SUPPLEMENTARY FILE 2 – CONSTRUCTION OF (IN)DEPENDENT VARIABLES AND THEIR MISSING VALUES

Overview of variables with corresponding questions from the Ghana Maternal Health Surveys (GMHS) 2007 and 2017, collapsing of categories and missing values

Study groups

Women with stillbirth

In GMHS 2007, women with stillbirth in their most recent birth were identified in the *women's file* using variables Q220C$01-16 (computed birth status). Q220C was used instead of Q220 (birth status as circled by the interviewer), as it accounted for Q221 ("Did that baby cry, move or breathe when it was born?"), Q230 ("How many months did this pregnancy last?") and the presence of absence of sections 3, 4 and 5 of the questionnaire. In some cases, this led to recoding of pregnancy outcome. Q220C number 01 to 16 were manually scanned for a 1 (indicating born alive) or a 2 (indicating born death), and the highest birth order was selected as this represented the most recent birth.

In GMHS 2017, women with stillbirth in their most recent birth were identified in the *birth file* using variable PREGOUT (pregnancy outcome); a variable created by DHS combining Q212C ("Was the baby born alive or born dead, or did you have a miscarriage or abortion?"), Q 212D ("Did that baby cry, move or breathe when it was born?) and Q220AC ("How many months did this pregnancy last?"). Variable Q403 (line number) indicated whether the birth was the most recent live or stillbirth.

Women with very early neonatal death

In GMHS 2007, women with very early neonatal death, a baby not surviving the first day of life, were identified in the *women's file* using Q220C$01-16 (computed birth status) (see *women with stillbirth*). When birth status indicated live birth, age at death was computed from Q227U$01-16 (Age at death (units)) indicating days/months/years, and Q227N$01-16 (Age at death (number)) indicating the number of units. Women saying their child age of death was 0 days were included.

In GMHS 2017, women with very early neonatal death were identified in the *birth file* using variable Q220U (Age of death (units)) indicating days/months/years and Q220N (Age of death (number)), indicating the number of units. Women saying their child age of death was 0 days were included.

Women with livebirth who survived the first day of life

In GMHS 2007, women with a liveborn surviving the first day of life were identified using Q503 (line number) to indicate all most recent births ending in live or stillbirth. The earlier identified women with stillbirth or very early neonatal death were subtracted.

In GMHS 2017, women with a liveborn surviving the first day of life were identified using Q403 (line number) to indicate all most recent births ending in live or stillbirth. The earlier identified women with stillbirth or very early neonatal death were subtracted.

Dependent variable

Caesarean section

Constructed with variables Q542 (delivery by caesarean section) in GMHS 2007 and Q433A (delivery by caesarean section) in GMHS 2017.

Missing values: in GMHS 2007, 14 out of 5,088 women had missing values for mode of birth. In GMHS 2017, three out of 12,077 women had missing values for mode of birth.

Handling of missing values: women with missing values for caesarean section were excluded from analyses.

Independent variables

Ethnicity

Constructed with variables Q112 (ethnicity) in 2007, and Q123 (ethnicity) in 2017. Original categories were merged to create larger groups (see table S1).

Missing values: In GMHS 2007, two women (<0.1%) had missing values for Q112.

Handling missing values: women with missing values for ethnicity were categorized as 'other'.

Region

Constructed with variables QREGION in GMHS 2007 and 2017. Original categories were merged to create larger groups (see table S1).

Missing values: there were no missing values.

Place of residence

Constructed with variables QURBRUR (urban/rural) in GMHS 2007 and QTYPE (urban/rural) in GMHS 2017.

Missing values: there were no missing values.

Household's wealth index

Constructed with variables QHWLTHI (wealth index quintile) in GMHS 2007 and 2017. Extracted from household database. Original categories were merged to create larger groups (see table S1).

Missing values: there were no missing values.

Exposure to mass media

Constructed with variables Q108 (reads newspaper), Q109 (listens to radio), Q110 (watches television) in GMHS 2007 and 2017. Variables were combined, where no exposure to mass media at least once a week meant women were classified as 'little exposed', exposure to one out of three mass media once a week as 'moderately exposed' and those exposed to more than one mass medium once a week were classified as 'highly exposed'.

Missing values: in GMHS 2007, 24 (0.5%) women had missing values: 11 for Q108, 5 for Q109 and 8 for Q110. In GMHS 2017

Handling of missing values: missing values in 2007 were categorized with help of variables QH13A (electricity), QH13B (radio), QH13C (television) and Q106 (highest educational level). Women with missing values for Q108 were considered to read a newspaper at least once a week when educational level was secondary or higher. Women with missing values for Q109 and Q110 were considered to listen to radio or watch television at least once a week when having electricity and a radio or television.

Maternal age during birth of last child

Constructed with variables Q103C (woman, individual file) and Q224C$01-16 (child, individual file) in GMHS 2007, Q215C (CMC child, birth file) and Q105C (CMC woman, individual file) in GMHS 2017

Century month codes (CMC) were used. The CMC of women's date of birth was subtracted from date of birth of child and divided by twelve. In 2007, Q503 (line number of last live or stillbirth) was used to select the correlating child's CMC from Q224C$01-16.

Missing values: there were no missing values.

Religion

Constructed with variables Q111 (religion) in GMHS 2007, and Q122 (religion) in GMHS 2017. Original categories were merged to create larger groups (see table S1).

Missing values: in GMHS 2007, three women (0.1%) had missing values for Q111.

Handling of missing values: women with missing values for religion were categorized as 'other' (see table S2 and S3).

Marital status

Constructed with variables Q701 (currently in union), Q702 (ever married or lived together) and Q703 (current marital status) in GMHS 2007 and 2017.

Missing values: there were no missing values.

Maternal educational status

Constructed with variables Q105 (ever attended school) and Q106 (highest educational level) in GMHS 2007, and Q107 (ever attended school) and Q108 (highest educational level) in GMHS 2017. Original categories were merged to create larger groups (see table S1).

Missing values: in GMHS 2007, one woman (<0.1%) had a missing value for Q105.

Handling of missing values: one woman with a missing value for Q105 was categorized as having 'no education' based on Q601$01-14 (not having heard of 12 out of 13 contraceptive methods) and Q108 (not reading newspaper) (see table S2 and S3).

Parity

Constructed with variables Q214 (total number of pregnancies), Q209 (number of miscarriages) and Q211 (number of abortions) in GMHS 2007, and Q207F (number of stillbirths) and Q208A (number of live births) in GMHS 2017.

In GMHS 2007, Q209 and Q214 were subtracted from Q211 to provide the number of pregnancies ending in live and stillbirths. In GMHS 2017, Q207F and Q208A were summed up. The index pregnancy was not included in the parity number.

Missing values: there were no missing values.

History of perinatal death

Constructed with variables Q213 (number of stillbirths), Q220C$01-16 (computed birth status), Q227U$01-16, Q227N$01-16 and Q503 (line number) in GMHS 2007, and PREGOUT (pregnancy outcome) Q427 (weighed at birth), Q220U (unit of age of death) and Q220N (number of age of death) in GMHS 2017

History of perinatal death was defined as having a stillbirth (loss of a pregnancy after 7 months of pregnancy and prior to birth) or early neonatal death (death of a child in 7 days after birth) prior to the most recent birth.

For prior stillbirths in GMHS 2007, Q213 was used. When it was more than one, women were considered to have a history of stillbirth. When Q213 counted one, the most recent birth outcome had to be inspected (see *study groups, women with stillbirth* above) to see whether this considered the index pregnancy, and, therefore, should not be considered as history. For prior early neonatal death, Q227U/N$01-16 were used. Every death within one week after birth (Q227U=1 and Q227N<7) was selected, using 'sort ascending/descending' command in SPSS. The line number of the death was compared to Q503 and excluded when similar so that the index pregnancy was not included as history.

For prior stillbirths in 2017, Q207F was used. When Q207F was more than one, women were considered to have a history of stillbirth. When it was one, PREGOUT was used to see whether the index pregnancy ended in stillbirth, and, therefor should not be considered as history. For prior early neonatal death, the birth file was used. All live births dying within one week (Q220U=1 and Q220U<7) were selected and births with maternity

care data available would be excluded. A variable was created, indicating early neonatal death. Subsequently, the birth file was merged with the women's file.

Missing values: there were no missing values.

Multiple gestation

Constructed with variables Q219$01-16 (single or multiple birth) and Q503 (line number of last live or stillbirth) in GMHS 2007, and Q212B (single or multiple birth) in GMHS 2017.

In GMHS 2007 individual file, multiple birth were selected from Q219 using 'sort ascending/descending' command in SPSS. A new variable was created, wherein the line number of multiple births were compared with Q503 and coded 1=multiple birth if they were identical.

In GMHS 2017, Q212B was used from the birth file and merged with the individual file.

Missing values: there were no missing values.

Peripartum complications, prolonged or obstructed labour and reduced fetal movements.

Peripartum complications – problems just before, during or after giving birth – were documented as string variables, so women could choose more than one available answer: Q530 (problems just before, during or after delivery) in GMHS 2007, and Q431C (suffered from any problem before/after delivery) Q431D (problems suffered before/after delivery) in GMHS 2017. To include women who had more than one complication during their last pregnancy, several dummy variables (0=no, 1=yes) were created: any peripartum complication, hypertensive disorder of pregnancy, peripartum bleeding, peripartum infection, prolonged or obstructed labour and reduced fetal movements.

Women with any string value other than P (no problem) in GMHS 2007 and any string value in GMHS 2017 were considered to have had a complication, and were categorized as such.

Women with string values including a J (prolonged labour), K (obstructed labour) or O (fistula) were categorized as having reported prolonged or obstructed labour.

Women with string values including a H (baby's movement was low) were categorized as having reduced fetal movements.

Missing values: in GMHS 2007, one woman (<0.1%) had missing values for Q530.

Handling of missing values: women were categorised based on Q509 in GMHS 2007 or Q411 in GMHS 2017 (problems when first receiving antenatal care). If data were not available, they were categorized as not having had peripartum complications

Number of antenatal visits

Constructed with variables Q512 (antenatal visits during pregnancy) in 2007, and Q405 (received antenatal care for pregnancy) and Q412 (antenatal visits during pregnancy) in 2017.

Missing values: in GMHS 2007, four women (0.1%) had missing values and 21 women (0.4%) chose *don't know* for Q512. In GMHS 2017, 25 women (0.2%) chose *don't know* for Q 412.

Handling of missing values: women who had received antenatal care (Q405=1), but did not know the number of visits (Q512/Q412=98) or had missing values, were categorized as having 1 – 3 antenatal care visits.

Antenatal care quality score

Constructed with variables Q513A (weight), Q513B (blood pressure), Q513C (urine sample), Q513D (blood sample), Q514 (signs of complications), Q515 (sources of care for complications), Q516 (tetanus injection), Q523 (iron tablet), Q525 (anthelmintic) in GMHS 2007, and Q413A (weight) , Q413B (blood pressure), Q413C

(urine sample), Q413D (blood sample), Q413E (signs of complications), Q413F (sources of care for complications), Q414 (tetanus injection), Q420 (iron tablet) and Q422 (anthelmintic) in GMHS 2017.

Variables were coded as dummy variables (0=No, 1=Yes), and summed up to provide a score of 0 – 9.

Missing values: in GMHS 2007, 44 women (0.9%) had missing values for components of antenatal care quality score. In GMHS 2017, 350 women (2.9%) had missing values for components of antenatal care quality score.

Handling of missing values: women not knowing if they received above mentioned antenatal services or having missed values, were considered as not having received a service (see table S2 and S3).

Birth attendant

Constructed with string variable Q526 (assistance at delivery) in GMHS 2007, and Q429 (assistance at delivery) in GMHS 2017.

For GMHS 2007, string variables where recoded into categorical variables: doctor, nurse, other. If string values included assistants from separate categories, the category with the lowest number was selected. For instance, if a doctor and nurse were said to have assisted, the woman would be categorized as having been assisted by a doctor.

Missing values: in GMHS 2007, 9 women (0.2%) had missing values for Q526.

Handing of missing values: women with missing values for birth attendant were categorized according to Q527 (place of birth) and Q542 (caesarean section) in 2007. If women gave birth in a private facility or by caesarean section, they were categorized as being assisted by a doctor. If they gave birth in a public facility, they were categorized as being assisted by a nurse. If women gave birth at home, they were categorized as being assisted by 'other' (see table S2 and S3).

Table S1. Collapsed independent variables; their question, original and merged categories and reference category. GMHS 2007 and 2017

* = option only available in GMHS 2017

Variable	Question	Original categories	Collapsed categories	Reference
Ethnicity	*"To which ethnic group do you belong?"*	Akan Ga/Dangme Ewe Guan Mole-Dagbani Grussi Gruma Hausa Other	Akan Ga/Dangme Ewe Mole-Dagbani Other	Akan
Region	Based on location of survey	Western Central Greater Accra Volta Eastern Ashanti Brong Ahafo Northern Upper East Upper West	Coastal (Western, Central, Greater Accra, Volta) Middle (Eastern, Ashanti, Brong Ahafo) Northern (Northern, Upper East, Upper West)	Coastal
Household's wealth status	Composite measure of a household's cumulative living standard	Lowest Second Middle Fourth Highest	Poor (Lowest, Second) Middle Rich (Fourth, Highest)	Poor
Religion	*"What is your religion?"*	Catholic Protestant Methodist Presbyterian Pentacostal Other Christian Muslim Traditional/spiritualist No religion	Christian (Catholic, Protestant, Methodist, Presbyterian, Pentacostal, Other Christian) Muslim Other (traditional/spiritualist, no religion)	Christian
Marital status	Several questions regarding current or previous marriages	Currently married Living together Widowed Divorced Separated Not in union	Together (currently married, living together) Not together (widowed, divorced, separated, not in union)	Together
Maternal education	*"What is the highest level of school you attended?"*	None Primary Middle JSS/JHS* Secondary SSS/SHS* Higher	None Primary Middle, JSS/JHS Secondary, SSS/SHS, higher	None

Table S2. Missing values in GMHS 2007

Independent variables	**Number of missing values or *don't know* responses (N=5,064)**	**%**
Ethnicity	Missing 2	<0.1
Region	0	
Place of residence	0	
Household's wealth index	0	
Exposure to mass media	Missing 24	0.5
- Radio	Missing 11	0.2
- Television	Missing 5	0.1
- Newspaper	Missing 8	0.2
Maternal age during birth of last child	0	
Religion	Missing 3	0.1
Marital status	0	
Maternal educational status	1	<0.1
- Ever attended school	1	<0.1
- Highest educational level	0	
Parity	0	
History of perinatal death	0	
Multiple gestation	0	
Peripartum complications	1	<0.1
Number of antenatal visits	Missing 4, *don't know* 21	0.1, 0.4
Antenatal quality score	Missing 44	0.9
- Blood pressure	0	
- Urine Sample	Missing 1	<0.1
- Blood sample	Missing 2	<0.1
- Weight	0	
- Complications	0	
- Where to go	Missing 2	<0.1
- Tetanus	0	
- Iron tablets	0	
- Drugs for intestinal parasites	Missing 40	0.8
Birth attendant	Missing 9	0.2

Table S3. Missing values in GMHS 2017

Independent variables	**Number of missing values or *don't know* responses (N=12,074)**	**%**
Ethnicity	0	
Region	0	
Place of residence	0	
Household's wealth index	0	
Exposure to mass media	0	
- Radio	0	
- Television	0	
- Newspaper	0	
Maternal age during birth of last child	0	
Religion	0	
Marital status	0	
Maternal educational status	0	
Parity	0	
History of perinatal death	0	
Multiple gestation	0	
Peripartum complications	0	
- Suffered from any problem?	0	
- Which problem?	0	
Number of antenatal visits	Missing 25	0.2
- Received antenatal care	0	
- How many visits	*Don't know* 25	
Antenatal quality score	350	2.9
- Blood pressure	0	
- Urine Sample	0	
- Blood sample	0	
- Weight	0	
- Complications	*Don't know* 23	0.2
- Where to go	*Don't know* 1	<0.1
- Tetanus	*Don't know* 49	0.4
- Iron tablets	*Don't know* 15	0.1
- Drugs for intestinal parasites	*Don't know* 319	2.6
Birth attendant	0	