Evaluation and Comparison of Patterns of Maternal Complications Using Generalized Linear Models of Count Data Time Series

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Abstract: Studying patterns of maternal complications is critical before, during and after childbirth. However, there is limited information on comparative trends of different maternal complications, particularly, in a resource-limited setting. In this study we fit six different types of maternal complications namely ante-partum haemorrhage (APH), eclampsia, obstructed labour, post-partum haemorrhage (PPH), ruptured uterus and sepsis to time series generalized linear model. We systematically compare the performance of the model in light of real data by checking its flexibility and serial correlation and the conditional distribution. We then, compute model fitting, assessment and prediction analysis for each maternal complication. Additionally, we provide a comparative review of the results by assessing the effect of intervention 1: basic emergency obstetric and new-born care (BEmONC) and intervention 2: comprehensive emergency obstetric and new-born care (CEmONC) services on trends in maternal complications. Results show that women with APH, eclampsia and obstructed labour at the time of delivery are significantly high. Maternal complication did not statistically vary by counties. The results of count GLM for APH showed presence of Intervention1 (BEmONC) reduces APH by a factor -0.189 (LCI =- 0.298, UCI= -0.0805) while CEmONC was not statistically significance. Similar inference is registered by PPH i.e. Intervention1 (BEmONC) is -0.17 (LCI =-0.258, UCI= - 0.082) while CEmONC remains insignificant. This can be interpreted to mean that public health facilities only require the basic minimum (BEmONC) infrastructure to cub APH and PPH. Mothers with sepsis and eclampsia were significantly more likely to experience maternal and perinatal deaths when delivering at facilities that lack BEmONC. Caregivers, who perform obstetric and maternal care, need be alert of maternal complications associated with PPH and obstructed labour. Introduction of BEmONC and CEmONC packages in maternal and neonatal clinics improved performance of caregivers in reducing maternal and pediatric complications and mortality.

Keywords: Maternal complications, Count Data time series, Trends, Goodness-of-fit, Conditional distribution.

1. BACKGROUND

Maternal complications namely ante-partum haemorrhage (APH), eclampsia, obstructed labour, post-partum haemorrhage (PPH), ruptured uterus and sepsis constitute to significant cause of disease burden for women of reproductive age globally and contribute to high mortality rates and disability in developing countries [1]. Maternal conditions dominate the burden of reproductive ill-health, accounting for at least 25% of the burden of diseases, particularly in Kenya [7].

Despite there being significantly, large number of women of reproductive age, who suffer from maternal related complications, little is known about pattern and predictive trends. Understanding timely and accurate patterns and trends of maternal complication is critical to health programs particularly, in reduction of mortality and morbidity, which affects a large proportion of women.

The 5th Millennium Development Goals (MDGs 5) puts a target of 75% reduction in the maternal mortality ratio (MMR) between 1990 and 2015. The review of MDGs, however showed reduction has fallen short of the target. Relatively few literature focuses on pattern and trends in maternal complications, particularly, key factors that contribute to maternal death, and indicators that shows association of maternal death and maternal complications before, during and after delivery [3]. The global MMR declined considerably between 1990 and 2008 by one-third [2]. The estimated proportion of decline however, varied among countries, with substantial improvements in Asia and North Africa and relatively, less improvement in sub-Saharan Africa [2]. Despite there being high numbers of maternal deaths and slower decline in MMR in sub-Saharan Africa, compared with other developing regions, literature that focus on systematic trends of various maternal complications is still minimal [2].

In this study, we revised generalized count data time series models. The models are applicable in many different areas where a number of events of interest per given time period are observed over time. A practical example is monthly number of maternal complications reported, which is routinely collected by ministry of health at private and public hospitals. One of the critical features of time trend data analysis is prediction of future count values to facilitate adequate

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planning in resource-limited settings and the detection of unusual patterns pointing at some adverse description of patterns for better interpretation and understanding of data that generates a given mechanisms. In practice, the generalized linear model (GLM) method is used for modelling observations that is conditional to the past events/information, where the GLM model is executed by choosing a particular suitable count data distribution and an appropriate link-function. Excellent summaries of count data predictive models [8-11].

This paper is concerned with methods for count time series based on GLM models with application to maternal complications. The aim is to shed light on regular trends and patterns of maternal complications occurring before, during and after delivery. The main objective of the study is to compare the trends of six different maternal complications occurring before, during and after delivery and to identify patterns associated with BEmONC/ CEmONC intervention.

In section 2, we look the methodology and cover data description and the generalized time series model for count data. The systematic analysis and results for maternal complications i.e. APH, eclampsia, obstructed labour, PPH, ruptured uterus and sepsis including motivation for the study are presented in section 3. We discuss overall results in section 4. Finally, we provide the concluding remarks and limitations of the study in section 5.

2. METHODOLOGY

2.1. Data Description

This is a retrospective study where data was extracted from 3 largest cities in Kenya, namely Nairobi, Mombasa and Kisumu. Our definition for maternal complication was based on WHO guideline for ante-partum haemorrhage (APH), eclampsia, obstructed labour, post-partum haemorrhage (PPH), ruptured uterus and sepsis.

We retrieved mother, neonatal and child health (MNCH) data from Kenya Public Health Information system called District Health Information System 2 (DHIS2). DHIS2 is a publicly available database that captures health related indicator regularly on a monthly basis. We specifically retrieved data from three major counties in Kenya from December 2014 to January 2017. The two tables below shows the general statistics of data retrieved from Nairobi, Mombasa and Kisumu counties for the period December 2014 to January 2017 for maternal, neonatal together with their associated various maternal complications.

During the period December 2014 to January 2017, maternal complication data from 896 facilities were retrieved with 48% of the facilities having either basic emergency obstetric and new-born care (BEmONC) or comprehensive emergency obstetric and new-born care (CEmONC) services.

2.2. Time Series Model

Let a count time series be $\Lambda_t : t \in N$ and $\gamma_t : t \in N$ be a time-varying r-dimensional covariate vector, say $\gamma_t = (\gamma_{t,1}, \gamma_{t,2}, \cdots, \gamma_{t,r})$. We can model the conditional expectation $E(\Lambda t | \vartheta_{t-1})$ of the count time series by a process, $\lambda_t : t \in N : E(\Lambda_t | \vartheta_{t-1} = \lambda_t).\vartheta_t$ is the joint historical process $\Lambda_t, \lambda_t, \gamma_t : t \in N$ until time t including the covariate information, time *t-1*.

The models' general form will be

$$\phi(\lambda_t) = \beta_0 + \sum_{k=1}^{p} \beta_k \hat{\phi}(\Lambda_{t-i_k}) + \sum_{k=1}^{p} \alpha_k \phi(\Lambda_{t-j_i}) + \eta^T \lambda_t \qquad (1)$$

Table 1: General Descriptive Statistics of Maternal, Neonatal and Child Health Data of Nairobi, Mombasa and Kisumu Retrieved from DHIS2 for the Period Dec 2014 to Jan 2017 (N is the Number of Facilities)

	N	Min(monthly)	Max(monthly)	Mean(monthly)	Std. Deviation
Live birth	60	49,810	87,329	72,711	9,263
Normal Deliveries	60	43,822	77,991	64,246	8,366
Neonatal deaths	60	406	1,038	804	169
Caesarean Sections	60	6,685	12,023	9,848	1,249
Assisted vaginal delivery	60	198	1,609	653	270
Babies discharge Alive	60	46,129	82,571	68,588	8,794
Maternal Deaths 20+ years	60	45	337	84	36
Maternal Deaths Audited	60	21	93	53	19

Table 2: General Descriptive Statistics of Maternal Complications Data Retrieved from DHIS2 for the Period Dec 2014 to Jan 2017 (N is the Number of Facilities)

	N	Min (monthly)	Max (monthly)	Mean (monthly)	Std. Deviation
APH (Ante partum Haemorrhage)	60	231	773	485	100
Eclampsia	60	204	533	393	79
Obstructed Labour	60	646	3001	973	290
PPH (Post-Partum Haemorrhage)	60	541	1260	902	185
Ruptured Uterus	60	47	93	66	11
Sepsis	60	53	236	135	31

Where $\phi:\mathbb{R}^+\to\mathbb{R}$ is a link function. $\hat{\phi}:\mathbb{N}^+\to\mathbb{N}$ is a transformation function. The parameter vector $\eta=(\eta_1,\eta_2,\ldots,\eta_r)^T$ corresponds to the effects of covariates. To allow for regression on arbitrary past observations of the response, define a set $P=(i_1,i_2,\ldots,i_p)$ and integers $0<i_1<i_2<\cdots\infty,$ with $P\in\mathbb{N}$. This formulation is useful particularly when dealing with modeling stochastic seasonality. Note that $\gamma_t=\phi(\lambda_t)$ is the linear predictor and the set *P* enables regression on the lagged observations i.e. $\Lambda_{t-i1},\Lambda_{t-i2},\cdots,\Lambda_{t-ip}$. Excellent and in-depth literature on this approach particularly, ARMA, INGARCH and other representation has been covered by [8-11, 13-16].

For parameter estimation, we assume quasi conditional maximum likelihood (ML) estimation. If the Poisson assumption holds, then the ML estimator can be obtained conventionally. However, if mixed Poisson assumption holds, quasi ML estimators can be obtained. Irrespective of the distributional assumption, the parameter space for the INGARCH model with covariates is given by equation (2) described below.

$$\Theta=\left\{\begin{array}{l}\theta\in\mathbb{R}p+q+r+1:\beta_0>0,\beta_1,\cdots,\beta_p,\alpha_1,\cdots,\\ \alpha_q,\eta_1,\cdots,\eta_r\geq 0,\sum_{k=1}^{p}\beta_k+\sum_{l=1}^{q}\alpha_l<1\end{array}\right\} \quad (2)$$

Where $\boldsymbol{\theta}$ is defined by $\boldsymbol{\theta}=(\beta_1,\cdots,\beta_p,\alpha_1,\cdots,\alpha_q,\eta_1,\cdots,\eta_r)^T$ is the vector of regression parameters. For further condition ensures that the fitted model has a stationary and ergodic solution with moments of any order see [9-11]. For intervention analysis which in our case is BEmONC/ CEmONC, the effect is multiplicative because we are employing log-linear model.

2.3. Description of CEmONC and BEmONC

A facility is considered BEmONC if the following basic 7 signals are functional and accessible; antibiotics are available for parenteral treatment of infection, Magnesium sulfate (MgSO4) agent is available for treating severe pre-eclampsia/eclampsia, uterotonics is available for treating PPH, there is manual vacuum aspiration of retained products of conception, vacuum-assisted delivery is available for assisted vaginal delivery, service providers can manually removal of placenta and perform newborn resuscitation. For CEmONC, a facility requires all components of BEmONC plus surgical capability, which includes anesthesia under cesarean section and blood transfusion.

3. RESULTS

For the 3 largest cities in Kenya (Nairobi, Kisumu and Mombasa), on average, every month live birth are 72,711, with normal deliveries being 64,246. Neonatal deaths are 804, while births from caesarean sections 9,848. Assisted vaginal deliveries are 653 while babies discharged alive are on average 68,588. Maternal deaths reported for mothers aged 20+ years is 84 per month while maternal deaths audited 53. For monthly average registered maternal complications, APH were 485, Eclampsia 393, obstructed labour 973, PPH 902, ruptured uterus 66 and Sepsis 135.

3.1. Antepartum Haemorrhage (APH)

An antepartum haemorrhage (APH) refers to bleeding from the vagina that occurs after the 20th week of gestation period and before child-birth. The common causes of bleeding during pregnancy are cervical ectropion, vaginal infection, placental edge bleed, placenta praevia or placental abruption Cervix [18]. The incidence of antepartum haemorrhage (APH) is reported as 3.5% of all pregnancies. It is a critical determinant of maternal and perinatal mortality. There has been a significant decline in maternal mortality as a result of APH caused by placenta praevia. However, cases of placental abruption have declined marginally,

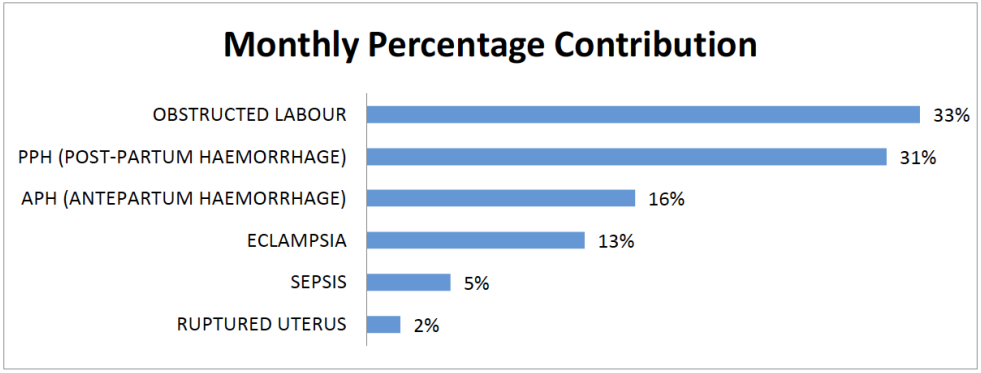

Figure 1: Percentage monthly contribution of six different types of maternal complications namely ante-partum haemorrhage (APH), eclampsia, obstructed labour, post-partum haemorrhage (PPH), ruptured uterus and sepsis. Obstructed labour contributes 33%.

particularly in sub-Saharan Africa. We fitted a count GLM model and assessed the two interventions, BEmONC and CEmONC. See Table **3** below.

3.2. Eclampsia

Eclampsia is described as severe maternal complication where the consequence of high blood pressure (BP) leads to seizures during pregnancy. Seizures in this context, refers to episodes of disturbed activities in the brain that causes epochs of low alertness, staring, and convulsions [17]. Naturally, eclampsia is a multisystem, disorder that is unique to pregnancy and a major cause of fetal/neonatal and maternal mortality and morbidity [22]. It has been documented recently, that preeclampsia which eventually leads to eclampsia accounts for approximately 15.9% of all maternal deaths in the United States of America and is a major cause of maternal and perinatal mortality and morbidity [22]. We fitted a count GLM model and assessed the two interventions, BEmONC and CEmONC. See Table **4** below for eclampsia collected in 60 facilities.

3.3. Post-Partum Haemorrhage (PPH)

A post-delivery maternal status is said to be PPH, if there is loss of more than 500 mL blood after delivery.

Table 3: Count GLM for APH with SE and CI (level = 95 %) obtained by normal approximation. Link function is log and distribution family is negative binomial. The Log-likelihood value is -255. Score test on intervention(s) of given type at given time is has p-value of < 0. Over dispersion coefficient σ_2 was estimated to be 0.018

Coefficient	Estimate	Std. Error	CI(Lower)	CI(Upper)
(Intercept)	3.033	0.6676	1.724	4.3412
B1	0.367	0.139	0.095	0.6398
Intervention1 (BEmONC)	-0.189	0.0555	-0.298	-0.0805
Intervention2 (CEmONC)	0.162	0.1653	-0.162	0.4858
σ2	0.017	N/A	N/A	N/A

Table 4: Count GLM for Eclampsia with SE and CI (level = 95 %) obtained by normal approximation. Link function is log and distribution family is negative binomial. The Log-likelihood value is -291. Over dispersion coefficient σ_2 was estimated to be 0.0622

Coefficient	Estimate	Std. Error	CI(Lower)	CI(Upper)
(Intercept)	3.6577	0.5855	2.51	4.8053
B1	0.2507	0.1203	0.015	0.4865
Intervention1 (BEmONC)	-0.2127	0.0759	-0.361	-0.0639
Intervention2 (CEmONC)	0.2046	0.2704	-0.325	0.7346
σ2	0.0622	N/A	N/A	N/A

Table 5: Count GLM for PPH with SE and CI (level = 95 %) obtained by normal approximation. Link function is log and distribution family is negative binomial. The Log-likelihood value is -293. Over dispersion coefficient σ_2 was estimated to be 0.0135

Coefficient	Estimate	Std. Error	CI(Lower)	CI(Upper)
(Intercept)	3.2288	0.6034	2.046	4.411
B1	0.4257	0.1075	0.215	0.636
Intervention1 (BEmONC)	-0.17	0.0449	-0.258	-0.082
Intervention2 (CEmONC)	-0.0567	0.1391	-0.329	0.216
σ2	0.0135	N/A	N/A	N/A

Typically, PPH is registered in 18% of births [19]. However, blood loss that exceeds 1,000 mL is clinically considered to be physiologically significant and can result in many cases results in hemodynamic instability. PPH accounts for 25% of maternal deaths in developing countries and a leading course of maternal mortality [19]. We fitted a count GLM model and assessed the two interventions, BEmONC and CEmONC. See Table **5** above.

3.4. Obstructed Labour

Labour is considered obstructed when a part of the fetus cannot progress into the birth canal as expected, despite evidence of strong uterine contractions. The complication remains a consistent cause of both maternal mortality and short, long-term disability among women. In resource limited setting, obstructed labour is common due to unavailability of functioning health systems and proper health service. Obstructed labour is a leading course of maternal morbidity and mortality in developing countries. The number of maternal mortality resulting from obstructed labour and/or ruptured uterus varies between 4% and 70% of all maternal deaths with mortality rate as high as 410/100,000 live births [23]. We fitted a count GLM model and assessed the two interventions, BEmONC and CEmONC. See Table **6** below for results of count GLM on obstructed labour.

3.5. Ruptured Uterus

Ruptured uterus occurs during active vaginal birth. The mother's uterus practically, tears so her baby slips into her abdomen. It is usually catastrophic with high incidence of maternal morbidity and mortality. Rupture of the uterus is more frequent in resources limited settings due to obstructed labour, and is an important determinant of direct maternal death [21, 24]. We fitted a count GLM model and assessed the two interventions, BEmONC and CEmONC. See Table **7** below

3.6. Sepsis

Sepsis is said to have develop when the immune system of a mother releases chemicals into the bloodstream to fight an infection which however, results to an inflammation in the whole body instead. This happens in several cases, where infection is associated with inadequate host response, which may develop to organ dysfunction [1–3]. Sepsis is usually associated with either fungal or viral infections. However, consequent inflammatory response is generally less in situations where most patients have a

Table 6: Count GLM for Obstructed Labor with SE and CI (level = 95 %) obtained by normal approximation. Link function is log and distribution family is negative binomial. The Log-likelihood value is -306. Score test on intervention (s) of given type at given time is has p-value <0. Over dispersion coefficient σ2 was estimated to be 0.0267

Coefficient	Estimate	Std. Error	CI(Lower)	CI(Upper)
(Intercept)	2.998	0.7485	1.531	4.4649
B1	0.4629	0.134	0.2	0.7256
Intervention1 (BEmONC)	-0.123	0.0558	-0.232	-0.0137
Intervention2 (CEmONC)	-0.0271	0.1883	-0.396	0.342
σ2	0.0267	N/A	N/A	N/A

Table 7: Count GLM for Ruptured Uterus with SE and CI (level = 95 %) obtained by normal approximation. Link function is log and distribution family is negative binomial. The Log-likelihood value is -298. Over dispersion coefficient σ2 was estimated to be 0.2096

Coefficient	Estimate	Std. Error	CI(Lower)	CI(Upper)
(Intercept)	2.4444	0.515	1.435	3.454
B1	0.1733	0.174	-0.167	0.514
Intervention1 (BEmONC)	-0.4108	0.153	-0.711	-0.111
Intervention2 (CEmONC)	-0.0415	0.58	-1.179	1.096
σ2	0.2096	N/A	N/A	N/A

Table 8: Count GLM for Sepsis with SE and CI (level = 95 %) obtained by normal approximation. Link function is log and distribution family is negative binomial. The Log-likelihood value is -220. Over dispersion coefficient σ2 was estimated to be 0.047

Coefficient	Estimate	Std. Error	CI(Lower)	CI(Upper)
(Intercept)	3.089	0.4993	2.1106	4.0679
B1	0.165	0.1345	-0.0986	0.4285
Intervention1 (BEmONC)	-0.249	0.0795	-0.405	-0.0933
Intervention2 (CEmONC)	0.101	0.2833	-0.4544	0.6562
σ2	0.047	N/A	N/A	N/A

bacterial infection. If treatment is not quick and effective, patients are likely to become critically ill and rapidly deteriorate into multiple organ failure and severe septic shock. Sepsis is documented to have an association with mortality rates of 30%, although the proportion may vary from one geographical location to another [20]. We fitted a count GLM model and assessed the two interventions, BEmONC and CEmONC. See Table **8** above for sepsis data fitted to GLM time series count data.

4. DISCUSSIONS AND CONCLUSION

This work provides a unified comparative assessment of six different maternal complications using count time series that follows GLM models. An important part of the model is the dependence on past estimates of the derived conditional mean, which allows for modelling of temporal correlation and therefore enable us to present the on trends of maternal complications incorporating covariate effects (CEmONC and BEmONC) within this framework. Quality and respectable maternal care remains a major predictor of maternal health outcomes and is adversely affected when the health facilities are overcrowded with limited BEmONC/ CEmONC signal functions. However, most government programs that focus on maternal health are still concentrating on antenatal care and training birth attendants while neglecting BEmONC and CEmONC facilities.

In this study, we assume either Poisson or Negative Binomial conditional distribution to implement model-based comparative evaluation and model assessment when fitting maternal complication count data in typical health facilities. On average every month, APH contributes to 16%, eclampsia 13%, obstructed labour 33%, PPH 31%, Ruptured Uterus 2% and sepsis 5% of maternal complications. Monthly average for caesarian births is 9,848 and therefore lack of adequate facilities across the three cities are some of the hindrances that contribute to high maternal mortality rates. Provision of BEmONC and CEmONC within reach and access of all pregnant mothers is one of the strategies that need to be employed in order to mitigate maternal mortality in Kenya. Here, we have assessed patterns, levels, and trends of maternal complications in the three major cities for the period Dec 2014 to Jan 2017. Results shows; the proportion of women who had eclampsia, APH, PPH and sepsis has significantly increased over that past 2 years. Effects of interventions were significant in BEmONC compared to CEmONC. Intervention analysis shows BEmONC and CEmONC is effective in mitigating maternal mortality and morbidity among women. BEmONC and CEmONC remain critical factors for improving the performance of

maternal care givers. Significant improvements are noted from the time interventions were implemented; a situation that is coherent with the study findings in [5-7]. Although the study assumes that most service providers within the catchment cities provided services rationally where BEmONC and CEmONC are available, to mothers before, during and after delivery within their facilities, and may not have had formal training indicating a countywide gap that needs to be addressed urgently [7].

The results of count GLM for APH showed presence of Intervention1 (BEmONC) reduces APH by a factor -0.189 (LCI =- 0.298, UCI= -0.0805) while CEmONC was not statistically significance. Similar inference is registered by PPH i.e. Intervention1 (BEmONC) is -0.17 (LCI =-0.258, UCI= - 0.082) while CEmONC remains insignificant. This can be interpreted to mean that public health facilities only require the basic minimum (BEmONC) infrastructure to cub APH and PPH. Going by the results, mothers with sepsis and eclampsia were significantly more likely to experience maternal and perinatal deaths when delivering at facilities that lack BEmONC. Results of other studies i.e. [1] that look at obstetric determinants of perinatal deaths in seven developing countries shows that spontaneous premature delivery and hypertensive disorders are the most maternal factors linked to perinatal mortality. The high infant mortality rate among mothers with severe complications is likely to be linked to a combination of the mothers' inability to breastfeed well, to take care of their infants, and to seek timely treatment intervention in the event of illness [1] compared with our inference show complications rate vary in countries and race [12]. Other studies have shown that 90% of maternal mortality was emergency admissions with complications requiring intensive care unit (ICU) care. Hence CEmONC facilities should include obstetric ICU care [5].

4.1. Conclusions

Maternal complication proportions did not vary by counties. Maternal care givers who perform obstetrical care need to be aware of high rate of maternal medical complications associated with PPH and obstructed labour. Introduction BEmONC package improved performance of providers in reducing maternal and new-born complications and mortality.

ABBREVIATIONS

APH = Antepartum haemorrhage

PPH = Post-partum haemorrhage

MMR = Maternal Mortality Rate

CEmONC = Comprehensive Emergency Obstetric and New-born Care (CEmONC)

BEmONC = Basic Emergency Obstetric and New-born Care

MNCH = Maternal, Neonatal and Child Health

MNH = Maternal and Neonatal Health

DHIS2 = District Health Information System 2

ICU = Intensive Care Unit

MDGs = Millennium Development Goals

EmOC = Emergency Obstetric Care

UCI = Upper Confidence Interval

LCI = Lower Confidence Interval

WHO = World Health Organization

BP = Blood Pressure

REFERENCES

[1] Iyengar K, Yadav R, Sen S. Consequences of maternal complications in women's lives in the first postpartum year: a prospective cohort study. Journal of Health, Population, and Nutrition 2012; 30(2): 226.

[2] Zureick-Brown S, Newby H, Chou D, Mizoguchi N, Say L, Suzuki E, Wilmoth J. Understanding global trends in maternal mortality. International Perspectives on Sexual and Reproductive Health 2013; 39(1).

[3] Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, Shackelford KA, Steiner C, Heuton KR, Templin T. Global, regional, and national levels and causes of maternal mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet 2014; 384(9947): 980-1004.

[4] Kishowar Hossain AHM. Utilization of antenatal care services in Bangladesh: an analysis of levels, patterns, and trends from 1993 to 2007. Asia Pacific Journal of Public Health 2010; 22(4): 395-406.

[5] Dasari P. Maternal mortality and its relationship to emergency obstetric care (EmOC) in a tertiary care hospital in South India. Obstetric Medicine 2015; 8(2): 86-91.

[6] Yego F, D'Este C, Byles J, Williams JS, Nyongesa P. Risk factors for maternal mortality in a Tertiary Hospital in Kenya: a case control study. BMC Pregnancy and Childbirth 2014; 14(1): 38.

[7] Warren C, Mwangi A, Oweya E, Kamunya R, Koskei N. Safeguarding maternal and newborn health: improving the quality of postnatal care in Kenya. International Journal for Quality in Health Care 2009; 22(1): 24-30.

[8] Czado C, Gneiting T, Held L. Predictive model assessment for count data. Biometrics 2009; 65(4): 1254-1261.

[9] Demidenko E. Mixed models: theory and applications with R. John Wiley & Sons 2013.

[10] Fokianos K, Rahbek A, Tjøstheim D. Poisson autoregression. Journal of the American Statistical Association 2009; 104(488): 1430-1439.

[11] Fokianos K, Tjøstheim D. Log-linear Poisson autoregression. Journal of Multivariate Analysis 2011; 102(3): 563-578.

[12] Gold KJ, Mozurkewich EL, Puder KS, Treadwell MC. Maternal complications associated with stillbirth delivery: a cross-sectional analysis. Journal of Obstetrics and Gynaecology 2016; 36(2): 208-212.

[13] Fokianos K, Fried R. Interventions in INGARCH processes. Journal of Time Series Analysis 2010; 31(3): 210-225.

[14] Fokianos K, Fried R. Interventions in log-linear Poisson autoregression. Statistical Modelling 2012; 12(4): 299-322.

[15] Liboschik T. Modelling count time series following generalized linear models. PhD Thesis TU Dortmund University 2016.

[16] Liboschik T, Kerschke P, Fokianos K, Fried R. Modelling interventions in INGARCH processes. International Journal of Computer Mathematics 2016; 93(4): 640-657.

[17] Sibai BM. Eclampsia: VI. Maternal-perinatal outcome in 254 consecutive cases. American Journal of Obstetrics and Gynecology 1990; 163(3): 1049-1054.

[18] Mukherjee S, Bhide A. Antepartum haemorrhage. Obstetrics, Gynaecology & Reproductive Medicine 2008; 18(12): 335-339.

[19] Mukherjee S, Arulkumaran S. Post-partum haemorrhage. Obstetrics, Gynaecology & Reproductive Medicine 2009; 19(5): 121-126.

[20] Vincent JL. The clinical challenge of sepsis identification and monitoring. PLoS Medicine 2016; 13(5): e1002022.

[21] Kidanto HL, Mwampagatwa I, Van Roosemalen J. Uterine rupture: a retrospective analysis of causes, complications and management outcomes at Muhimbili National Hospital in Dar es Salaam, Tanzania. Tanzania Journal of Health Research 2012; 14(3).

[22] Backes CH, Markham K, Moorehead P, Cordero L, Nankervis CA, Giannone PJ. Maternal preeclampsia and neonatal outcomes. Journal of Pregnancy 2011; 2011.

[23] Neilson JP, Lavender T, Quenby S, Wray S. Obstructed labour: reducing maternal death and disability during pregnancy. British Medical Bulletin 2003; 67(1): 191-204.

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