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Traditional Pooled Data Estimates of the Socio-economic Determinants of Maternal Mortality in sub-Saharan Africa: Case Study of MDG Era

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Abstract. The study focuses on the socio-economic determinants of maternal mortality in SSA with the broad objective of investigation the contributions of selected socio-economic factors to maternal deaths in the region. A panel of 43 countries in sub-Saharan Africa based on data availability covering the MDG era (1995-2015) was cautiously analyzed using the traditional pooled panel estimators (fixed and random effects). This generated remarkable elasticity estimates valuable for policy intervention. The fixed and random effects results revealed a profound contributions of socio-economic variables to maternal mortality in SSA. Log of labour force participation rate for women, the log of one period lag of life time risk of maternal mortality, log of female employment rate, log of per capita health expenditure, log of fertility rate all proved to be significant determinants of maternal mortality in SSA. In addition, the log of HIV prevalence among women and the log of one period lag of secondary school enrolment as a proxy for education also demonstrated to be significant determinants of maternal deaths. Only GNI per capita showed a weak relationship with maternal mortality. This means that GNI may not be useful significantly when policy measures are taken to address maternal deaths in SSA.

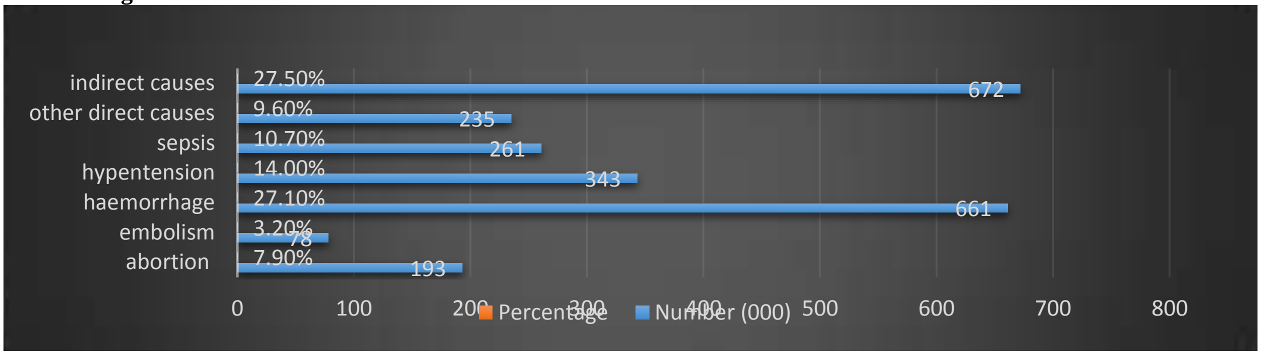
Keywords: Traditional pooled data estimator, socioeconomic variables, MDG era, SSA

1. Introduction

Globally, 830 women died every day due to complications of pregnancy and childbirth (WHO, 2015). Most of these deaths which could have been prevented happened in most of the less developing countries. Of these deaths which occurred every day in the world, about 550 deaths occurred in SSA daily and this represents about 66.3 per cent of the global deaths that occurred daily in the world compared to 180 that occurred daily in Southern Asia and 5 daily in developed countries (WHO, 2015). According to the most current estimate by WHO (2019), SSA was the only region in the world with high MMR for 2017, estimated at 542 with lifetime risk of maternal death being 1 in 37, compare with just 1 in 7800 in Australia and New Zealand. The estimated maternal deaths for the SSA region in 2017 was estimated at 196 000 deaths, representing 66 per cent of the global deaths (254 000). Given this development, continuous efforts have been made by governments, sub-regional governments, health experts and health agencies and organisations (for instance, WHO, UNICEF, UNIFPA, UN, WORLD BANK), to reduce maternal deaths in the world. One of the outcomes of these efforts was the commitment to reduce maternal mortality ratio to less than 70 per 100 000 live births by 2030. Apparently, some efforts was made in this direction by reducing MMR by 5 per cent in the MDG era while a significant decline of 38 per cent globally was recorded between 2000 and 2017 (UNICEF, 2019).Thus, if further progress must be made and sustained toward achieving less than 70 per 100000 live births between 2015 and 2030 globally with specific focus on SSA, the first step is to identify the causes of maternal deaths in the region and address the underlying issues specifically.

Several scholars (for instance, Say, et al, 2014; WHO, 2015 & 2019) have identified several factors to be responsible for the global causes of maternal deaths. The main causes of death are haemorrhage, hypertension, sepsis, abortion, embolism and indirect causes due mostly to the interaction between pre-existing medical conditions and pregnancy. In Figure 1, the global distribution of the causes of maternal deaths in 2014, haemorrhage accounts for the leading causes of maternal deaths globally. Statistically, about 661 maternal deaths occurred as a result of haemorrhage and this represents about 27.1 per cent of the global causes of maternal deaths.

Figure 1: Global distribution of the causes of maternal death in 2014



Source: Author's computation using data from the study of Say,Chau, Gemmill, Tuncalp, Moller, Daniels, Gulmezoglu, Temmerman and Alkema (2014).

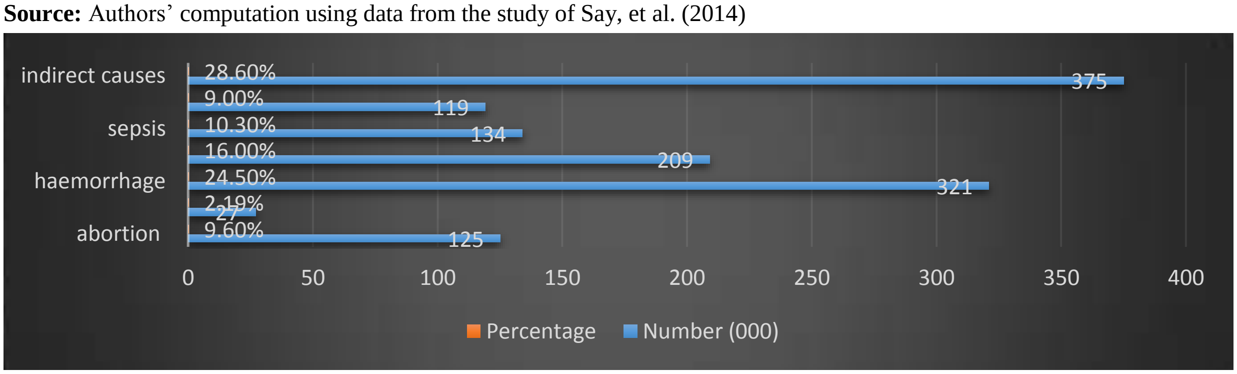
Following closely on the global causes of maternal deaths in Figure 1 is hypertension. In 2014, about 343 maternal deaths was as a result of hypertension and this represent about 14 per cent of the total number of maternal deaths globally. Sepsis, embolism, abortion and other direct causes (including deaths due to obstructed labour or anaemia) account for 10.7, 3.2, 7.9 and 9.6 per cent respectively for the global causes of maternal deaths worldwide. More worrisome is the number of maternal deaths that occurred indirectly. In Figure 1 still, about 672 maternal deaths occurred due to indirect causes and this represent about 27.5 per cent of the global causes of maternal deaths.

1.1 Distribution of the causes of maternal deaths in SSA

Figure 1 showed clearly the global distribution of maternal deaths in the world. Given that SSA countries are severely affected by maternal deaths globally followed by South Asia, it is therefore pertinent to know the distribution of maternal deaths to the regions particularly SSA where the burden is more acute. Figure 2 shows the distribution of the causes of maternal deaths in SSA. In the figure, indirect causes of maternal deaths account for the highest causes in SSA unlike the global distribution in Figure 1. About 28.6 per cent of maternal deaths that occurred in SSA was as a result of indirect causes. Here is where the target should be if the problem of maternal deaths must be addressed. Hence, this research is focused in this direction, particularly with the onus of identifying these factors (socio-economic) and providing policy interventions and health programme decision to support medical intervention in reducing the burden of maternal deaths in SSA. From Figure 2, haemorrhage still accounts for the leading medical causes of maternal deaths in SSA about 16 per cent. This is followed closely by hypertension, other direct cause and sepsis. This figure revealed that hypertension is a silent killer. About 16 per cent of maternal deaths in SSA was due to hypertension. Embolism accounts for the lowest causes of maternal deaths in SSA with about 2.19 per cent. More interesting is the statistics in figure 2, it shows the number of maternal deaths that occurred as a result of unsafe abortions. This accounted for about 9.6 percent of maternal deaths in SSA compared to the percentage in Figure 1.

Figure 2: Distribution of the causes of maternal death in SSA countries

Source: Authors' computation using data from the study of Say, et al. (2014)



A critical look at figure 2 reveals some interesting facts about SSA distribution of maternal deaths. Apparently, most of the leading causes of deaths are avoidable like haemorrhage, hypertension, embolism, sepsis and abortion, if proper medical interventions and health programmes and policies are in place especially for the rural areas. Thus understanding the causes of deaths are key requirement for further progress in the reduction of maternal deaths particularly in SSA. Hence, the study was motivated to identify the underlying socio-economic factors affecting maternal mortality in SSA using panel data analysis. The study focuses specifically on the MDG era with the overall objective of identifying critical non-medical factors but limited to socio-economic variables. The knowledge of the interaction of these variables with maternal mortality ratio would assist to provide appropriate economic policy to tackle MMR reduction. As strong motivation for the study, aside from contributing to extant literature in the case of SSA, the study creates an avenue for further understanding of the interaction between socio-economic variables and MMR, making this highly useful particularly for policy makers of the region; thus complements the efforts towards the development of effective and efficient intervention policies within the region. The findings from the study will be very useful (complementing medical interventions) in providing policy direction and guild in achieving the target of less than 70 live births per 100,000 by 2030. It therefore seeks to fill a clear gap.

The study is divided into four sections. Section one addresses introductory issues relating to maternal deaths and health, material and methodology are discuss in section two. Section three highlights analysis of regression results while conclusion and recommendations are place in section four.

2. Material and Methodology

2.1 Material

Sub-Saharan Africa is the region of Africa that is situated south of the Saharan desert. It consists of 48 African countries that are fully or partially located south of the Saharan. In 2015, the population of the SSA region was about 800 million (World Bank, 2015). The current growth rate of the population is 2.3 per (UN, 2015). The UN projected a population size between 1.5 and 2 billion for the region by 2050 with a population density of 80 per km^2. More than 40 per cent of the population in SSA are below 15 years of age (World Bank 2015). This perhaps explains one of the reasons for the high maternal deaths in the region particularly due to the incidences of under-age pregnancy and illegal abortions. The Gross National Income (GNI) of the region stood at 102,185.3billion US Dollars in 2015 (World Bank, 2015) based on purchasing power parity (PPP). With 14.5 per cent population living below 1.25 Dollars a day (World Bank, 2015), the economic activity in the region appeared to be slow and growing gradually. In 2015, economic activity in sub-Saharan Africa fell to its lowest level in some 15years and output expanded only by 3.4 percent, just a little above population growth in the region (IMF, 2016).

Sub-Saharan Africa is one of the regions of the world that is confronted with several challenges. This range from political, socio-cultural, economic issues and health outcomes. Particularly with respect to health issues, many countries in SSA (like Nigeria, Malawi, Uganda, and Mozambique for instance) still have to combat with malaria, tuberculosis, HIV/AIDS, infant and child mortality and a host of others. Also healthcare services in the region is one of the poorest in the world. For instance, according to DSW (2016), many countries such as Ethiopia, Malawi and Mozambique in SSA do not have one trained physician available for every 10,000 inhabitants. Also, in 27 countries of SSA every tenth child dies before getting to fifth birthday. This account for the high rate of child mortality in the region thus medical care is very poor in SSA.

Furthermore, the region is one of the poorest in the world in terms of per capita income (UN, 2015), and 72 percent of the population of SSA lives in less than US$ 2 a day DSW (2016). According to Oriakhi, Osemwengie and Amaechi (2014), SSA and almost African countries have seen monumental surge in the level of poverty recently, and this is very alarming. Table 1 in appendix shows the relationship between some socio-economic indicators and maternal mortality rate in SSA in 2015. Several studies (for example, Case, Lubotsky, and Paxson 2002) has showed that high socio-economic status are related to better health. In the Table, Nigeria has a GDP of 1105343 USD-the highest in 2015, with annual real GDP growth of 6.0 between 2007 and 2015. Sao Tome Principe has the lowest GDP of 664 USD with 4.5 annual growth rate between 2007 and 2015. In truth, the income of a country-measured by her GDP relates with the condition of her maternal health because the size of her GDP determines the proportion of resources allocated to the health sector. In developing countries, particularly SSA countries, the proportion of income allocated to the health sector is a far-cry from the WHO Standard projection of 15% of the annual budget. Hence, why maternal mortality and other health problems still remain very high. Total fertility-the average number of children per women- has some correlation with maternal mortality rate. High fertility rate may lead to high maternal deaths especially in developing countries where standard health facilities and trained medical personnel are seriously inadequate.

The gender development index (GDI) and human development index (HDI) are critical indicators of development of a society and the individual. SSA still has the lowest indicator in the world. High GDI and HDI indicate high level of development. These indicators are closely connected to the health sector or system as well as maternal mortality. Low GDI/HDI may be associated with high mortality rates vice versa. This may also explain why maternal mortality rates are significantly low in advanced/developed world compared to low income/less developing countries. For example, SSA countries where the burden of maternal mortality is seriously acute in the world is a developing region. This understanding is necessary to give policy makers/government agencies in this region a sense of direction in reducing maternal mortality by improving the well-being of their society through infrastructural development and other development indicators. Table 1 also shows the country adult female literacy rate and maternal mortality in SSA. Female literacy especially between the ages of birthing is critical for maternal mortality. SSA region still has the lowest adult female literacy in the world and this has serious implication for maternal mortality.

2.2 Cross-Sectional Analysis of Maternal Mortality Ratio in SSA Countries between 1990 and 2015, and MDG goal 5 achieved.

This section review the cross-sectional analysis of MMR in SSA countries between 1990 and 2015 as well as the progress made toward achieving MDG-5. The estimates and the progress made to achieve MDG-5 by all the SSA countries are reported in Table 2 in Appendix. Of all the 50 SSA countries, data were not available for 4 of the SSA countries- Cape Verde, Reunion, Seychelles and Western Sahara for the periods. From Table 2, Sierra Leone led the top chart of SSA countries with the highest maternal deaths in 1990 and this was estimated approximately at 2630 deaths per 100,000. In 2000, the figure rose to 2650 maternal deaths and later drop to 1360 in 2015 with annual average percentage change in MMR between the periods (1990 – 2015) being 2.6%. This was closely followed by Eritrea, Liberia, Chad, Mozambique and Nigeria with Maternal deaths estimates of 1590, 1500, 1450, 1390 and 1350 respectively in 1990. Thus, the top ten countries with the highest maternal deaths in 1990 were Sierra Leone, Eritrea, Liberia, Chad, Mozambique, Nigeria, Equatorial Guinea, Rwanda, African Republic and Ethiopia. On the bottom of the Table, Mauritius, South Africa and Botswana have the lowest maternal deaths in 1990 and Mauritius being the least SSA countries with maternal deaths of 81 in 1990.

In 2005, the estimate was slightly different given the need for countries to reduce maternal deaths by 75% in line with the target of achieving MDG-5 before 2015. Sierra Leone top the table with an estimated maternal deaths of 1990, followed by Chad, Central African Republic, Liberia, Nigeria and Somalia which had maternal deaths estimates of 1170, 1060, 1020, 946 and 939 respectively in 2005. On the bottom of the Table, Mauritius occupied the country in SSA with the least maternal deaths estimate of 39 in 2005. However, 2015 was very critical, since it marked the end of the MGD targets particularly MGD-5. According to WHO (2015), Nigeria and India were estimated to account for over one third of all maternal deaths worldwide in 2015, with an approximate 58 000 maternal deaths (19%) and 45 000 maternal deaths (15%), respectively. Sierra Leone was estimated to have the highest MMR at 1360 with 2.6 % annual average percentage change in MMR between 1990 and 2015. Despite the desire to achieve, MDG-5 in 2015 by reducing maternal mortality ratio by 75%, SSA countries still had the highest MMR in the world. Apparently, eighteen sub-Saharan Africa countries was estimated to have very high MMR in 2015, with estimates ranging from 999 down to 500 deaths per 100 000 live births: Central African Republic (881), Chad (856), Nigeria (814), South Sudan (789), Somalia (732), Liberia (725), Burundi (712), Gambia (706), Democratic Republic of the Congo (693), Guinea (679), Côte d'Ivoire (645), Malawi (634), Mauritania (602), Cameroon (596), Mali (587), Niger (553), Guinea-Bissau (549) and Kenya (510), WHO (2015).

Furthermore, in 2015, WHO identified two countries with the highest estimated lifetime risk of maternal mortality in the world, and these countries are found in SSA. The two countries are: Sierra Leone with an approximate risk of 1 in 17, and Chad with an approximate risk of 1 in 18. The estimated lifetime risk of maternal mortality in high-income countries was given as 1 in 3300 in comparison with 1 in 41 in low-income countries (WHO, 2015). Also, WHO (2015) opines that in sub-Saharan Africa, 2.0% of all maternal deaths are estimated to be AIDS-related indirect maternal deaths, yielding an AIDS-related indirect MMR of 11 maternal deaths per 100 000 live births. In 2015, five countries: South Africa (32%), Swaziland (19%), Botswana (18%), Lesotho (13%) and Mozambique (11%), all in SSA were reported by WHO to have 10% or more of maternal deaths estimated to be AIDS-related indirect maternal deaths.

Looking at the average annual percentage change in MMR between 1990 and 2015 vis-a-vis the progress made toward achieving MDG-5, Table 2 in Appendix shows that little or no progress was made on the whole. At the level of country, Rwanda was the only country in SSA that achieved MDG-5 of reducing maternal mortality rate by 75% in 2015. The country had 77.7% change in MMR between 1990 and 2015 with an average annual percentage change of 6.0 in MMR between 1990 and 2015. On the global level, nine countries were categorized by WHO (2015) to have achieved MDG-5A including Rwanda: Bhutan, Cambodia, Cabo Verde, the Islamic Republic of Iran, the Lao People's Democratic Republic, Maldives, Mongolia and Timor-Leste. Furthermore, based on MMR reduction point-estimates and uncertainty intervals between 1990 and 2015, WHO categorized 39 countries under MDG region as "making progress" and this include 11 countries in SSA: Angola, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Madagascar, Mozambique, Sudan, Tanzania, Uganda and Zambia with an average annual percentage change in MMR between 1990 and 2015 of 3.5%, 3.3%, 5.4%, 4.6%, 5.0%, 3.2%, 4.2%, 3.5%, 3.7%, 2.8% and 3.8% respectively.

On the category of "insufficient progress", WHO categorized 21 countries in the globe to have made insufficient progress in the achievement of MDG-5A. Of this number, 16 countries including Chad, Botswana, Sierra Leone, Ghana and Burkina Faso are in SSA. Leaving only 5 to the other region of the world. Finally, 26 countries were categorized as having made "no progress" globally. 16 out of these numbers fall under SSA. This include Nigeria, South Africa, Kenya, Gambia, Zimbabwe, Swaziland, Lesotho, Malawi, Congo Brazzaville, Congo Democratic Republic, Cameroon, Benin, Cote d'Ivoire, Central Africa Republic, Gabon, Mauritania and Namibia, and all of them having an average annual percentage change in MMR between 1990 and 2015 of less than 2.1%.

In a nutshell, from the overall statistics, it is very apparent that more effort should be made to address Maternal deaths in SSA particularly if the Sustainable Development Goal (SDG) target of a global MMR below 70 will be achieved between 2015 and 2030, and this will require reducing global MMR by an average of 7.5% each year between 2015 and 2030. Specifically, this will also require more than three times the 2.3% annual rate of reduction observed globally between 1990 and 2015 (WHO, 2015).

Table 1: Estimate of Some Selected Socio-Economic Indicators and Maternal Mortality Rate in SSA Countries in 2015.

Country	**GDP (PPP) USD 2015**	**Annual real GDP growth (average over 2007-15)**	**Maternal mortality Rate 2015**	**Adult female literacy Rate (%) 2010-15 (Pop. over 15)**	**Total fertility rate (Per women) 2015**	**Fertility rate by age (15-64) % 2015**	**HDI 2015**
Angola	185246	6.2	477	60.7	6.0	50.0	41
Benin	21156	4.5	405	27.3	4.7	55.0	47
Botswana	37160	4.7	129	88.9	2.8	64.4	91
Burkina Faso	31184	5.9	371	29.3	5.4	52.0	60
Burundi	7882	3.4	712	83.1	5.9	52.7	61
Cameroon	72109	4.1	596	68.9	4.6	54.3	65
Cape Verde	3479	3.0		83.1	2.3	65.8	88
Central African Republic	3052	-1.4	882	24.4	4.2	57.1	33
Chad	32003	5.0	856	31.9	6.1	49.8	24
Comoros	1214	1.7	335	73.7	4.4	56.9	72
Congo (Brazzaville)	28919	4.4	442	72.9	4.8	53.7	77
Congo (Democratic Republic)	63266	6.9	693	66.0	5.9	51.0	51
Côte d'Ivoire	78335	4.6	645	32.5	4.9	54.5	57
Djibouti	3093	5.2	229	-	3.1	63.1	67
Equatorial Guinea	25944	6.8	342	93.0	4.7	57.9	68
Eritrea	7939	1.9	501	65.5	4.2	54.6	48
Ethiopia	1602	10.5	353	41.1	4.3	55.1	33
Gabon	34409	4.5	291	81.0	3.8	57.8	75
The Gambia	3269	3.7	706	47.6	5.7	51.5	66
Ghana	113349	6.7	319	71.4	4.1	57.8	67
Guinea	15276	2.2	679	22.8	4.9	54.4	40
Guinea-Bissau	2676	3.3	549	48.3	4.8	56.0	58

Kenya	143051	5.1	510	74.9	4.3	55.3	69
Lesotho	5777	4.7	487	88.3	3.1	49.8	81
Liberia	3781	6.3	725	32.8	4.6	54.7	48
Madagascar	35556	2.6	353	62.6	4.4	55.5	75
Malawi	20558	5.6	634	58.6	5.0	51.4	69
Mali	29151	3.9	587	29.2	6.1	50.0	47
Mauritania	16427	3.7	602	41.6	4.5	56.8	59
Mauritius	24509	4.0	53	88.5	1.5	71.1	98
Mozambique	33726	7.0	489	45.4	5.3	51.3	58
Namibia	24839	4.6	265	84.5	3.5	59.8	90
Niger	18960	5.6	553	11.0	7.6	47.0	42
Nigeria	1105343	6.0	814	49.7	5.6	53.3	59
Rwanda	20321	7.5	290	68.0	3.8	56.2	79
Sao Tome and Principe	664	4.8	156	68.4	4.5	54.3	76
Senegal	36300	3.8	315	43.8	5.0	53.3	65
Seychelles	2533	4.7	-	95.7	2.3	69.7	-
Sierra Leone	9832	5.1	1360	37.7	4.5	55.0	43
Somalia	-	-	732	-	6.4	50.5	9
South Africa	724010	2.3	138	93.1	2.3	65.7	92
Sudan	167421	4.0	311	68.6	4.3	56.2	43
Swaziland	10869	1.9	389	87.5	3.2	59.1	86
Tanzania	138304	6.7	398	75.9	5.1	51.6	65
Togo	10816	4.1	368	85.3	4.5	55.0	41
Uganda	79753	6.5	343	66.9	5.7	59.4	58
Zambia	64647	7.0	224	56.0	5.3	51.2	63
Zimbabwe	27916	3.1	443	84.6	3.9	55.4	77

Note: purchasing power parity (PPP), human development index (HDI)
Sources: Author’s compilation from United Nations and Africa Development Bank (AfDB) Statistical Annex (2015)

2.3 Methodology

2.3.1 The Health Theory

The proponents (Shiffman for instance) of the health theory argue that early interventions in maternal care such as antenatal care, family planning services, safe and legal abortion, trained medical attendants at delivery and emergency obstetric care are of great significance in order to reduce maternal mortality. Shiffman (2000) opined that policy adoption and implementation for public health especially those concerning women’s health will reduce maternal mortality rate. According to Shiffman (2000), the policies will include both information and education of women coupled with the improvements in health care.In this light, Shiffman (2000) added that changes in socio-economic alone will not achieve better health for women, instead, good interventions, priorities and policies in maternal health will make positive impact in the reduction of maternal mortality.

In line with the heath theory, several studies have shown that the decline in maternal mortality was due not only with the availability of skilled health workers but also with the availability of health facilities with the appropriate equipment and emergency obstretic care. For instance, in a study carried out by Buor and Bream (2004) in sub Saharan Africa showed that deliveries with assistance of skilled healthcare personnel and life expectancy at birth strongly correlated with maternal mortality. The study also suggested that GNP per capital and health expenditure per capita strongly correlated with maternal mortality. In another study that was carried out in 1996 in Matlab, Bangladesh, the study disputed the results from an earlier study which claimed that the decline in maternal mortality was due to increasing presence of skilled midwifes. The new study carried out discovered that midwifes frequently referred patients to hospitals were expertise and proper equipment were available. The study concluded that deliveries in hospitals with the right equipment and emergency obstretic care were available may be crucial for a decline in maternal mortality (Shiffman, 2000).

To conclude the health theory, Gerein, Green and Pearson (2006) summarizes that maternal mortality is a result of poor health care systems that are incapable of dealing with complications during pregnancies, and deliveries. The non-availability of enough skilled health care providers could lead to the increase in maternal mortality rate and therefore suggest that more and better-trained health care providers are therefore needed in order to reduce maternal mortality. In all, the theory identified socio-economic variables such as education, income, investment in healthcare, healthcare expenditure as key determinants of maternal mortality.

Table 2: Maternal Mortality Ratio (MMR) in Sub-Saharan African Countries in 1990 to 2015 and Progress made toward achieving MDG goal 5.

Country	Year						% change in MMR between 1990 and 2015	Average annual % change in MMR between 1990 and 2015	Progress made towards MDG Goal 5
	1990	1995	2000	2005	2010	2015			
Angola	1160	1150	924	705	561	477	58.9	3.5	Made some progress
Benin	576	550	572	502	446	405	29.7	1.4	No progress made
Botswana	243	238	311	276	169	129	46.9	2.5	Insufficient progress
Burkina Faso	727	636	547	468	417	371	49.0	2.7	Insufficient progress
Burundi	1220	1210	954	863	808	712	41.6	2.2	Insufficient progress
Cameroon	728	749	750	729	676	596	18.1	0.8	No progress made
Central African Republic	1290	1300	1200	1060	909	882	31.6	1.5	No progress made
Chad	1450	1430	1370	1170	1040	856	41.0	2.1	Insufficient progress
Comoros	635	563	499	436	388	335	47.2	2.6	Insufficient progress
Congo (Brazzaville)	603	634	653	596	509	442	26.7	1.2	No progress made
Congo (Democratic Republic)	879	914	874	787	794	693	21.2	1.0	No progress made
Côte d'Ivoire	745	711	671	742	717	645	13.4	0.6	No progress made
Djibouti	517	452	401	341	275	229	55.7	3.3	Made some progress
Equatorial Guinea	1310	1050	702	483	379	342	73.9	5.4	Made some progress
Eritrea	1590	1100	733	619	579	501	68.5	4.6	Made some progress
Ethiopia	1250	1080	897	743	523	353	71.8	5.0	Made some progress
Gabon	422	405	405	370	322	291	31.0	1.5	No progress made
Gambia	1030	977	887	807	753	706	31.5	1.5	No progress made
Ghana	634	532	467	376	325	319	49.7	2.7	Insufficient progress
Guinea	1040	964	976	831	720	679	34.7	1.7	Insufficient progress
Guinea-Bissau	907	780	800	714	570	549	39.5	2.0	Insufficient progress
Kenya	687	698	759	728	605	510	25.8	1.2	No progress made
Lesotho	629	525	649	746	587	487	22.5	1.0	No progress made
Liberia	1500	1800	1270	1020	811	725	51.7	2.9	Insufficient progress
Madagascar	778	644	536	508	436	353	54.6	3.2	Made some progress
Malawi	957	953	890	648	629	634	33.8	1.6	No progress made
Mali	1010	911	834	714	630	587	41.9	2.2	Insufficient progress
Mauritania	859	824	813	750	723	602	29.9	1.4	No progress made
Mauritius	81	60	40	39	59	53	34.6	1.6	Not available
Mozambique	1390	1150	915	762	619	489	64.8	4.2	Made some progress
Namibia	338	320	352	390	319	265	21.6	1.0	No progress made
Niger	873	828	794	723	657	553	36.7	1.8	Insufficient progress
Nigeria	1350	1250	1170	946	867	814	39.7	2.0	No progress made
Rwanda	1300	1260	1020	567	381	290	77.7	6.0	Achieved
Sao Tome and Principe	330	263	222	181	162	156	52.7	3.0	Insufficient progress

Senegal	540	509	488	427	375	315	41.7	2.2	Insufficient progress
Sierra Leone	2630	2900	2650	1990	1630	1360	48.3	2.6	Insufficient progress
Somalia	1210	1190	1080	939	820	732	39.5	2.0	Insufficient progress
South Africa	108	62	85	112	154	138	-27.8	-1.0	No progress made
Sudan	744	648	544	440	349	311	58.2	3.5	Made some progress
Swaziland	635	537	586	595	436	389	38.7	2.0	No progress made
Tanzania	997	961	842	687	514	398	60.1	3.7	Made some progress
Togo	568	563	491	427	393	368	35.2	1.7	Insufficient progress
Uganda	687	684	620	504	420	343	50.1	2.8	Made some progress
Zambia	577	596	541	372	262	224	61.2	3.8	Made some progress
Zimbabwe	440	449	590	629	446	443	-0.7	0.0	No progress made

Source: WHO, UNICEF, UNIFPA, World Bank Group and the United Nations Population Division Estimate of Maternal Mortality 1990 to 2015.

2.3.2 Model Specification

Relationship between Socio-economic Variables and Maternal Mortality Ratio

The focus of this section is to specify the socio-economic determinants of maternal mortality rates. The model for estimation is highly drawn from the *health theory* and is expressed in equation 1 as:

$Log\text{MMR}_{it} = \alpha_{0i} + \alpha_{1i} Log\text{MMR}_{it-1} + \alpha_{2i} Log\text{LFPR}_{it} + \alpha_{3i} Log\text{LTRM}_{it-1} + \alpha_{4i} Log\text{HPC}_{it-1} + \alpha_{5i} Log\text{GNI} + \alpha_{6i} Log\text{FR}_{it-1} + \alpha_{7i} Log\text{PHIV}_{it} + \alpha_{8i} Log\text{FEMP}_{it} + \alpha_{9i} Log\text{EDU}_{it-1} + \mu_{it}$ -- 1.

$i = 1, 2, \ldots, N$, $t = 1, 2, \ldots, T$. Apriori expectation: $\boldsymbol{\alpha}_{1i}, \boldsymbol{\alpha}_{3i}, \boldsymbol{\alpha}_{61}, \boldsymbol{\alpha}_{7i} > 0$; $\boldsymbol{\alpha}_{2i}, \boldsymbol{\alpha}_{4i}, \boldsymbol{\alpha}_{5i}, \boldsymbol{\alpha}_{8i}, \boldsymbol{\alpha}_{9i} < 0$.

Where: Log indicates logarithm, MMR is maternal mortality rate of country i at time t (dependent variable). The independent variables of country i at time t – Labour force participation rate (LFPR), life Time Risk of Maternal Mortality (LTRM), Healthcare Per Capita expenditure (HPC), Gross National Income (GNI), Fertility Rate (FR), HIV/AIDs prevalence (PHIV) and Education level (EDU).

2.3.3 Estimation Techniques

The equation 1 specified above is a dynamic auto-regressive distributed lag model due to the presence of lagged dependent variable on the right hand side of the model and also the existence of individual effects characterizing the heterogeneity among the countries. Baltagi (2008) argues that the use of ordinary least squared (OLS) estimator in the presence of lagged dependent variable among the explanatory variables and also the presence of characterizing heterogeneity among countries will yield biased and inconsistent estimates. Thus, the study adopts the traditional pooled estimates techniques of fixed and random effects. However, the study will conduct Hausman test to decide between fixed or random effects. Here we will run a Hausman test where the null hypothesis is that the preferred model is random effects (where the unique disturbance terms (U_i) are not correlated with the regressors) and the alternative would be fixed effects (where the unique disturbance terms (U_i) correlate with the regressors).

Further, panel unit root tests suggested by Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) will be adopted. This is because the conventional time series unit root tests- Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests are not suitable for panel studies (Izilein & Osemwengie, 2017). Panel unit root tests minimizes the risks of structural breaks cum increases the power of unit root test as a result of the length of observations, thus has this advantage over non-panel unit root tests. Specifically, the IPS unit root test suggest a panel unit root tests for a random walk residual within the domain of a dynamic model with fixed effects that allow heterogeneity of the autoregressive root under the alternative hypothesis. The LLC on the other hand, uses a pooled Dickey-Fuller test and also assume that the individual processes are cross-sectional independent. Several studies, for instance, Izilein and Osemwengie (2017), Shaibu and Osemwengie (2017) are recent examples of studies that have utilized IPS and LLC panel unit root tests. More so, a recent test of panel co-integration, the panel residual co-integration test, proposed by Kao (1999) was employed. The test uses the ADF approach to testing for the existence of long-run relationship in panel model.

2.3.4 Sources of Data

A panel data from 43 SSA countries (see Appendix) based on availability were sourced from World Development Indicators (WDI) from 1994 to 2015. This period was chosen because it coincides with the period where MDGs was launched and terminated. Understanding and identifying the interaction between the selected socio-economic variables and maternal mortality rate within these periods will help to stimulate appropriate policy measures for the achievement of SDG-5A, of reducing maternal mortality rate by 2030.

3. Discussion of Results

3.1 Panel Unit Root Test Results

Table 3 presents the panel unit root test results for all the variables used in the analysis. The study used both the homogenous and heterogeneous unit root tests proposed by Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) respectively. The results show that all the variables are stationary at level using the LLC test under homogenous unit root process at 5 percent level of significance. But, under the heterogeneous unit root process using IPS test, the results indicate four variables (LMMR, LLTRM, LGNI and LEDU) had unit roots at level. At first difference, they became unit root free and difference stationary at 1 percent level of significance. Therefore, we reject the hypothesis of a unit root in the variables. With this, the Rao's co-integration test was conducted.

Table 3: Panel Unit Root Test of Variables and Kao Residual Co-integration Test Result

Variables	Common Unit Root Process (LLC)		Individual Unit Root Process (IPS)	
@ Level	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
@ First Difference				
DLMMR			-2.41***	Stationary
DLGNI			-15.94***	Stationary
DLLTRM			-3.74***	Stationary
DLEDU			-3.35***	Stationary
Kao Residual Co-integration Test Result				
ADF t-Statistic = -6.10			ADF t-Statistic Prob. = 0.00***	

Note: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels respectively
Author's estimates using Eviews 9.

3.2 Panel co-integration Test (Kao Test) Results

According to the results displayed in Table 1, the null of hypothesis of no co-integration in the LMMR model can be rejected at the 1 percent level of significance based on the ADF associated probability value of 0.00. Given, the test results (Kao) for co-integration, we can therefore conclude that a long-run equilibrium relationship exist among the variables in the LMMR model.

3.3 Analysis of Fixed and random Effects Results and the Policy Implication

In a panel model, the individual effect terms can be modeled as either random or fixed effects. If the individual effects are correlated with the other regressors in the model, the fixed effect model is consistent and the random effects model is inconsistent. On the hand, both random and fixed effects are consistent and random effects is efficient. Therefore, based on the Hausman test result in Table 4, the study rejects the null hypothesis that the random effects is an efficient estimator of the true parameters of the model and accept fixed effects estimator as efficient and consistent. For the purpose of robustness, we present and analyse the random effects results as well, and compare the results with fixed effects estimates. Table 4 reports the traditional pooled estimators' results (fixed and random effects).

Table 4: Fixed and Random Effects Results

Variable	Fixed effects	Random effects
LLFPR	0.47*** (4.17)	0.16*** (2.85)
LLTRM(-1)	1.02*** (33.65)	0.99*** (85.60)
LHPC	-0.01*** (-2.49)	-0.02*** (-4.69)
LGNI	0.005 (1.05)	-0.0006 (-0.24)
LPHIV	0.03*** (4.42)	0.02*** (6.22)
LFEMP	-0.35*** (-3.52)	-0.15*** (-3.17)
LFR(-1)	-0.94*** (13.25)	-1.006*** (-28.68)
LEDU(-1)	-0.009 (-1.03)	-0.007** (-1.88)
	Adj. R-sq = 0.99	Adj. R-sq = 0.96
	F-stat. = 2390 P-value = 0.00	F-stat. = 2044 P-value = 0.00
Hausman Test	Chi-square Stat. = 40.4962 Prob.= 0.0000	

Note: t-statistics are reported in bracket below each coefficient. *, ** and *** indicate statistical significance at 10%, 5% and 1% levels respectively.
Source: *Author's computation*

Generally, from the results in Table 4, 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 percent level of significance. Interestingly, the results obtained from the fixed effects model and the results of the random effects in Table 4 are slightly different (not too distant) from the random effects results in terms of the significance of the variables. The one period lag of LEDU that was statistically significant at 5 percent level in the random effects results, proved to be weak in fixed effects results. Overall, both the fixed effects and random effects results have robust explanatory power as shown by the adjusted coefficients of determination and the F-statistic values displayed in Table 4.

Interesting findings are obtained with regards to the individual variable in terms of signs and magnitudes. For instance, LLFPR has a positive significant impact on LMMR in fixed and random effects results at 1 percent level of significance. Surprisingly, the coefficient of LLFPR has a greater impact on LMMR in the fixed effects results compare to random effects results. In this direction, one percent increase in LLFPR will cause LMMR to rise by 47 percent in the fixed effects results and 16 percent in the random effects results. However, the positive sign of LLFPR may not be acceptable *a priori*. This may be due to the inclusion of a particular country in the group of SSA used for estimation.

The log of lagged life time risk of maternal mortality (LLTRM (-1)) proved to be significant determinant of LMMR in the results displayed in Table 4. In terms of signs expectation, fixed effects and random effects had the positive expected signs at significant 5 percent level. Following the fixed effects and random effects results therefore, one percent increase in previous year maternal risk (LLTRM (-1)) will increase LMMR by 102 percent and 99 percent respectively in SSA. This means that reducing current level of maternal deaths is predicated on how previous risk of maternal mortality was tackled.

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. The impact generated by both results (fixed effects and random effects) particularly, LHPC on LMMR is almost similar. For example, from the results, one percent increase in health investment will lead to reduction in maternal deaths by 1 percent in the fixed effects results and 2 percent in the random effects results at 5 percent level of significance. These 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 reported in Table 4. Both variables had the expected sign but LEDU (-1) was weak in explaining changes in LMMR in the fixed effects results. On the basis of magnitude, LMMR would improve or reduce if LFEMP increases by 35 percent in the fixed effects results and 15 percent in the random effects results. In the same vain, increasing previous investment in education would led to fall in LMMR in the current period by 0.7 percent in the random effects results.

HIV prevalence among pregnant women is estimated to affect maternal mortality in the SSA region. From the result in Table 4, it was observed that LPHIV has a positive significant impact on LMMR. One percent rise in LPHIV will cause LMMR to increase by 2 percent in the random effects results and 3 percent in the fixed effects results at 5 percent level of significance. 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 percent level of significance. Both the fixed effects and random effects results indicate a fall in LMMR by 94 percent and 100.6 percent respectively in the current period. This negative signs observed in both the fixed effects and random effects results may probably be attributed to improvement or development in other factors such as improvement in maternal education, social status of women and female labour supply which are capable of reducing fertility rate thereby reducing maternal deaths.

On the whole, one of the variables that proved to be weak determinant of LMMR in SSA, given both the fixed and random effects results, is gross national income per capital. Though the association between LGNI and LMMR yielded negative outcome in the random effects results as prescribed by theory, the insignificant 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.

4 Conclusion and Recommendations

The discussion of the study so far focused on the socio-economic determinants of maternal mortality in SSA with the broad objective of investigation the contributions of these factors to maternal deaths in the region. A panel of 43 countries in sub-Saharan Africa based on applicability to the broad objective and data availability were employed using data from the period of 1995 to 2015. What followed was a robust analysis, cautiously carried out using the traditional pooled panel estimators (fixed and random effects) and this generated remarkable elasticity estimates which will be valuable for policy intervention and stance.

The fixed and random effects results revealed a profound contribution of the socio-economic variables to maternal mortality in SSA. Log of labour force participation rate for women, the log of one period lag of life time risk of maternal mortality, log of female employment rate, log of per capita health expenditure, log of fertility rate all proved to be significant determinants of maternal mortality in SSA. In addition to these variables, the log of HIV prevalence among women and the log of one period lag of secondary school enrolment as a proxy for education also demonstrated to be significant determinants of maternal deaths. Only GNI per capita showed a weak relationship with maternal mortality. This means that GNI may not be useful significantly when policy measures are taken to address maternal deaths in SSA.

The study recommends that conscious efforts should be made by policy makers and the leaders of SSA to allocate more resources to the health sector as this will not only assist to acquire state of the art facilities that will be effective for efficient and prompt delivery of service but will also improve health care delivery generally. This will then contribute remarkably in maternal health which is a core component of general health and thus lead to significant improvement in maternal mortality. Importantly, based on the results, a comprehensive policy intervention is recommended to cushion the impact of life time risk of maternal deaths and HIV prevalence among women of reproductive age on maternal mortality in SSA. Finally, women should be given more opportunity in workforce/employment and education should be prioritized as this will help to improve their income and status which will in turn translate to improvement in maternal health, and thus reduction in maternal deaths.

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