Manual. Calverton: ICF International; 2012.
32. Macro international Inc. Sampling manual. DHS-III basic documentation no. 6. Calverton: Macro international Inc; 1996.
33. Ota E, Haruna M, Suzuki M, Anh D, Tho L, Tam N, et al. Maternal body mass index and gestational weight gain and their association with perinatal outcomes in Viet Nam. Bull World Health Organ. 2011;89(2):127–36.
34. Said A, Manji K. Risk factors and outcomes of fetal macrosomia in a tertiary Centre in Tanzania: a case-control study. BMC Pregnancy Childbirth. 2016;16:243. https://doi.org/10.1186/s12884-016-1044-3.
35. Blanc AK, Wardlaw T. Monitoring low birth weight: an evaluation of international estimates and an updated estimation procedure. Bull World Health Organ. 2005;83(3):178–85.
36. Kananura R, Tetui M, Mutebi A, Bua J, Waiswa P, Kiwanuka S, et al. The neonatal mortality and its determinants in rural communities of eastern Uganda. Reprod Health. 2016;13:13. https://doi.org/10.1186/s12978-016-0119-y.
37. World Health Organization. Making every baby count: audit and review of stillbirths and neonatal deaths, 2016. Geneva: World Health Organization; 2016.
38. Ministry of Health. Situation analysis of newborn health in Uganda. Kampala: Government of Uganda; 2008.
39. Ministry of Health. Situation analysis of newborn health in Uganda: current status and opportunities to improve care and survival. Kampala: Government of Uganda. Save the Children, UNICEF, WHO; 2008.
40. Yasmin S, Osrin D, Paul E, Costello A. Neonatal mortality of low-birth-weight infants in Bangladesh. Bull World Health Organ. 2001;79(7):608–14.
41. Golestan M, Fallah R, Akhavan Karbasi S. Neonatal mortality of low birth weight infants in Yazd — Iran. Early Hum Dev. 2008;84:S26.
42. Gaiva M, Fujimori E, Sato A. Neonatal mortality in infants with low birthweight. Revista da Escola de Enfermagem da USP. 2014;48(5):778–86.
43. Hedstrom A, Ryman T, Otai C, Nyonyintono J, McAdams R, Lester D, et al. Demographics, clinical characteristics and neonatal outcomes in a rural Ugandan NICU. BMC Pregnancy Childbirth. 2014;14:327. https://doi.org/10.1186/1471-2393-14-327.
44. Wang H, Liddell CA, Coates MM, Mooney MD, Levitz CE, Schumacher AE, et al. Global, regional, and national levels of neonatal, infant, and under-5 mortalities during 1990-2013: a systematic analysis for the global burden of disease study 2013. The Lancet (London, England). 2014;384(9947):957–79.
45. Waiswa P, Peterson S, Namazzi G, Ekirapa E, Naikoba S, Byaruhanga R, et al. The Uganda newborn study (UNEST): an effectiveness study on improving newborn health and survival in rural Uganda through a community-based intervention linked to health facilities - study protocol for a cluster randomized controlled trial. Trials. 2012;13:213. https://doi.org/10.1186/1745-6215-13-213.
46. Newborn Steering Committee. Kampala. Uganda: Save the Children, Healthy Child Uganda, UNICEF, on behalf of the national Newborn Steering Committee: 2011. Newborn Health Implementation Framework Standards for Newborn Health Services: Health Facility Assessments.
47. Mbonye A, Sentongo M, Mukasa G, Byaruhanga R, Sentumbwe-Mugisa O, Waiswa P, et al. Newborn survival in Uganda: a decade of change and future implications. Health Policy Plan. 2012;27(suppl 3):iii104–17.
48. Kraft A, Nguyen K, Jimenez-Soto E, Hodge A. Stagnant neonatal mortality and persistent health inequality in middle-income countries: a case study of the Philippines. PLoS One. 2013;8(1):e53696.
49. Walakira E.J.D., Muhangi S.. Munyuwiny F,. Matovu E,. Awich I., Ddumba Nyanzi J. et al. (2016). The state of the Ugandan child – an analytical overview. Kampala/Washington DC: USAID/QED.
50. Boltena A, Khan F, Asamoah B, Agardh A. Barriers faced by Ugandan university students in seeking medical care and sexual health counselling: a cross-sectional study. BMC Public Health. 2012;12:986. https://doi.org/10.1186/1471-2458-12-986.
51. Sandberg J, Odberg Pettersson K, Asp G, Kabakyenga J, Agardh A. Inadequate knowledge of neonatal danger signs among recently delivered women in southwestern rural Uganda: a community survey. PLoS One. 2014;9(5):e97253.
52. Croke K. The political economy of child mortality decline in Tanzania and Uganda, 1995–2007. Stud Comp Int Dev. 2012;47(4):441–63.
53. Berhan Y, Berhan A. A meta-analysis of socio-demographic factors for perinatal mortality in developing countries: a subgroup analysis of the National Surveys and small-scale studies. Ethiop J Health Sci. 2014;24(0):41.
54. Izugbara C. Single motherhood and neonatal and infant mortality in Sierra Leone, Burkina Faso and Burundi. Public Health. 2016;135:122–30.
55. Ramaiya A, Kiss L, Baraitser P, Mbaruku G, Hildon Z. A systematic review of risk factors for neonatal mortality in adolescent Mother's in sub Saharan Africa. BMC Res Notes. 2014;7(1):750.
56. Mekonnen Y, Tensou B, Telake D, Degefie T, Bekele A. Neonatal mortality in Ethiopia: trends and determinants. BMC Public Health. 2013;13:483. https://doi.org/10.1186/1471-2458-13-483.
57. Ezeh O, Agho K, Dibley M, Hall J, Page A. Determinants of neonatal mortality in Nigeria: evidence from the 2008 demographic and health survey. BMC Public Health. 2014;14:521. https://doi.org/10.1186/1471-2458-14-521.
58. Gisore P, Shipala E, Otieno K, Rono B, Marete I, Tenge C, et al. Community based weighing of newborns and use of mobile phones by village elders in rural settings in Kenya: a decentralised approach to health care provision. BMC Pregnancy Childbirth. 2012;12:15. https://doi.org/10.1186/1471-2393-12-15.
59. Arunda M, Emmelin A, Asamoah B. Effectiveness of antenatal care services in reducing neonatal mortality in Kenya: analysis of national survey data. Glob Health Action. 2017;10(1):1328796.
60. Borah M, Agarwalla R. Maternal and socio-demographic determinants of low birth weight (LBW): a community-based study in a rural block of Assam. J Postgrad Med. 2016;62(3):178.
61. Mombo-Ngoma G, Mackanga J, González R, Ouedraogo S, Kakolwa M, Manego R, et al. Young adolescent girls are at high risk for adverse pregnancy outcomes in sub-Saharan Africa: an observational multicountry study. BMJ Open. 2016;6(6):e011783.
62. Guimarães A, Bettiol H, Souza L, Gurgel R, Almeida M, Ribeiro E, et al. Is adolescent pregnancy a risk factor for low birth weight? Rev Saude Publica. 2013;47(1):11–9.
63. Elizabeth N, Christopher O, Patrick K. Determining an anthropometric surrogate measure for identifying low birth weight babies in Uganda: a hospital-based cross-sectional study. BMC Pediatr. 2013;13:54. https://doi.org/10.1186/1471-2431-13-54.
64. Channon A, Padmadas S, McDonald J. Measuring birth weight in developing countries: does the method of reporting in retrospective surveys matter? Matern Child Health J. 2010;15(1):12–8.
65. Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: when? Where? Why? Lancet. 2005;365:891–900. https://doi.org/10.1016/S0140-6736(05)71048-5.

Study III

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ORIGINAL ARTICLE

Cesarean delivery and associated socioeconomic factors and neonatal survival outcome in Kenya and Tanzania: analysis of national survey data

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ABSTRACT

Background: The increasing trends in cesarean delivery are globally acknowledged. However, in many low-resource countries, socioeconomic disparities have created a pattern of underuse and overuse among lower and higher socioeconomic groups. The impact of rising cesarean delivery rates on neonatal survival is also unclear.

Objective: To examine cesarean delivery and its associated socioeconomic patterns and neonatal survival outcome in Kenya and Tanzania.

Methods: We employed binary logistic regression to analyze cross-sectional demographic and health survey data on neonates born in health facilities in Kenya (2014) and Tanzania (2016).

Results: Cesarean delivery rates ranged from 5% among uneducated, rural Tanzanian women to 26% among educated urban women in Kenya to 37.5% among managers in urban Tanzania. Overall findings indicated higher odds of cesarean delivery among mothers from richest households, adjusted odds ratio (aOR) 1.4 (95% CI 1.2–1.8), those insured, aOR 1.6 (95% CI 1.3–1.9), highly educated, aOR 1.6 (95% CI 1.2–2.0) and managers aOR 1.7 (95% CI 1.3–2.2), compared to middle class, no insurance, primary education and unemployed, respectively. Overall, compared to normal births and while adjusting for maternal risk factors, cesarean delivery was significantly associated with neonatal mortality in Kenya and Tanzania, overall aOR 1.7 (95% CI 1.2–2.7). However, statistical significance ceased when fetal risk factors and number of antenatal care visits were further controlled for, aOR 1.6 (95% CI 0.9–2.6).

Conclusion: Disproportionate access to cesarean delivery has widened in Kenya and Tanzania. Higher risks of cesarean-related neonatal deaths exist. Medically indicated or not, the safety and/or choice of cesarean delivery is best addressed on individual basis at the health-facility level. However, policy initiatives to eliminate incentives, improve equitable access and accountability to reduce unnecessary cesarean deliveries through well-informed decisions are needed. Efforts to prevent unintended pregnancies among adolescents as well as training of health workers and continuous research to improve neonatal outcomes are vital.

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Background

The increasing trends of cesarean delivery (CD) are globally acknowledged [1–3]. However, socioeconomic inequities in many low- and middle-income countries (LMIC) appear to have created a pattern of underuse and overuse based on income and levels of education [2,4]. The impact of cesarean delivery trends on neonatal survival has also not been adequately examined [5–7]. A recent multi-country study estimated a tripling of CD rates since 1990 to 19% in 2014 with wide variations among and within regions and countries [1]. Estimated rates in Latin America and the Caribbean varied from 5% to 58% while rates in high-income countries (HIC) in the Nordics ranged between 15% and 27% [1,2,8]. Whereas the World Health Organization (WHO) emphasizes access to CD for all mothers in medical need, the organization's 2015 review found that an optimal population-level CD rate should not exceed 10–15% based on medical indication [9]. Studies by Betrán et al. and Boatin et al. recommended increased access to CD in sub-Saharan Africa due to low CD rates, high maternal death rates, and slowly declining rates of newborn deaths within the first month, i.e. neonatal mortality rates (NMR) [1,2]. However, recent UNICEF country reports from certain sub-Saharan (SSA) countries including Kenya and Tanzania reveal unusual trends. The reports indicate comparatively higher rates of CD and disappointingly low declines in neonatal mortality rates among higher socioeconomic (SE) groups, despite higher coverages of both pre- and postnatal care and skilled birth assistance among these subpopulations [10–12]. New WHO recommendations such as 8+ antenatal visits [13] will expedite reduction of NMR to achieve target 2 of the Sustainable Development Goal 3 [14]. However, monitoring the impact of country-specific

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trends of CD rates and subsequent policy adjustments might sustain neonatal survival gains.

Cesarean delivery (or C-section) is an obstetric surgical procedure meant to save the life of a mother and her baby. Breech presentation, antepartum hemorrhage, fetal distress, prolonged and obstructed labor, placenta previa and other life-threatening medical indications require CD for safe delivery [5–7]. However, most of the rising elective CD rates among low-risk births in many LMIC are due to maternal request or physicians' preference without plausible clinical indications [15–17]. In HIC such as Sweden, childbirth fear has also been associated with CD [18]. Elective CD has been associated with sepsis and respiratory problems, which are major causes of neonatal deaths globally [19]. While cesarean delivery has prevented many adverse pregnancy outcomes, the quality and conditions under which some procedures (both elective and emergency) are executed in many low-resourced settings have also resulted in many morbidities [20,21] and preventable mortalities [5,22–28]. The trade-offs between morbidities and benefits are generally unclear but also costly for weak health-care systems [29,30]. A cohort study in South America reported a significant increased risk of neonatal death among elective cesarean deliveries [28]. Another study in the USA also indicated a two-fold rise in neonatal deaths among CD-newborns without medical indication even after adjusting for key confounders [31]. Similarly, recent enquiry into maternal deaths in South African health facilities revealed 3 times higher risk of maternal deaths among CD births [24]. A systematic review in LMIC also found similar adverse neonatal outcomes after CD [24].

In many low-resourced settings, inadequate record-keeping makes it difficult to determine whether the adverse pregnancy outcomes occurred before birth or intrapartum or because of the CD procedure itself [29,32]. A study in five low-income countries (LIC) in SSA and Southeast Asia (SEA) found that 40% of health facility records had no CD fetal outcome information [6]. Nonetheless, although inadequate access to CD and delays by the expectant mothers to seek or reach care clearly have adverse impacts [33,34], incomplete records have also concealed emergency challenges of health facilities and impeded improvements in care as well as accountability [6,35–37]. Higher neonatal deaths associated with CD are reported in SSA than any other region [21]. It should be noted, however, that audits of a few upgraded and well-funded health facilities in SSA including Tanzania have reported reduction of both unnecessary CD and CD-related neonatal deaths [32,38].

In Kenya and Tanzania where about 100 neonates die daily in each country [10], CD rates among the richest and the secondary+ educated mothers, for Kenya 2014 and Tanzania 2016 indicate an overall difference of more than seven folds higher rates compared to the poorest and the uneducated, respectively, in both countries [11,12]. However, neonatal death rates among the highest SE groups in the two countries were markedly higher compared to those of lowest SE groups. Further since 2003, NMR among the lowest SE categories in Kenya declined by almost half to 20 deaths per 1000 live births in 2014; in contrast, there was almost no overall change in NMRs among the highest SE groups [11,39]. Similar trends can be seen in Tanzania [12,40]. A summary of these reports can be seen in Figures 1 and 2. We identified no population-based studies concerning socioeconomic patterns of CD in relation to NMR in the two countries. A recent global study by Ye et al. investigated the associations between CD rates and NMR accounting for human development index

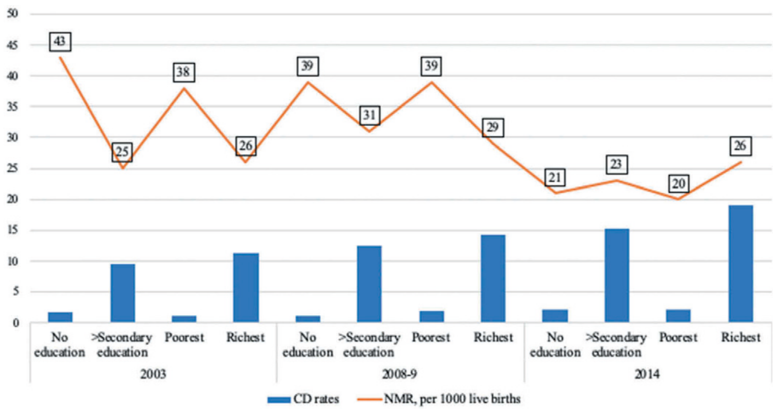

Figure 1. Neonatal mortality rates (NMR) and cesarean delivery (CD) rates among highest and lowest socioeconomic groups in Kenya between 2003 and 2014 [11,39].

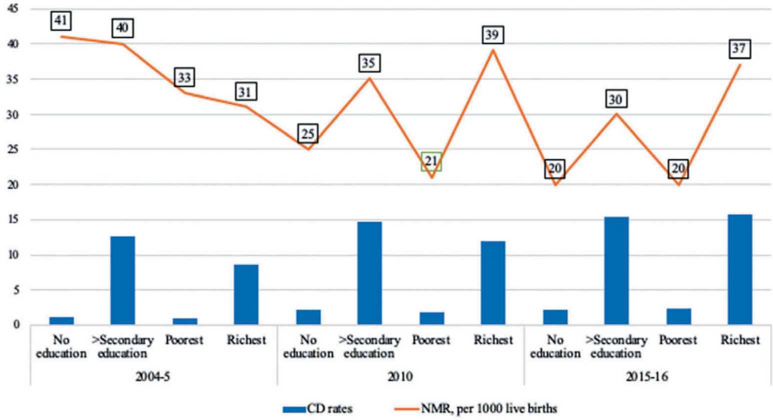

Figure 2. Neonatal mortality rates (NMR) and cesarean delivery (CD) rates among highest and lowest socioeconomic groups in Tanzania between 2004 and 2016 [12,40].

but the study did not adjust for within-country socioeconomic disparities [41]. This study examined the socioeconomic factors associated with cesarean delivery in Kenya and Tanzania. A secondary aim was to assess the impact of cesarean delivery on neonatal survival in both countries.

Methods

Study settings

With approximately equal population sizes totaling about 100 million in 2015–2018, Kenya and Tanzania are the most populous countries in the East Africa Community (EAC). Fertility rates were 3.9 – 5 in 2014–2015 [42]. The sex ratio in both countries is 1:1, with women of reproductive age (15–49) comprising roughly 11–12 million in each country [43,44]. More than two-thirds of the populations live in rural areas as farmers [11,12,45]. Maternal health care is free in first-level health centers in both countries, and as a result, institutional births increased to over 60% in recent years [11,12]. In 2015 over 1.5 and 2 million babies were born in Kenya and Tanzania, respectively [10]. In Tanzania, CD rates ranged from 1.1% in the Simiyu region to 17% in Dar es Salaam [12]. In Kenya, CD rates ranged from 2.9% in the northeast to 20.7% in Nairobi [11]. Inadequate financing and equipping of the health facilities are major challenges. A recent assessment in SSA indicated that 18% of health facilities providing CD services did not report presence of any surgical care provider [21].

Data source and study design

Demographic and Health Survey (DHS) data from Kenya (2014) and Tanzania (2015–2016) with ≥90% response rates were used. We utilized only institutional birth records of the most recent live-born neonates. DHS collects countrywide data on vital reproductive and sociodemographic information in a cross-sectional design. We obtained access to the datasets from DHS secretariat following a written request. The DHS program obtained permission from the host countries, Kenya and Tanzania, to distribute datasets for purposes of health research for common good. The respondents remain completely anonymous and cannot be traced using the data provided. More details on DHS methods of data sampling and collection are publicly available from https://dhsprogram.com/What-We-Do/Survey-Types/DHS-Methodology.cfm.

Variables

Outcome and predictor variables

Cesarean delivery (CD) was the main outcome variable for the various socioeconomic variables in the study. Neonatal mortality (NM) was a secondary outcome variable for predictor variable CD. NM was dichotomized as 'lived' and 'died'.

Maternal and pregnancy-related variables

These constituted potential confounders or explanatory variables that have been hypothesized in many previous studies to be independently associated with either or both CD and neonatal mortality (NM). Major direct causes of NM include sepsis, preterm births, birth asphyxia, and pneumonia [46]. Whereas some of these variables are not direct causes of NM or CD, they are important proxy risk factors and indirect or intermediate risk factors in the causal pathway for both NM and CD. For example, low birthweight is a known underlying risk factor for both preterm and birth asphyxia. Others include; *Maternal age*, which was classified as '15–24', '25–34' and '35–49' years, with age-group 25–34 used as a reference group, the younger and older age-groups have been associated with adverse pregnancy outcomes [47,48]. *Marital status* was dichotomized as 'single' and 'married' [49]. *Maternal BMI* was categorized as under- and overweight, normal, and obese (non-pregnant and non-postpartum). *Parity* was classified as 'primiparous' (first-time mothers), 'para 2–3' and 'para 4+' [50]. *Newborn sex* and *multiple births* were included, as male sex and multiple gestations have been associated with higher death rates [51,52]. *Number of antenatal care (ANC) visits* was included; higher ANC visits is associated with skilled care and lower neonatal deaths [52]. *ANC* was categorized in terms of detailed as well as broader groupings to examine both current WHO recommendations (>8 visits) [13] and recommendations at the time of data collection (>4 visits), as shown in Tables 1 and 2. *Birthweight* was also included as higher birthweight (>4 kg) and low birthweight (<2.5 kg) are risk factors for both CD and NM, respectively [52,53]. *Facilities of delivery* were included, as private compared to government facilities are associated with CD [54].

Socioeconomic variables

Similarly, the socioeconomic variables included were chosen due to their association with higher CD rates. Thus, urban relative to rural *place of residence* has been associated with higher CD rates [2]. W*ealth, formal occupation*, having *health insurance and* higher *maternal educational levels* have also been associated with higher CD rates of cesarean deliveries in many countries [2,4].

Data analysis

Analytical software Stata version 12 (College Station, TX: Stata Press.) was used for analysis. Prior to any analysis, we applied sampling weights and adjusted for complex sample design as recommended by the DHS program in order to correct for disproportionate sampling and ensure the population representativeness of the data. Pearson's chi-square test was used to examine the distribution of study variables. Binomial logistic regression was employed to assess the association between socioeconomic variables and cesarean delivery while controlling for confounders such as maternal age, birthweight, parity and multiple gestations. Similarly, regression analysis was used to examine the association between CD and neonatal mortality with adjustments for confounding at 95% confidence interval.

Results

Overall, about 13 382 (60%) of mothers delivered in a health facility in Kenya and Tanzania, with similar proportion of institutional births in each country. Table 1 presents the distribution of study variables by mode of delivery. About 13% and 10% of births were through C-section in Kenya and Tanzania, respectively, with overall wider SE disparities in CD rates within the countries. In both countries, socioeconomic status of wealth, higher education level, health insurance and higher maternal occupation were associated with cesarean delivery, $p < 0.05$. Other factors such as urban residency and use private or mission health facility of birth were also associated with CD in both countries, $p < 0.05$.

Table 2 shows the distribution of study variables by neonatal survival in Kenya (2014) and Tanzania (2015–2016). Chi-square test results indicated an association between C-section and neonatal mortality in both countries, $p < 0.05$. Aggregate analysis also indicated an array of variables that were associated with neonatal mortality including lack of formal education among others, Table 2. A graphical summary of cesarean delivery rates by socioeconomic characteristics and place of delivery is shown in Figure 3 and Table 3. Cesarean delivery rates ranged from 5% among formally uneducated rural women in Tanzania to 26% among highly educated urbanites in Kenya and to 37.5% among urban women in managerial positions in Tanzania. A difference of 19% and 32% between the lowest and highest CD rates in the socioeconomic groups was also observed in Kenya and Tanzania, respectively. Similar, wider disparities in CD trends were shown in both countries on the basis of having health insurance coverage (Figure 3, graph B).

Table 4 and Figure 4 present adjusted odds ratios for the association between socioeconomic factors and cesarean delivery. Overall findings indicated higher odds of cesarean delivery among mothers from richest households, aOR 1.4 (95% CI 1.2–1.8), those with health insurance, aOR 1.6 (95% CI 1.3–1.9), highly educated, aOR 1.6 (95% CI 1.2–2.0), urban residents, aOR 1.3 (95% CI 1.2–1.5), those in managerial positions, aOR 1.7 (95% CI 1.3–2.2) and among births in mission health facilities, aOR 1.9 (95% CI 1.6–2.2), compared to middle class, no insurance, rural residents, unemployed and government facilities, respectively. Similar trends were observed in Tanzania. However, in Kenya, the higher odds of CD among those with managerial positions and the richest was not statistically significant. Comparatively, the managers and those who delivered in mission hospitals had about 3 times higher odds of cesarean delivery in Tanzania.

Table 5 shows adjusted odds ratios for the association between cesarean delivery and neonatal mortality.

Table 1. Characteristics of sociodemographic, maternal and newborn variables by cesarean delivery in health-facility births in Kenya 2014 and Tanzania 2015–2016.

	Overall, N = 13,372			Kenya (N = 8738)			Tanzania (N = 4634)		
	Cesarean	Normal	P value	Cesarean	Normal	P value	Cesarean	Normal	P value
Characteristics	%	%	95% CI	%	%	95% CI	%	%	95% CI
Place of residence									
Rural	9.9	90.1		11.3	88.7		7.8	92.2	
Urban	14.9	85.1	**<0.001**	15.5	84.5	**<0.001**	13.4	86.6	**<0.001**
Maternal age									
15–24	9.3	90.7		10.3	89.7		7.3	92.7	
25–34	12.8	87.2		13.6	86.4		11.1	88.9	
35–49	14.4	85.6	**<0.001**	17	83	**<0.001**	10.6	89.4	**<0.01**
Marital status				8767					
Single	11.9	88.1		13.6	86.4		8.9	91.2	
Married	12.1	87.9	>0.05	13.2	86.8	>0.05	10	90	>0.05
Wealth index									
Poorest	7.8	92.2		8.4	91.6		6.7	93.3	
Poor	9.3	90.7		11.1	88.9		5.2	94.8	
Middle	10.4	89.6		11.7	88.3		7.8	92.2	
Richer	12.1	87.9		13.9	86.1		9.1	90.9	
Richest	17.8	82.2	**<0.001**	18.7	81.3	**<0.001**	16.1	83.9	**<0.001**
Education level									
No education	6.9	**93.1**		7.8	92.2		5.9	94.1	
Primary	10.4	**89.6**		11.6	88.4		8.5	91.6	
≥Secondary	15.9	**84.1**	**<0.001**	16.2	83.8	**<0.001**	14.7	85.3	**<0.001**
Parity									
Primiparous	14.7	**85.3**		15.7	84.3		12.7	87.3	
Para 2-3	12.9	**87.0**		13.8	86.2		10.9	89.1	
Mode of delivery data missing, excluded n = 10, P value – chi-square test									
Para 4+	8.5	**91.5**	**<0.001**	10	90	**<0.001**	6.3	93.7	**<0.001**
Sex of newborn									
Male	12.2	87.2	>0.05	13.5	86.5	>0.05	9.5	90.5	>0.05
Female	11.9	88.1		12.9	87.1		10	90	
Birthweight									
<2500 g	13.1	86.9		15.1	84.9		11.2	88.8	
2500-4000 g	10.7	89.3		12	88		9.6	90.4	
>4000 g	14	86.0	**<0.01**	16	84	**0.01**	12.1	87.9	**<0.05**
Multiple births									
No	11.7	88.3		13	87		9.4	90.6	
Yes	27.1	72.7	**<0.001**	28.1	71.9	**<0.001**	25	75	**<0.001**
Health facility of birth									
Gov`t facility	10.3	89.7		11.6	88.4		7.9	92.1	
Mission hospital	19.5	80.5	**<0.001**	19.7	80.3	**<0.001**	18.9	81.1	**<0.001**
Private	–	–	**–**	N/A	N/A		15.7	84.3	**<0.001**
Antenatal visits									
0 ANC visits	11.6	88.4	**<0.001**	9.1	90.9	**<0.001**	15.8	84.2	**<0.001**
1–3 visits	9.5	90.5		10.4	89.6		8.2	91.8	
4-7 visits	13.2	86.8		14.5	85.5		10.5	89.5	
8or> visits	23.6	76.4		22.4	77.6		30.9	69.1	
Antenatal visits II									
<4 visits	9.6	90.4	**<0.001**	10.3	89.7	**<0.001**	8.4	91.7	**<0.01**
4≥ visits	13.7	86.3		14.9	85.1		10.9	89.1	
Health insurance									
No	9.9	90.1		11.1	88.9		8.9	91.1	
Mode of delivery data missing, excluded n = 10, P value – chi-square test. N/A -not available									
Yes	18.2	81.8	**<0.001**	18.5	81.5	**<0.001**	17.8	82.3	**<0.001**
Missing	*628*	*3907*		*628*	*3907*				
Occupation									
Not working	10.3	89.7		11	89		9.3	90.7	
Technical, managerial	21.8	78.2		17.7	82.3		30.9	69.1	
Self-employed farmer	8.6	91.4		11.7	88.3		7.1	92.9	
Domestic service and manual work	11.5	88.5	**<0.001**	12.8	87.2	**<0.001**	10.3	89.7	**<0.001**
Maternal BMI,									
Underweight, <18.5	8.0	92.0		9.0	91.0		6.5	93.5	
Normal,18.5–24.99	9.1	90.9		10.6	89.4		7.4	92.6	
Overweight, 25–29.99	13.8	86.2		15.1	84.9		11.4	88.6	
Obese, ≥ 30	20.0	80.0	**<0.001**	19.5	80.5	**<0.001**	20.8	79.2	**<0.001**
Missing	*695*	*4588*		*667*	*4187*		*28*	*401*	

Mode of delivery data missing, excluded n = 10, P values - from chi-square test at 95% Confidence Interval (CI).
All bold values are statistical significant values.
All italic values signify missing values.

Overall, after controlling for maternal risk factors in Model 1, cesarean delivery had 1.7 times higher odds of neonatal deaths compared to normal births, aggregate aOR 1.7 (95% CI 1.2–2.7). After further adjustments for fetal risk factors in Model 2 and antenatal care visits in model 3, the adjusted OR ceased to be

Table 2. Distribution of study variables by neonatal survival outcome in Kenya 2014 and Tanzania 2015–2016.

	Overall, N = 12,898			Kenya (N = 8446)			Tanzania (N = 4452)		
Variables/Classification	Died	Lived	P-value 95% CI	Died (%)	Lived (%)	P-value 95% CI	Died (%	Lived (%)	P-value 95% CI
Cesarean delivery									
Yes	42(19.2)	1521(12.0)		27 (20.6)	1099(13.2)		15(17.1)	422(9.7)	
No	177(80.8)	11,158(88.0)	**0.001**	104(79.4)	7216(86.8)	**0.01**	73(83)	3942(90.3)	**0.02**
Place of residence									
Rural	131(59.8)	7430(58.6)		77(58.8)	4573(55.0)		54(61.4)	2857(65.5)	
Urban	88(40.2)	5249(41.4)	>0.05	54(41.2)	3742(45.0)	>0.05	34(38.6)	1507(34.5)	>0.05
Maternal age									
15-24	67(30.6)	3903(30.8)		37(28.2)	2515(30.3)		30(34.1)	1388(31.8)	
25-34	88(40.2)	6079(47.9)		56(42.8)	4193(50.4)		32(36.4)	1886(43.2)	
35-49	64(29.2)	2697(21.3)	**<0.01**	38 [29]	1607(19.3)	**<0.05**	26(29.6)	1090(25.0	>0.05
Marital status									
Single	43(19.6)	2251(17.8)		19(14.5)	1427(17.2)		24(27.3)	824(18.9)	**<0.05**
Married	176(80.4)	10,428(82.2)	>0.05	112(85.5)	6888(82.8)	>0.05	64(72.7)	3540(81.1)	
Wealth index									
Poor & poorest	71(32.4)	4133(32.6)		50(38.2)	2842(34.2)		21(23.9)	1289(29.5)	
Middle	53(24.2)	2454(19.4)		34 [26]	1641(19.8)		19(21.6)	813(18.6)	
Rich & richest	95(43.4)	6094(48.0)	>0.05	47(35.8)	3832(46.1)	**<0.05**	48(54.6)	2262(51.8)	0.05
Educational level									
No education	27(12.3)	1216(9.6)		17(13.0)	629(7.6)		10(11.4)	587(13.5)	
Primary	134(61.2)	6903(54.4)		76(58.0)	4253(51.2)		58(65.9)	2650(60.7)	
≥Secondary	58(26.5)	4560(36.0)	**0.01**	38(29.0)	3433(41.3)	**<0.01**	20(22.7)	1127(25.8)	>0.05
Parity									
Primipara	53(24.2)	3551(28.0)		28(21.4)	2363(28.4)		25(28.4)	1188(27.2)	
[a]Mode of delivery data missing, excluded, n[a] = 10	Overall missing survival status data excluded, n = 503			Missing/excluded, n = 321			Missing/excluded, n = 182		
a – Among babies having survival status information, 10 lacked mode of delivery data and were excluded from analysis. P-values – chi-square									
Para 2-3	79(36.1)	5026(39.6)		48(36.6)	3487(41.9)		31(35.2)	1539(35.3)	
Para 4+	87(39.7)	4102(32.4)	0.05	55(42.0)	2465(29.7)	**0.01**	32(36.4)	1637(37.5)	>0.05
Sex of newborn									
Male	123(56.2)	6602(52.1)		67(51.2)	4360(52.4)		56(63.6)	2242(51.4)	
Female	96(43.8)	6077(47.9)	>0.05	64(48.9)	3955(47.6)	>0.05	32(36.4)	2122(48.6)	**<0.05**
Birthweight									
<2500 g	25(22.1)	519(6.5)		9(20.9)	264(6.8)		16(22.9)	255(6.2)	
2500–4000 g	70(62.0)	6568(81.9)		26(60.5)	3165(81.5)		44(62.9)	3403(82.3)	
>4000 g	18(15.9)	931(11.6)	**<0.01**	8(18.6)	452(11.7)	**<0.01**	10(14.3)	479(11.6)	**<0.01**
Missing	106	4661		88	4434		18	227	
Multiple births									
No	205(93.6)	12,439(98.1)		121(92.4)	8162(98.2)		84(95.5)	4277(98.0)	
Yes	14(6.4)	240(1.9)	**<0.01**	10(7.6)	153(1.9)	**<0.001**	4(4.5)	86(2.0)	>0.05
Decision for CS									
Before labor	N/A	N/A		N/A	N/A		3 [20]	120(28.4)	>0.05
After labor	N/A	N/A		N/A	N/A		12(80.0)	302(71.6)	
Missing							73	3942	
Facility of birth									
Government facility	177(82.7)	10,082(79.6)		103(81.8)	6508(78.5)		74 (84.1)	3574(81.9)	
Mission hospital	36(16.8)	2430(19.2)	>0.05	23(18.2)	1786(21.5)	>0.05	13 (14.8)	644(14.8)	>0.05

(*Continued*)

Table 2. (Continued).

	Overall, N = 12,898			Kenya (N = 8446)			Tanzania (N = 4452)		
Variables/Classification	Died	Lived	P-value 95% CI	Died (%)	Lived (%)	P-value 95% CI	Died (%	Lived (%)	P-value 95% CI
Private	1 (0.5)	146(1.2)					1(1.1)	146(3.3)	
Missing	5	21		5	21				
Antenatal visits									
0 ANC visits	11(5.1)	126(1.0)	**<0.001**	9(6.9)	93(1.1)	**<0.001**	2(2.3)	33(0.8)	>0.05
a – Among newborns having survival information, 10 lacked mode of delivery data and were excluded from analysis. P-values from chi-square test. N/A-not available									
1–3 ANC visits	95(43.6)	4797(38.0)		50(38.5)	2919(35.2)		45(51.1)	1878(43.2)	
4–7 ANC visits	108(49.5)	7328(58.0)		67(51.5)	4949(59.8)		41(46.6)	2379(54.8)	
≥8 or ANC visits	4 (1.8)	373(3.0)		4(3.1)	320(3.9)		0(0)	53(1.2)	
Missing	1	55		1	34		0	21	
Antenatal visits II				N = 4431					
<4 visits	106(48.6)	4923(39.0)	**<0.01**	59(45.4)	3012(36.4)	**<0.05**	47(53.4)	1911(44.0)	>0.05
4 or more visits	112(51.4)	7701(61.0)		71(54.6)	5269(63.6)		41(46.6)	2432(56.0)	
Missing	1	55		1	34		0	21	
Health insurance									
No	128 (88.3)	7116(85.0)	>0.05	49(86)	3151(78.7)	>0.05	79(89.8)	3965(90.9)	>0.05
Yes	17(11.7)	1252(15.0)		8(14.0)	853(21.3)		9(10.2)	399(9.1)	
Missing	74	4311		74	4311				
Maternal BMI									
Underweight, <18.5	10(8.1)	533(6.9)	>0.05	5(9.8)	262(7.1)	>0.05	5(6.9)	271(6.8)	>0.05
Normal, 18.5–24.99	66(53.7)	4526(58.9)		29(56.9)	2091(56.4)		37(51.4)	2435(61.2)	
Overweight, 25–29.99	27(22.0)	1762(22.9)		12(23.5)	946(25.5)		15(20.8)	816(20.5)	
Obese, ≥ 30	20(16.3)	863(11.2)		5(9.8)	408(11.0)		15(20.8)	455(11.4)	
Missing	96	4995		80	4608		16	387	

[a]Among newborns having survival information, 10 lacked mode of delivery data and were excluded from analysis. P-values from chi-square test.
All bold values indicate statistical significance at 95% confidence Interval (CI).

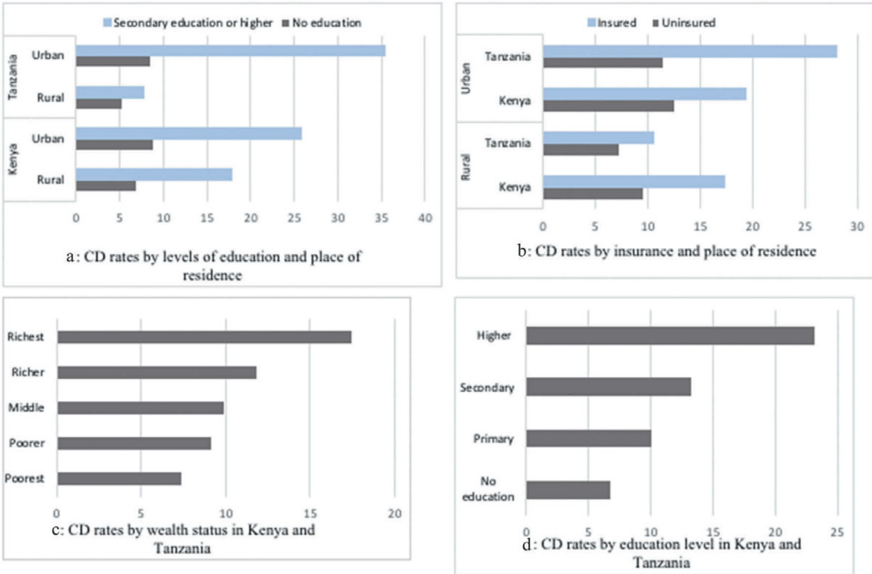

Figure 3. Graphical representations A, B, C, and D showing cesarean delivery rates by socioeconomic characteristics and place of residence in 2014-2016, in Kenya and Tanzania.

statistically significant, 1.6 (95% CI 0.9–2.6). Aggregate wealth quintile-specific analysis shown in Table 6, adjusted for all Model 3 factors except education level (due to high its correlation with wealth), showed 4.4 folds of higher neonatal mortality among the poorest after cesarean delivery. All other wealth quintiles showed no statistical significance.

Discussion

Overall, our study found that cesarean delivery in Kenya and Tanzania was associated with higher socioeconomic status, indicating that the rising cesarean births might not necessarily be driven by only medical indication, as advised by the WHO. After adjusting for potential confounders, the richest, the highly educated, the insured, managers, urban residents and those who delivered in mission or private facilities comparatively had about 1.4–1.9 times higher odds of cesarean delivery. These findings are in agreement with other studies from LMIC [2,4]. Compared to normal births, cesarean delivery also indicated association with neonatal mortality; however, after further adjusting for key confounders, the findings ceased to be statistically significant. Nonetheless, wealth quintile-specific analysis further indicated that the poorest had the highest odds (OR,4.4) of cesarean-related neonatal deaths even though they had the lowest cesarean delivery rates. These findings partly concur with previous health facility-based studies across many low-and middle-income settings that suggest that cesarean delivery (CD), both emergency and planned, has had net poor perinatal and neonatal outcomes [5,22–28]

This study is perhaps the first of its kind to examine the influence of socioeconomic factors on cesarean delivery and neonatal survival outcome resulting from C-section at national levels in Kenya and Tanzania. C-section as an increasingly preferred mode of birth does not guarantee better neonatal outcomes in East Africa. These findings suggest that a comprehensive evaluation of the rising CD-decisions is needed. Medical indication [9] and maternal informed choice after counseling should be the only basis for cesarean delivery. Other influencing factors such as financial gains should not be an underlying factor for a CD-decision. Streamlining of policies for safe delivery such as comprehensive implementation of practical guidelines including Robson 10-group classifications and recording of delivery decisions and outcomes ought to be implemented at all levels of health institutions in Kenya and Tanzania. The policies should also address delays to seek or receive care and fears of litigations [33,34,55]. Factors surrounding CD appear to be multifaceted and complex in low-resourced health systems in Kenya and Tanzania. However, with existing evidence-based research on CD and recommendations based on increasing research evidence at population levels, rapid progress in policy development and subsequent reduction in CD-related inequities and mortalities can be realized.

A good indication of progress was that even after controlling for only maternal factors, the odds of

Table 3. Within country cesarean section rates, by socioeconomic status, place of delivery and place of residence in Kenya 2014 and Tanzania 2015–16.

	Overall, N = 13,372	Kenya, N = 8738		Tanzania = 4634	
	(95% CI)	Rural	Urban	Rural	Urban
All	12.0 (11.5–12.6)	11.3	15.5	7.8	13.4
Wealth status					
Poorest	7.8 (6.6–9.0)	7.8	10.5	7.2	Missing
Poorer	9.3 (8.1–10.4)	11.2	10.6	5.0	8.6
Middle	10.4 (8.8–9.1)	11.6	11.9	7.9	6.7
Richer	12.1 (11.0–13.2)	13.5	14.2	9.5	8.5
Richest	17.7 (16.4–19.0)	15.6	19.1	1.0	17.5
Education level					
No education	6.9 (5.4–8.2)	6.8	8.8	5.3	8.5
Primary	10.4 (9.7–11.1)	10.8	12.9	7.6	10.2
Secondary	13.6 (12.5–14.7)	11.7	15.1	10.3	17.9
Higher	23.5 (21.0–26.0)	17.8	25.8	7.7	35.4
Maternal occupation					
Not working	10.3 (9.0–11.6)	10.6	11.3	8.0	10.7
Managerial, technical, clerical	21.8 (18.7–24.8)	14.6	19.7	20.2	37.5
Self-employed farmer	8.6 (7.6–9.6)	11.4	12.7	6.9	8.5
Manual, domestic services	11.5 (10.4–12.6)	10.3	14.9	8.2	12.2
Health insurance					
No	9.9 (9.2–10.6)	9.9	12.7	7.5	11.7
Yes	18.2 (16.1–20.3)	17.5	19.2	10.7	29.2
Health facility of birth					
Government	10 (9.7–10.8)	10.0	13.7	5.7	11.7
NGO or religious	19.5 (17.9–21.0)	18.4	20.6	18.5	19.9
Private		N/A	N/A	4.2	25.9

Table 4. Logistic regression analysis showing associations between socioeconomic factors, place of residence and cesarean delivery in Kenya 2014 and Tanzania, 2015–2016.

Overall N = 13,372	Overall	Kenya	Tanzania
Variables	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Wealth status			
Poorest	0.9(0.7–1.2)	0.8(0.6–1.2)	0.9(0.6–1.4)
Poor	0.9(0.7–1.2)	0.9(0.7–1.2)	0.6(0.4–1.0)
Middle	Ref	Ref	Ref
Rich	1.1(0.9–1.4)	1.1(0.8–1.4)	1.1(0.7–1.4)
Richest	**1.4(1.2–1.8)**	1.2(0.9–1.6)	**1.6(1.2–2.2)**
Educational level			
No education	0.8(0.6–1.0)	0.9(0.6–1.4)	0.8(0.5–1.1)
Primary	Ref	Ref	Ref
Secondary	**1.2(1.0–1.4)**	1.1(0.8–1.2)	**1.4(1.1–1.8)**
Higher	**1.6(1.2–2.0)**	**1.4(1.0 – 1.8)**	**2.4(1.3–4.4)**
Maternal occupation			
Not working	Ref	Ref	Ref
Managerial, technical, clerical	**1.7(1.3–2.2)**	1.3(0.9–1.7)	**2.9(1.9–4.3)**
Self-employed farmer	0.9(0.7–1.1)	1.0(0.8–1.3)	0.9(0.7–1.3)
Manual, domestic services	1.02(0.84–1.22)	1.0(0.8–1.3)	1.1(0.8–1.5)
Health Insurance			
No	Ref	Ref	Ref
Yes	**1.6(1.3–1.9)**	**1.4(1.2–1.8)**	**1.8(1.4–2.4)**
Place of residence			
Rural	Ref	Ref	Ref
Urban	**1.3(1.2–1.5)**	**1.2(1.0–1.4)**	**1.5(1.2–1.8)**
Health facility of birth			
Government facility	Ref	Ref	Ref
Mission health facility	**1.9(1.6–2.2)**	**1.5(1.2–1.8)**	**2.7(2.1–3.4)**
Private facility	N/A	N/A	**2.2(1.3–3.5)**

Each socioeconomic factor independently adjusted for maternal age, birthweight, parity, multiple births.
aOR, adjusted odds ratio. Missing data were excluded from analysis.
Bold values indicate statistically significant adjusted odds ratios.

neonatal mortality following CD in Kenya was not statistically significant. Although our study does not ascertain whether or not neonatal deaths occurred as a result of cesarean procedure itself or due to fetal or pregnancy complications or both, it nonetheless reveals that irrespective of whether there was a medical indication or not, CD-born neonates had higher odds of mortality, among the poorest and overall in Tanzania when only maternal risk factors were adjusted for. Supportive of these findings, another most recent cohort study in *The Lancet* found that neonatal deaths after CD in Africa were double the global NM estimate and maternal deaths after CD were 50 times higher in LMIC in Africa

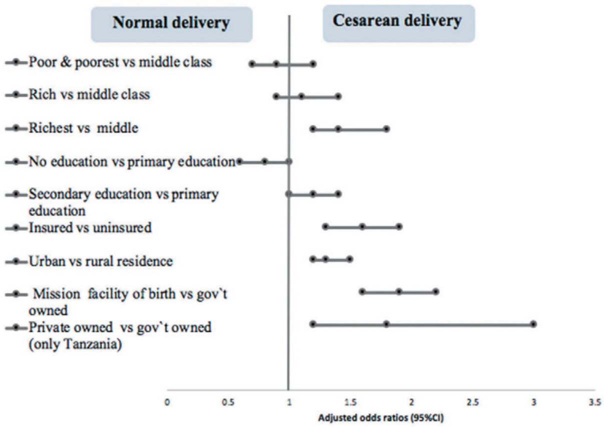

Figure 4. Forest plot presentation of adjusted odds ratios, 95% confidence interval (Table 4), showing aggregate associations between socioeconomic characteristics and cesarean delivery in Kenya and Tanzania, 2014–2016.

Table 5. Binomial logistic regression analysis (models 1–3) for the associations between cesarean delivery and neonatal mortality, adjusted odds ratios (aOR) in Kenya 2014 and Tanzania, 2015–2016.

	Model 1			Model 2			Model 3		
	aOR (95% CI)			aOR (95% CI)			aOR (95% CI)		
	Overall, N = 12,898	Kenya	Tanzania	Overall	Kenya	Tanzania	Overall	Kenya	Tanzania
Cesarean section									
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	**1.7(1.2–2.7)**	1.6(0.8–3.4)	**1.8(1.0–3.2)**	**1.6(1.0–2.7)**	1.5(0.7–3.5)	1.7(0.9–3.4)	1.6(0.9–2.6)	1.4(0.6–3.2)	1.7(0.9–3.4)

Model 1: Adjusted for maternal factors (Maternal age, parity, education level and BMI) Model 2: Model 1 factors and fetal risk factors (multiple births and birthweight), Model 3: Models 1 & 2 factors and number of antenatal visits.
Bold values indicate statistically significant odds ratios.

Table 6. Wealth quintile-specific logistic regression for the association between cesarean delivery and neonatal mortality in Kenya and Tanzania, 2014–2016.

Wealth quintiles	Adjusted odds ratios (95% CI)
Poorest (n = 1044)	**4.4 (1.2–16.3)**
Poor (n = 1313)	1.0 (0.1–7.8)
Middle (n = 1528)	0.5 (0.1–2.3)
Rich (n = 2025)	2.4 (0.9–6.3)
Richest (n = 2014)	1.3 (0.5–3.4)

Adjusted for maternal factors (maternal age, parity, BMI, excluding education), fetal risk factors (multiple births and birthweight) and number of antenatal visits. Missing data were excluded from analysis

relative to HIC. The study cited anesthesia complications and peripartum hemorrhage as major risk factors [56].

Disparities in adverse neonatal outcomes due to socioeconomic inequities in Kenya and Tanzania appear to diminish over the years and that can be attributed to improved access to health care among the poor and partly due to the slowly declining neonatal death rates among the wealthy as compared to the poor. Recent rising access to C-section associated with higher socioeconomic groups in east Africa [10–12] does not seem to achieve corresponding improved neonatal outcomes. Review of resource allocations and cost-effectiveness in maternity care in these low-resourced health systems could save resources for better neonatal and pregnancy outcomes. Whereas the choice and safety of CD could be well addressed at individual and health facility levels, multifaceted and holistic approaches could improve equitable access and neonatal outcomes. CD on medical grounds and/or well-informed choice (counseling) with zero economic advantage can be positively impactful. Additionally, at administrative levels, mandatory recording of mode of delivery and neonatal outcomes at facility levels could enable continuous auditing, monitoring, and accountability. At community levels, sexual and reproductive health education could ease the burden in the health systems through eliminating unplanned pregnancies, curb delays to seek care, and minimize CD risks. At district and county levels, continuous and equitable allocation of funds to health facilities together with requirements for accountability would improve access. Nationally, continuous training of new health personnel including anesthesiologists and capacity development of existing cadres using the most-updated evidence-based practices would ensure improved quality of cesarean procedures.

Contrary to our findings, elsewhere in Nepal, a country with similar economic conditions as Tanzania but considerably lower gross domestic product per capita compared to Kenya, a significant reduction of neonatal mortalities, including CD-related, has been found [57]. To highlight the difference, for instance, a comparison can be made between two parallel studies [58,59] from matching district-level hospitals with similar year of data collection and numbers of cesarean deliveries (330 vs 327) in Kenya [58] and Nepal [59]. The majority (43%) of patients in Nepal hospitals were of disadvantaged lower caste comparable to patients in the refugees` area in northeastern Kenya. The studies reported 7.3% vs 1.5% neonatal deaths in Kenya and Nepal, respectively.

Considering the 10 years countdown to SDG 2030, to accelerate improved equitable access and better CD-related neonatal survival, we suggest three more approaches. In addition to Betran et al.'s 2018 [55] recommendations of educational interventions for expectant mothers, effective leadership, training of health workforce, adequate equipping and financing, removal of economic incentives for CD and quenching fears of litigations, we suggest the following. Firstly that the National Road Map Strategic Plans for Maternal, Newborn Health and the decentralized health commissions in Tanzania and Kenya should consider adopting the much stronger community-level frameworks that have shown nationwide success through accountability and pregnancy-related support for women in Nepal [57] and Rwanda [60]. Even if all pregnant women accessed hospitals in Kenya and Tanzania, the health-care system would be insufficient to care for them all, much less the C-section cases. Thus, secondly, we suggest strengthening sexual and reproductive education to prevent unplanned pregnancies especially among teenage girls. Thirdly, we proposed mandatory recording of birth, newborns' health and mortality information at the health facilities to enable effective and continuous research, monitoring and accountability.

Methodological considerations

Over 60% of births in Kenya and Tanzania were institutional, an increase of over 10% from previous years. In addition, the response rate for women interviewed in the DHS program was over 90% for both countries. This improved the analytical power, external validity and representativeness of our findings. Furthermore, the random sampling strategy of DHS data collection minimized selection bias. We also applied sample weights and adjusted for complex sampling design to improve internal validity and representativeness of our sample. Our study found evidence of associations; however, causal interpretation cannot be inferred due to lack of medical confirmation of the actual reason for CD and the cause(s) of neonatal deaths. Our data could also not differentiate between cesarean deliveries that were planned (or elective) or emergency. A key limitation to our study is the many missing survival outcome status of health-facility born babies, the missing, n (503) could have perhaps altered our results if they were not uniformly distributed across. Recall bias as a limitation in cross-sectional design could not be entirely ruled out in our study; however, reproductive events are of significance to women and evidence of accurate recall has been reported [61]. Further, we used the most recent birth data which minimized recall bias. Also, we used non-pregnancy and non-postpartum BMI rather than the actual BMI before and at delivery time, which may have limited our accuracy.

Conclusion

Disproportionate access to C-section in Kenya and Tanzania is widening along socioeconomic disparity lines. Higher risks of cesarean-related neonatal mortality exist. Choice and/or safety of cesarean delivery can best be addressed on individual basis at health-facility levels. Policy improvements to promote holistic approaches of equitable access on medical grounds as well as informed choice to reduce unnecessary C-sections is vital. Moving forward, reproductive health education to minimize unintended pregnancies, mandatory recording of birth, health and death information for continuous research, monitoring and accountability could improve overall neonatal outcomes. Equipping of health facilities, training and continuous capacity development of health workers to enhance safe delivery services are vital.

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Author contributions

MOA conceptualized and designed the study, obtained datasets, conducted analysis, interpreted the results, drafted and reviewed the manuscript. BOA and AA participated in the interpretation of the results and critically reviewed all sections of the manuscript. All authors approved the final manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethics and consent

DHS collected and stored vital reproductive and sociodemographic data countrywide after obtaining ethical permission from the host countries, Kenya and Tanzania. The host countries also authorized the DHS program to distribute data for health research aimed at improving public health. DHS ensured confidentiality during data collection process. The respondents remained completely anonymous and all identifiers were removed thus the rights of the respondents were protected. Guidelines for DHS surveys are approved by the ICF Institutional Review Board and the review boards of the host countries, Kenya and Tanzania. The DHS surveys thus abide by the guidelines for epidemiological research of the Council of International Organizations of Medical Sciences (CIOMS). We obtained access to secondary datasets for this study from DHS program after registration and submission of a written request.

Paper context

The increasing trends of cesarean delivery in Kenya and Tanzania is well known. However, no national peer-reviewed studies in our knowledge have examined the socioeconomic disparities in access and the impact of increasing trends of cesarean sections on the survival of neonates in these low-resourced countries. In this study, we aimed to examine utilization and neonatal outcomes of cesarean delivery with the hope to inform policy to improve newborn survival in Kenya and Tanzania.

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References

[1] Betrán A, Ye J, Moller A, et al. The increasing trend in caesarean section rates: global, regional and national estimates: 1990-2014. PLoS One. 2016;11(2):e0148343.
[2] Boatin A, Schlotheuber A, Betran A, et al. Within country inequalities in caesarean section rates: observational study of 72 low and middle income countries. BMJ;2018:k55.DOI:10.1136/bmj.k55
[3] Stanton C, Holtz S. Levels and trends in cesarean birth in the developing world. Stud Fam Plann. 2006;37:41–48.
[4] Ronsmans C, Holtz S, Stanton C. Socioeconomic differentials in caesarean rates in developing countries: a retrospective analysis. Lancet. 2006;368:1516–1523.
[5] Lavender T, Hofmeyr G, Neilson J, et al. Caesarean section for non-medical reasons at term. Cochrane Database Syst Rev. 2012. DOI:10.1002/14651858.CD004660.pub3.
[6] Landry E, Pett C, Fiorentino R, et al. Assessing the quality of record keeping for cesarean deliveries: results from a multicenter retrospective record review in five low-income countries. BMC Pregnancy Childbirth. 2014;14(1):1.
[7] Shah A, Fawole B, M'imunya J, et al. Cesarean delivery outcomes from the who global survey on maternal and perinatal health in africa. Obstetric Anesthesia Digest. 2011;31:16.
[8] Pyykönen A, Gissler M, Løkkegaard E, et al. Cesarean section trends in the Nordic Countries - a comparative analysis with the Robson classification. Acta Obstet Gynecol Scand. 2017;96(5):607–616.
[9] Betrán A, Torloni M, Zhang J, et al. WHO Working Group. WHO statement on caesarean section rates. BJOG. An Int J Obstetrics Gynaecol. 2016;123(5):667–670.
[10] Maternal and Newborn Health Disparities Country profiles. UNICEF DATA [Internet]. UNICEF DATA. 2019 cited 2019 Nov 23. Available from: https://data.unicef.org/resources/maternal-newborn-health-disparities-country-profiles/.
[11] Kenya National Bureau of Statistics (KNBS), Ministry of Health, National AIDS Control Council, Kenya Medical Research institute, National Council for Population and Development and ICF international. Kenya demographic and health survey. Nairobi: KNBS and ICF International, Inc; 2015.
[12] Ministry of Health, Community Development, Gender, Elderly and Children - MoHCDGEC/Tanzania Mainland, Ministry of Health - MoH/Zanzibar, National Bureau of Statistics - NBS/Tanzania, Office of Chief Government Statistician - OCGS/Zanzibar, and ICF. 2016. Tanzania Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) 2015-16. Dar es Salaam/Tanzania: MoHCDGEC, MoH, NBS, OCGS and ICF International; 2016.
[13] World Health Organization (WHO). WHO recommendations on antenatal care for a positive pregnancy experience. Geneva: World Health Organization; 2016. Available from https://apps.who.int/iris/bitstream/handle/10665/250796/9789241549912-eng.pdf;jsessionid=EDF5B454E6B8B1540DF56A5488095503?sequence=1
[14] IAEG-SDG. 2018. SDG Indicators. UNSD, Sustainable development goals [Internet]. [cited 2019 Oct]. Available from: https://unstats.un.org/sdgs/indicators/indicators-list/
[15] Heemelaar S, Nelissen E, Mdoe P, et al. Criteria-based audit of caesarean section in a referral hospital in rural Tanzania. Trop Med Int Health. 2016;21:525–534.
[16] Briand V, Dumont A, Abrahamowicz M, et al. Individual and institutional determinants of caesarean section in referral hospitals in Senegal and Mali: a cross-sectional epidemiological survey. BMC Pregnancy Childbirth. 2012;12(1):1.
[17] Litorp H, Kidanto H, Nystrom L, et al. Increasing caesarean section rates among low-risk groups: a panel study classifying deliveries according to Robson at a university hospital in Tanzania. BMC Pregnancy Childbirth. 2013;13(1):1.
[18] Karlström A. Women's self-reported experience of unplanned caesarean section: results of a Swedish study. Midwifery. 2017;50:253–258.
[19] Boutsikou T, Malamitsi-Puchner A. Caesarean section: impact on mother and child. Acta Paediatrica. 2011;100(12):1518–1522.
[20] Hansen AK, Wisborg K, Uldbjerg N, et al. Elective caesarean section and respiratory morbidity in the term and near-term neonate. Acta Obstet Gynecol Scand. 2007;86:389–394.

[21] Ologunde R, Vogel J, Cherian M, et al. Assessment of cesarean delivery availability in 26 low- and middle-income countries: a cross-sectional study. Am J Obstet Gynecol. 2014;211(5):504.e1–504.e12.
[22] Harrison MS, Pasha O, Saleem S, et al. prospective study of maternal, fetal and neonatal outcomes in the setting of cesarean section in low- and middle-income countries. Acta Obstet Gynecol Scand. 2017;96 (4):410–420.
[23] MacDorman M, Declercq E, Menacker F, et al. Infant and neonatal mortality for primary cesarean and vaginal births to women with "no indicated risk," USA, 1998–2001 birth cohorts. Birth. 2006;33(3):175–182.
[24] Gebhardt G, Fawcus S, Moodley J, et al. Maternal death and caesarean section in South Africa: results from the 2011–2013 saving mothers report of the national committee for confidential enquiries into maternal deaths. South Afr Med J. 2015;105:287.
[25] Sobhy S, Zamora J, Dharmarajah K, et al. Anaesthesia-related maternal mortality in low-income and middle-income countries: a systematic review and meta-analysis. Lancet Glob Health. 2016;4:e320–e327.
[26] Wylie B, Mirza F. Cesarean delivery in the developing world. Clin Perinatol. 2008;35:571–582.
[27] Kinenkinda X, Mukuku O, Chenge F, et al. Césarienne à Lubumbashi, République Démocratique du Congo II: facteurs de risque de mortalité maternelle et périnatale. Pan Afr Med J. 2017;26:208.
[28] Villar J, Carroli G, Zavaleta N, et al. Maternal and neonatal individual risks and benefits associated with caesarean delivery: multicentre prospective study. BMJ. 2007;335(7628):1025.
[29] Harrison M, Goldenberg R. Cesarean section in sub-Saharan Africa. Matern Health Neonatol Perinatol. 2016;2:1.
[30] Gibbons L, Belizán MJ, Lauer J, et al. The global numbers and costs of additionally needed and unnecessary caesarean sections performed per year: overuse as a barrier to universal coverage. World Health Report (2010). Background Paper, No 30. 2010; Geneva: World Health Organization.
[31] MacDorman M, Declercq E, Menacker F, et al. Infant and neonatal mortality for primary cesarean and vaginal births to women with "no indicated risk," USA, 1998–2001 birth cohorts. Birth. 2006;33:175–182.
[32] Chu K, Cortier H, Maldonado F, et al. Cesarean section rates and indications in Sub-Saharan Africa: a multi-country study from medecins sans frontieres. PLoS One. 2012;7(9):e44484.
[33] Ackers L, Ioannou E, Ackers-Johnson J. The impact of delays on maternal and neonatal outcomes in Ugandan public health facilities: the role of absenteeism. Health Policy Plan. 2016;31(9):1152–1161.
[34] Waiswa P, Kallander K, Peterson S, et al. Using the three delays model to understand why newborn babies die in eastern Uganda. Trop Med Int Health. 2010;15:964–972.
[35] Mgawadere F, Unkels R, Kazembe A, et al. Factors associated with maternal mortality in Malawi: application of the three delays model. BMC Pregnancy Childbirth. 2017;17:1.
[36] Kruk M, Leslie H, Verguet S, et al. Quality of basic maternal care functions in health facilities of five African countries: an analysis of national health system surveys. Lancet Glob Health. 2016;4:e845–e855.
[37] Epiu I, Tindimwebwa J, Mijumbi C, et al. Challenges of anesthesia in low- and middle-income countries. Anesthesia Analg. 2017;124(1):290–299.
[38] Nyamtema A, Mwakatundu N, Dominico S, et al. Increasing the availability and quality of caesarean section in Tanzania. BJOG. 2016;123:1676–1682.
[39] Central Bureau of Statistics - CBS/Kenya, Ministry of Health - MOH/Kenya, and ORC Macro. Kenya Demographic and Health Survey 2003. Calverton, Maryland: CBS, MOH, and ORC Macro; 2004.
[40] National Bureau of Statistics - NBS/Tanzania and ORC Macro. Tanzania demographic and health survey 2004-05. Dar es Salaam, Tanzania: NBS/Tanzania and ORC Macro; 2005.
[41] Ye J, Zhang J, Mikolajczyk R, et al. Association between rates of caesarean section and maternal and neonatal mortality in the 21st century: a worldwide population-based ecological study with longitudinal data. BJOG. 2015;123:745–753.
[42] The World Bank. World Bank Open Data, Indicators, Fertility rate, total (births per woman) - Kenya, Tanzania, 2014–2015. Washington DC: World Bank; 2019 [cited 2019. Aug]. Available from: https://data.worldbank.org/indicator/SP.DYN.TFRT.IN?locations=KE-TZ
[43] Kenya Population By Age Groups. Kenya Data Portal [Internet]. Kenya Data Portal. 2019 [cited 2019 Jan]. Available from: https://kenya.opendataforafrica.org/lpdtibb/kenya-population-by-age-groups
[44] Tanzania Population By Age Groups. Tanzania Data Portal [Internet]. Tanzania Data Portal. 2019 [cited 2019 Jan]. Available from: https://tanzania.opendataforafrica.org/uzoxekc/tanzania-population-by-age-groups
[45] The World Bank Rural population (percentage of total population); 2019c [cited 2019. Jan]. Available from: https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS
[46] World Health Organization (WHO). Newborn death and illness. Geneva: World Health Organization; 2011. Available from https://www.who.int/pmnch/media/press_materials/fs/fs_newborndealth_illness/en/
[47] Leader J, Bajwa A, Lanes A, et al. The effect of very advanced maternal age on maternal and neonatal outcomes: a systematic review. J Obstet Gynaecology Canada. 2018;40:1208–1218.
[48] Cunnington A. What's so bad about teenage pregnancy? J Fam Plan Reprod Health Care. 2001;27 (1):36–41.
[49] Ramaiya A, Kiss L, Baraitser P, et al. A systematic review of risk factors for neonatal mortality in Adolescent Mother's in Sub Saharan Africa. BMC Res Notes. 2014;7(1):1.
[50] Kozuki N, Lee A, Silveira M, et al. The associations of parity and maternal age with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. BMC Public Health. 2013;13(Suppl 3):S2.
[51] Zhao D, Zou L, Lei X, et al. Gender differences in infant mortality and neonatal morbidity in mixed-gender twins. Sci Rep. 2017;7:1.
[52] Veloso F, Kassar L, Oliveira M, et al. Analysis of neonatal mortality risk factors in Brazil: a systematic review and meta-analysis of observational studies. J Pediatr (Rio J). 2019;95(5):519–530.
[53] Chiossi G, Pedroza C, Costantine M, et al. Customized vs population-based growth charts to

identify neonates at risk of adverse outcome: systematic review and Bayesian meta-analysis of observational studies. Ultrasound Obstet Gynecol. 2017;50(2):156–166.

[54] Beogo I, Mendez RB, Gagnon M. Determinants and materno-fetal outcomes related to cesarean section delivery in private and public hospitals in low- and middle-income countries: a systematic review and meta-analysis protocol. Syst Rev. 2017;6(1):1.

[55] Betrán A, Temmerman M, Kingdon C, et al. Interventions to reduce unnecessary caesarean sections in healthy women and babies. Lancet. 2018;392:1358–1368.

[56] Bishop D, Dyer AR, Maswime S, et al. Maternal and neonatal outcomes after caesarean delivery in the African Surgical Outcomes Study: a 7-day prospective observational cohort study. Lancet Glob Health. 2019;7(4):e513–e522.

[57] Pradhan Y, Upreti S, Pratap KCN, et al. Newborn survival in Nepal: a decade of change and future implications. Health Policy Plan. 2012;27(suppl_3): iii57–iii71.

[58] Kamotho D, Pertet A, Ogwayo I. Decision to incision interval for emergency caesarean section and post-operative outcomes in a resource limited rural Kenyan public hospital. Int J Reprod Contraception Obstetrics Gynecology. 2018;7(7):2573.

[59] Bhandari B. Maternal and fetal outcomes following cesarean section in comprehensive emergency obstetric care program at Nuwakot district hospital. Nepal J Obstetrics Gynaecol. 2016;10:40–44.

[60] Ministry of Health Rwanda. National Community Health Policy. Kigali: Ministry of Health Rwanda; 2015.

[61] McCarthy K, Blanc A, Warren C, et al. Can surveys of women accurately track indicators of maternal and newborn care? A validity and reliability study in Kenya. J Glob Health. 2016;6(2):2.

Study IV

BMJ Open

Determinants of continued maternal care seeking during pregnancy, birth and postnatal and associated neonatal survival outcomes in Kenya and Uganda: analysis of cross-sectional, Demographic and Health Surveys data

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ABSTRACT

Objectives To examine how maternal and sociodemographic factors determine continued care-seeking behaviour from pregnancy to postnatal period in Kenya and Uganda and to determine associated neonatal survival outcomes.
Design A population-based analysis of cross-sectional data using multinomial and binary logistic regressions.
Setting Countrywide, Kenya and Uganda.
Participants Most recent live births of 24 502 mothers within 1–59 months prior to the 2014–2016 Demographic and Health Surveys.
Outcomes Care-seeking continuum and neonatal mortality.
Results Overall, 57% of the mothers had four or more antenatal care (ANC) contacts, of which 73% and 41% had facility births and postnatal care (PNC), respectively. Maternal/paternal education versus no education was associated with continued care seeking in majority of care-seeking classes; relative risk ratios (RRRs) ranged from 2.1 to 8.0 (95% CI 1.1 to 16.3). Similarly, exposure to mass media was generally associated with continued care seekin; RRRs ranged from 1.8 to 3.2 (95% CI 1.2 to 5.4). Care-seeking tendency reduced if a husband made major maternal care-seeking decisions. Transportation problems and living in rural versus urban were largely associated with lower continued care use; RRR ranged from 0.4 to 0.7 (95% CI 0.3 to 0.9). The two *lowest* care-seeking categories with no ANC and no PNC indicated the highest odds for neonatal mortality (adjusted OR 4.2, 95% CI 1.6 to 10.9). 23% neonatal deaths were attributable to inadequate maternal care attendance.
Conclusion Strategies such as mobile health specifically for promoting continued maternal care use up to postnatal could be integrated in the existing structures. Another strategy would be to develop and employ a brief standard questionnaire to determine a mother's continued care-seeking level during the first ANC visit and to use the information to close the care-seeking gaps. Strengthening the community health workers system to be an integral part of promoting continued care seeking could enhance care seeking as a stand-alone strategy or as a component of aforementioned suggested strategies.

Strengths and limitations of this study

- ► The national representativeness of the data and the large sample size of the study allowed for valid stratified analysis with implications for national policy developments to improve neonatal survival outcomes for countries in the sub-Saharan Africa region.
- ► Recall bias may not be completely eliminated from the study since the data were collected retrospectively through interviews.
- ► However, by selecting the most recent births and owing to the fact that childbirth is a special event not easily forgettable, the study findings reflect the reality with considerable validity.
- ► The study was based on maternal attendance to care and not the actual obstetric services received; thus, aspects related to lack of drugs, inadequate facilities or quality of care were not captured in our study.

INTRODUCTION

In 2019, close to 7000 newborns worldwide died within their first 28 days of life (neonatal period), as per the United Nations Inter-Agency Group for Child Mortality Estimation.[1] Roughly three-quarters of these deaths occurred during childbirth and the first week of the neonatal period,[1 2] and the major causes included infections such as sepsis and pneumonia, birth complications and prematurity-related problems such as asphyxia and low birth weight.[3] Comprehensive antenatal care (ANC), skilled birth attendance and postnatal (afterbirth) care (PNC) have long been recognised as key strategies that profoundly contribute to newborn survival.[4 5] In 2015, 64% of women globally had four or more ANC contacts,[6] and prevalence of health facility births was 80% in 2019.[7] In high-income countries such as Sweden, where neonatal death rate is among the lowest globally (1.4 deaths per 1000 live births, in 2019), almost all mothers obtain comprehensive ANC, facility births and PNC services.[8] However, in sub-Saharan African (SSA) and Southeast Asian countries, where over 70% of all neonatal deaths occur,[9] use of the components of care is relatively low and varies substantially.[10–12]

Accordingly, since 2005, the WHO has been advocating for the implementation of continuum of care strategy,[13] a concept that promotes continual access to care from prepregnancy to the first few weeks of after childbirth.[13 14] While several SSA countries including Kenya and Uganda report over 80% coverage of at least one ANC contact with a skilled provider,[15 16] late initiation of ANC visits, lower health facility births and very low PNC use still pose enormous challenges. A *Lancet* study reported that prevalence of early initiation of ANC contact (<14 weeks of gestation) was only 24% in SSA, much lower compared with 85% in high-income countries.[17] The challenge in a number of SSA countries, however, is that despite the removal of user fees for all maternal and child health service in many countries, a number of sociodemographic factors and maternal characteristics still remain critical determinants of care use that hinder or motivate choices and preferences in maternal care seeking.[18]

Andersen and Newman behavioural model of use of healthcare services has widely been used to identify factors that influence care-seeking behaviour.[19] The model outlines three main factors that interact to predict use of care, and they included societal, individual and health system determinants[19] (see diagrammatic details in online supplemental file 1). The model has been employed by studies to examine use of the different components of maternal and newborn care such as ANC,[20 21] childbirth[22] or PNC.[23] However, very few studies in SSA have assessed how factors in the Andersen and Newman model modify care-seeking behaviour along the continuum of care from pregnancy to postnatal period, and even much fewer within the context of free maternity policy.

A recent community-based study in Ethiopia showed that women with higher education, married women and those with autonomy in healthcare decision were likely to complete continuum of care.[24] Whereas the study provided critical findings, it considered only one ANC visit and not the WHO or Ministry of Health (MoH)-recommended number of contacts.[24] Another similar study by Oh *et al* in 2013 in Gambia also found a number of factors associated with maternal care-seeking continuum and early ANC visits.[25] However, the study lacked PNC estimates for facilities deliveries.[25] Another subnational study in Tanzania found, among other factors, knowledge or experience of pregnancy danger signs was associated with higher care seeking.[26] A 2019 Cochrane review of several qualitative studies found that influence by others, illness-free pregnancy, financial dependence and selective use of ANC are potential barriers to continual maternal care use.[27] The few existing studies on continuum of care seeking in SSA are very informative but limited in one way or another, and none to our knowledge examined associated neonatal survival outcomes.

Kenya and Uganda are among the 10 countries in SSA countries with most neonatal deaths[28] and despite relatively free or subsidised maternity policy in both countries and relatively higher gross domestic product than some countries in the East Africa region such as Rwanda, neonatal mortality rates have declined much slower compared with Rwanda.[29 30] Thus, this study aimed to examine how sociodemographic and maternal factors influence care-seeking behaviour in the care-seeking continuum from pregnancy, childbirth to postnatal period in Kenya and Uganda. A secondary aim was to estimate the impact of levels of continued maternal care seeking on neonatal survival.

METHODS

Study settings

Kenya and Uganda have closely comparable demographics and are in relatively similar state of maternal healthcare policy and pathway towards achieving universal coverage. The total population in Kenya and Uganda as of 2016–2019 was about 90 million.[31 32] More than 70% of the populations live in the rural areas with agriculture as their main source of livelihood.[31 33 34] The sex ratio is approximately 1:1,[31 35] and general life expectancy at birth in 2016 was similar in both countries; for women, it was 64 and 67 years in Uganda and Kenya, respectively.[36] Maternal mean age at first childbirth is 19–20 years. Neonatal mortality rates in both countries were about 22 deaths per 1000 live births in 2016.[30] Like a number of countries in SSA, Kenya and Uganda provide free maternal care services in primary-level health facilities.[37] Although the goal of the free maternity programmes in Kenya and Uganda is to eliminate all maternity-related costs, due to inadequate or slow distribution of funding in some health facilities, certain hidden costs such as for ultrasound, access to hospital card and laboratory services among others are still incurred out-of-pocket.[38–42] Additionally, indirect expenses such as costs of transportation to the health facility are still challenges common among poor households.[39] Further, in Kenya, prior to June 2013, maternal services were partly free and partly subsidised.[43]

Data source and study design

We obtained the cross-sectional, population-representative, Demographic and Health Surveys (DHS) datasets for Kenya 2014 and Uganda 2016 after a formal request to the DHS secretariat. DHS collects sociodemographic, maternal and child health data across the whole country in a two-stage cluster sampling procedure. The DHS uses standard procedures and protocols that ensure complete anonymity of the respondents and adherence to international ethical standards for research. We used the data for the most recent live births, 1–59 months prior

Table 1 Classification of continuum of care-seeking classes during the antenatal period, childbirth and within 28 days of postnatal period in Kenya and Uganda

	≥4 ANC visits	2–3 ANC visits	1 ANC visit	0 ANC visit
Health facility births				
PNC— yes	Highest	Higher	Seventh lowest	–
PNC— no	High	Moderately high	Sixth lowest	Third lowest
Birth outside of health facility				
PNC— yes	Slightly high	Moderately lower	Fifth lowest	Second lowest
PNC— No	Moderately low	Very low	Fourth lowest	Lowest

ANC, antenatal care; PNC, postnatal care.

to the surveys. More details on data collection procedure can be accessed from DHS methodology and manuals.[44 45]

Study variables

Outcome variables

Care-seeking continuum was the primary outcome variable. It constituted a combination of the number of ANC visits, health facility birth and at least one PNC contact within 28 days postpartum (after birth). Continuum of care seeking was categorised into 15 classes based on relative adherence to basic (modified) WHO and MoH recommendations for care attendance from pregnancy to postnatal period prior to 2016, that is, before the current WHO recommendation of 8 ANC visits. Since data for both countries were collected prior to the new WHO 2016 ANC recommendations, we used previous Focused ANC recommendations. A mother with a combination of four or more visits, health facility birth (skilled birth) and at least one PNC contact was classified in the *highest* category of care seeking, and those with least/no amount of care were categorised as the *lowest* class. The intermediate categories were classified on the basis of optimal and perceived descending level of care-seeking behaviour as *higher, high, moderately high, slightly high, moderately low, moderately lower, very low, seventh lowest, sixth lowest, fifth lowest, fourth lowest, third lowest, second lowest* and *lowest*, as shown in table 1.

The first component of classification was in accordance with the number of ANC visits a mother had; the second level was on the basis of whether or not a mother delivered at the health facility; and the last part of continuum of care was whether or not a mother had PNC visit within 28 days postpartum.

Neonatal mortality was a secondary outcome variable that was dichotomised into 'yes' (died) and 'no' (lived), depending on whether the neonate lived or not. The predictor variables for this outcome variable were the modified classes of care-seeking continuum discussed previously as the primary outcomes.

Independent variables

These constituted sociodemographic factors and maternal characteristics that were examined across all care-seeking continuum categories of the primary outcome variable. They included variables that the modified Andersen and Newman behavioural model for care use identified as predictors of care-seeking behaviour.[19] Further, the categorisation of these variables was also informed by a number of maternal and child health studies previously conducted in SSA. They included *maternal age*, which was initially grouped as 15–19, 20–24, 25–29, 30–34, 35–39, 40–44 and 45–49 years old, and we recategorised it into 15–24, 25–34 and 35–49 years years old, while *place of residence* remained as *rural* and *urban.*[46] *Marital status* was dichotomised into single or married.[47] A mother having a *problem with longer distance/transportation to nearest health facility* was classified as 'yes' if it was a problem and 'no' if it was not.[48] *Desire to have a newborn child, whether or not the mother was told about pregnancy complications*[49] and *having exposure to mass media*[50] were all categorised as yes and no. The variable *who ultimately makes maternal care-seeking decisions* was categorised as respondent (woman) alone, husband alone or joint decision.[51] *Education* was categorised as no education, primary education and secondary or higher.[52] *Parity* (number of children ever born) was categorised as primiparous (for first time mothers), para 2–3 (for those with two to three children) and para 4+.[46] *Wealth status* was classified into poor (poor/poorest), middle and rich (rich/richest).[52 53] The wealth status in DHS is indexed based on household cumulative living standards, taking into account assets possessed, water and sanitation facilities. Place of residence was classified into rural and urban.[53]

Mapping the predictor: outcome relationship using directed acyclic graphs (DAGs)

Prior to the analysis, the DAGs by Textor and colleagues[54] were used to map the predictors of both care-seeking behaviours and neonatal mortality on the basis of existing peer-reviewed evidence and to identify any confounding bias in our models. Online supplemental file 2, diagrams 1.a and b, illustrate the process. For diagram 1.b, the lower levels of care seeking are represented by a lack of a care component(s) that is/are major non-causal risk factor for neonatal mortality.

Data analysis

We used cross-tabulations to examine the distribution of mothers across variables and variable categories in the different levels of care-seeking continuum. We also investigated correlations between ANC visits and proportions of health facility childbirths and PNC visits. Multinomial logistic regression models examined the associations between sociodemographic and maternal factors and continued care seeking at different care-seeking classes/categories, with the lowest class as the reference group. The independent variables were mutually adjusted for each other.

Binary logistic regression was used to determine the OR for the associations between the various classes of care-seeking continuum and neonatal mortality. For plausible and valid analysis, nine classes with satisfactory data were used in the overall mortality analysis with the *highest* class as the reference group. Low birthweight babies and multiple gestations are strong independent risk factors for neonatal death[55 56] and thus were excluded in the mortality analysis to obtain adjusted OR (aOR). The rest of the classes were not used owing to fewer numbers in certain neonatal mortality strata. Similarly, country-specific analysis resulted in elimination of more strata with fewer numbers. Further, the resulting significant aORs were used to estimate attributable risk fraction (AR) and population attributable risk fraction (PAR) for both countries combined. This was to determine proportion of neonatal deaths that would be prevented if mothers in a given lower level of care-seeking continuum had sought care at the highest class. We used Stata V.16 and Microsoft Excel for analysis and to generate graphical summaries of results. Sampling weights were applied, and we accounted for complex sampling design recommended by the DHS methodology guide. Missing data due to nonresponse were mostly negligible compared with the subpopulation sample sizes and relatively randomly spread across the variable subgroups; they were nevertheless omitted in our analysis. For the variable 'knowledge about pregnancy, birth complications', where data were missing for Uganda, the analysis was only performed for Kenya where plausible.

Estimating attributable neonatal mortality risk proportions associated with low levels of care-seeking continuum

The attributable risk proportions (AR) and population attributable neonatal mortality risk proportion (PAR) were obtain by the formulas $AR=[(OR1)/OR)]\times 100$ and $PAR=Pe * [(OR1)/OR)]\times 100$, respectively, where OR is the statistically significant aOR associated with that care-seeking class and Pe is the proportion of the total mortalities in that given care-seeking class.

Public and patient involvement

No patients or the public were directly involved in this study.

RESULTS

Table 2 and figure 1 indicate that over 95% of mothers had at least one ANC visit, and about 56% had four or more ANC contacts in Kenya and Uganda. Of those who had four or more ANC visits, 73% gave birth at a health facility and about 41% had newborn PNC check-up within 28 days after birth as shown in table 2.

The scatter plot in figure 2 shows a positive correlation between number of ANC visits and both proportions of facility births and PNC visits. Further, figure 3 shows that a single early ANC visit in the first or second trimester increased the likelihood of health facility childbirth as opposed to late ANC visit in the third trimester.

Table 2 Distribution of mothers by continuum of care-seeking classes during the antenatal period, childbirth and within 28 days postnatal in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data, N=24 502

	≥4 ANC visits, N=13 888	2–3 ANC visits, N=8744	1 ANC visit, N=775	0 ANC visit, N=1095
Health facility births				
PNC—yes	4961 (35.7)	2355 (26.9)	115	68 (6.2)
PNC—no	5179 (37.3)	2782 (31.8)	213	106 (9.6)
Birth outside of health facility				
PNC—yes	752 (5.4)	632 (7.2)	63	121 (11.1)
PNC—no	2996 (21.6)	2975 (34.0)	384	800 (73.1)

ANC, antenatal care; PNC, postnatal care.

Table 3 shows the distribution of maternal and sociodemographic characteristics by care-seeking behaviour from pregnancy to postnatal period. Majority (≥46%) of the mothers were between 25 and 34 years of age in all care-seeking categories. Overall, about 71% of the mothers lived in a rural setting, and 37% of all women had problems with distance to the nearest health facility. Roughly 30% and 57% of those who had the highest and the lowest care-seeking tendencies, respectively, indicated distance could be a hindrance to care seeking. Slightly over half of all the mothers had primary education. About 40% of the highest careseekers had secondary or higher education, while 60% of the lowest careseekers had no formal education. Similar trends were observed among their husbands/partners (education).

Table 4 shows the results of the multinomial regressions for the associations between independent factors and different classes of care-seeking continuum from pregnancy to childbirth and 28 days postnatal, with the lowest class being the reference category. Maternal primary or

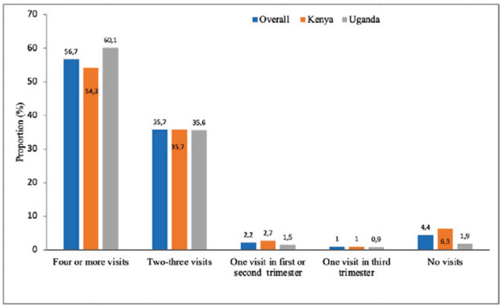

Figure 1 Proportions of antenatal care visits by number of antenatal care contacts in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data.

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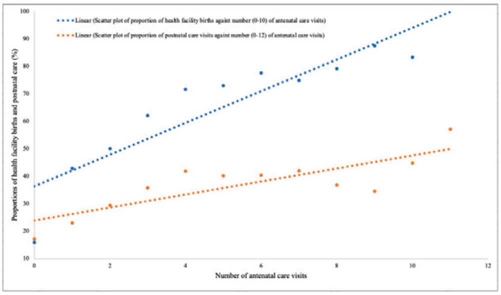

Figure 2 Scatter plot showing correlation between number of antenatal care visits and proportions of facility births and postnatal care visits in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data.

higher education levels compared with no formal education,were significantly associated with higher care-seeking behaviour in almost all care-seeking categories except among those who had one ANC visit/facility birth/no PNC (sixth lowest) or less; relative risk ratios (RRRs) ranged from 2.1 to 8.0 (95% CI 1.1 o 16.3). Similarly, trends were observed among those with husbands having primary education and above; RRRs ranged from 2.1 to 6.4 (95% CI 1.3 to 10.6). Generally, the higher the level of education, the higher the care-seeking tendency. Exposure to mass media (radio/television) was generally associated with higher care-seeking tendency; RRRs ranged from 1.8 to 3.2 (95% CI 1.2 to 5.4). There was minimal indication that desire to have a child improves care seeking, although high RRR to seek care were observed among those who had two or more ANC visits, but findings were not statistically significant except in the high category.

Problem with distance to the health facility (vs no problem) was largely a demotivating factor to care seeking. In six care-seeking categories, the RRRs ranged from 0.6 to 0.7 (95% CI 0.5 to 0.9), whereas in the remaining

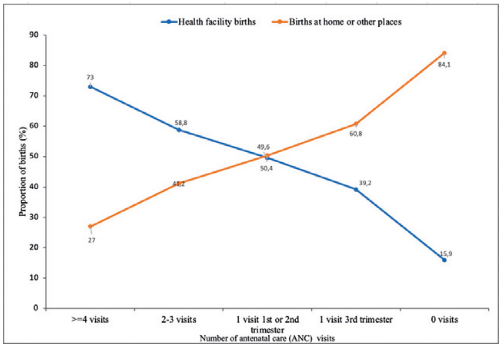

Figure 3 Proportion of hospital and home births by number of antenatal care visits in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data.

categories, very low to lowest, the association was marginally not statistically significant; RRRs ranged from 0.6 to 1.1 (95% CI 0.3 to 1.4). Higher parity versus primiparous was not associated with care seeking except in a few care-seeking categories among those who had 2–3 ANC visits. Generally, being told about pregnancy and birth complications significantly increased the tendency to seek care in Kenya.

Older maternal age compared with young age was generally not significantly associated with care seeking at all levels of care-seeking continuum, RRRs ranged from 0.4 to 0.9 (95% CI 0.3 to 1.7), except marginally significant in moderately high and seventh lowest classes. Living in a rural area versus urban was significantly associated with lower care-seeking tendency in nine categories. The remaining care-seeking categories indicated lower tendency but not significant results. Care seeking was also notably hindered when the husband/partner rather than the woman made major decisions for maternal care seeking in about nine care-seeking categories. Being married showed variably and inconsistent associations with care seeking in most care-seeking classes, there was no significant association with care-seeking when compared with single mothers. Compared with the poor, the middle wealth status only showed significantly higher care-seeking tendency in the first four higher care-seeking classes and two other random classes; the rest were not statistically significant. Additionally, being rich indicated almost no significant association with care seeking. figure 4 summarises in a forest plot the selected (extremes) results from table 4.

Table 5 presents the ORs for the associations between continued care-seeking categories and neonatal mortality, with the highest category as the reference class. Figure 5 shows a forest plot of aOR for overall results in table 5. Overall, third lowest and lowest categories were associated with about ourfolds odds of neonatal mortality (aOR 4.2, 95% CI 1.6 to 10.9). For joint Kenya and Uganda, moderately high and very low levels of care seeking also showed significant higher odds of neonatal death; aOR ranged 1.9–2.4 for the two classes. However, the remaining two categories (fourth lowest and moderately low) did not indicate any statistically significant association with mortality. For Kenya only, lowest, very low, moderately low, moderately high and high versus highest were all significantly associated with neonatal deaths and neonates in the lowest class were six times likely to die. For Uganda, only very low category was significantly associated with neonatal death (aOR 1.7, 95% CI 1.1 to 2.7), and the lowest class showed higher odds but had a marginally not significant aOR 2.5 (95% CI 1.0 to 6.0). We observe that the proportion of Ugandan mothers seeking continued care at the highest level was more than twice (33.8%) that of Kenya (13.4%)

Still in table 5, in combined country findings, comparing higher and moderately high classes both with two to three ANC visits and facility childbirth, the only difference is lack of PNC attendance in the moderately high class,

Table 3 Distribution of maternal and sociodemographic factors, by continuum of care-seeking classes combining ANC visits, delivery and PNC in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data

	≥4 ANC visits, n=13 888				2–3 ANC visits, n=8744				1 ANC visit, n=775				0 ANC visit, n=1027		
Variables	Highest (facility birth and PNC) n (%)	High (facility birth, no PNC n (%)	Slightly high (no facility birth, PNC) n (%)	Moderately low (no facility birth, no PNC) n (%)	Higher (facility birth, PNC) n (%)	Moderately high (facility birth, no PNC) n (%)	Moderately lower (no facility birth, PNC n (%)	Very low (no facility birth, no PNC) n (%)	7th lowest (facility birth, PNC) n (%)	6th lowest (facility birth, no PNC) n (%)	5h lowest (no facility birth, PNC) n (%)	4th lowest (no facility birth, no PNC) n (%)	3rd lowest (facility birth, no PNC) n (%)	2nd lowest (no facility birth, PNC) n (%)	Lowest (no facility birth, no PNC) n (%)
Maternal age (years)															
15–24	1625 (32.8)	1680 (32.4)	213 (28.3)	815 (27.2)	832 (35.3)	1001 (36.0)	159 (25.2)	778 (26.2)	51 (44.4)	77 (36.2)	20 (31.8)	123 (32.0)	43 (40.6)	36 (29.7)	189 (23.6)
25–34	2406 (48.5)	2513 (48.5)	315 (46.6)	1410 (47.1)	1064 (45.2)	1240 (44.6)	303 (47.9)	1385 (46.6)	35 (30.4)	91 (42.7)	17 (27.0)	160 (41.7)	41 (38.7)	52 (43.0)	360 (45.0)
35–49	930 (18.7)	986 (19.1)	189 (25.1)	771 (25.7)	459 (19.5)	541 (19.4)	170 (26.9)	812 (27.3)	29 (25.2)	45 (21.1)	26 (41.2)	101 (26.3)	22 (20.7)	33 (27.3)	251 (31.4)
Place of residence															
Urban	1669 (33.6)	2096 (40.5)	164 (21.8)	483 (16.1)	677 (28.8)	956 (34.4)	122 (19.3)	409 (13.8)	30 (26.1)	79 (37.1)	14 (22.2)	52 (13.5)	33 (31.1)	18 (14.9)	85 (10.6)
Rural	3292 (66.4)	3083 (59.5)	588 (78.2)	2513 (83.9)	1678 (71.3)	1826 (65.6)	510 (80.7)	2566 (86.2)	85 (73.9)	134 (62.9)	49 (77.8)	332 (86.5)	73 (68.9)	103 (85.1)	715 (89.4)
Distance to the nearest health facility is a big problem.															
No	3490 (70.3)	1561 (66.5)	472 (62.8)	876 (52.3)	1580 (67.1)	810 (62.9)	379 (60.1)	862 (50.5)	74 (64.4)	60 (63.2)	36 (57.1)	97 (47.1)	34 (68)	62 (51.2)	148 (42.8)
Yes	1471 (29.7)	785 (33.5)	280 (37.2)	798 (47.7)	775 (32.9)	477 (37.1)	252 (39.9)	844 (49.5)	41 (35.6)	35 (36.8)	27 (42.9)	109 (52.9)	16 (32.0)	59 (48.8)	198 (57.2)
Maternal education level															
No education	435 (8.8)	389 (7.5)	167 (22.2)	811 (27.1)	241 (10.2)	271 (9.8)	140 (22.2)	726 (24.4)	15 (13.0)	42 (19.7)	18 (28.6)	139 (36.2)	20 (18.9)	63 (52.0)	486 (60.8)
Primary	2535 (51.1)	2721 (52.5)	486 (64.6)	1789 (59.7)	1369 (58.2)	1645 (59.1)	399 (63.1)	1960 (65.9)	73 (63.5)	124 (58.2)	37 (58.7)	218 (56.8)	57 (53.8)	52 (43.0)	280 (35.0)
Secondary and higher	1991 (40.1)	2069 (40.0)	99 (13.2)	396 (13.2)	745 (31.6)	866 (31.1)	93 (14.7)	289 (9.7)	27 (23.5)	47 (22.1)	8 (12.7)	27 (7.0)	29 (27.3)	6 (5.0)	34 (4.3)
Partner/husband education level															
No education	255 (6.1)	128 (6.5)	118 (16.9)	276 (19.1)	142 (7.4)	68 (6.5)	98 (16.8)	259 (17.5)	7 (8.4)	17 (23.0)	13 (23.2)	39 (23.8)	4 (13.8)	52 (49.5)	173 (55.0)
Primary	1860 (44.6)	991 (50.3)	401 (57.5)	815 (56.5)	1011 (52.4)	590 (56.2)	348 (59.8)	938 (63.5)	46 (55.4)	39 (52.7)	32 (57.1)	96 (58.5)	19 (65.5)	43 (41.0)	109 (35.3)
Secondary and higher	2059 (49.3)	851 (43.2)	179 (25.6)	352 (24.4)	777 (40.2)	392 (37.3)	136 (23.4)	280 (19.0)	30 (36.1)	18 (24.3)	11 (19.6)	29 (17.7)	6 (20.7)	10 (9.5)	27 (8.7)
Knowledge about pregnancy, birth complications (only Kenya)															
No	537 (32.8)	319 (39.1)	348 (47.4)	286 (63.4)	341 (45.6)	250 (53.7)	349 (55.6)	351 (66.9)	29 (64.4)	23 (50.0)	44 (69.8)	63 (75.9)	–	–	–

Continued

Table 3 Continued

Variables	≥4 ANC visits, n=13888				2–3 ANC visits, n=8744				1 ANC visit, n=775				0 ANC visit, n=1027		
	Highest (facility birth and PNC) n (%)	High (facility birth, no PNC n (%)	Slightly high (no facility birth, PNC) n (%)	Moderately low (no facility birth, no PNC) n (%)	Higher (facility birth, PNC) n (%)	Moderately high (facility birth, no PNC) n (%)	Moderately lower (no facility birth, PNC n (%)	Very low (no facility birth, no PNC) n (%)	7th lowest (facility birth, PNC) n (%)	6th lowest (facility birth, no PNC) n (%)	5h lowest (no facility birth, PNC) n (%)	4th lowest (no facility birth, no PNC) n (%)	3rd lowest (facility birth, no PNC) n (%)	2nd lowest (no facility birth, PNC) n (%)	Lowest (no facility birth, no PNC) n (%)
Yes	1099 (67.2)	496 (60.9)	386 (52.6)	165 (36.6)	407 (54.4)	216 (46.3)	279 (44.4)	174 (33.1)	16 (35.6)	23 (50.0)	19 (30.2)	20 (24.1)	–	–	–
Desire to have a child															
No	142 (8.7)	215 (9.2)	97 (12.9)	206 (12.3)	249 (10.6)	153 (11.9)	120 (19.0)	257 (15.1)	24 (20.9)	22 (23.2)	18 (28.6)	40 (19.4)	7 (14.0)	29 (24.0)	48 (13.9)
Yes	1496 (91.3)	2132 (90.8)	654 (87.1)	1469 (87.7)	2106 (89.4)	1133 (80.1)	512 (81.0)	1449 (84.9)	91 (79.1)	73 (76.8)	45 (71.4)	166 (80.6)	43 (86.0)	92 (76.0)	298 (86.1)
Who ultimately makes care-seeking decisions															
Respondent alone	1337 (32.7)	548 (28.6)	229 (36.6)	461 (32.2)	600 (31.9)	343 (33.0)	172 (33.0)	416 (28.9)	28 (34.2)	14 (19.4)	16 (36.4)	49 (30.2)	10 (35.7)	18 (22.2)	61 (20.7)
Both	1776 (43.5)	834 (43.4)	236 (37.8)	600 (41.9)	834 (44.3)	437 (42.1)	186 (35.7)	612 (42.4)	32 (39.0)	36 (50.0)	13 (29.6)	56 (34.6)	8 (28.6)	31 (38.3)	134 (45.6)
Husband alone	973 (23.8)	537 (28.0)	160 (25.0)	370 (25.9)	448 (23.8)	258 (24.9)	163 (31.3)	414 (28.7)	22 (26.8)	22 (30.6)	15 (34.1)	57 (35.2)	10 (35.7)	32 (39.5)	99 (33.7)
Parity															
Primiparous	1293 (26.1)	1388 (26.8)	96 (12.8)	324 (10.8)	555 (23.6)	715 (25.7)	68 (10.8)	295 (9.9)	32 (27.8)	53 (24.9)	10 (15.9)	53 (13.8)	28 (26.4)	13 (10.7)	98 (12.3)
Para 2–3	1877 (37.8)	2113 (40.8)	287 (38.2)	988 (33.0)	855 (36.3)	1061 (38.1)	219 (34.7)	906 (30.5)	28 (24.4)	72 (33.8)	16 (25.4)	108 (28.1)	33 (31.1)	36 (29.8)	200 (25.0)
Para 4+	1791 (36.1)	1678 (32.4)	369 (49.0)	1684 (56.2)	945 (40.1)	1006 (36.2)	345 (54.6)	1774 (59.6)	55 (47.8)	88 (41.3)	37 (58.7)	223 (58.1)	45 (42.5)	72 (59.5)	502 (62.7)
Wealth status															
Poor	1785 (36.0)	1739 (33.6)	497 (66.1)	1953 (65.2)	994 (42.2)	1181 (42.5)	446 (70.6)	2108 (70.9)	52 (45.2)	106 (49.8)	50 (47.2)	285 (74.2)	43 (68.3)	103 (85.1)	684 (85.5)
Middle	854 (17.2)	1031 (19.9)	132 (17.6)	556 (18.5)	457 (19.4)	565 (20.3)	127 (20.1)	498 (16.7)	24 (20.9)	44 (20.7)	20 (18.9)	60 (15.6)	10 (15.9)	15 (12.4)	51 (6.4)
Rich	2322 (46.8)	2409 (46.5)	123 (16.4)	487 (16.3)	904 (38.4)	1036 (37.2)	59 (9.3)	369 (12.4)	39 (33.9)	63 (29.6)	36 (34.9)	39 (10.29	10 (15.9)	3 (2.5)	65 (8.1)
Marital status															
Single	859 (17.3)	880 (17.0)	123 (16.4)	435 (14.5)	464 (19.7)	403 (20.6)	109 (17.3)	458 (15.4)	33 (28.7)	55 (25.8)	19 (30.2)	90 (23.4)	38 (35.9)	39 (32.2)	123 (15.4)
Married	4102 (82.7)	4299 (83.0)	629 (83.6)	2561 (85.5)	1891 (80.3)	1558 (79.5)	523 (82.7)	2517 (84.6)	82 (72.3)	158 (74.2)	44 (69.8)	294 (76.6)	68 (64.1)	82 (67.8)	677 (84.6)
Mass media exposure															
No	804 (16.2)	484 (20.6)	733 (14.1)	521 (18.7)	204 (27.1)	993 (33.2)	176 (27.9)	1105 (37.1)	26 (22.6)	56 (26.3)	17 (27.0)	170 (44.3)	27 (25.5)	61 (50.4)	508 (36.6)

Continued

Table 3 Continued

Variables	≥4 ANC visits, n=13 888				2–3 ANC visits, n=8744				1 ANC visit, n=775				0 ANC visit, n=1027		
	Highest (facility birth and PNC) n (%)	High (facility birth, no PNC n (%)	Slightly high (no facility birth, PNC) n (%)	Moderately low (no facility birth, no PNC) n (%)	Higher (facility birth, PNC) n (%)	Moderately high (facility birth, no PNC) n (%)	Moderately lower (no facility birth, PNC n (%)	Very low (no facility birth, no PNC) n (%)	7th lowest (facility birth, PNC) n (%)	6th lowest (facility birth, no PNC) n (%)	5h lowest (no facility birth, PNC) n (%)	4th lowest (no facility birth, no PNC) n (%)	3rd lowest (facility birth, no PNC) n (%)	2nd lowest (no facility birth, PNC) n (%)	Lowest (no facility birth, no PNC) n (%)
Yes	4157 (83.8)	1871 (79.4)	4446 (85.9)	2261 (81.3)	548 (72.9)	2001 (66.8)	456 (72.1)	1870 (62.9)	89 (77.4)	157 (72.7)	46 (73.0)	214 (55.7)	79 (74.5)	60 (49.6)	291 (36.4)

ANC, antenatal care; PNC, postnatal care.

indicating that lack of PNC contributes significantly to neonatal deaths (aOR 2.2, 95% CI 1.4 to 3.4). Similarly, in Kenya, 16% of mothers were in this (moderately high) category (aOR 3.4, 95% CI 1.6 to 7.4). In Uganda, only about 8% of mothers were in this category. It can generally be observed that care-seeking tendencies are higher in Uganda compared with Kenya, with mothers seeking care at highest level more than doubles that of Kenya (33.8% vs 13.4%). Similarly, at the *lowest* level, Uganda is more than thrice lower than Kenya (1.5% vs 5.6%)

Figure 6 shows that, overall, for both Kenya and Uganda, 23% of neonatal deaths were attributable to inadequate maternal care seeking during pregnancy, childbirth and 28 days postnatal period in Kenya and Uganda. Insufficient care seeking within the lowest and third lowest care-seekers accounted for almost three-quarters (75%) of neonatal deaths in those groups. About 9% of neonatal deaths in Kenya and Uganda could be attributable to home births, no PNC visits and inadequate ANC visits.

DISCUSSION

Although 95% of mothers initiated the first ANC visit in Kenya and Uganda, only about 20% completed recommended (modified) care attendance of four or more ANC visits, health facility birth and at least one PNC visit within 28 days after birth. Despite the relatively free or subsidised maternity costs in first level facilities in Uganda and Kenya, several factors still exert profound influence on care-seeking behaviour along the continuum of care that consequently impact neonatal survival. Overall, being educated indicated the highest odds of continual care seeking, and parental education was two to eight times associated with continued care seeking in most of the care-seeking categories. The higher the education level, the higher tendency to seek care. Our results concur with other studies that have shown associations between education and uptake of ANC,[57 58] institutional birth[57 59] and PNC.[60] Further, consistent with our findings, studies have reported higher use of obstetric care among mothers exposed to mass media.[61] Being told of pregnancy complications also improved care seeking (in Kenya). Over 23% of neonatal deaths in Kenya and Uganda would be prevented if mothers adhered to recommended care attendance. Desire to have a child, parity and being married did not show any consistent associations with continued care-seeking behaviour. Advance maternal age indicated lower tendency to seek care, but the findings were not statistically significant.

Conversely, a husband as the main or joint decision maker concerning maternal health care seeking was generally a significant demotivating factor to care seeking among the women in Kenya and Uganda. Although our study could not examine this further, other studies have shown that gender inequality, negative sociocultural factors and women's financial marginalisation tend to hinder women's independent decision making in healthcare especially in low-income and

Table 4 Multinomial logistic regression showing relative risk ratios for the associations between maternal and sociodemographic factors and maternal continuum of care-seeking behaviour in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data

Variables	Highest (≥4 ANC visits, facility birth and PNC)	Higher (2–3 ANC visits, facility birth, PNC)	High (≥4 ANC visits, facility birth, no PNC)	Moderately high (2–3 AN C visits, facility birth, no PNC)	Slightly high (≥4 ANC visits, no facility birth, PNC)	Moderately low (≥4 ANC visits, no facility birth, no PNC)	Moderately lower (2–3 ANC visits, no facility birth, PNC)	Very low (2–3 ANC visits, no facility birth, no PNC)	7th lowest (1 ANC visit, facility birth, PNC)	6th lowest (1 ANC visit, facility birth, no PNC)	5th lowest (1 ANC visit, no facility birth, PNC)	4th lowest (1 ANC visit, no facility birth, no PNC)	3rd lowest (no ANC visit, facility birth, no PNC)	2nd lowest (no ANC visit, no facility birth, PNC)
Versus lowest (no ANC, no facility birth, no PNC) care-seeking level, 95% CI)														
Maternal education level														
No education	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Primary	3.2 (2.3 to 4.4)	3.2 (2.2,4.6)	3.4 (2.4 to 4.9)	2.7 (1.9 to 4.0)	2.1 (1.5 to 3.1)	2.3 (1.6 to 3.2)	2.1 (1.5 to 3.2)	2.8 (2.0 to 4.0)	2.6 (1.2 to 5.7)	1.5 (0.7 to 3.0)	1.7 (0.8 to 3.8)	1.7 (1.0 to 2.8)	2.6 (0.8 to 9.0)	0.9 (0.5 to 1.6)
Secondary and higher	8.0 (4.0 to 16.3)	6.9 (3.3 to 14.1)	6.9 (3.4,14.2)	4.9 (2.3 to 10.2)	2.5 (1.2 to 5.4)	3.1 (1.5 to 6.4)	3.9 (1.8 to 8.4)	2.9 (1.7 to 4.9)	3.4 (1.1 to 10.7)	1.7 (0.5 to 5.4)	2.1 (0.6 to 8.2)	1.5 (0.5 to 4.1)	4.3 (0.8,23.0)	0.6 (0.1 to 2.9)
Partner/husband education level														
No education	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Primary	3.3 (2.4 to 4.7)	3.4 (2.4 to 5.0)	3.6 (2.5 to 5.3)	4.7 (3.1 to 7.1)	2.6 (1.8 to 3.9)	2.1 (1.5 to 3.1)	2.7 (1.8 to 4.0)	2.7 (1.9 to 3.8)	3.4 (1.3 to 8.7)	1.9 (0.9 to 4.1)	1.9 (0.8 to 4.4)	2.5 (1.5 to 4.4)	–	1.2 (0.7 to 2.2)
Secondary and higher	6.4 (3.8 to 10.6)	5.5 (3.2 to 9.2)	6.2 (3.7 to 10.6)	7.2 (4.1 to 12.7)	3.7 (2.1 to 6.5)	3.0 (1.8 to 5.1)	3.4 (1.9 to 6.0)	2.9 (1.7 to 4.9)	6.0 (2.1 to 17.4)	2.3 (0.9 to 6.1)	2.1 (0.7 to 6.3)	3.3 (1.5 to 6.9)	–	1.2 (0.5 to 3.0)
Distance to the nearest health facility is a big problem.														
No	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	0.6 (0.5 to 0.8)	0.6 (0.5 to 0.8)	0.7 (0.5 to 0.9)	0.7 (0.5 to 0.9)	0.6 (0.5 to 0.8)	0.8 (0.6 to 1.0)	0.7 (0.5 to 0.9)	0.8 (0.6 to 1.1)	0.7 (0.4 to 1.2)	0.6 (0.3 to 1.0)	0.7 (0.4 to 1.3)	1.1 (0.7 to 1.6	0.6 (0.3 to 1.4)	0.8 (0.5 to 1.3)
Desire to have a child														
No	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	1.5 (1.0 to 2.2)	1.3 (0.9 to 2.0)	1.6 (1.1 to 2.4)	1.2 (0.8 to 1.8)	1.3 (0.8 to 2.0)	1.4 (1.0 to 2.2)	0.9 (0.5 to 1.3)	1.3 (0.9 to 2.0)	0.7 (0.3 to 1.4)	0.8 (0.4 to 1.7)	0.5 (0.2 to 1.2)	1.0 (0.6 to 1.8)	0.5 (0.2 to 1.7)	0.4 (0.2 to 0.7)
Mass media exposure														
No	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	3.2 (2.4 to 4.2)	2.7 (2.0 to 3.6)	2.7 (2.0 to 3.6)	2.7 (2.0 to 3.7)	3.0 (2.2 to 4.1)	2.1 (1.6 to 2.8)	3.0 (2.2 to 4.2)	1.8 (1.4 to 2.4)	2.9 (1.6 to 5.4)	1.6 (0.9 to 3.0)	3.2 (1.6 to 6.3)	1.5 (1.0 to 2.4)	2.0 (0.8 to 4.8)	2.0 (1.2 to 3.2)
Told about pregnancy, birth complications (only Kenya) versus very low care-seeking level														
No	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	–	–	–	–	–	–	–
Yes	2.6 (2.0 to 3.2)	1.7 (1.3 to 2.2)	2.1 (1.7 to 2.8)	1.1 (1.0 to 1.7)	2.0 (1.6 to 2.5)	1.2 (0.9 to 1.6)	1.5 (1.2 to 1.9)	–	–	–	–	–	–	–
Who ultimately makes care-seeking decisions														
Respondent alone	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Both	0.5 (0.4 to 0.8)	0.6 (0.4 to 0.8)	0.6 (0.4 to 0.9)	0.5 (0.4 to 0.8)	0.5 (0.3 to 0.7)	0.5 (0.4 to 0.8)	0.5 (0.3 to 0.7)	0.7 (0.5 to 0.9)	0.5 (0.3 to 0.9)	1.3 (0.6 to 2.5)	0.4 (0.2 to 0.9)	0.5 (0.3 to 0.9)	0.4 (0.1 to 1.0)	0.9 (0.5 to 1.7)
Husband alone	0.5 (0.4 to 0.7)	0.5 (0.4 to 0.7)	0.7 (0.5 to 0.9)	0.5 (0.3 to 0.7)	0.5 (0.3 to 0.7)	0.5 (0.3 to 0.7)	0.7 (0.4 to 1.0)	0.7 (0.5 to 0.9)	0.5 (0.3 to 1.0)	1.1 (0.5 to 2.5)	0.6 (0.3 to 1.4)	0.7 (0.4 to 1.2)	0.7 (0.3 to 1.8)	1.1 (0.6 to 2.2)

Continued

Table 4 Continued

Variables	Highest (≥4 ANC visits, facility birth and PNC)	Higher (2–3 ANC visits, facility birth, PNC)	High (≥4 ANC visits, facility birth, no PNC)	Moderately high (2–3 AN C visits, facility birth, no PNC)	Slightly high (≥4 ANC visits, no facility birth, PNC)	Moderately low (≥4 ANC visits, no facility birth, no PNC)	Moderately lower (2–3 ANC visits, no facility birth, PNC)	Very low (2–3 ANC visits, no facility birth, no PNC)	7th lowest (1 ANC visit, facility birth, PNC)	6th lowest (1 ANC visit, facility birth, no PNC)	5th lowest (1 ANC visit, no facility birth, PNC)	4th lowest (1 ANC visit, no facility birth, no PNC)	3rd lowest (no ANC visit, facility birth, no PNC)	2nd lowest (no ANC visit, no facility birth, PNC)
Maternal age (years)														
15–24	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
25–34	0.9 (0.6 to 1.3)	0.7 (0.5 to 1.1)	0.6 (0.4 to 1.0)	0.6 (0.4 to 0.9)	0.9 (0.5 to 1.3)	0.6 (0.4 to 0.9)	0.9 (0.6 to 1.5)	0.6 (0.4 to 1.0)	0.4 (0.2 to 0.8)	0.8 (0.3 to 1.7)	0.4 (0.2 to 1.2)	0.5 (0.3 to 0.9)	0.5 (0.2 to 1.3)	0.5 (0.1 to 1.0)
35–49	0.8 0.5 to 1.3	0.6 (0.4 to 1.1)	0.6 (0.4 to 1.0)	0.5 (0.3 to 0.8)	0.9 (0.5 to 1.5)	0.5 (0.3 to 0.8)	0.8 (0.5 to 1.5)	0.6 (0.4 to 1.1)	0.4 (0.1 to 0.9)	0.9 (0.3 to 2.4)	0.8 (0.3 to 2.3)	0.6 (0.3 to 1.2)	0.3 (0.1 to 1.4)	0.3 (0.1 to 0.7)
Place of residence														
Urban	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Rural	0.4 (0.2 to 0.6)	0.4 (0.2 to 0.6)	0.3 (0.2 to 0.5)	0.4 (0.3 to 0.7)	0.4 (0.2 to 0.6)	0.7 (0.4 to 1.1)	0.4 (0.2 to 0.6)	0.7 (0.4 to 1.1)	0.3 (0.2 to 0.7)	0.2 (0.1 to 0.4)	0.4 (0.2 to 1.0)	0.6 (0.3 to 1.2)	0.5 (0.2 to 1.5)	0.4 (0.2 to 0.8)
Marital status														
Single	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Married	1.9 (1.1 to 3.3)	1.7 (1.0 to 3.0)	2.0 (1.2 to 3.5)	2.0 (1.1 to 3.7)	0.6 (0.3 to 1.0)	2.4 (1.3 to 4.3)	0.5 (0.3 to 1.0)	1.6 (0.9 to 2.8)	1.5 (0.5 to 4.5)	1.9 (0.6 to 6.9)	0.3 (0.1 to 0.6)	1.9 (0.7 to 5.3)	1.0 (0.2 to 4.5)	0.2 (0.1 to 0.5)
Wealth status														
Poor	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Middle	1.8 (1.1 to 3.0)	2.0 (1.2 to 3.3)	2.2 (1.3 to 3.6)	1.9 (1.1 to 3.2)	1.3 (0.8 to 2.2)	1.9 (1.2 to 3.2)	1.3 (0.8 to 2.2)	1.5 (0.9 to 2.6)	2.7 (1.3 to 5.6)	2.6 (1.2 to 5.9)	1.4 (0.6 to 3.3)	1.8 (0.9 to 3.4)	1.7 (0.5 to 5.4)	0.9 (0.4 to 2.1)
Rich	1.3 (0.8 to 2.0)	1.2 (0.7 to 1.8)	1.2 (0.8 to 1.9)	1.1 (0.7 to 1.8)	0.4 (0.2 to 0.7)	0.8 (0.5 to 1.3)	0.2 (0.1 to 0.3)	0.6 (0.4 to 0.9)	1.1 (1.5 to 2.4)	1.3 (0.6 to 2.9)	0.3 (0.1 to 1.1)	0.4 (0.2 to 0.9)	1.2 (0.4 to 3.6)	0.1 (0.0 to 0.4)
Parity														
Primiparous	Ref.	Ref.	Ref.	Ref.	Ref	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Para 2–3	0.9 (0.6 to 1.5)	1.1 (0.6 to 1.8)	1.1 (0.6 to 1.7)	1.1 (0.6 to 1.8)	1.6 (0.9 to 2.8)	1.7 (1.0 to 2.9)	2.0 (1.1 to 3.6)	1.9 (1.1 to 3.2)	1.1 (0.5 to 2.7)	0.9 (0.3 to 2.3)	0.9 (0.3 to 2.6)	1.5 (0.7 to 3.3)	1.9 (0.5 to 6.8)	2.7 (1.0 to 7.6)
Para 4+	0.7 (0.4 to 1.2)	0.9 (0.5 to 1.6)	0.9 (0.5 to 1.6)	1.1 (0.6 to 1.9)	2.2 (0.6 to 2.2)	2.3 (1.3 to 4.0)	1.6 (0.8 to 3.1)	2.5 (1.4 to 4.5)	1.9 (0.7 to 5.2)	0.9 (0.3 to 2.7)	0.9 (0.3 to 3.1)	2.1 (0.9 to 5.1)	1.0 (0.2 to 4.9)	2.8 (0.9 to 8.4)

Predictor variables mutually adjusted for each other.
ANC, antenatal care; PNC, postnatal care; ref., reference.

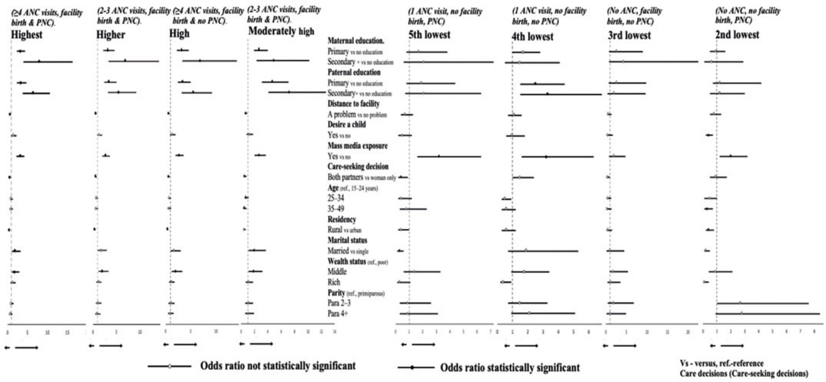

Figure 4 Showing relative risk ratios for the associations between maternal and sociodemographic factors and maternal continuum of care-seeking behaviour in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data. ANC, antenatal care; PNC, postnatal care.

middle-income (LMIC) settings.[62 63] Over 80% of the mothers in this study were married and over 70% lived in rural areas, meaning most women are housewives with subsistence farming as source of livelihood. Thus, maternal dependency on the husbands to seek care revolves mainly around financial support for repeated transportation and minor hospital expenses, and this can hinder a woman's decision to seek care. This partly

Table 5 Crude and aORs for the association between classes of care-seeking behaviour in continuum of care and neonatal mortality in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data

Classes of care-seeking behaviour	Overall crude OR (95% CI) n=22 538	Overall aOR* (95% CI)	Proportion of the total in Kenya (%) n=12 579	Kenya only aOR* (95% CI)	Proportion of the total in Uganda (%) n=9959	Uganda only aOR* (95% CI)
Highest (≥4 ANC visits, health facility birth, yes PNC)	Ref.	Ref.	13.4	Ref.	33.8	Ref.
Higher (2–3 ANC visits, Health facility birth, yes PNC), mis=47	1.5 (1.0 to 2.4)	1.3 (0.7 to 2.2)	6.1	1.4 (0.4 to 4.2)	16.3	0.9 (0.5 to 1.5)
High (≥4 ANC visits, health facility birth, no PNC), mis=72	1.5 (1.0 to 2.2)	1.5 (1.0 to 2.3)	29.8	2.9 (1.4 to 6.0)	15.6	1.0 (0.6 to 1.7)
Moderately high (2–3 ANC visits, health facility birth and no PNC), mis=33	2.4 (1.6 to 3.7)	2.2 (1.4 to 3.4)	16.0	3.4 (1.6 to 7.4)	8.4	1.6 (0.9 to 2.7)
Moderately low (≥4 ANC visits, no facility birth, no PNC), mis=44	1.3 (0.8 to 2.1)	1.3 (0.8 to 2.2)	14.5	2.6 (1.2 to 5.9)	12.4	0.8 (0.4 to 1.4)
Very low (2–3 ANC visits, no facility birth, no PNC), mis=48	1.9 (1.3 to 2.8)	1.9 (1.3 to 2.9)	14.7	2.8 (1.3 to 6.2)	12.0	1.7 (1.1 to 2.7)
4th lowest (1 ANC visit, no health facility births, no PNC), mis=2	2.2 (0.7 to 6.7)	2.2 (0.7 to 7.3)	2.1	_	1.2	_
3rd lowest (no ANC, health facility births and no PNC), mis=2	7.8 (3.5 to 17.5)	4.2 (1.6 to 10.9)	0.5	–	0.4	–
Lowest (no ANC, no facility births and no PNC), mis=17	4.5 (2.5 to 7.8)	4.2 (2.3 to 7.8)	5.6	6.0 (2.6 to 13.6)	1.5	2.5 (1.0 to 6.5)

Due to non-response, proportionally (relatively random) distributed across all strata.
*Adjusted/restricted to birth weight ≥2500 g and singleton births.
ANC, antenatal care; aOR, adjusted OR; mis, missing; PNC, postnatal care.

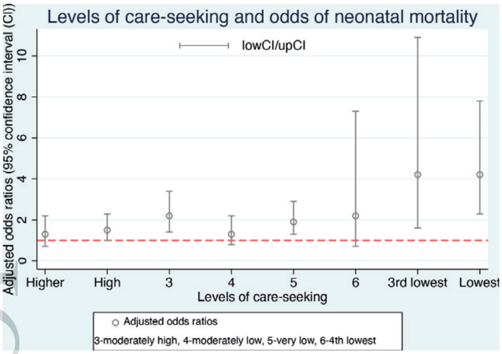

Figure 5 Forest plot showing adjusted ORs between continued care-seeking behavioural classes/levels and neonatal mortality, using Kenya and Uganda, 2014–2016 Demographic and Health Surveys data.

explains why being married did not indicate consistent significance to care seeking.

Also, congruent with our findings, a systematic review in Africa by Dahab and Sakellariou reported lack of women autonomy in health decisions as major hindrance to maternity care seeking.[64] However, a study in Nepal with a similar social setting reported that a complex balance between a woman's independence in maternity decision making and the husband's involvement can enhance maternity care seeking.[65] Living in rural compared with urban areas and longer distance to the nearest health facility largely indicated lower tendency to care seeking; this was especially true (significant) among relatively high care-seeking classes. However, the associations were not statistically significant among mostly lower careseekers. In agreement with most of our findings, two systematic reviews also found longer distance to health facility[64] and rural residency[58] as factors that impede care seeking.

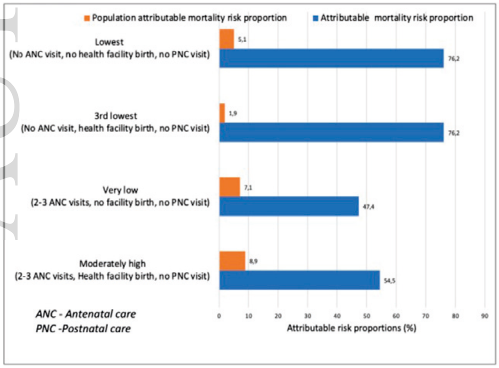

Figure 6 Attributable and population attributable neonatal mortality risk proportion for lower categories of care seeking in Kenya and Uganda, using Demographic and Health Surveys 2014–2016 data.

Being rich did not show any significant association with higher tendency to seek care as would be expected; however, the use of cumulative living standard and assets possessed to determine wealth status does not translate to having liquid cash, readily available to support care seeking. Further research on a valid method to determine wealth status that incorporates monetary availability could be explored.

The far-reaching impacts of maternal and sociodemographic factors on the maternal care-seeking continuum necessitate both short-term and long-term solutions with overarching implications for policy improvements. The 2030 Sustainable Development Goals 4, 5 and 10, which focus on inclusive education and gender equality and reducing inequalities, resonate closely with most of the recommendations emanating from our findings. In the long term, strengthening education for all with purposeful emphasis on maternity care seeking should be integrated into the educational curriculum. A recent systematic review in SSA recommended female education as a strong enabling factor for ANC visits.[20] Improving knowledge and skills for all will inculcate women-led maternal health decision making and create a supportive social environment that would enhance completion of the care-seeking continuum. In the short term, health promotion for maternal care seeking among pregnant or nursing mothers will improve use and consequently greater neonatal survival.

The positive correlations between ANC and facility birth and PNC found in figure 2 indicate that even the first contact with health personnel can improve continued care use, and these findings concur with other studies.[66,67] The third lowest and lowest categories with no ANC, no PNC and only facility birth in the third lowest accounted for 76% of within-category neonatal deaths each and a total of 7% deaths in the total population. Even though these two lowest categories had the highest within-category attributable mortality risks, they contributed relatively lower population attributable deaths partly because there were rather fewer mothers in these categories. In comparison, the mothers in the very low and moderately high categories with two to three ANC visits, no PNC plus facility birth only in the moderately high class accounted for relatively lower within-category deaths each (50%); however, they accounted for more neonatal deaths in the Kenya/Uganda population (16%) since relatively more mothers were in this category.

Given the findings in figure 5, the results of the first three care-seeking classes (higher, high and moderately high) and last two classes (third lowest and lowest) seem to corroborate theoretical expectations in the 'hierarchy' of consequences of inadequate care seeking. However, the odds for neonatal mortality in class 4 (moderately low) and class 6 (fourth lowest) were not statistically significant for neonatal deaths as would be expected. Notably, in table 5, the moderately low with ≥4 ANC visits and no facility birth and no PNC showed significant association with neonatal death in Kenya but not in Uganda.

A possible explanation would be that the quality of ANC given in Uganda was perhaps better and protective than that in Kenya. We could not deduce any possible explanations from our findings for why the OR in the fourth lowest compared with the highest class was not statistically significance despite the low level of care received.

Further, in table 5, the only difference in care-seeking between higher and moderately high categories (vs highest class) is lack of PNC in the latter class. Thus, the statistical significance in the odds for mortality in the moderately high class and not in the higher class reveals that PNC could be very protective and is critical for neonatal survival. Our findings show that PNC is the least attended-to component of care continuum. WHO and other studies also agree that PNC is a crucial phase yet most neglected part of care.[68 69] We recommend strategies that enhance PNC use in Kenya and Uganda. One such strategy would be to emphasise PNC right from the first ANC contact, which has not been the case. PNC attendance existed only in the checklists for fourth ANC visit in the focused ANC recommendations in both Kenya and Uganda.[70 71] This implied that majority of mothers with less than four ANC visits got very limited information that could induce PNC attendance. The current WHO guidelines for eight ANC visits recommend emphasis on continuity of care including PNC; however, it is not clear on how PNC use would be promoted during ANC visits in non-midwife-led continuity of care models such as Kenya and Uganda and other LMIC if it is not clearly specified.[72] The twice higher proportion of Uganda women in the highest category than Kenya could be attributable to the fact that Uganda's abolition of user fees in 2001 took place much earlier than in Kenya (2013).

Although it was not possible for our study to determine attributable mortality risks for each specific care component, nonetheless, we can deduce that over 23% of neonatal deaths in Kenya and Uganda could be avoided through basic maternal and newborn care recommendations prior to 2016. We can also reason that if Kenya and Uganda would fully implement the current WHO recommendations of eight ANC visits, it would lead to higher rates of facility births and ensure PNC as indicated in figure 2, then much higher proportions of neonatal deaths would be eliminated.

For mothers with problems with distance to the nearest health facility, strengthening, structuring and funding the community health workers (CHWs) strategy to engage families, community and health facilities could help align the care-seeking continuum especially for PNC that is currently poorly attended. The village health workers (VHTs) in parts of Uganda, for example, have achieved profound improvement in promoting maternal care seeking.[73] However, high attrition rate is a major challenge to CHW programmes such as VHTs in Uganda due to poor governmental support.[74] Given the readily available telephone communication in East Africa, the integration of a mobile health (mHealth) programme specifically for maternal care-seeking in the existing mHealth structure in Kenya[75] and Uganda[76] is another viable approach. A cost-free two-way mHealth messaging approach could facilitate follow-up, counter sociodemographic barriers and profoundly improve continued care seeking. Engaging the CHW in this endeavour would be feasible with minimal extra investment.

Studies in Kenya and Uganda reported increased use of ANC and delivery services due to free maternity policy.[77–79] Reports evaluating impacts of free maternity policies in Kenya and Uganda highlight increase of ANC coverage and health facility births, but almost no mention is made of the impact on PNC.[40 80] Other studies have reported that free maternity policy increased mainly facility births.[81 82] The universal health policy in Uganda and the *Linda mama* strategy[83] in Kenya advocate for universal access to quality maternity health services but do not offer transportation for poor mothers or health providers in/to remote areas, yet most mothers are rural dwellers. Additionally, there are hidden hospital charges due to underfunding or delayed distribution of funds.[39 41 43]

Another worthwhile strategy to improve continued maternity care use among mothers would be to develop a standard questionnaire or a protocol for estimating the level of continued care seeking based on a brief interview of the mother at first ANC visit. The results could be used to determine the degree of follow-up that can be employed to close the care-seeking gap. Such questionnaires have previously been used in to assess health seeking behaviour in sexually transmitted diseases, for example.[84] It could be based on identified cluster of items including sociodemographic factors that impact care-seeking behaviours that after prolonged testing, and validation could be shortened using factor analysis. Previous maternity history of care-seeking continuum could also be used to improve such a standard. Poor care-seeking mothers can then be enrolled in a messaging list or maternity mHealth programme. This can be a less-costly health promotion strategy that could easily be integrated in ANC set-up in low-resource healthcare settings.

Methodological considerations

The large sample size of the maternal and child data of the latest Kenya and Uganda DHS, which are nationally representative, allowed for valid stratified analysis for deeper understanding of neonatal health and survival. The study is thus externally valid and generalisable in other similar settings. Like many cross-sectional surveys, recall bias may not be completely eliminated from the study. Nonetheless, by selecting the most recent live births for analysis and because childbirth is a special occurrence that mothers may not easily forget within a short period of time, our findings considerably reflect the reality of maternal care and associated neonatal survival in these countries.

A strength to our study was the use of directed acyclic graphs that enabled us to explicitly map the predictor–outcome relationship for well-guided analysis and identification of possible confounders. Our study could not examine other factors such as poor attitude of nurses and lack of information on healthcare services offered, which have been found by both quantitative and qualitative studies to hinder care use in LMIC countries.[85 86] Another limitation to our study was that inadequate facilities and drugs have also been associated with poor care seeking, but our data did not capture these specific aspects.[87] In addition, the cross-sectional survey design of the DHS dataset does not allow collection of data on quality of care. Our study did not incorporate factors such as intimate partner violence (IPV), which is prevalent in many countries. IPV is known to be associated with poor care-seeking behaviour.[88] Further studies can investigate this.

CONCLUSION

Further multicountry large-scale population-based research and systematic reviews could enable development and use of a brief standard questionnaire to determine a mother's continued care-seeking level during the first ANC visit and use the information to close the care-seeking gaps where it is most needed. This is especially viable in LMIC with limited health workforce. Similar standard questionnaires have been used previously in other areas to assess care-seeking behaviour.[89 90] The use of mHealth specifically for promoting continued maternal care use up to postnatal can be integrated in the existing structures. Strengthening the existing CHW system to be an integral part of promoting continued maternal care-seeking could enhance care seeking as a stand-alone strategy or as a component of the aforementioned suggested strategies.

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REFERENCES

1 United Nations Inter-Agency Child Mortality Estimation. Levels and trends in child mortality, 2020. Available: https://www.unicef.org/media/79371/file/UN-IGME-child-mortality-report-2020.pdf [Accessed Jan 2021].
2 UNICEF. Neonatal Mortality. Neonatal period is the most vulnerable time for a child [Internet], 2020. Available: https://data.unicef.org/topic/child-survival/neonatal-mortality/ [Accessed Jan 2021].
3 World Health Organization. Newborn death and illness, 2011. Available: https://www.who.int/pmnch/media/press_materials/fs/fs_newborndealth_illness/en/
4 World Health Organization. Newborn death and illness, 2005. Available: https://www.who.int/pmnch/media/press_materials/fs/fs_newborndealth_illness/en/ [Accessed Jan 2021].
5 World Health Organization. Newborns: improving survival and well-being: key facts, 2021. Available: https://www.who.int/news-room/fact-sheets/detail/newborns-reducing-mortality [Accessed Jan 2021].
6 World Health Organization. Positive experiences, key to antenatal care uptake and quality, 2019. Available: https://www.who.int/reproductivehealth/antenatal-care-uptake/en/ [Accessed Jan 2021].
7 World Health Organization. Newborns: improving survival and well-being, 2020. Available: https://www.who.int/news-room/fact-sheets/detail/newborns-reducing-mortality [Accessed Jan 2021].
8 Swedish Public Health Agency (Folkhälsomyndigheten). Infant mortality (Spädbarnsdödlighet), 2019. Available: https://www.folkhalsomyndigheten.se/folkhalsorapportering-statistik/tolkad-rapportering/folkhalsans-utveckling/resultat/halsa/spadbarnsdodlighet/ [Accessed Jan 2021].
9 UN IGME. *Levels and trends in child mortality report 2019. estimates developed by the un Inter-agency group for child mortality estimation*, 2019.
10 Tessema ZT, Yazachew L, Tesema GA, *et al*. Determinants of postnatal care utilization in sub-Saharan Africa: a meta and multilevel analysis of data from 36 sub-Saharan countries. *Ital J Pediatr* 2020;46:175.
11 Tran TK, Nguyen CTK, Nguyen HD, *et al*. Urban - rural disparities in antenatal care utilization: a study of two cohorts of pregnant women in Vietnam. *BMC Health Serv Res* 2011;11:120.
12 Doctor HV, Nkhana-Salimu S, Abdulsalam-Anibilowo M. Health facility delivery in sub-Saharan Africa: successes, challenges, and implications for the 2030 development agenda. *BMC Public Health* 2018;18:765.
13 World Health Organization. *Make every mother and child count*. Geneva, Switzerland, 2005.
14 Kerber KJ, de Graft-Johnson JE, Bhutta ZA, *et al*. Continuum of care for maternal, newborn, and child health: from slogan to service delivery. *Lancet* 2007;370:1358–69.
15 Benova L, Dennis ML, Lange IL, *et al*. Two decades of antenatal and delivery care in Uganda: a cross-sectional study using demographic and health surveys. *BMC Health Serv Res* 2018;18:758.
16 Kichamu GAJ, Karimurio L. Maternal and child health: demographic and health survey.
17 Moller A-B, Petzold M, Chou D, *et al*. Early antenatal care visit: a systematic analysis of regional and global levels and trends of coverage from 1990 to 2013. *Lancet Glob Health* 2017;5:e977–83.
18 Gilson L, McIntyre D. Removing user fees for primary care in Africa: the need for careful action. *BMJ* 2005;331:762–5.
19 Andersen R, Newman JF. Societal and individual determinants of medical care utilization in the United States. *Milbank Mem Fund Q Health Soc* 1973;51:95–124.
20 Okedo-Alex IN, Akamike IC, Ezeanosike OB, *et al*. Determinants of antenatal care utilisation in sub-Saharan Africa: a systematic review. *BMJ Open* 2019;9:e031890.
21 Neupane B, Rijal S, G C S, *et al*. Andersen's model on determining the factors associated with antenatal care services in Nepal: an evidence-based analysis of Nepal demographic and health survey 2016. *BMC Pregnancy Childbirth* 2020;20:308.

22 Jadoon B, Mahaini R, Gholbzouri K. Determinants of over and underuse of caesarean births in the eastern Mediterranean region: an updated review. *East Mediterr Health J* 2019;25:837–46.
23 Gu H, You H, Yan Z, *et al*. Determinants of the utilization of postpartum family visits: evidence from rural areas of eastern China. *PLoS One* 2018;13:e0194061.
24 Shitie A, Assefa N, Dhressa M, *et al*. Completion and factors associated with maternity continuum of care among mothers who gave birth in the last one year in Enemay district, Northwest Ethiopia. *J Pregnancy* 2020;2020:1–9.
25 Oh J, Moon J, Choi JW, *et al*. Factors associated with the continuum of care for maternal, newborn and child health in the Gambia: a cross-sectional study using demographic and health survey 2013. *BMJ Open* 2020;10:e036516.
26 Mohan D, LeFevre AE, George A, *et al*. Analysis of dropout across the continuum of maternal health care in Tanzania: findings from a cross-sectional household survey. *Health Policy Plan* 2017;32:791–9.
27 Downe S, Finlayson K, Tunçalp Özge, *et al*. Provision and uptake of routine antenatal services: a qualitative evidence synthesis. *Cochrane Database Syst Rev* 2019;6:Cd012392.
28 World Health Organization. Africa's newborns–counting them and making them count. Available: https://www.who.int/pmnch/media/publications/aonsection_I.pdf [Accessed Jan 2021].
29 Masaba BB, Mmusi-Phetoe RM. Neonatal survival in Sub-Sahara: a review of Kenya and South Africa. *J Multidiscip Healthc* 2020;13:709–16.
30 The World Bank. Open Data, indicators, neonatal (per 1000 live births)-Kenya, Uganda, Rwanda. 1994–2019, 2021. Available: https://data.worldbank.org/indicator/SH.DYN.NMRT?locations=KE-UG-RW [Accessed Jan 2021].
31 Kenya National Bureau of Statistics. *2019 Kenya population and housing census.: distribution of population by socio-economic characteristics*, 2019.
32 Uganda Bureau of Statistics (UBOS). *2020 statistics Abstract*, 2020.
33 Uganda National Web Portal. Agriculture, 2021. Available: https://www.gou.go.ug/content/agriculture [Accessed Jan 2021].
34 The World Bank. Open data source: agriculture and rural development, 2021. Available: https://data.worldbank.org/topic/agriculture-and-rural-development?locations=KE-UG [Accessed Jan 2021].
35 Uganda Bureau of Statistics (UBOS). Population and census, 2020. Available: https://www.ubos.org/explore-statistics/20/ [Accessed Jan 2021].
36 The World Bank. Open data source: Life expectancy at birth, females - Kenya, Uganda, 2021. Available: https://data.worldbank.org/indicator/SP.DYN.LE00.FE.IN?locations=KE-UG [Accessed Jan 2021].
37 Leone T, Cetorelli V, Neal S, *et al*. Financial accessibility and user fee reforms for maternal healthcare in five sub-Saharan countries: a quasi-experimental analysis. *BMJ Open* 2016;6:e009692.
38 Ministry of health. *Situation analysis of newborn health in Uganda: current status and opportunities to improve care and survival*. Kampala: Government of Uganda. Save the Children, UNICEF,WHO, 2008.
39 Masaba BB, Mmusi-Phetoe RM. Free maternal health care policy in Kenya; level of utilization and barriers. *Int J Afr Nurs Sci* 2020;13:100234.
40 Odokonyero TMF, Adong A, *et al*. Universal health coverage in Uganda: the critical health infrastructure, healthcare coverage and equity 2017.
41 Ministry of health. Linda Mama programme positioning Kenya on the pathway to UHC, health PS.
42 Ross AB, DeStigter KK, Rielly M, *et al*. A low-cost ultrasound program leads to increased antenatal clinic visits and attended deliveries at a health care clinic in rural Uganda. *PLoS One* 2013;8:e78450.
43 Kenya National Commission on Human rights. *Implementing free maternal health care in Kenya*, 2013.
44 Croft TA, Allen, K MJ, *et al*. *Guide to DHS statistics*. Rockville Maryland, USA: ICF, 2018.
45 ICF International. *Demographic and health survey: Interviewer's manual*. Rockville, Maryland, 2019.
46 Asamoah BO, Agardh A, Cromley EK. Spatial analysis of skilled birth attendant utilization in Ghana. *Glob J Health Sci* 2014;6:117–27.
47 Sandberg J, Odberg Pettersson K, Asp G, *et al*. Inadequate knowledge of neonatal danger signs among recently delivered women in southwestern rural Uganda: a community survey. *PLoS One* 2014;9:e97253.
48 Fisseha G, Berhane Y, Worku A, *et al*. Distance from health facility and mothers' perception of quality related to skilled delivery service utilization in northern Ethiopia. *Int J Womens Health* 2017;9:749–56.
49 Mwilike B, Nalwadda G, Kagawa M, *et al*. Knowledge of danger signs during pregnancy and subsequent healthcare seeking actions among women in urban Tanzania: a cross-sectional study. *BMC Pregnancy Childbirth* 2018;18:4.
50 Asp G, Odberg Pettersson K, Sandberg J, *et al*. Associations between mass media exposure and birth preparedness among women in southwestern Uganda: a community-based survey. *Glob Health Action* 2014;7:22904.
51 Ahinkorah BO, Budu E, Seidu A-A, *et al*. Barriers to healthcare access and healthcare seeking for childhood illnesses among childbearing women in sub-Saharan Africa: a multilevel modelling of demographic and health surveys. *PLoS One* 2021;16:e0244395.
52 Adedokun ST, Yaya S. Factors influencing mothers' health care seeking behaviour for their children: evidence from 31 countries in sub-Saharan Africa. *BMC Health Serv Res* 2020;20:842.
53 Chakraborty NM, Fry K, Behl R, *et al*. Simplified asset indices to measure wealth and equity in health programs: a reliability and validity analysis using survey data from 16 countries. *Glob Health Sci Pract* 2016;4:141–54.
54 Textor J, van der Zander B, Gilthorpe MS, *et al*. Robust causal inference using directed acyclic graphs: the R package 'dagitty'. *Int J Epidemiol* 2016;45:1887–94.
55 Vilanova CS, Hirakata VN, de Souza Buriol VC, *et al*. The relationship between the different low birth weight strata of newborns with infant mortality and the influence of the main health determinants in the extreme South of Brazil. *Popul Health Metr* 2019;17:15.
56 Magee BD. Role of multiple births in very low birth weight and infant mortality. *J Reprod Med* 2004;49:812–6.
57 Enos JY, Amoako RD, Doku IK. Utilization, predictors and gaps in the continuum of care for maternal and newborn health in Ghana. *Int J MCH AIDS* 2021;10:43–53.
58 Tekelab T, Chojenta C, Smith R, *et al*. Factors affecting utilization of antenatal care in Ethiopia: a systematic review and meta-analysis. *PLoS One* 2019;14:e0214848.
59 Nigusie A, Azale T, Yitayal M. Institutional delivery service utilization and associated factors in Ethiopia: a systematic review and meta-analysis. *BMC Pregnancy Childbirth* 2020;20:364.
60 Tolera H, Gebre-Egziabher T, Kloos H. Risk factors for women's non-utilization of decentralized primary health care facilities for postnatal care in rural Western Ethiopia. *Ther Adv Reprod Health* 2020;14:2633494120928340.
61 Acharya D, Khanal V, Singh JK, *et al*. Impact of mass media on the utilization of antenatal care services among women of rural community in Nepal. *BMC Res Notes* 2015;8:345.
62 Sumankuuro J, Crockett J, Wang S. Sociocultural barriers to maternity services delivery: a qualitative meta-synthesis of the literature. *Public Health* 2018;157:77–85.
63 Ganle JK, Obeng B, Segbefia AY, *et al*. How intra-familial decision-making affects women's access to, and use of maternal healthcare services in Ghana: a qualitative study. *BMC Pregnancy Childbirth* 2015;15:173.
64 Dahab R, Sakellariou D. Barriers to accessing maternal care in low income countries in Africa: a systematic review. *Int J Environ Res Public Health* 2020;17:4292.
65 Thapa DK, Niehof A. Women's autonomy and husbands' involvement in maternal health care in Nepal. *Soc Sci Med* 2013;93:1–10.
66 Fekadu GA, Kassa GM, Berhe AK, *et al*. The effect of antenatal care on use of institutional delivery service and postnatal care in Ethiopia: a systematic review and meta-analysis. *BMC Health Serv Res* 2018;18:577.
67 Atuhaire R, Atuhaire LK, Wamala R, *et al*. Interrelationships between early antenatal care, health facility delivery and early postnatal care among women in Uganda: a structural equation analysis. *Glob Health Action* 2020;13:1830463.
68 Tiruneh GT, Worku A, Berhane Y, *et al*. Determinants of postnatal care utilization in Ethiopia: a multilevel analysis. *BMC Pregnancy Childbirth* 2020;20:549.
69 World Health Organization. *Who recommendations on postnatal care of the mother and newborn*. Geneva, Switzerland: World health Organization, 2014.
70 Ministry of health. *Essential maternal and newborn clinical care guidelines for Uganda*, 2016.
71 Services MoPHaSaMoM. National guidelines for quality obstetrics and perinatal care.
72 World Health Organization. *Who recommendatons on antenatal for a positive pregnancy experience*, 2016.
73 Fund UNC. Village health teams, key structures in saving mothers and their babies from preventable deaths, 2018. Available: https://www.unicef.org/uganda/stories/village-health-teams-key-structures-saving-mothers-and-their-babies-preventable-deaths [Accessed Jan 2021].

74 Agarwal S, Abuya T, Kintu R, *et al*. Understanding community health worker incentive preferences in Uganda using a discrete choice experiment. *J Glob Health* 2021;11:07005.
75 Kenya Moh. *Kenya standards and guidelines for mHealth systems*, 2017-.
76 Kamulegeya LH, Ssebwana J, Abigaba W, *et al*, eds. *Mobile Health in Uganda: A Case Study of the Medical Concierge Group*, 2019.
77 Lang'at E, Mwanri L, Temmerman M. Effects of implementing free maternity service policy in Kenya: an interrupted time series analysis. *BMC Health Serv Res* 2019;19:645.
78 Atuoye KN, Barnes E, Lee M, *et al*. Maternal health services utilisation among primigravidas in Uganda: what did the MDGs deliver? *Global Health* 2020;16:40.
79 Njuguna J, Kamau N, Muruka C. Impact of free delivery policy on utilization of maternal health services in County referral hospitals in Kenya. *BMC Health Serv Res* 2017;17:429.
80 Abuya TDM, Amanda D, *et al*. *Impacts of removing user fees for maternal health services on universal health coverage in Kenya*, 2018.
81 Tama E, Molyneux S, Waweru E, *et al*. Examining the implementation of the free maternity services policy in Kenya: a mixed methods process evaluation. *Int J Health Policy Manag* 2018;7:603–13.
82 Gitobu CM, Gichangi PB, Mwanda WO. The effect of Kenya's free maternal health care policy on the utilization of health facility delivery services and maternal and neonatal mortality in public health facilities. *BMC Pregnancy Childbirth* 2018;18:77.
83 Ministry of Health Kenya. *Linda Mama programme positioning Kenya on the pathway to UHC, health PS*, 2020.
84 World Health Organization. *A rapid assessment of health seeking behaviour in relation to sexually transmitted disease*, 1995.
85 Nachinab GT-E, Adjei CA, Ziba FA, *et al*. Exploring the determinants of antenatal care services uptake: a qualitative study among women in a rural community in northern Ghana. *J Pregnancy* 2019;2019:3532749.
86 Kyei-Nimakoh M, Carolan-Olah M, McCann TV. Access barriers to obstetric care at health facilities in sub-Saharan Africa-a systematic review. *Syst Rev* 2017;6:110.
87 Xu K, Evans DB, Kadama P, *et al*. Understanding the impact of eliminating user fees: utilization and catastrophic health expenditures in Uganda. *Soc Sci Med* 2006;62:866–76.
88 Musa A, Chojenta C, Geleto A, *et al*. The associations between intimate partner violence and maternal health care service utilization: a systematic review and meta-analysis. *BMC Womens Health* 2019;19:36.
89 Stack RJ, Mallen CD, Deighton C, *et al*. The development and initial validation of a questionnaire to measure help-seeking behaviour in patients with new onset rheumatoid arthritis. *Health Expect* 2015;18:2340–55.
90 World Health Organization. *Draft protocol. A rapid assessment of health seeking behaviour in relation to sexually transmitted disease*, 1995.

Study V

Survival patterns of neonates born to adolescent mothers and the effect of pregnancy intentions and marital status on newborn survival in Kenya, Uganda, and Tanzania, 2014–2016.

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Abstract

Background: Adolescent pregnancy and associated higher neonatal mortality are major global health challenges. In low-and middle-income countries (LMIC) where over 90 percent of the 21 million global adolescent pregnancies occurred in 2018, half were unintended and close to a fifth experienced unsafe abortion. In Kenya, Uganda, and Tanzania, the survival of neonates born to adolescents over time during neonatal period and the proportion neonatal deaths contributed by adolescent newborns to the overall neonatal deaths are unclear.

Objectives: To assess survival patterns among neonates born to adolescents and the effect of pregnancy intentions and marital status on survival in Kenya, Uganda, and Tanzania.

Methods: Cross-sectional survey data from demographic and health survey in Kenya, Uganda, and Tanzania, 2014-2016 were used. Kaplan-Meier estimates were used to determine visual patterns of newborn survival over neonatal period for adolescent mothers compared to mothers aged 20-29 years. Cox proportion hazards regression models were used to determine the hazard ratios for the predictors of neonatal survival.

Findings: About 50% of pregnancies among adolescents were unintended and neonatal mortality rate was twice higher among adolescents than mothers aged 20-29 years (26.6 versus 12.0 deaths per 1000 live births). The median survival time for neonatal death was 2 days for adolescent-born babies and 4 days among older mothers. Overall, the hazard of death for all adolescent-born neonates was about 2-folds more compared to mothers 20–29-year-old, hazard ratio (HR) 1.80 (95%CI 1.22-2.63). Among married adolescents with unintended newborn pregnancy, the HR was 4-times higher compared to corresponding older mothers, HR 4.08(95% CI 1.62-10.31). Among married, primiparous adolescent mothers with unintended pregancies, the the HR was 6-times higher compared to corresponding older mothers.

Conclusion: Higher unintended pregnancy and associated neonatal deaths among neonates born to adolescent mothers contribute substantially to preventable neonatal deaths in East Africa Community (EAC). Our findings reassert calls for Kenya, Uganda, and Tanzania to fully implement policy guidelines that facilitate to continued education among female adolescents. EAC could also fund creative efforts that capitalize on sociocultural norms to reduce adolescent pregnancy. Enacting a regulatory policy for all adolescent obstetric care to be conducted by high skilled personnel in well-equipped health facilities could be considered.

Introduction

Adolescent pregnancy and associated neonatal mortality are major global health burdens (1). It is estimated that every year, 21 million pregnancies occur among girls aged 15-19 years, of which in 2018 about 12 million gave birth (2) with the birth rates ranging between 12 and 97 births per 1000 adolescent girls in high- and low-income countries respectively (3). The world health organization (WHO) estimates that in low-and middle-income countries (LMIC) where over 90 percent of global adolescent pregnancies occur each year (1), half of them are unintended (1, 2), many suffered miscarriages and about 3.9 million underwent unsafe abortion (1). In 2019, 2.4 million newborns died in their first 4 weeks after birth (neonatal period) (4), and the leading causes (risk factors) for these deaths included infections, prematurity, and birth complications (4). Neonates born to adolescent mothers are known to be at the highest risk for these major risk factors of neonatal deaths, as compared to older mothers aged 20-34 (3, 5, 6). However, the proportion of deaths among neonates born to adolescent mothers to the overall global neonatal deaths is unclear.

In certain high income countries (HIC) such as Sweden, adolescent pregnancy is not a major burden mainly due to constant efforts that are made to minimize sexual risky behaviours through sexual and reproductive education and access to contraceptives(7). In LMIC where adolescent pregnancy rates are highest, over 30% marry before 18 years of age (3), mostly due to societal pressure, sexual coercion, poverty, lack of access or motivation in education and early child-bearing as well as limited knowledge and access to contraceptives (8). Child marriage is a leading risk factor driving adolescent pregnancy (1, 8, 9) and the highest levels of these marriages are in sub-Saharan Africa (SSA) (10). A recent meta-analysis by Kassa et al. estimated the pooled prevalence of adolescent pregnancy in SSA with East African countries (EA) registering among the highest prevalence (21.5%) in the region (11) but also globally (12). Most adolescent pregnancies in SSA result in severe health consequences, maternal and neonatal mortalities in addition to school dropout and have far-reaching socioeconomic impacts on individuals and society (1, 13)

In Kenya, Uganda, and Tanzania where neonatal death rates are persistently high (14-16), very few studies have investigated neonatal survival pattern among adolescent mothers. A 2018 study by Neal et al. in SSA including East African countries found higher odds of neonatal deaths among adolescent girls compared to mothers who were 20-29 years old (17). A 2021 hospital-based study in Kampala, Uganda by Serunjogi and colleagues also found higher odds of early neonatal deaths and other adverse outcomes among adolescent mothers as compared to mothers aged 20-34 years (18). Another study in Morogoro region in Tanzania also found similar results (19). However, all the studies in the East African Community modelled neonatal death as a one-time event and no studies to our knowledge examined the newborn survival pattern over time for adolescent mothers during the neonatal period.

Elsewhere in southern Asia, studies have found significant higher odds of neonatal deaths among mothers (of all ages) whose newborn pregnancy was unintended (unwanted or mistimed) compared to intended pregnancies (20, 21), but such studies are rare in SSA and almost none among adolescents. A 2020 study on factors associated with unintended pregnancies among all mothers of reproductive age (15-49 years) in SSA reviewed about 29 studies but none reported on neonatal mortality outcomes (22). Nonetheless, WHO in 2019 citing Darroch et al. reported that full avoidance of unintended pregnancy through contraceptives and full provision of maternal and newborn care would reduce global neonatal deaths by 80% per year (23, 24). Marital status (single motherhood), also known to be a determinant of neonatal survival (25), has not been adequately investigated among adolescents in SSA. This study aims to examine neonatal survival pattern among adolescent mothers and the effect of pregnancy intentions and marital status on mortality in Kenya, Uganda, and Tanzania. The findings may highlight aspects of neonatal survival among adolescents that could have implications for prioritization and allocation of sexual and reproductive health resources to effectively reduce adolescent pregnancy and overall neonatal mortality in the three East Africa countries.

Methods

Study setting

Kenya, Uganda and Tanzania are the 3 most populated countries in the East African Community with an estimated total population of 140 million and sex ratio of about 1:1. Over 70% of the population live in rural areas with farming as their main economic activity (26-28). Adolescents aged 15-19 years constitute about 20% of the total population in EA and about half (15 million) are girls (29-31). The prevalence of adolescent pregnancy in East Africa is about 21 percent (11).

Data source and study design

Pooled nationally representative demographic and health survey (DHS) data from Kenya (2014), Uganda and Tanzania (2015-2016) were used. DHS collects nationwide reproductive data using a cross-sectional design. Data for the most recent live-born, singleton neonates born to adolescent mothers, 15-19 years old was used. For comparison, corresponding mothers 20-29 years old were also included in the study data and used as a reference. We utilized data for 18,248 neonates born within five years preceding the commencement of DHS data collection. We sent a written request to the DHS secretariat and obtained permission to use the datasets. The measure DHS has been mandated by host countries to collect health data for purposes of research to improve maternal and newborn health. DHS obtained ethical consent from all participants and the ethical approvals from the country review boards. Participant's anonymity is fully upheld, and participants were made aware that they can quit the interviews at any point in the data collection process. More details on DHS survey instruments and methodology can be obtained from https://dhsprogram.com/methodology/Survey-Types/DHS-Methodology.cfm

Study variables

Outcome and predictor variables

Neonatal mortality (newborn death within 28 days after birth) was the outcome variable. Maternal adolescents aged 15-19 years old was the predictor variable with the older mothers aged 20-29 years old as the reference age group. Stratified models were used to determine the effects of marital status and pregnancy intentions on neonatal survival for adolescent mothers as compared to the corresponding mothers in the older age-group.

Explanatory variables

These constituted confounding variables that have been associated with either adolescent pregnancy or neonatal mortality and morbidity. They included sociodemographic factors as well as maternal health care and newborn factors. Maternal education level is known to influence neonatal survival (32). This was dichotomized into no education/primary and secondary/higher education. Poor economic (wealth) status has also been linked to neonatal mortality (33), this was categorized into poor, middle and rich. The wealth status was computed based on living standards considering family assets and access to water and sanitation facilities. Place of residence, particularly rural (remote) and urban slum residency has also been associated with neonatal deaths compared to urban non-slum areas (34, 35). Place of residence was categorized as rural and urban. Sex of child (36) was categorized as male or female and low birthweight categorized as yes (<2500g) and no (≥2500g) (37). As part of the study objectives, marital status and pregnancy intentions were also hypothesized to impact neonatal survival among adolescent mothers. Pregnancy intention was grouped as intended or unintended. These were further dichotomized into married if currently married and single if never married or divorced/separate or widowed. Antenatal-and postnatal - care visits and health facility delivery are known to reduce the risk of neonatal morbidity and death (38, 39); these were also adjusted for in the analysis model according to the WHO recommendations that applied at the time of data collection. Additionally, other variables associated with adolescent pregnancy, i.e. use/access to and decision making for use of modern contraceptives (40, 41) and age at first sexual intercourse were also included in the study (42).

Data analysis

The Kaplan-Meier method was used to estimate the visual pattern of survival of neonates during 28 days after birth. The survival time was right censored. Log-rank method was used to assess the equality of the survival curves. Multivariate analysis was conducted using cox proportion hazards regression models to assess the hazard of death among neonates born to adolescents versus neonates born to mothers 20-29 years old, while adjusting for other risk factors. Stratified analyses by marital status and newborn pregnancy intentions were also executed. Both crude and adjusted hazard ratios were obtained at 95% confidence interval (95% CI). The proportional hazard assumptions were assessed using both global test and the log-log transformation to the survival function. We also used chi square to examine the distribution of sociodemographic, maternal, and newborn variables between adolescent mothers 15-19 years old and mothers aged 20-29 years, at significance level, $p < 0.05$. We utilized Stata analytical software version 16 (College Station, TX: Stata Press).

Results

Table 1 below indicates that about 50% of all adolescent mothers had their first sexual encounter at 15 years old or below compared to 28% among older mothers, 20-29 years old. Despite having over 63% of adolescent mothers being married, about half of all pregnancies among adolescents were unintended and over 73% of unmarried (single) adolescents had unintended pregnancy. More than three-quarters (76.5%) of adolescent mothers in Kenya, Uganda and Tanzania live in rural areas as compared to 69% of older mothers.

Table 2 shows the distribution of study variables by censored and neonatal mortality. The neonatal mortality rate (NMR) was two times higher (26.6 versus 12.0 deaths per 1000 live births) among adolescents than among older mothers. Newborn sex, antenatal care visits, postnatal care visits, wealth status, parity and marital status indicated association with neonatal survival status ($P < 0.05$) across these sub-populations.

Figure 1 (a-b) below are Kaplan Meier survival curves showing a statistically significant (log rank, chi square (one degree of freedom), $X^2(1) = 13.27$, $P=0.0003$) difference in neonatal survival by maternal age, for neonates born to adolescent mothers compared to those born to mothers, 20-29 years old.

Similar below, are Figure 2 (a-d), Figure 3 (e-h) and Table 3, showing that survival time associated with neonatal deaths was significantly shorter for adolescent mothers than corresponding older mothers for all stratified analysis except among single (unmarried) mothers (P=0.4939), irrespective of their pregnancy intentions. However, the number of mothers in the unmarried category was relatively very small.

Table 3 shows the log rank estimates of the neonatal survival functions for adolescent mothers and mothers 20-29 years old, both overall and stratified by marital status or pregnancy intentions or both. It indicates significantly shorter time-to-death for neonates born to adolescent mothers. Further stratification by marital status or pregnancy intentions shows similar findings, for married mothers (*P*=0.0007) and for mothers who had (*P*=0.0001) or did not have (*P*=0.0035) intentions for the newborn pregnancies.

Table 4 presents the findings from cox proportional hazard regression model showing overall hazard ratios (HR) for neonatal mortality among adolescent mothers compared to mothers, 20-29 years old. In model 1, when adjusted for sociodemographic factors and sex of the newborn, adjusted hazard ratio (aHR) for neonatal death among adolescents was almost twice higher, i.e., aHR 1.80 (95% CI 1.22-2.63). Additional adjustments for antenatal care, place of birth and postnatal care also generated a statistically significant HR, i.e., aHR 1.78(95%CI 1.20-2.64). The results also show that being a female newborn, having more than 4 ANC visits and at least one PNC visits during first 28 days after birth were protective while LBW was associated with higher hazard of death among adolescent-born neonates.

Test for proportional-hazards assumption

The p-value global Schoenfeld test was 0.4128, not statistically significant and the graphical representation in Figure 2 is the log-log transformation to the overall survival function, the two curves for the two age-groups of mothers are roughly parallel without meeting or intersecting. both the non-statistically significance p-value of the global test and the roughly parallel curves of the log-log transformation indicate that the proportion hazard assumption is satisfied.

Table 5. shows adjusted hazard ratios for neonates born to adolescents versus neonates born to mothers, 20-29 years old, stratified by marital status or pregnancy intentions. The aHR for neonatal deaths among adolescents was more than 2-folds

higher compared to those born to older mothers, among all married mothers versus unmarried, aHR 2.20(95% CI 1.37-3.52) and among all adolescent mothers whose pregnancy was intended, aHR 2.84 (1.67-4.81) or unintended, aHR 2.51(1.32-4.79). The aHR among the unmarried was not statistically significant, aHR 1.13(95%CI 0.59-2.27)

In Table 6, further stratification by combined marital status and newborn pregnancy intentions indicate a 4-fold higher hazard of neonatal deaths for married adolescent mothers whose pregnancy was unintended, aHR 4.08(95% CI 1.62-10.31), compared to corresponding older mothers aged 20-29 years. HR among married adolescent mothers whose pregnancy was intended was about 3 times higher compared to their older counterparts, aHR 2.86 (95% CI 1.55-5.26). However, HR were higher but not statistically significant among unmarried adolescent mothers with or without pregnancy intentions.

Discussion

Overall, after adjusting for confounders, the hazard of death among neonates born to adolescents was 1.8 times higher compared to those born to mothers 20-29 years old and over 50% of adolescent pregnancies were unintended. Considering only mothers who had unintended pregnancies, the hazard of neonatal deaths among adolescents was over 2.5-fold higher than in older mothers. The highest (4-fold) hazard of neonatal-death was among adolescents from unintended pregnancies in marital union. Insufficient data hindered further comparative analysis among unmarried mothers.

Our overall findings for hazard of mortality among neonates born to adolescent mothers is comparable to recent findings of a study conducted in 45 LMIC by Neal et al. that found adjusted odds of neonatal death of 1.2 to 1.6 among adolescents compared to older mothers. Other recent studies in China (5), Uganda (18), Canada (43) and a 2020 systematic review in high income countries (44) also reported comparable similar odds of neonatal deaths. Further, the United States 2020 national report indicated highest NMR among adolescents mothers (45) and we also found twice higher NMR among teenage mothers compared to mothers 20-29 years old (26.6 versus 12.0 deaths per 1000 live births). Adolescent pregnancy and associated higher neonatal mortality as well as maternal deaths are more prevalent in LMIC, although they are global health burdens affecting even certain high-income countries (46, 47). Whereas the focus should be geared towards interventions that prevent adolescent pregnancies, nonetheless, for every pregnant adolescent in Kenya, Uganda and Tanzania, antenatal and postnatal care and childbirth ought to be handled with a sense of high-risk status that necessitates emergency preparedness at all stages of care and in all maternity centers.

In contrast, a study in rural Nepal found no significant difference in neonatal mortality among adolescent mothers compared to mothers 20-24 years old after adjusting for a range of variables including birthweight and preterm births (48). The study however found much higher NMR associated with LBW and preterm births among adolescent mothers than mothers 20-24 years old (48). Although our study could not examine possible physiological pathways leading to higher neonatal deaths among adolescents, we found higher hazard of neonatal deaths among adolescents even after adjusting for birthweight. Nevertheless, a 2021 Lancet study of a population-based cohort in England found that younger mother (age<20 years) and older mothers (age>37 years) had lowest birthweight newborns (49). The study also found LBW newborns were prevalent in deprived areas indicating that undernutrition as well as adolescent age and much older maternal age are pathways to LBW. Two current systematic reviews also reported that LBW is common among adolescents and is associated with neonatal deaths (50, 51). However, LBW and preterm are known to be leading causes of neonatal deaths in south Asia and sub-Saharan Africa (37); thus, this largely explains the lower survival rate of neonates born to adolescents in our study. Preconception interventions aimed to reduce risky sexual behaviours during pre-pregnancy as suggested by Schmidt et al (52) and ensuring all adolescent births occur in a well-equipped health facility could be policy-enforced in East Africa. Additionally, adequate care preparations for LBW newborns such as artificial respirators, kangaroo mother care (KMC), thermoregulators and nutritional necessities could be availed for all adolescent childbirths (53). Furthermore, programs to improve parental efficacy during neonatal period could be considered for adolescent mothers in the three East African countries (54).

Our findings highlight the complexity of the challenge to reduce preventable neonatal deaths in East Africa. In order to achieve agenda 2030, target 3.2 that aims to lower NMR to 12 per 1000 live births (55), focus on adolescents will have to be highly prioritized in East Africa. With 21% teen pregnancy prevalence and close to 27 deaths per 1000 live births in Kenya, Uganda and Tanzania (11), neonates born to adolescents contribute a substantial proportion of total neonatal deaths. Preventing these deaths requires much more than just access to obstetric healthcare services. Adolescent age is a critical developmental stage, biologically, socially(47) and mentally (49). Over half of adolescents in our study had unintended pregnancy and in our stratified findings among married mothers, the hazard of death doubled to 4-folds for neonates born to adolescents from unintended pregnancies. Further, 80% of our sample were married and while studies reveal that the number one cause of adolescent pregnancy is marriage (1, 8, 9, 11), it is also very plausible to hypothesize from our findings that unintended pregnancy is a major risk factor for adolescent marriage. A study reported that unlike south Asia where adolescent marriages are planned in advance, in SSA (56), unintended pregnancy precede "unplanned" adolescent marriages (56, 57). Consequently in SSA, adolescent marriages are prone to school dropout, poverty (58), HIV infections (59), intimate partner violence (60, 61), and associated negative mental health impacts (62) that in turn lead to poor neonatal outcomes (63). Studies among all mothers of reproductive age indicate that unintended pregnancy is a risk factor for neonatal death and poor utilization of obstetric health services (20, 21). In Brazil a study found that adolescent age was a risk factor for LBW (leading to lower survival rate) only among mothers without partners (64)

Efforts to reduce adolescent pregnancies in East Africa have not yielded any marked outcomes in recent years. The Uganda adolescent health policy of 2004 had its target to halve the proportion of women bearing a child before 20 years of age to 31% and by 2015 over 51% of women still had their first-born before 20 years of age (65). Similar statistics are reported in Kenya (66) and Tanzania (67). The challenge seems to be implementation of the guidelines. In Uganda, the revised 2020 guidelines for prevention of teenage pregnancy in schools provide a comprehensive outline of the roles of key actors (68). In Kenya, the national adolescent sexual and reproductive health policy has detailed a multisectoral approach (69). In Tanzania, the national adolescent strategy outlines a comprehensive action plan for 2018-2022(70). The need to effectively implement the sexual and reproductive education proposed by all the three guidelines cannot be overemphasized and sociocultural norms highlighted as a major hindrance cannot be underestimated. Our findings provide a vital rationale to synergize advocacy efforts at both national level and in the East African community to enable reduction of adolescent pregnancy and related neonatal deaths. Creative efforts to penetrate and highlight sociocultural norms that promote education among adolescent girls and discourage unfavorable norms to maximize protective effects of girl education ought to be fostered and funded. Although many policies exist in East Africa, sexual and reproductive health and rights education (SRHR) is not practically emphasized in most schools except for sexual and reproductive physiology and HIV prevention(71-74). With the high levels of unintended pregnancies and adolescent marriage, we suggest that well instituted, regular and expert guided SRHR talks with parents and adolescents be continuously conducted in communities and schools to raise awareness. Training and engaging local, youthful role models as health educators would ensure sustainability.

Methodological considerations

Our large dataset combining three nationally representative data enable plausible analysis and valid findings for the three of the most populated East African countries where few to no population-based studies have been conducted on survival pattern among adolescent-born neonates. The retrospective nature of the cross-sectional data collection of the DHS could have been affected by recall bias. Another limitation to our study is that the high numbers of abortions among adolescents in East Africa that could have resulted into live births and could have been captured our analysis but were not thus giving rise to the possibility of underestimation in our results. Further research could examine unsafe abortions and stillbirths that could be avoided among adolescents if access to contraceptives was provided during pre-pregnancy in EA. Furthermore, high maternal deaths among adolescent mothers, including related to unsafe abortion could have underestimated the hazards found in this study.

Conclusion

High prevalence child marriage and unintended pregnancy associated with much lower neonatal survival rate among adolescents in EA contribute significantly to the overall neonatal deaths in East Africa. This is a key rationale to fully support implementation of adolescent policy guidelines and fund creative efforts capitalizing on sociocultural norms aimed at reducing adolescent pregnancy. A regulatory policy requiring all adolescent antenatal and postnatal care and childbirth to be conducted by skilled personnel in a well-equipped health facility could be considered in Kenya, Uganda, and Tanzania.

References

1. World Health Organization. Adolescent pregnancy. 2019.
2. Darroch J WV, Bankola A, Ashford L, . Adding it up: costs and benefits of meeting the contraceptiveneeds of adolescents. . New York, Guttmacher Institute; 2016.
3. World Health Organization. World Health Statistics. Monitoring Health for the SDGs. . 2019.
4. World Health Organization. Newborns: improving survival and well-being 2020 [Available from: https://www.who.int/news-room/fact-sheets/detail/newborns-reducing-mortality.
5. Zhang T, Wang H, Wang X, Yang Y, Zhang Y, Tang Z, et al. The adverse maternal and perinatal outcomes of adolescent pregnancy: a cross sectional study in Hebei, China. BMC Pregnancy Childbirth. 2020;20(1):339.
6. Marvin-Dowle K, Kilner K, Burley VJ, Soltani H. Impact of adolescent age on maternal and neonatal outcomes in the Born in Bradford cohort. BMJ Open. 2018;8(3):e016258.
7. A. L. Adolescent Pregnancy in Sweden. In: Cherry A., Dillon M. (eds) International Handbook of Adolescent Pregnancy. . Springer, Boston, MA.2014.
8. Okine L D-GM. Drivers of repeat pregnancy among teenage mothers in Accra, Ghana. Children and Youth Services Review. 2020;113.
9. United Nations Population Fund - UNFPA. Girlhood, not motherhood: Preventing adolescent pregnancy. 2015.
10. UNICEF. Child Marriage 2020 [Available from: https://data.unicef.org/topic/child-protection/child-marriage/.
11. Kassa GM, Arowojolu AO, Odukogbe AA, Yalew AW. Prevalence and determinants of adolescent pregnancy in Africa: a systematic review and Meta-analysis. Reprod Health. 2018;15(1):195.
12. UNFPA. Adolescent pregnancy: A review of evidence. 2013.
13. UNESCO. Early and unintended pregannacy and the education sector: Evidence review and recommendations. Paris: : United Nations Educational, Scientific and Cultural Organization; 2017.
14. UNICEF. Maternal and Newborn Health Disparities Country profiles. UNICEF DATA [Internet]. UNICEF DATA. [cited 2021 August]. Available from: https://data.unicef.org/resources/maternal-newborn-health-disparities-country-profiles/. [
15. Ministry of Health RoU. Situation analysis of newborn health in Uganda: current status and opportunities to improve care and survival. Kampala: government of Uganda. Save the children, UNICEF, WHO; 2008.
16. Oza S, Cousens SN, Lawn JE. Estimation of daily risk of neonatal death, including the day of birth, in 186 countries in 2013: a vital-registration and modelling-based study. Lancet Glob Health. 2014;2(11):e635-44.
17. Neal S, Channon AA, Chintsanya J. The impact of young maternal age at birth on neonatal mortality: Evidence from 45 low and middle income countries. PLoS One. 2018;13(5):e0195731.

18. Serunjogi R, Barlow-Mosha L, Mumpe-Mwanja D, Williamson D, Valencia D, Tinker SC, et al. Comparative analysis of perinatal outcomes and birth defects amongst adolescent and older Ugandan mothers: evidence from a hospital-based surveillance database. Reprod Health. 2021;18(1):56.
19. Selemani M, Mwanyangala MA, Mrema S, Shamte A, Kajungu D, Mkopi A, et al. The effect of mother's age and other related factors on neonatal survival associated with first and second birth in rural, Tanzania: evidence from Ifakara health and demographic surveillance system in rural Tanzania. BMC Pregnancy Childbirth. 2014;14:240.
20. Singh A, Chalasani S, Koenig MA, Mahapatra B. The consequences of unintended births for maternal and child health in India. Popul Stud (Camb). 2012;66(3):223-39.
21. Singh A, Singh A, Mahapatra B. The consequences of unintended pregnancy for maternal and child health in rural India: evidence from prospective data. Matern Child Health J. 2013;17(3):493-500.
22. Bain LE, Zweekhorst MBM, de Cock Buning T. Prevalence and Determinants of Unintended Pregnancy in Sub -Saharan Africa: A Systematic Review. Afr J Reprod Health. 2020;24(2):187-205.
23. World Health Organization. Contraception. 2019.
24. Darroch JE SE. Adding It Up: Investing in Contraception and Maternal and Newborn Health, 2017.; 2017.
25. Izugbara C. Single motherhood and neonatal and infant mortality in Sierra Leone, Burkina Faso and Burundi. Public Health. 2016;135:122-30.
26. Statistics. KNBo. 2019 Kenya Population and Housing Census.: Distribution of population by socio-economic characteristics. . 2019.
27. Uganda. NPCRo. State of Uganda Populaton report 2018 2020.
28. Tanzania NbosURo. Tanzania in figures 2017. 2017.
29. WHO. United Republic of Tanzania Contraception within the context of adolescents' sexual and reproductive lives: Country profile. 2020.
30. region WA. Adolescent health in Kenya 2018. 2018.
31. Uganda U. Adolescent development [cited 2021 August]. Available from: https://www.unicef.org/uganda/what-we-do/adolescent-development.
32. Fonseca SC, Flores PVG, Camargo KR, Jr., Pinheiro RS, Coeli CM. Maternal education and age: inequalities in neonatal death. Rev Saude Publica. 2017;51:94.
33. Markovitz BP, Cook R, Flick LH, Leet TL. Socioeconomic factors and adolescent pregnancy outcomes: distinctions between neonatal and post-neonatal deaths? BMC Public Health. 2005;5:79.
34. Kimani-Murage EW, Fotso JC, Egondi T, Abuya B, Elungata P, Ziraba AK, et al. Trends in childhood mortality in Kenya: the urban advantage has seemingly been wiped out. Health Place. 2014;29:95-103.
35. Ezeh OK, Agho KE, Dibley MJ, Hall J, Page AN. Determinants of neonatal mortality in Nigeria: evidence from the 2008 demographic and health survey. BMC Public Health. 2014;14:521.

36. Ogbo FA, Ezeh OK, Awosemo AO, Ifegwu IK, Tan L, Jessa E, et al. Determinants of trends in neonatal, post-neonatal, infant, child and under-five mortalities in Tanzania from 2004 to 2016. BMC Public Health. 2019;19(1):1243.
37. UNICEF W. Every newborn: an action plan to end preventable deaths. Geneva: World Health Organization; 2014.
38. Kuhnt J, Vollmer S. Antenatal care services and its implications for vital and health outcomes of children: evidence from 193 surveys in 69 low-income and middle-income countries. BMJ Open. 2017;7(11):e017122.
39. World Health Organization. Continuum of care for maternal, newborn, and child health:
from slogan to service delivery Geneva: World Health Organization; 2007 [Available from: https://www.who.int/pmnch/topics/20071003lancet.pdf?ua=1.
40. Sserwanja Q, Musaba MW, Mukunya D. Prevalence and factors associated with modern contraceptives utilization among female adolescents in Uganda. BMC Womens Health. 2021;21(1):61.
41. Ahinkorah BO, Hagan JE, Jr., Seidu AA, Sambah F, Adoboi F, Schack T, et al. Female adolescents' reproductive health decision-making capacity and contraceptive use in sub-Saharan Africa: What does the future hold? PLoS One. 2020;15(7):e0235601.
42. Ahinkorah BO, Kang M, Perry L, Brooks F, Hayen A. Prevalence of first adolescent pregnancy and its associated factors in sub-Saharan Africa: A multi-country analysis. PLoS One. 2021;16(2):e0246308.
43. Shrim A, Ates S, Mallozzi A, Brown R, Ponette V, Levin I, et al. Is young maternal age really a risk factor for adverse pregnancy outcome in a canadian tertiary referral hospital? J Pediatr Adolesc Gynecol. 2011;24(4):218-22.
44. Marvin-Dowle K, Soltani H. A comparison of neonatal outcomes between adolescent and adult mothers in developed countries: A systematic review and meta-analysis. Eur J Obstet Gynecol Reprod Biol X. 2020;6:100109.
45. Prevention. USDoHaHSCfDCa. Racial and Ethnic Differences in Mortality Rate of Infants
Born to Teen Mothers: United States, 2017–2018. 2020.
46. World Health Organization. Adolescent pregnancy 2020 [Available from: https://www.who.int/news-room/fact-sheets/detail/adolescent-pregnancy.
47. Dangal G. Teenage pregnancy: complexities and challenges. JNMA J Nepal Med Assoc. 2006;45(162):262-72.
48. Sharma V, Katz J, Mullany LC, Khatry SK, LeClerq SC, Shrestha SR, et al. Young maternal age and the risk of neonatal mortality in rural Nepal. Arch Pediatr Adolesc Med. 2008;162(9):828-35.
49. Harron K, Gilbert R, Fagg J, Guttmann A, van der Meulen J. Associations between pre-pregnancy psychosocial risk factors and infant outcomes: a population-based cohort study in England. Lancet Public Health. 2021;6(2):e97-e105.
50. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, et al. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Health. 2019;7(7):e849-e60.

51. DeMarco N, Twynstra J, Ospina MB, Darrington M, Whippey C, Seabrook JA. Prevalence of Low Birth Weight, Premature Birth, and Stillbirth Among Pregnant Adolescents in Canada: A Systematic Review and Meta-analysis. J Pediatr Adolesc Gynecol. 2021;34(4):530-7.
52. Schmidt R HN, Poole N. Preconception interventions. In: Health CoEfWs, editor. 2016.
53. Carducci B, Bhutta ZA. Care of the growth-restricted newborn. Best Pract Res Clin Obstet Gynaecol. 2018;49:103-16.
54. Shandra Bos L, Shorey S, Kulantaipian TS, Sng JSP, Tam WWS, Koh SSL. Effectiveness of the Neonatal Discharge Program for Very Low-Birth-Weight Infants on Parental Efficacy and Psychological Distress. J Perinat Neonatal Nurs. 2018;32(4):E11-e21.
55. development UNDoeasaS. Transforming our world: the 2030 Agenda for Sustainable Development [cited 2021 August 2021]. Available from: https://sdgs.un.org/2030agenda.
56. Petroni S, Steinhaus M, Fenn NS, Stoebenau K, Gregowski A. New Findings on Child Marriage in Sub-Saharan Africa. Ann Glob Health. 2017;83(5-6):781-90.
57. Ahinkorah BO, Hagan JE, Jr., Seidu AA, Budu E, Hormenu T, Mintah JK, et al. Access to Adolescent Pregnancy Prevention Information and Services in Ghana: A Community-Based Case-Control Study. Front Public Health. 2019;7:382.
58. Ahonsi B, Fuseini K, Nai D, Goldson E, Owusu S, Ndifuna I, et al. Child marriage in Ghana: evidence from a multi-method study. BMC Womens Health. 2019;19(1):126.
59. Joint United Nations Programme on HIV/AIDS (UNAIDS). Joint United Nations Programme on HIV and AIDS World AIDS Campaign: women, girls, HIV and AIDS 2004.
60. Kidman R. Child marriage and intimate partner violence: a comparative study of 34 countries. Int J Epidemiol. 2017;46(2):662-75.
61. Ibarra-Nava I, Choudhry V, Agardh A. Desire to delay the first childbirth among young, married women in India: a cross-sectional study based on national survey data. BMC Public Health. 2020;20(1):350.
62. Gupta S, Taneja N, Kapoor SK, Kumar A. Comparison of Mental Health Status of Married and Unmarried Girls of Late Adolescent Age in an Urban Slum of Delhi. Indian J Community Med. 2020;45(2):145-8.
63. Ferri CP, Mitsuhiro SS, Barros MC, Chalem E, Guinsburg R, Patel V, et al. The impact of maternal experience of violence and common mental disorders on neonatal outcomes: a survey of adolescent mothers in Sao Paulo, Brazil. BMC Public Health. 2007;7:209.
64. Guimarães AM, Bettiol H, Souza L, Gurgel RQ, Almeida ML, Ribeiro ER, et al. Is adolescent pregnancy a risk factor for low birth weight? Rev Saude Publica. 2013;47(1):11-9.
65. Uganda RH. SUSTAIN UGANDA’S PROGRESS BY PREVENTING ADOLESCENT PREGNANCY
IN THE DISTRICTS 2020 [cited 2021 August]. Available from: https://www.pmadata.org/sites/default/files/data_product_results/PMA2020-Uganda-R3-Adol-Health-brief.pdf.

66. Development NCFPa. Teenage Pregnancy In Kenya 2021 [Available from: https://ncpd.go.ke/2021/02/26/teenage-pregnancy-in-kenya/.
67. Tanzania UNPF-. Fact Sheet: Teenage Pregnancy.
68. Ministry of Education and Sports RoU. REVISED GUIDELINES FOR THE PREVENTION AND MANAGEMENT OF TEENAGE PREGNANCY IN SCHOOL SETTINGS IN UGANDA. Kampala, Uganda2020.
69. Ministry of Health RoK. NATIONAL ADOLESCENT SEXUAL AND REPRODUCTIVE HEALTH POLICY. 2015.
70. MINISTRY OF HEALTH CD, GENDER, ELDERLY AND CHILDREN. United Republic of Tanzania. NATIONAL ADOLESCENT HEALTH AND DEVELOPMENT STRATEGY 2018 - 2022. 2018.
71. Wanje G, Masese L, Avuvika E, Baghazal A, Omoni G, Scott McClelland R. Parents' and teachers' views on sexual health education and screening for sexually transmitted infections among in-school adolescent girls in Kenya: a qualitative study. Reprod Health. 2017;14(1):95.
72. Ninsiima AB CG, Michielsen K, et al. . Institutional and contextual obstacles to sexuality education policy implementation in Uganda. Sex Edu. 2020.
73. Nkata H, Teixeira R, Barros H. A scoping review on sexual and reproductive health behaviors among Tanzanian adolescents. Public Health Rev. 2019;40:4.
74. Institute G. Sexuality Education in Kenya: New Evidence from Three Counties 2017 [Available from: https://www.guttmacher.org/fact-sheet/sexuality-education-kenya.

Tables and figures

Table 1. Distribution of study variables by adolescent mothers (≤19 years old) and mothers 20-29 years old, in Kenya, Uganda and Tanzania, 2014-2016.

Variables	15-19 years, N=2255 n (%)	20-29 years, N=15993 n (%)	P value 95%CI
Marital status			
Single	821(36.5)	2730(17.3)	0.001
Married	1427(63.5)	13088(82.7)	
Newborn pregnancy intended			
Intended	884 (49.6)	7534(62.8)	0.001
Unintended (unwanted/mistimed)	898(50.4)	4461(37.2)	
Education level			
No education	178(7.9)	2209(14.7)	0.001
Primary/secondary or higher education	2070(92.1)	12827(85.3)	
Place of residence			
Urban	530(25.5)	4890(30.6)	0.001
Rural	1725(76.5)	11103(69.4)	
Wealth Status			
Poor	1217(54.0)	7275(45.5)	0.001
Middle	445(19.7)	2905(18.2)	
Rich	593(26.3)	5813(36.4)	
Decision maker for using contraceptives			
Mainly respondent	1031(24.1)	61(18.5)	0.02
Mainly husband/ partner, others	350(8.2)	39(11.8)	
Joint decision	2894(67.7)	230(69.7)	
Modern contraceptive use			
Yes	464(20.6)	4684(29.3)	0.001
No	1791(79.4)	11309(70.7)	
Age at first sexual encounter			
<15 years	1176(52.2)	4543(28.4)	0.001
16-18 years	909(40.3)	6401(40.0)	
19-28 years	5(0.2)	2864(17.9)	
At first union	165(7.3)	2185(13.7)	
Parity			
Primiparous	964(42.8)	10563(66.0)	0.001
Multiparous (≥1)	1291 (57.2)	5430(34.0)	

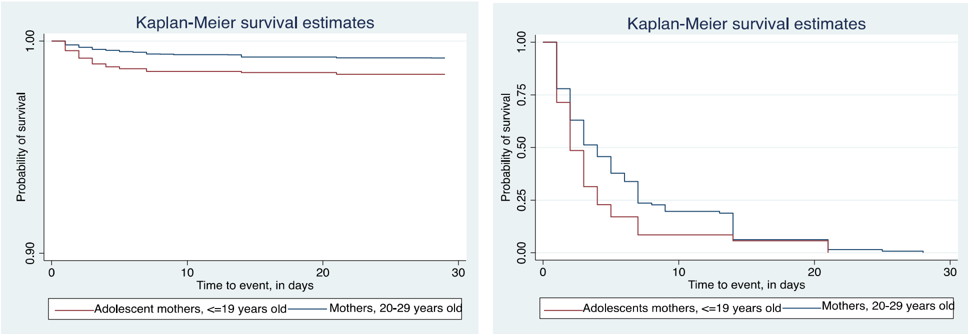
CI – Confidence interval. Primiparous – first time mothers, Multiparous – Given birth at least once previously

Table 2: Distribution of study variables by neonatal survival status among adolescents and mothers aged 20-29 years in Kenya, Uganda and Tanzania, 2014-2016.

	Censored	Died	P value (95%CI)
Maternal age			
[a]Adolescents,15-19 years	2160(12.2)	59(23.8)	0.001
[b]20-29 years	15616(87.8)	189(76.2)	
Marital Status			
Single (unmarried)	3443(19.6)	60(24.7)	0.046
Married	14159(80.4)	183(75.3)	
Newborn pregnancy intentions			
Intended	8173(61.0)	126(64.3)	0.345
Unintended	5231(39.0)	70(35.7)	
Place of residence			
Rural	12504(70.3)	175(70.6)	0.939
Urban	5272(29.7)	73(29.4)	
Education level			
No or primary education	12485(70.2)	181(73.0)	0.347
Secondary or higher	5291(29.8)	67(27.0)	
Wealth status			
Poor	8287(46.6)	112(45.2)	0.042
Middle	3236(18.2)	60(24.2)	
Rich	6253(35.2)	76(30.7)	
Sex of newborn			
Male	9084(51.1)	150(60.5)	0.003
Female	8692(48.9)	98(39.5)	
ANC visits			
<4	7770 (43.9)	138(55.7)	0.001
≥4	9945(56.1)	110(44.4)	
Place of delivery			
Home	5512(31.0)	69(28.0)	0.315
Health facility	12251(69.0)	177(72.0)	
PNC visit within 28 days after birth			
Yes	4424(26.0)	29(11.7)	0.001
No	12595(74.0)	219(88.3)	
Low birthweight			
Yes	1989(12.7)	62 (29.7)	0.001
No	13685(87.3)	147(70.3)	
Parity			
Primiparous	11273 (63.4)	92(37.1)	0.001
Multiparous (≥1)	6503(36.6)	155 (62.9)	

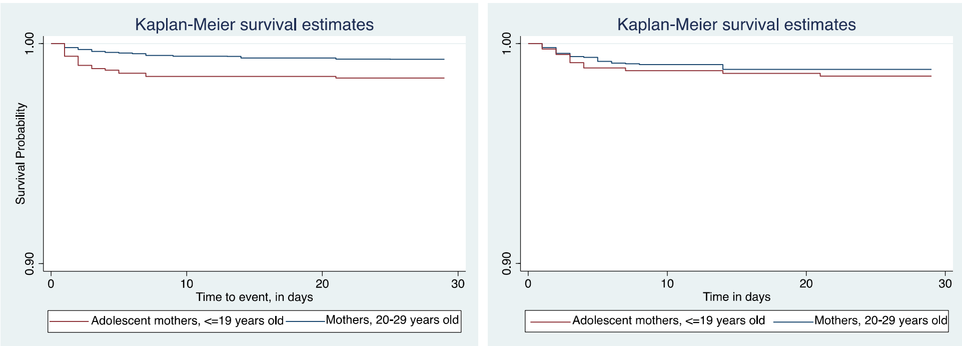
[a]Neonatal mortality rate (NMR)=26.6 per 1000 live births
[b]Neonatal mortality rate (NMR)=12.0 per 1000 live births

LBW – Low birthweight.
NBW -Normal birthweight. CI-Confidence interval
Primiparous – first time mothers, Multiparous – Given birth at least once previously

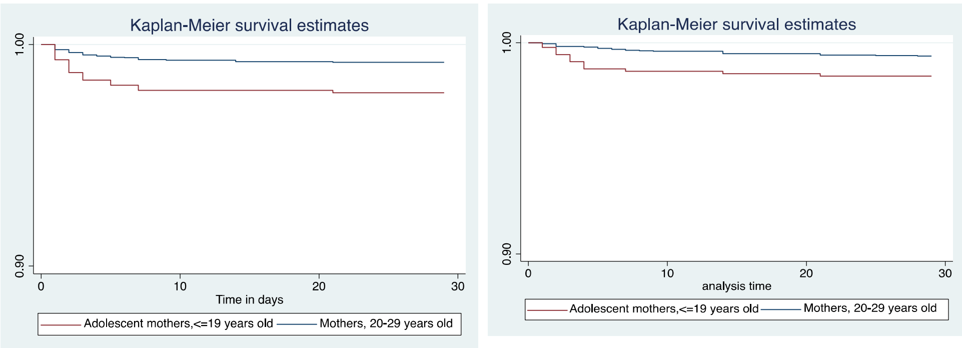


(a)All neonates, no truncation Log rank test, *P* value = 0.0003
(b) Survival after right-truncating neonates that lived beyond 28 days. Median survival time for: Adolescent-born neonates = 2 days. Mothers, 20-29 years=4 days

Figure 1 a-b. Kaplan-Meier survival functions for neonates born to adolescent mothers (< ≤19 years old) and those born to mothers aged 20-29 years in Kenya, Uganda and Tanzania, 2014-2016.

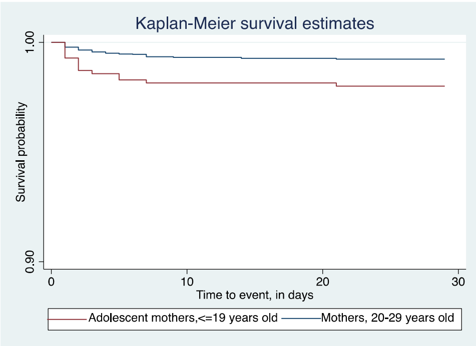


(a)Among the married mothers
(b)Among single mothers (Unmarried)

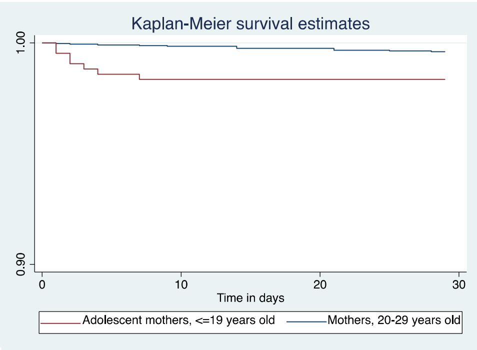


(c)Among intended newborn pregnancy
(d)Among unintended newborn pregnancy

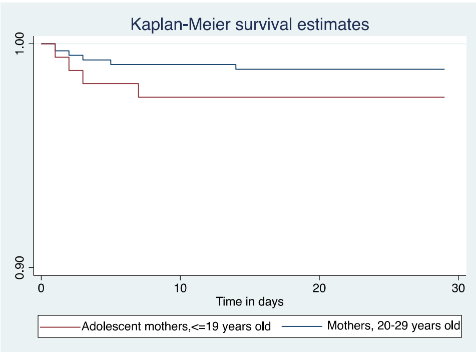
Figure 2 a-d. Kaplan-Meier survival curves by maternal age-group, stratified by marital status, (a)-(b) or Pregnancy intentions (c)-(d)



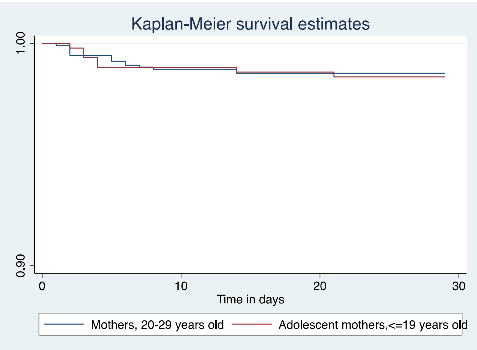
(a)Among married and pregnancy intended



(b)Among Married and pregnancy unintended.



(c) Among singles and pregnancy intended



(d)Among singles (unmarried) and pregnancy unintended

Figure 3 a-d. Kaplan-Meier survival curves by maternal age-group, stratified by marital status and Pregnancy intentions for adolescent-born neonates versus neonates born to mothers 20-29 years old in Kenya, Uganda and Tanzania, 2014-2016.

Table 3. Log rank estimates of neonatal survival functions between adolescent mothers and mothers 20-29 years old in Kenya, Uganda and Tanzania, 2014-2016, overall and stratified by marital status and/or Pregnancy intentions and parity.

Groups and subgroups	Adolescents 15-19 years old		Mothers, 20-29 years		Log rank, *P* values (95% CI)
	Total number of live births	Deaths	Total number of live births	Deaths	
Overall	2219	59	15805	189	0.0003
Marital status					
Married	1401	37	12941	146	0.0007
Single (Unmarried)	812	21	2691	39	0.4939
Newborn pregnancy intentions					
Intended	864	31	7435	95	0.001
Unintended	884	24	4417	46	0.0035
Marital status and Pregnancy intentions					
Married and pregnancy was intended	696	24	6409	79	0.0008
Married and pregnancy was unintended	419	12	3266	27	0.0008
Single (Unmarried) and pregnancy was intended	167	6	952	14	0.1897
Single and pregnancy was unintended	463	12	1110	19	0.7940
Parity					
Primiparous	940	19	10425	73	0.001
Multiparous (≥1)	1279	40	5380	116	0.039

CI-confidence interval. Primiparous – first time mothers, Multiparous – Given birth at least once previously

Table 4: Cox proportion hazards regression models showing hazard of death for neonates born to adolescents compared to those born to mothers, 20-29 years old in Kenya, Uganda, and Tanzania, 2014-2016.

Variable	Unadjusted HR	Model 1*(95%CI) aHR*	Model 2 (95%CI) aHR**	Model 3 (95%CI) aHR**
Adolescent (≤19 years)	**1.98(1.36-2.87)**	**1.80(1.22-2.63)**	**1.78(1.20-2.64)**	**1.86(1.06-3.29)**
20-29 years old	1.00	1.00	1.00	1.00
Place of residence				
Rural	0.90(0.64-1.24)	0.98(0.69-1.41)	0.93(0.65-1.34)	0.82(0.49-1.38)
Urban	1.00	1.00	1.00	1.00
Education level				
No or primary education	1.32(1.00-1.72)	1.15(0.79-1.66)	1.10(0.76-1.60)	0.70(0.42-1.16)
Secondary or higher	1.00	1.00	1.00	1.00
Wealth status				
Poor	0.97(0.70-1.34)	0.75(0.53-1.07)	0.70(0.49-1.00)	0.75(0.43-1.30)
Middle and rich	1.00	1.00	1.00	1.00
Marital status				
Single/unmarried	1.57(1.11-2.22)	1.41 (0.98-2.01)	1.41(0.98-2.02)	—
Married	1.00	1.00	1.00	—
Newborn pregnancy intended*				
Unintended	0.85(0.65-1.11)	0.75(0.52-1.10)	0.72(0.49-1.05)	—
Intended	1.00	1.00	1.00	—
Antenatal care (ANC) visits				
<4	**1.45(1.06-1.97)**		**1.40(1.02-1.93)**	**1.73(1.08-2.77)**
≥4	1.00		1.00	1.00
Place of delivery				
Home	0.94(0.67-1.32)		1.01(0.70-1.46)	0.74(0.29-1.85)
Health facility	1.00		1.00	1.00
Postnatal care (PNC) visit(s) within 28 days after birth				
No	**1.76(1.16-2.66)**		**1.69(1.11-2.56)**	**2.78(1.49-5.20)**
Yes	1.00		1.00	1.00
Sex of child				
Female	**0.69(0.49-0.92)**	**0.67(0.49-0.93)**	**0.66(0.48-0.91)**	**0.58(0.34-0.95)**
Male	1.00	1.00	1.00	1.00
Low birthweight				
Yes	**3.57(2.49-5.14)**			**4.43(2.76-7.11)**
No	1.00			

Model 1. Adjusted for sociodemographic factors, pregnancy intentions and sex of child
Model 2. Adjusted for all model 1 covariates and ANC, PNC, and Place of delivery
Model 3. Adjusted for all covariates in model 1 and model 2 (except marital status and pregnancy intentions) and low birthweight
*Marital status was used to determine HR in all models 1 and 2 in the absence of “Newborn pregnancy intended” variable and newborn pregnancy intended was added to the model in the absence of variable “Marital status” due to collinearity
Bolded results are statistically significant (95 % confidence interval (CI)). LBW – low birthweight, NBW

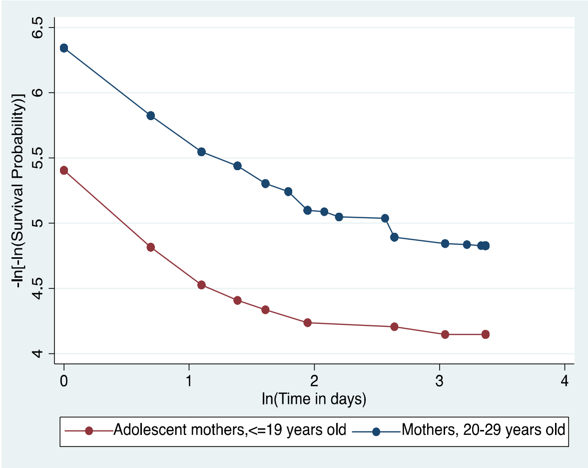


Figure 4. Graphical assessment of proportional-hazards assumption

Table 5. Adjusted hazard ratios (aHR)* for neonatal mortality among adolescent mothers compared to mothers, 20-29 years old in Kenya, Uganda, and Tanzania, 2014-2016, stratified by marital status or †pregnancy intentions.

Variable	Model 1, aHR	Model 2, aHR	Model 3, aHR	Model 4, aHR
Adolescent mothers, ≤ 19 years old	2.20 (1.37-3.52)	1.13(0.59-2.27)	2.84(1.67-4.81)	2.51(1.32-4.79)
Mothers, 20-29 years old	1.00	1.00	1.00	1.00

Model 1- Among married mothers
Model 2- Among unmarried mothers
Model 3-Neonates from intended pregnancy
Model 4-Neonates from unintended pregnancy

*Adjusted for sociodemographic factors and maternal care variables (antenatal and postnatal attendance and place of delivery and PNC)

†Whether or not the neonate pregnancy was intended. LBW was not adjusted for due to insufficient data in various strata.

Table 6. Adjusted hazard ratios (aHR)* for neonatal mortality among adolescent mothers compared to mothers, 20-29 years old in Kenya, Uganda, and Tanzania, 2014-2016, stratified by marital status and †pregnancy intentions, both overall and among primi-and multi-parous mothers.

Overall				
Variable	Model 1, AHR	Model 2, AHR	Model 3, AHR**	Model 4, AHR**
Adolescent mothers, 15-19 years old	2.86 (1.55-5.26)	4.08 (1.62-10.31)	1.89 (0.59-6.08)	1.13 (0.46-2.80)
Mothers, 20-29 years old	1.00	1.00	1.00	1.00
Among primiparous only (First time mothers)				
Adolescent mothers, ≤ 19 years old	4.32 (1.41-13.27)	6.48 (1.37-30.71)	–	1.56 (0.39-6.09)
Mothers, 20-29 years old	1.00	1.00	–	1.00
Among multiparous only (Given birth at least once previously)				
Adolescent mothers, ≤ 19 years old	1.84 (0.89-3.80)	2.43 (0.75-7.98)	–	0.63 (0.19-2.11)
Mothers, 20-29 years old	1.00	1.00	–	1.00

Model 1- Among married mothers and newborn from intended pregnancy
Model 2- Among married mothers and newborn from unintended pregnancy
Model 3- Among unmarried mothers and newborn from intended pregnancy
Model 4- Among unmarried mothers and newborn was unintended pregnancy

*Adjusted for sociodemographic factors and maternal care variables (antenatal and postnatal attendance and place of delivery)
†Whether or not the neonate pregnancy was intended. Birth weight was not adjusted for due to insufficient data in the various strata.
** Insufficient mortality data among unmarried (single) mothers with intended pregnancies hindered plausible analysis