Vitamin A Supplementation and Low Birth Weight's Relationship with Declining Under Five Mortality Rate in Africa from 2000-2015

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CLUSTER M71CW: Health Before, During, and After Pregnancy

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ABSTRACT

Introduction: Since 1980, under-five mortality rate (UFM) has been steadily declining globally although developing countries, especially African countries, still report UFM rates more than double the global average of 37 deaths per 1000 live births. Postnatal vitamin A coverage and low birth weight incidence are two variables we will analyze for their association with higher UFM rates in developing countries.

Methods: Through a cross-sectional study, we will analyze the percentage of children under 5 that receive enough vitamin A supplementation, prevalence of low birth weight, and number of under-five deaths per 1000 infants for 10 countries (n=10) based on data provided by UNICEF for the years 2000, 2005, 2010, and 2015. This data will be analyzed via correlation coefficients and graphical representations generated in SAS. Sample data were chosen based on greatest availability since most countries lacked data for the vitamin A variable.

Results: All ten countries were able to reduce their UFM by half between 2000 and 2015, except for Benin and Zimbabwe which reduced UFM by a third. There was a higher correlation coefficient of -0.463 between Vitamin A supplementation and UFM rates, and a lower correlation coefficient of 0.262 between low birth weight prevalence and UFM rates.

Conclusions: While we are unable to determine a causal relationship using percentages of raw data, from this study we can conclude that there is a weak association between Vitamin A Coverage and UFM and a moderately strong association between Low Birth Weight incidence and UFM.

INTRODUCTION

Under-five mortality rate (UFM) is defined as the number of children under 5 years of age dying per 1000 live births and is often an indicator of the quality of childhood life, resources, and health as well as national progress in children's rights, especially regarding access to proper healthcare, nutrition, etc.[1] As a result, chronically underdeveloped third-world countries with slow progress in children's rights and persistent economic and political hardship tend to have consistently high UFM. This can be commonly seen in African countries like Rwanda, where UFM still measured above 180 deaths per 1000 live births, 4 times the global UFM of 43 per 1000 in 2015.[2] However, a lot of progress in reducing global UFM by two-thirds (93 per 1000 in 1990 to 43 per 1000 in 2015[2]) has been attributed to global measures like the United Nations Millennium Development Goals (2000-2015).[3] These goals have included eradicating world hunger, reducing child mortality, improving maternal health, and combatting various diseases like malaria.[3] These have helped address many driving forces of high UFM, such as premature birth, perinatal problems, congenital anomalies, malnutrition, and infectious diseases.[4] With Africa making the greatest reduction in UFM,[11] this paper will focus on low birth weight (LBW) and Vitamin A coverage's correlation with UFM in various parts of Africa from 2000 to 2015.

Low birth weight (<2500 g) is a universal high-risk factor for under-five mortality, especially for babies born at an extremely low birth weight (<1000 g).[5] Biologically, this induces severe vision loss, pulmonary dysplasia, growth failure, and developmental delay, all of which make it less likely the baby will survive until 5 years old.[5] Subpar African healthcare systems that typically are "unable to meet the basic requirement for good healthcare systems"[7] introduce greater prenatal and maternal risks for these fatal health conditions in comparison to more developed countries. For instance, in sub-Saharan Africa, where most of our targeted countries are located, only 52% of women received adequate prenatal care from 2010 to 2018, 13% below the global rate.[6] Such alarmingly low rates of prenatal care have been linked to higher incidence of LBW,[5] suggesting that improvement in prenatal care may be a key aspect in reducing LBW. Furthermore, in several developing countries like Brazil, the harsh divide between low-cost public and high-cost private healthcare systems has caused up to an 85% increase in newborn fatality in public hospitals versus private hospitals.[5] This divide is especially impactful in Africa where the majority of middle-income families rely on public healthcare.[22]

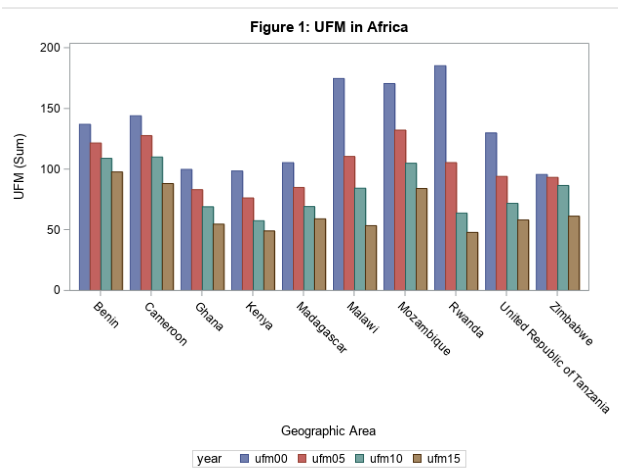
Micronutrient deficiencies (iron, iodine, folate, zinc, and vitamin A) are also prominent in low-income countries, particularly for pregnant women and children under 5. These deficiencies can severely stunt organ and bone growth, trigger serious infections, and cause permanent and potentially fatal blindness.[8] Vitamin A can prevent infant diarrhea, infant respiratory death, and respiratory infection and enhance the immune, visual, and reproductive systems of all ages if sufficiently supplemented at recommended levels of 400 mcg for newborns and 770 mcg for pregnant women.[9] A study based in Indonesia concluded that financial crises like the 2008 world food price crisis can cause increased rates of vitamin A deficiency and night blindness for over a decade after due to a gradual shift from preformed vitamin A foods like eggs to less expensive vitamin A deficient diets like rice.[10] A similar, more permanent effect is bound to be seen in Africa where food prices are constantly unaffordable due to excessive food imports.

METHODS

All data was sourced from UNICEF (https://data.unicef.org/). Our initial dataset spanned 2000 to 2018 for all 195 countries and included available yearly data for under-five mortality rate (number per 1000 live births), vitamin A coverage (% for all children under five years old that receive recommended doses of Vitamin A), and low birth weight (% of all newborns born weighing under 2500 grams). Countries with any missing data were eliminated to avoid skewing our data and unnecessary knowledge gaps. Based on these criteria, we then selected ten African countries to work with, which are Benin, Cameroon, Ghana, Kenya, Madagascar, Malawi, Mozambique, Rwanda, United Republic of Tanzania, and Zimbabwe.

We used SAS to analyze summary statistics and generate bar graphs and scatter plots between independent variables (Vitamin A coverage and Low Birth Weight) and the dependent variable (Under Five Mortality Rate by year and country). Pearson correlation values were calculated between each independent variable and the dependent variable per year for all ten countries ($n = 10$), with $|r| > 0.7$ as an indicator of a strong relationship.

RESULTS



The recorded under-five mortality (UFM), Vitamin A Coverage/Dosage (VAD), and Low Birth Weight Incidence Rate (LBW) values for each of the 10 African countries can be found in Table 1 and Figure 2a-d. Notable outliers in the data include abnormally low VAD% (16%) for Mozambique in 2005 and drastic declines in VAD% for Ghana, Kenya, and Malawi between 2010 and 2015 and for Zimbabwe between 2005 and 2010. Five countries recorded no Vitamin A Coverage at all in 2000 (which may be due to sourcing errors), but in all other years there was at least partial Vitamin A Coverage. Rwanda consistently had the lowest LBW% numbers while Mozambique consistently had the highest LBW% numbers among all years and 10 countries. All countries had declines at 5-year intervals although Zimbabwe experienced the smallest declines of all 10 countries (Figure 1).

Table 1. Master Dataset Cross-Tabulation for 2000 and 2005

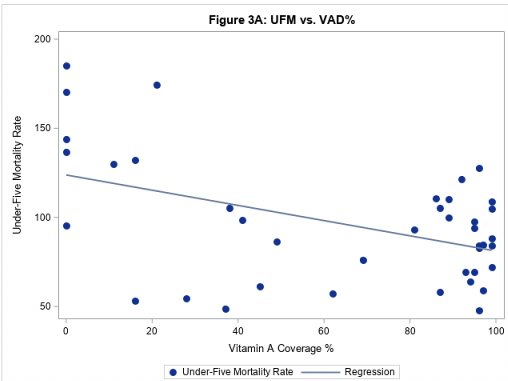
Year	*2000*			*2005*			*2010*			*2015*		
Country	*VAD (%)*	*LBW (%)*	*UFM (per 1000)*	*VAD (%)*	*LBW (%)*	*UFM (per 1000)*	*VAD (%)*	*LBW (%)*	*UFM (per 1000)*	*VAD (%)*	*LBW (%)*	*UFM (per 1000)*
Benin	0	18.7	136.84	92	17.8	121.49	99	17.3	109.00	95	16.9	97.63
Cameroon	0	13.1	143.93	96	12.6	127.50	89	12.3	110.06	99	12.0	87.97
Ghana	89	16.1	99.74	96	15.3	83.01	93	14.8	69.12	28	14.2	54.56
Kenya	41	12.3	98.46	69	12.2	76.28	62	11.9	57.42	37	11.5	48.91
Madagascar	38	19.8	105.37	97	18.7	84.81	95	17.8	69.32	97	17.1	59.01
Malawi	21	17.2	174.59	86	15.8	110.54	96	15.2	84.18	16	14.5	53.30
Mozambique	0	16.7	170.42	16	15.2	132.04	99	14.4	104.90	99	13.8	83.95
Rwanda	0	10.3	185.16	87	9.2	105.41	94	8.4	63.84	96	7.9	47.71
United Republic of Tanzania	11	12.4	129.73	95	11.6	93.90	99	10.9	71.93	87	10.5	58.11
Zimbabwe	0	12.4	95.51	81	12.7	93.10	49	12.9	86.43	45	12.6	61.28

The distribution of the data points per variable per year is described in Table 2 below. Overall, average UFM and standard deviation declined by half from 2000 to 2015, indicating relatively similar progress in UFM reduction for all ten countries. Interestingly, the percentage of children born with LBW had no change at all across these 4 years of data, although Vitamin A Coverage managed to suddenly decrease by 17% between 2010 and 2015 despite previous positive trends. Standard deviation also doubled between these years.

Table 2. Summary Table (Mean of Percentages)

Year	**Variable**	**Range**	**Mean ± Std.Dev.**
2000	UFM (per 1000 live births)	95.51 - 185.16	133.98 ± 34.08
	Vitamin A (%)	0.00 - 89.00	20.00 ± 29.08
	LBW (%)	10.30 - 19.80	14.90 ± 3.20
2005	UFM (per 1000 live births)	76.28 - 132.04	102.81 ± 19.65
	Vitamin A (%)	16.00 - 97.00	81.50 ± 34.61
	LBW (%)	9.20 - 18.70	14.11 ± 2.95
2010	UFM (per 1000 live births)	57.42 - 110.06	82.62 ± 19.50

	Vitamin A (%)	49.00 - 99.00	87.50 ± 17.42
	LBW (%)	8.40 - 17.80	13.59 ± 2.89
2015	UFM (per 1000 live births)	47.71 - 97.63	65.24 ± 17.80
	Vitamin A (%)	18.00 - 99.00	69.90 ± 33.99
	LBW (%)	7.00 - 17.10	13.10 ± 2.83



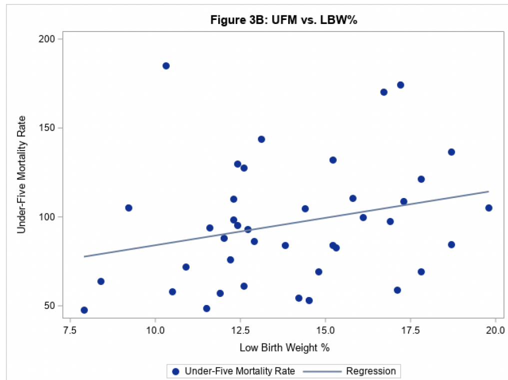


***Figure 3A:** regression line has r value of -0.463

****Figure 3B:** regression line has r value of 0.262

Table 3. Correlation Coefficient Values Per Year (UFM x VAD, UFM x LBW)

Variable	**Year**	**Vitamin A Coverage**	**Low Birth Weight**
Under 5 Mortality Rate	2000	-0.53642	-0.06684
	2005	-0.38177	0.08492
	2010	0.22595	0.34820
	2015	0.55050	0.43187
	Overall	-0.46260	0.26186

In Figures 3a-b, we are analyzing the association between VAD% and LBW%, two possible factors linked to UFM, and UFM itself using all years' data. In Figure 3a, the correlation coefficient (r) is -0.463, signifying a moderately negative relationship between VAD% and UFM. In Figure 3b, the correlation coefficient (r) is 0.262, signifying a rather weak positive relationship between LBW% and UFM, and this relationship is nearly twice as strong as the relationship between LBW% and UFM in this study.

However, looking at yearly correlation coefficient data in Table 3 may give us better insight into our overall correlation trends. Most remarkably, both independent variables (VAD% and LBW%) changed from a negative association to a positive association in 2010 and 2005 respectively. For both variables, correlation only continues to grow stronger after this change.

DISCUSSION

In this study, we found that average yearly UFM and standard deviation for all 10 African countries studied was cut in half from 2000 to 2015, possibly due to the worldwide Millenium Development Goals (MDG) that created more uniform rates of progress across Africa. These goals aimed to reduce global hunger rates by half, UFM by two-thirds, achieve universal access to maternal healthcare services, and prevent further spread of malaria, especially in high-risk populations like African children under five years of age.[3] While all the health-related MDGs listed above made significant progress via global immunizations, direct high-dosage vitamin treatments, and push for at least one antenatal care visit per mother, the only goal successfully met was in decreasing malaria incidence rates from 158 to 94 new cases per 1,000.[23] This was implemented through insecticide-treated nets and indoor spraying of insecticides.[3] A new agenda (Sustainable Development Goals) has been implemented for 2016-2030 and will attempt to decrease global UFM to 25 per 1000 live births, reduce premature mortality by one-third, end tropical disease epidemics (including malaria), and continue to ensure universal reproductive access.[26] As of 2020, it seems that the global UFM of 37 per 1000 is on-pace to meet the goal.[2]

Although most of the ten African countries studied here greatly reduced UFM by approximately half, Zimbabwe and Benin only managed to reduce their UFM by only a third. This is due to severe waves of economic crises, recessions, and hyperinflations in 2008, 2014, and 2015 that have caused a shortage of healthcare workers and, as a result, have deterred any attempt in working toward lower UFM from 2000 to 2015.[12-13]

We also found some evidence that higher VAD% is linked with lower UFM and found weaker evidence that lower LBW% is linked with lower UFM. Between 2005 and 2010, the association between VAD% and UFM changed from negative to positive while the same change occurred for the association between LBW% and UFM in the 2000-2005 time interval. While this paper only focused on health-related factors, future studies should look into non-health-related factors such as equity gaps, health financing, and both utilization and access to antenatal care and family planning to evaluate more effective interventions in reducing UFM.[24-25]

The moderately negative correlation found here between VAD% and UFM reflects previous and recent studies' findings. Large doses of vitamin A were administered to 1,223,856 children under five in 19 countries, resulting in reduced death risk and death due to diarrhea by 12%.[14] Because vitamin A acts as an anti-infectious vitamin, it is also effective in reducing the incidence rate of potentially-fatal infectious diseases like measles and meningitis.[14] Furthermore, although VAD% has declined by 18% from 2010 to 2015, this is actually a sign that Vitamin A deficiency is no longer a public health issue since lower VAD% means less international intervention required via high-dose nutrient administration.[15] Rather, due to laws requiring vitamin A fortification in common diet/cooking products like sugar, flour, oil, sweet potatoes, and maize in Malawi, vitamin A is now supplemented more naturally and locally.[15]

While this study interestingly found a weak negative correlation between LBW% and UFM, other studies performed in Indonesia and Jordan otherwise found a strong positive association between high LBW% and high UFM, with babies born at a low birth weight to be up to 4.8 times more likely to die before 5 years old compared to children born at a normal birth weight.[16] Children born at a low birth weight had more motor dysfunction and lacked a complete immune system, making them more susceptible to fatal infections and short-term morbidities like chronic lung disease,[17-18] and increasing the chance of special healthcare childhood needs that many parents in developing countries may not have the money or resources to address.[19] Our study also identified Mozambique to have consistently far above average UFM and LBW% compared to the other nine countries, and other studies have confirmed these same findings and have attributed this phenomenon to Mozambique's high percentage of rural dwellers (66% of the national population[20]). Living in a rural setting can severely deprive them of significant job opportunities, antenatal care/treatment in early pregnancy (<25 weeks), and sufficient water supply as well as increase vulnerability to extreme poverty, maternal psychosocial stress, gestational hypertension, and heightened cortisol levels that can prematurely stimulate labor.[21]

Some limitations of this paper included sample size, as 10 countries are not representative of all 54 African countries, especially since each country's situation is unique and ungeneralizable. Because our only source of data is from the UNICEF dataset, the data analyzed from 2000, 2005, 2010, and 2015 are merely snapshots in time without any significant context. Furthermore, the only data we had access to was raw data, so no significant findings can truly be yielded from processed data (percentages). Some strengths include no missing data because we intentionally excluded any countries that had at least one missing data point. Another strength was our ability to examine the effect of the Millenium Development Goals since they were applied for the same period of time as this study (2000-2015). A third strength was looking into why specific countries (like Mozambique) had stunted relative progress in all variables.

In conclusion, our findings suggest that improving Vitamin A Dosage and reducing Low Birth Weight occurrence have some effect on reducing under-five mortality as a result of the

United Nations' Millennium Development Goals. However, there needs to be more efforts made in addressing each country's individual financial, healthcare quality, and social setbacks, which are primary factors in continuing to decrease UFM at a steady rate to meet the new SDG criteria.

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