



# Socio-economic Determinants of Maternal Mortality in Sub-Saharan Africa: Evidence from Generalized Method of Moments (GMM) Approach to Panel Data Analysis

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## Abstract

The paper provides robust evidence regarding socio-economic determinants of maternal mortality in Sub-Saharan Africa (SSA). Panel data from selected 43 Sub-Saharan African countries over the period of 1995-2015 are used to analyze the impact of socio-economic variables on maternal mortality model. A model of generalized method of moments (GMM) was adopted in the analysis of data. For robustness, the test for the existence of first and second order serial correlation in the error term, and the test to establish the validity of the instruments were conducted. The sys-GMM results showed strong evidence in support of the impact of per capita health expenditure, fertility rate, female labour force participation rate, female employment, prevalence of HIV/AIDS, life time risk of maternal mortality and education on maternal mortality in SSA. The study identified these socio-economic variables as key policy instruments in reducing maternal mortality in SSA. In addition, the results have important policy implications both domestically for countries in SSA with high rate of maternal deaths, and globally if the SDG-5 of reducing maternal deaths by 75% on or before 2030 must be achieved.

**Keywords:** Socio-Economic Determinants, Maternal Mortality, Healthcare, SSA, sys-GMM

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## Introduction

Sub-Saharan African countries have been the most affected by maternal deaths and also have the highest cases of maternal deaths in the world (WHO, 2015). Nearly, more than half of the cases of maternal deaths in the world occur in Sub-Sahara Africa. WHO (2005) estimates indicate that over 500, 000 women die annually in the world as a result of complications linked to pregnancy or childbirth, and 250,000 (50 per cent) of these statistics live in SSA where the problem is most severe. Also, the Sub-Saharan African region has about the highest life time risk of maternal deaths, 1 in 36 (WHO, 2015). Furthermore, the distribution of the causes of maternal deaths in the world according to Say, Chou, Gemmill, Tuncalp, Moller, Daniels, Gulmezoglu, Temmerman and Alkema (2014), showed that the medical causes of maternal deaths, haemorrhage for instance,



accounted for about 27.1 per cent of maternal deaths, followed by hypertension which has a record of 14 per cent maternal deaths. Embolism and sepsis stood at 3.2 per cent and 10.7 per cent deaths respectively. Unsafe abortion had 7.9 per cent deaths of the total world report. The world direct causes of maternal health which include deaths due to obstructed labour or anaemia, stood at 9.6 per cent. Apparently, the indirect causes of maternal deaths have the highest statistics and percentages in the world (Say et al., 2014). This figure (27.5 per cent) is very disturbing and thus calls for serious concerns and more researches in this area if the problem of maternal deaths must be addressed.

In relation to SSA countries, the distribution reveals that indirect causes of maternal deaths in SSA countries accounts for about 28.6 per cent of the world's distribution of the causes of maternal deaths, followed by haemorrhage which had a record of 24.5 per cent deaths. Direct causes- hypertension, embolism, sepsis and abortion have a record of 9, 16, 2.1, 10.3 and 9.6 per cent respectively of SSA distribution of the causes of maternal bereavements in the world (Say et al., 2014). This implies that more devotions should be paid to SSA countries and South Asia in the goal to reduce maternal deaths. Also, the target of MDG-5 was basically to reduce maternal deaths by 75 per cent between 1990 and 2015. While significant progress was made in this direction by reducing world maternal mortality by 5 per cent, SSA countries still have the greatest burden and worst still, bear the lowest annual reduction rate of 0.1 per cent (UNICEF, 2008). Therefore, if further progress must be made in this direction, the focus should be SSA countries and South Asia where maternal deaths are more acute. The progress in this direction would begin from the identification of the causes of deaths linked to childbirth and the understanding of their interrelationships.

Previous studies on the determinants of maternal death have mostly focused on medical determinants leaving less evidence on the non-medical determinants. Yet, the non-medical determinants of maternal health account for over 28.5 per cent of SSA distribution of maternal deaths, higher than medical causes (Say et al., 2014). Consequent upon this, and given the need to reduce maternal deaths and evaluate the feats of MDG-5, it is worthwhile for more empirical researches in this direction especially in SSA. Also, empirical researches on SSA countries are very scanty. The few ones (Bour & Bream, 2004; Laithapersal-Pilly & Udjo, 2014; Dersarkissian, Thompson & Arah, 2013; Sliwa & Anthony, 2016; and Changizi, Rezaeizadeh, Janani, Shariat & Habibelahi, 2017) used analytical method such as binomial regression, correlation and so on, and based their theoretical framework on explanatory or analytical approaches. The current study deviates by focusing on the non-medical causes of maternal deaths employing a novel/robust method of GMM approach to panel data analysis, and develop a framework (mortality model) that may be suitable for Africa . Also, the current study will identify the basic socio-economic determinants/factors affecting maternal mortality and provides policy directions/interventions along this line especially to achieve SDG goal-5 of reducing maternal deaths by half on or before 2030.

Dictated by data availability, the study covers the period of 1995 to 2015 utilizing panel data from 43 SSA countries, namely, Angola, Cameroon, Burkina Faso, Comoros, Ghana, Kenya, Guinea Bissau, Lesotho, Madagascar, Liberia, Mali, Namibia, Mauritania, Senegal, South Africa, Sierra Leone, Sudan, Tanzania, Zimbabwe, Benin, Eritrea, Zambia, Central Africa Republic, Ethiopia, Mozambique, Uganda, Guinea, Niger, Botswana, Burundi, Chad, Rwanda, Congo Brazzaville, Equatorial Guinea, Congo Democratic Republic, Togo, Côte d'Ivoire, Gabon, Gamble, Malawi, Mauritius, Nigeria and Switzerland. The period was chosen to understand and examine the impact of socio-economic variables on maternal mortality between the introduction and termination of MDG-5. The contributions of these variables to maternal mortality ratio in this

period will be very useful for policy direction for the attainment of SDG-5 (of reducing maternal deaths by 75 per cent by 2030) since the period coincided with the introduction and termination of MDGs in 2015.

## Material and Model

### Material

A large body of studies (for instance, Shen & Williamson, 1997; Audu, Tukai & Bukar, 2010; Wild, Barclay, Kelly & Martins, 2010; Falnes, Moland, Tylleskar, Depaoli, Leshabari & Engebretsen, 2011; Stoeckl, Meisinger, Peters, Thorand, Huth, Heier, Rathmann, Kowall, Stoeckl & Doring, 2011; Atuhaire & Kaberuka, 2016; and Ariyo, Ozodiegwu & Doctor, 2017) exist in literature to support theories on the influence of socio-economic dynamics on maternal mortality. For example, fertility is a major factor that contributes to maternal mortality. Fertility the average number of children per women is a measure of a woman status and acceptance in the society especially in the African society where child birth is highly celebrated and valued. Fertility is high among women between the ages of 16 and 30. Teenage pregnancy is a crucial factor in maternal mortality and this has serious implication for maternal mortality. Also, late childbearing among women of older eons may expose them to the risk of maternal deaths.

Royston, Armstrong and WHO (1989) identified the age at which women get pregnant to be an important determinant of maternal mortality. In a recent study, Audu et al. (2010) see the eons (early and old age) as critical factors influencing maternal mortality. Furthermore, in developing regions including SSA region, 40 per cent of mothers give birth before completing age 20 and teen-age girls have a 20-200 per cent higher possibility of dying from pregnancy interrelated causes than fully-grown mothers. Thus, younger the girls, the higher the possibility of deaths (United Nations, 1995). Similarly, Say and Raine (2007) averred that the age of the woman, the previous childbirth experience, the number of children already had, and the knowledge of healthcare services, can also affect pregnancy and delivery management. In addition, Gribble and Heffey (2008) reported that pregnancy among adolescents is strongly associated with high rate of maternal mortality. All these can lead to maternal deaths if not properly managed.

The status of a woman in the society has a close association with her use of maternal health facilities and her level of education. The level of education is critical for women's self-efficacy and confidence in making independent decisions outside the family. This shows the close connection between social and biological explanations of maternal deaths (Santow, 1995; Grown, Gupta, & Pande, 2005). Low status of woman, can lead to other abuses from her husband and family members. For instance, where male spouses are abusive and get physical or sexually violent, women tend to face the direct danger of maternal mortality. Apart from male partners, other members of the family especially the in-laws and other relatives can wield influence (Wild et al., 2010 and Falnes et al., 2011). Also premature rupture of membranes, stillbirths, miscarriages, and even death can occur in the instance of increase violence during pregnancy (Garcia-Moreno & Watts, 2000; Jewkes, 2002; Ellsberg, Jansen, Heise, Watts & Garcia-Moreno, 2008; and Stoeckl et al., 2011).

Education, especially the level of woman's education, her relations and the society can strongly affect maternal mortality. Available evidence (WHO, 1991; Briggs, 1993; Fred, 1992 and Muzyamba, Groot, Tomini & Pavlova, 2017) showed that education is very key to preventing maternal mortality and enhancing maternal behaviour. Several studies carried out recently in SSA and other regions of the world, for example, in Namibia, Kenya, Bangladesh and Tajikistan, averred that women's level of education and exposure to reproductive healthcare were identified

as having fundamental influence on maternal mortality (Chowdhury, Botlero, Koblinsky, Saha, Dieltiens, & Ronsmans, 2007; Fan & Habibov, 2009; Fotso, Ezeh & Essendi, 2009; and Zere, Oluwole, Kirigia, Mwikisa, & Mbeeli, 2011). For instance, in Namibia, educated women would prefer skilled healthcare givers to attend to them compared to those with little or no education. Also, educated women would prefer caesarean section than going through the rigorous pains of labour during childbirth or delivery (Zere et al., 2010 and Harrison & Pasha, 2017).

The growth and income level of the society affects the size of the income of the family and thus affects maternal health. A society with higher level of income may likely spend more on reproductive health and maternal care as well as other proximate factors such as infrastructure, goods and accessible roads, nutritious food, and so on ( Su, Chong, Chan, Fok, Tun, Ng & Rauff, 2007 and Kincaid, 2000). Thus, poverty is a serious factor that affects maternal mortality because it reduces the socio-economic status of women and bears direct impact on the families. Lanre-Abass (2008) strongly asserted that poverty is a major economic factor that causes maternal death as it deters women from receiving appropriate and adequate medical care due to their incapability to afford decent antenatal care services. Thus, poverty is critical to maternal mortality and can influence/aggravate other conditions that lead to maternal deaths.

Another factor considered to be inimical to maternal health is the cultural practices, social norms and traditions prevailing in the society. Culture, traditions and social values have a way of influencing communication among people and determines their position in the society (Abel, 2008). Cultural practices which are believed to be in opposition to the tradition of some people in the society can create fear, anxieties, even social exclusion. The cultural practices in existence in most SSA countries affect the right of the girl child thereby leading to discrimination, social divide and inequality. The influence on the girl child's right can lead to several awful decisions such as drop out of school, marrying young, initiate early childbearing without recourse to spacing. In fact certain construal of religious or cultural beliefs can influence reproductive rights and daunt some reproductive practices such as family planning among young girls of childbearing age. All these have serious implication for maternal mortality.

## Mortality Model

Mortality model (MM) will set the theoretical premises on which the model will be formulated in this study. MM is a derived model from the celebrated work of Grossman (1972) on the concept of "health capital and demand for health". From Grossman point of view, good health was a commodity that yields satisfaction to the individual, and the individual can maximise the utility of "good health" subject to certain constraints. To achieve this, Grossman considered good health as a strong capital stock that yields an output of healthy time. The underlying assumption of the model is that the individual is gifted (endowed) with an initial stock of health that (increases) or decreases with age depending on whether the individual (increases) or decreases his investment in healthcare. This implies that investment in healthcare increases the general well-being including the socioeconomic condition (income, market goods, age etc.) of the individual and can lead to improvement in health outcomes (life expectancy and maternal mortality rate). As a corollary, no investment or decrease in investment in quality healthcare on the other hand could lead to reduction in socioeconomic well-being of the individual and thus produce output of poor healthy time (illness) which makes the individual susceptible or vulnerable to diseases that would lead to mortality or death. Therefore, improvement in the general well-being of the individual by way of investment in healthcare over time is key to the survival and the contribution of the individual to economic productivity. The individual will therefore demand for healthcare or services not only as to improve his stock of healthy time but also to increase his productive capacity in the economy.

Following Grossman (1972), the individual production function for good health ( $h_i$ ) will be presented as

$$h_i = h_i(z_i, t) \dots\dots\dots 1$$

Equation 1 states that the individual produces good health ( $h_i$ ) with the inputs of commodities ( $z_i$ ) and his own time ( $t$ ). Where  $h_i$  is the individual production of good health,  $z_i$ , and  $t$  is the set of other commodities purchased by the individual in period for the purpose of producing good health ( $h_i$ ) in  $t$  period and the time ( $t$ ) he spends either earning money to produce ( $h_i$ ) in period  $t$  respectively.

Since the focus is on the macro economy, therefore the production function of the individuals in the economy at a given point in time can be aggregated to obtain the market production function. Equation 1' shows this relation.

$$H_i = H_i(Z_i T_i) \dots\dots\dots 1'$$

Where  $H_i = (H_{0i}, H_{1i}, H_{2i}, \dots, H_{ni})$ ,  $Z_i = (Z_{0i}, Z_{1i}, Z_{2i}, \dots, Z_{ni})$  and  $T_i = (T_{0i}, T_{1i}, T_{2i}, \dots, T_{ni})$ . Equation 1' is the similar version of equation 1, showing the societal production function of good health using  $Z_{0i} \dots Z_{ni}$  and  $T_{0i}, \dots, T_{ni}$  as inputs. Since it is assumed that the individual is gifted /endowed with initial stock of health ( $H_{0i}$ ) which was inherited or passed on to the individual by their parents. The stock of health will therefore depend on the inputs of the parents on the production of their good health. It can be argued that only healthy and viable parents (in terms of resources and physical well-being) can produce healthy offspring. Therefore, it can be said that the initial health ( $H_{0i}$ ) of the offspring at birth will depend on the state of health of the parents. Given this assumption therefore, the initial stock of health of the individual at birth will therefore follow the same pattern with equation 1, and if a generation of offspring born in the society at any point in time is considered, the initial stock of health will be similar to equation 1'.

Following Grossman, the initial stock of health tends to depreciate over time at an increasing rate and can be increased by investment in healthcare or demand for healthcare. Importantly, mortality will occur when the stock of health of the individual  $H_i$  falls below a certain level. This happened where there is no investment or fall in investment in healthcare. This result is presented in equation 2.

$$H_i = H_{min} \dots\dots\dots 2$$

Since our interest is to derive MM, thus from equation 2, Mortality ( $M$ ) of the  $i^{th}$  individual can be equal to  $H_{min}$  such that

$$M_i = H_{min} = H_i \dots\dots\dots 3$$

Equation 3 states that mortality is equal to the minimum stock of health that is needed or required for the survival of the individual. From the foregoing, mortality of the  $i^{th}$  individual ( $M_i$ ) is equal to the stock of health of the  $i^{th}$  individual ( $H_i$ ) at the minimum stock of health of the individual ( $H_{min}$ ). This is given by equation 4.

$$M_i = H_i \dots\dots\dots 4$$

By implication, mortality equation is a function of the stock of health of the individual at a given time period, vice versa.

$$M_i = M(H_i) \dots\dots\dots 5$$

The time path of life, which is the rate of change in the stock of health over time is equal to zero. That is,

$$\frac{\partial H_t}{\partial t} = 0 \text{ (the case of homogenous function)}$$

At the level of the society, Equation 3 can only occur when the economy or society does not invest in the health sector. Investment in the health sector is very critical for the survival of the individuals in the society as well as the productive capacity of the economy. This means that investment in the health sector is not only important to the general health of the populace but also to the growth and development of the economy. Unhealthy population cannot contribute to market and non-market sector of the economy, thus the economy will be unhealthy. Hence Grossman stated that the length of life (time path of life) of the individual depends on the quantities of stock of health ( $H_t$ ) that the individual maximises subject to production and resource constraints.

In this regard, Grossman paid serious attention to investment in healthcare by stating that net investment in stock of health equals gross investment less depreciation. This relation is shown in equation 6.

$$H_{t+1} - H_t = I_t - d_t H_t \text{ .....6}$$

Where  $I_t$  is gross investment,  $H_{t+1}$  is the stock of health in period  $t + 1$ ,  $d_t$  is the rate of depreciation in period  $t$ . Note that the rate of depreciation ( $d_t$ ) tends to vary with the age ( $A_t$ ) of the individual, such that

$$d_t = \delta(A_t), \frac{\partial d_t}{\partial A_t} < 0, \lim_{t \rightarrow 0} d = 0 \text{ .....7}$$

Rearranging equation 6, gross investment is given as

$$I_t = H_{t+1} - H_t + d_t H_t \text{ .....8}$$

Equation 8 shows how investment in healthcare relates to the stock of health of the individual. Thus the rate of depreciation is assumed to be exogenous. To maintain or keep the stock of good health ( $H$ ) from decreasing, the individuals need to invest in good health by investment in healthcare and producing other commodities that are needed to keep  $H$  constant or increasing. Going by this, equation 9 shows the investment production function needed to keep  $H$  constant or increasing. Grossman stated his health investment function to depend on a set of inputs such as medical care ( $\bar{M}$ ), time input ( $T$ ) and the stock of human capital ( $E$ ) which can be taken as the level of education.

$$I_t = I(\bar{M}_t, TH_t, E_t) \text{ .....9}$$

To Grossman, the level of education or stock of human capital is very critical not only to the production of good health but also to the production of health investment. The importance of income to health investment can be emphasized at this point. All the inputs stated in equation 9 depend on the level of income. Also, in macroeconomic literature, income is a significant determinant of investment. Thus, following income theory of investment and Donald (1991), equation 9 can be modified to include income as input.

$$I_t = I(\bar{M}_t, TH_t, Y_t, E_t) \text{ .....10}$$

Where  $Y_t$  is the income of the individual or the society at period  $t$ . Grossman also identified the importance of other variables or commodities in the production of good health. The commodities production function is shown in equation 11.

$$Z_i = Z(X_i, T, E_i) \dots\dots\dots 11$$

In equation 11,  $X_i$  is the goods input in the production of commodity  $Z_i$ ,  $T$  is the time spent in the production of  $Z_i$  and  $E_i$  is the stock of human capital needed to produce commodity  $Z_i$ .

Apparently, one input that is common to equation 1, 10 and 11 is time  $T$ . Following Grossman, time function divided into healthy days and sick days will be given as

$$T = T(TG^+, TL^-); \frac{\partial T}{\partial TG} >, \frac{\partial T}{\partial TL} < 0 \dots\dots\dots 12$$

Where  $TG$  is the number of healthy days in a given year and  $TL$  is the amount of time lost in the production of good health, healthcare investment and other commodities due basically to sickness/injuries. Note that time lost to the production of good health entered into the function is negative. Till now inputs functions (equation 11 and 12) necessary to produce good health stated in equation 1 are derived. Next, mortality model using equation 1 to 12 is to be derived.

From equation 9 therefore, the stock of good health will be stated as

$$-H_t = I_t - d_t H - H_{t+1} \dots\dots\dots 13$$

If it is assumed the limit of  $d_t$  to equal zero as  $d_t$  tends to zero at death as  $t$  shown in equation 8, and also at death the stock of health in the next period  $H_{t+1}$  will cease to exist, equation 13 will reduce to

$$-H_t = I_t \dots\dots\dots 14$$

Equation 14 states that gross investment in healthcare is equal to the negative stock of health. Further, substituting for  $T$  and  $I_t$  in equation 11 and 14 respectively from 12 and 10 respectively, will yield equation 15 and 16.

$$Z_i = Z(X_i, TG, TL, E_i) \dots\dots\dots 15$$

$$-H_t = H(\bar{M}_t, TH, Y_t, E_t) \dots\dots\dots 16$$

Equation 4.15 shows that the production of commodity depends on both days of good health ( $TG$ ) and time loss ( $TL$ ) to illness or sicknesses. Given that labour (skill) is a special kind of factor, the state or condition of health is critical to the production process and the contribution to market and non-market sector of the economy.

Therefore, equation 15 and 12 is collapsed into  $1' TG, TL$ .

$$H_t = H_t(X_i, TG, TL, E_t) \dots\dots\dots 17$$

To eliminate  $H_t$  as input on the right-hand side of equation 16, equation 17 is substituted into 16 and this gives equation 18.

$$-H_t = H(\bar{M}_t, TX_i, TG, TL, TE_t, Y_t, E_t) \dots\dots\dots 18$$

Re-writing equation 18 in the form expressed in equation 19 by taking the negative sign to the right.

$$H_t = -H(\bar{M}_t, TX_i, TG, TL, TE_t, Y_t, E_t) \dots\dots\dots 19$$

Therefore, to obtain mortality model (MM), equation 19 is substituted into the right-hand side of equation 4 and this will yield mortality model as shown in equation 20.

$$M_t = -M(\bar{M}_t, TX_i, TG, TL, TE_t, Y_t, E_t) \dots\dots\dots 20$$

Equation 20 states that mortality is a function of input of medical care ( $\bar{M}_t$ ), the time spend producing input of goods ( $X$ , input of healthy days ( $TG$ ), time loss to sickness or injury ( $TL$ ), time spend schooling or increasing the stock of human capital ( $TE_t$ ) and human capital stock ( $E_t$ ). Equation 20 shows that medical care, other goods or time spend producing other goods, healthy days, time spend schooling, income and the level of education enter MM as negative. But note that time loss to injury or sickness was negative as indicated in equation 12. It therefore means that this will enter MM as positive given the negative sign. The MM has shown the importance of time in maternal mortality. For example, time spend considering whether to attend pre and postnatal care, to deliver in hospital or at home or other traditional care, to attend a given health institution/centre or not, and so on, has a grave implication for maternal mortality rate.

Furthermore, equation 20 can be expressed in its scalar form as stated in equation 21

$$m = -m(\bar{m}_1, \bar{m}_2, \dots, \bar{m}_n; tx_1, tx_2, \dots, tx_n; tg_1, tg_2, \dots, tg_n; tl_1, tl_2, \dots, tl_n; te_1, te_2, \dots, te_n; y_1, y_2, \dots, y_n; e_1, e_2, \dots, e_n) \dots\dots\dots 21$$

Where  $m$  is the individual mortality,  $\bar{M} = (\bar{m}_1, \bar{m}_2, \dots, \bar{m}_n)$ ,  $TX = (tx_1, tx_2, \dots, tx_n)$ ,  $TG = (tg_1, tg_2, \dots, tg_n)$ ,  $TL = (tl_1, tl_2, \dots, tl_n)$ ,  $TE = (te_1, te_2, \dots, te_n)$ ,  $Y = (y_1, y_2, \dots, y_n)$ ,  $E = (e_1, e_2, \dots, e_n)$  and  $n$  represents numbers of variables in each sub-group. Given this scalar form of equation 20, equation 21 is transformed into explicit form by forming a probability density function for the variables  $m, tx, tg, tl, te, y$  and  $e$  using calculus. This will result in equation 22.

$$m = -\Pi \bar{m}_i^{\alpha_i} \Pi tx_i^{\beta_i} \Pi tg_i^{\gamma_i} \Pi tl_i^{\theta_i} \Pi te_i^{\rho_i} \Pi y_i^{\tau_i} \Pi e_i^{\phi_i} \dots\dots\dots 22$$

Where  $\alpha_i, \beta_i, \gamma_i, \theta_i, \rho_i, \tau_i$  and  $\phi_i$  are elasticities and  $\Pi$  is the probability density function. Taking the logarithm of equation 22 and rearranging terms will yield equation 23.

$$\ln M = -\sum \alpha_i (\ln \bar{m}_i) - \sum \beta_i (\ln tx_i) - \sum \gamma_i (\ln tg_i) + \sum \theta_i (\ln tl_i) - \sum \rho_i (\ln te_i) - \sum \tau_i (\ln y_i) - \sum \phi_i (\ln e_i) \dots\dots 23$$

Where ( $i = 1, 2, 3, \dots, n$ ),  $\sum$  is a summation operator which adds up all the factors within each scalar variable and  $\ln$  is natural logarithm. In actual sense equation 23 can be interpreted as health outcome model as a function of socio-economic factors. On the whole, equation 23 is the fundamental equation used in this study.

Therefore, modifying equation 23 to add other socio-economic variables and health variables, the model for estimation in log-linear form is expressed in equation 24 as:

$$\ln MMR_{it} = \alpha_{0i} + \alpha_{1i} \ln MMR_{it-1} + \alpha_{2i} \ln LFPR_{it} + \alpha_{3i} \ln LTRM_{it-1} + \alpha_{4i} \ln HPC_{it-1} + \alpha_{5i} \ln GNI + \alpha_{6i} \ln FR_{it-1} + \alpha_{7i} \ln PHIV_{it} + \alpha_{8i} \ln FEMP_{it} + \alpha_{9i} \ln EDU_{it-1} + \mu_{it} \dots\dots\dots 24$$

$i = 1, 2, \dots, N$ , and  $t = 1, 2, \dots, T$ . We would expect  $\alpha_{1i}, \alpha_{3i}, \alpha_{6i}, \alpha_{7i} > 0$ ;  $\alpha_{2i}, \alpha_{4i}, \alpha_{5i}, \alpha_{8i}, \alpha_{9i} < 0$ .

Where  $MMR_{it}$  is maternal mortality rate of country  $i$  at time  $t$ , the dependent variable. Explanatory variables-  $LFPR_{it}$  is female labour force participation rate of country  $i$  at time  $t$ ,  $LTRM_{it-1}$  is previous level of life time risk of maternal mortality of country  $i$  at time  $t$ ,  $HPC_{it-1}$  is previous level of health care investment of country  $i$  at time  $t$ . This is measured in terms of per capita health expenditure.  $GNI_{it}$  is gross national income per capita of country  $i$  at time  $t$  which is used as a measure of standard of living of the individual,  $FR_{it-1}$  is previous fertility rate level of country  $i$  at time  $t$ ,  $PHIV_{it}$  is the HIV/AIDs prevalence,  $FEMP_{it}$  is Female employment used as proxy for social status of women in country  $i$  at time  $t$  and  $EDU_{it-1}$  is previous level of education of country  $i$  at time  $t$ .

## Method of Data Analysis and Sources of Data

Obviously, equation 24 is a dynamic auto-regressive distributed lag model due to the existence of lagged endogenous variable on the right hand side of the model and also the existence of individual effects characterizing the heterogeneity among the countries. If ordinary least squared (OLS) estimator is used, it will give rise to biased and inconsistent estimates as argued by previous studies like Baltagi (2008). Therefore, the appropriate estimator is system GMM suggested by Arellano and Bond (1991) and then further advanced by Blundell and Bond (1998). The GMM estimator is generally consistent and asymptotically normal thus suitable for this study compared to the traditional panel estimator of fixed and random effects which ignores simultaneity bias. In addition, the GMM estimator, according to Arellano and Bond (1991) is suitable for linear functional relationship that is dynamic, relying on its own previous realizations and exogenous variables that are not firmly exogenous as well as studies with few time periods and large cross sectional units. Also, GMM is elegant and robust in the case of missing data, reverse causality and simultaneity bias. GMM is closely related to economic theory and the data are purely used to produce estimate of the parameters involving minimum statistical assumptions and less attention is paid to the fit of the model.

Basically, two specification tests are adopted by this study as offered by Arellano and Bond (1991), and Blundell and Bond (1998). They are the test for the existence of first and second order serial correlation in the error term or the disturbances, and the test to establish the validity of the instruments. Prior to GMM estimation, panel unit root tests would be conducted for all the variables using both homogenous and heterogeneous unit root tests suggested by Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) respectively. These techniques to unit root tests were applied recently by Izilein and Osemwengie (2017), and Shaibu and Osemwengie (2017).

The study employs panel data analysis for 43 selected SSA countries from 1995 to 2015. This period is chosen because of the availability of data and the period also coincides with the introduction and the termination of MDGs. Though the benchmark of MDGs was 1990, but data for some of the socio-economic variables (for instance government per capita expenditure on health) are not available between 1990 and 1994. Hence the choice of 1995 to 2015. The World Bank Development Indicator 2016 was used as source of data for the study.

## Analysis of Regression Results

### Results of Panel Unit Root Tests

Table 1 presents the panel unit root tests results in logarithm. The tests were conducted using distinct effects and linear trends. The unit root results suggest that all the variables are unit root free (stationary) at level using the LLC test under common unit root process at 5 per cent level of significance and thus reject the presence of a unit root. However, under the distinct unit root process using IPS test, the results show that four variables (LMMR, LLTRM, LGNI and LEDU) out of nine, had unit roots at level. After first difference, they became unit root free and difference stationary at 1 per cent level of significance. Therefore, the presence of a unit root in the variables is rejected.

**Table 1. Panel Unit Root Tests of Variables**

Variables	Homogenous Unit Root Process (LLC)		Heterogeneous Unit Root Process (IPS)	
	Stat. & Significant Level	Remark	Stat. & Significant Level	Remark
LMMR	4.29***	Stationary	4.90	Non-Stationary
LHPC	-1.77**	Stationary	-3.57***	Stationary
LLFPR	-1.88**	Stationary	-2.17***	Stationary
LLTRM	-3.18***	Stationary	-0.04	Non-Stationary
LGNI	-3.66***	Stationary	-0.39	Non-Stationary
LFEMP	-2.66**	Stationary	-3.99***	Stationary
LFR	-30.49***	Stationary	-43.11***	Stationary
LEDU	-2.30**	Stationary	1.63	Non-Stationary
LPHIV	-6.37***	Stationary	-6.55***	Stationary
<b>@ First Difference</b>				
DLMMR			-2.41***	Stationary
DLGNI			-15.94***	Stationary
DLLTRM			-3.74***	Stationary
DLEDU			-3.35***	Stationary

Note: \*, \*\* and \*\*\* show statistical significance at 10 per cent, 5per cent and 1per cent levels respectively. L= logarithm.

Source: Author's estimation using Eviews 9.

## Discussion of the one-step GMM Empirical Results

The difference system GMM model proposed by Arellano and Bond's dynamic panel data estimator was used to investigate the impact of the selected socio-economic variables on maternal mortality (LMMR) in SSA. The model is practically useful for- linear functional relationship that is dynamic, in the case of missing data which was a major feature of some of the variables used in the analysis and especially, the case of simultaneity bias. Generally, GMM estimator are known to produce coefficients that are consistent and asymptotically normal. Table 2 reports the system GMM results.

**Table 2. Panel GMM Results: LMMR as Dependent Variable**

Variable	Coefficient	Standard Error	t-Statistic	Probability
LMMR(-1)	1.329508	0.084562	15.72227	0.0000
LLFPR	0.212934	0.086872	2.451115	0.0146
LLTRM(-1)	-0.530187	0.096481	-5.495243	0.0000
LHPC	-0.019879	0.011525	-1.724875	0.0852
LGNI	-0.009616	0.008905	-1.079850	0.2808

LPHIV	0.025126	0.010780	2.330870	0.0202
LFEMP	-0.130351	0.065943	-1.976706	0.0487
LFR(-1)	0.562341	0.125538	4.479442	0.0000
LEDU(-1)	-0.025364	0.010546	-2.405115	0.0165
<b>Effects Specification</b>				
Mean Dependent Variable		-0.018540	S.D. dependent variable	0.044070
Standard Error of Regression		0.027752	Sum squared residual	0.365051
J-statistic		1.084940	Instrument rank	182
Probability (J-statistic)		0.224302		

Source: Author's estimation using Eviews 9

**Table 3. Arellano-Bond Test Results (Serial Correlation)**

Test Order	M-Statistic	Rho	SE(Rho)	Probability
AR(1)	-5.554221	-0.097418	0.017539	0.0000
AR(2)	0.051722	0.000830	0.016045	0.9587

Source: Author's estimation using Eviews 9

Generally, from the results in Table 2, it can be deduced that all the variables (LLFPR, LLTRM, LHPC, LPHIV, LFEMP, LFR and LEDU) are significant determinants of maternal mortality in SSA at 5 per cent level of significance (except LGNI). Interesting outcomes are obtained with regards to the individual variable in terms of signs and magnitudes. For instance, LLFPR has a positive significant impact on LMMR at 1 percent level of significance. In this direction, 1 per cent increase in LLFPR will cause LMMR to rise by 21 per cent. However, the positive sign of LLFPR may not be acceptable a priori. While it has been established in literature recently (for instance, Albanesi & Olivetti, 2016) that improvement or reduction in maternal mortality led to increase in female labour supply, the reverse relationship has not been given more empirical evidences. Intuitively, it is expected that increase in female labour participation would lead to improvement in maternal health particularly maternal mortality given that low fertility and increase in maternal health education are associated with female labour force participation. Therefore, the explanation for the unexpected sign obtained from the empirical result may be attributed to lack of time for maternal care by pregnant women or lack of preventive or avoidable measures during pregnancy before delivery. Other factors such as the hazard of labour supply, work inflexibility or poor working conditions, the inclusion of a particular country in the group of SSA, and so on, could explain the reason for the positive sign.

The log of lagged life time risk of maternal mortality (LLTRM (-1)) proved to be significant determinant of LMMR at 1 per cent level of significance as displayed in Table 2. Another interesting finding is the log of per capita health expenditure (LHPC) as a proxy for health investment which indicates significant negative impact on LMMR, and in line with theory. From the results, 1 per cent increase in health investment will lead to reduction in maternal deaths by 1 per cent at 5 per cent level of significance. The results have shown that capital investment in the health sector is not only critical in reducing maternal deaths but also improving maternal health generally.

Furthermore, the log of female employment (LFEMP), proxy for social status of women and gross secondary school enrolment (LEDU (-1)), proxy for education investment both revealed to be significant negative determinants of maternal mortality in SSA in the results in Table 2. Both variables had the expected signs. On the basis of magnitude, LMMR would improve or reduce if LFEMP increases by 13 per cent. In the same vein, increasing previous investment in education would lead to fall in LMMR in the current period by 2 per cent. This finding underscored the importance of investment in education as indicated by Grossman (1972) in his model.

HIV prevalence among pregnant women has been estimated to affect maternal mortality in the SSA region (Novigon, Olakojo & Nonvignon, 2012). The findings from this study has underscored this position. From the result in Table 2, it was observed that LPHIV has a positive significant impact on LMMR. 1 per cent rise in LPHIV will cause LMMR to increase by 2 per cent at 5 per cent level of significance. This result is in line with the evidence obtained by Novigon et al. (2012), where they estimated both the random and fixed effects models and observed that HIV prevalence leads to higher crude deaths and mortality rate in SSA. Thus, HIV prevalence not only increases mortality rate but also contributes to poor health outcomes. Another important variable that affected maternal mortality is fertility rate. In this study, it was observed that fertility rate impacts significantly on maternal mortality at 5 per cent level of significance. Based on the results reported in Table 2, 1 per cent rise in previous fertility rate would lead to 56 per cent increase in the current level of maternal mortality in SSA.

Overall, one of the variables that proved to be weak determinant of LMMR in SSA, is gross national income per capita. This result collaborates the finding of Lalthapersad-Pillay and Udjo (2014), where they observed weak correlation between GNI per capita and maternal mortality. In addition, the result is also in support of the finding of Akinkugbe and Afeikhena (2006), which concluded that per capita income is not a significant determinant of health status in SSA. This result however contradicts the finding of Alvarez, Gil, Hernandez and Gil (2009) who concluded that GNI per capita is significantly inversely related to maternal mortality. Though the association between LGNI and LMMR yielded negative outcome as prescribed by theory, but the insignificance of the variable may be attributed to the nature of the data employed or the inclusion of a particular country in SSA into the sample. Thus, further empirical work is needed in this area to further strengthen the existing evidence. It can be noted in the results also that the lagged of the log of the dependent variable (LMMR (-1)) has a significant positive effect on the current level of LMMR such that 1 per cent rise in previous LMMR will worsen the present level of LMMR by 132 per cent at 1 percent level of significance.

Clearly, the hypothesis of over-identifying restrictions are valid and cannot be rejected given the J-probability value of 0.22 reported in the results (Table 2). This suggests that the instruments used in the study are valid. More so, the Arellano and Bond statistics probability values for the first and second serial correlation are apparently in order (Table 3). The tests show that the first order statistics (p-value = 0.00) is statistically significant, while the second order statistic (p-value=0.95) is not statistical significant, which is what is expected if the model error terms are serial uncorrelated in levels. Overall, the general diagnostic results are robust as reported in Table 2 and 3.

## Conclusion

The study has investigated the socio-economic determinants of maternal mortality in SSA for a panel of 43 countries over the period of 1995 – 2015. Importantly, the application of sys-GMM estimation techniques was a novel feature of the current study. The sys-GMM results showed

strong evidence in support of the impact of per capita health expenditure, fertility rate, female labour force participation, female employment, prevalence of HIV, life time risk of maternal mortality and education on maternal mortality in SSA.

So far, the most important contributions of the current study is the significant impact on maternal mortality demonstrated by all the variables used in the estimation. Clearly the results suggested that all the variables except LGNI are significant determinants of LMMR in SSA. The SSA region has the lowest gross national income per capita if compared to the other regions in the world. Also, poverty is quite high in the region and this may explain the weak performance of the LGNI variable. The policy focus should be on alleviating poverty and inequality gaps (income, HDI, etc) rocking the region in addition to improving quality of education in general, healthcare system, women status and the control of fertility rate in the region.

Significantly, the study is coming at the time when the sustainable development goals (SDGs) was recently launched. The overall findings of the study will therefore be useful for policy interventions in SSA particularly the target to make sustainable progress in the SDG-5 of reducing maternal deaths by 75 percent before 2030.

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