HEALTH ECONOMIC VALUE OF BLOOD IN SUB-SAHARAN AFRICA: THE CASE OF MATERNAL BLEEDING

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INTRODUCTION

- Blood transfusion is an essential component of the health care system of every country[1-77]. Patients who require blood transfusion services as part of the clinical management of their condition have the right to expect that enough safe blood will be available to meet their needs[29].
- Millions of lives are saved each year through blood transfusions. In 2013, the most recent year for which global data are available, approximately 100 million blood units were donated worldwide[88]. 5.6 million of those were collected in Africa (5.6%). An estimated million (4.3%) of those units were donated in sub-Saharan Africa (SSA), which has approximately 12% of the global population. In SSA, the access to enough safe blood is not guaranteed. Previous research demonstrated that African countries in general struggle to match blood supply to blood demand[29,47]. Examples of such countries include Kenya[1-24], Ghana[25-40] and Ivory Coast[41-47].
- Though there is a good understanding on the relationship between blood supply and morbidity and mortality within a country, studies that directly measure the impact of increased blood supply on healthcare performance are not publicly available within Kenya, Ghana and Ivory Coast. More specifically, very few studies in this region have looked at predictors of survival of patients requiring acute massive transfusion (e.g. due to maternal bleeding) or chronic transfusion (e.g. due to chronic anemia)[12-13].

OBJECTIVES

This research intends to estimate the health economic impact of blood shortages on maternal bleeding in Kenya, Ivory Coast and Ghana.

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METHODOLOGY

The study consisted out of 3 steps. First the volume and consequences of maternal bleeding were identified by means of literature review and epidemiologic research. Next, the costs associated with the treatment of severe maternal bleeding were mapped. Lastly, a de novo budget impact model was created that compared costs associated with consequences of severe maternal bleeding (i.e. the cost of a life lost according to WHO and European Commission Guidelines) versus the cost of investment in blood supply.

RESULTS

Maternal Mortality

- Our literature review[1-47,50,54,55,57,59] suggests that within the 3 countries of investigation a substantial gap exists between the need for blood and the availability of blood. This gap results in the delay of initiating life-saving transfusions or not providing required transfusions at all[5,11,12].
- Worldwide, an estimated 800 women die every day from preventable causes related to pregnancy or childbirth[62,63,69,70].
- Within the region the maternal mortality ratio may range from 320 to 2000 per 100 000 live births, with an average of 555 maternal mortality cases per 100 000 births. On average the percentage of maternal deaths that can be explained by shortages of blood may be as high as 29%, with a minimal level of contribution of 8.3% and a maximum of up to 68.3%. Other contributing factors that were identified include abortion (24%), hypertensive disease during pregnancy (13%), sepsis (13%), and cardiac disease (7%). Moreover, not only the mother is at risk but also the unborn infant can be a victim of blood shortage[15,22,27,33,34,36,38,40,46,49,57,58,62,66-69].
- Ninety-nine percent of maternal deaths occur in low-resourced countries and the leading cause of death is post-partum hemorrhage (PPH)[62,63,69,70].

Severe post-partum hemorrhage

- As demonstrated, not all maternal anemia is caused by PPH. Though PPH is a life threatening acute maternal condition that requires urgent blood transfusion[24,63,65,69,70,72,73].
- PPH is potentially severe when there is a blood loss of >500mL after vaginal or of >1000mL after cesarean delivery, a bleeding rate in excess of 150 mL per minute and/or hemodynamic changes suggestive of excessive blood loss[24,63,65,69,70,72]. All women who carry a pregnancy beyond 20 weeks' gestation are at risk for PPH and its sequelae[68].
- Shortage of blood is the single most contributing factor to the mortality of PPH. Most of the deaths associated with PPH occur in resource-poor settings with many home-deliveries and where effective methods of prevention and treatment (such as blood transfusion) are not accessible[13,49,59,60,62-67,73-75].
- Our research demonstrated that severe PPH accounts for minimally 10% of maternal mortality rates[15,22,27,33,36,38,40,49,57,58,62,66-69].

Lives lost due to PPH

To estimate the lives lost due to PPH, a de novo model was created.

- Assuming 100 000 births in a year, based on literature review[22,33,60,73,75] the expected number of births confronted with PPH is 21 830 (21,8%).
- 2 960 of those PPH related births are likely to be severe (2,96%)[61,63-65,70,73,75].
- Based on the shortage of blood in the region, it was assumed that 75% of women would not have blood transfusion available and 25% would have access to life-saving blood transfusion.
- As a consequence, within the non-transfused segment a mortality of 433 on a 100 000 is expected. In our estimations we applied a bottom up approach starting from PPH incidence to estimate the total mortality figure. Reported total maternal mortality numbers for the region result in a lower mortality rate. This could be driven by the fact that rural access to care is limited and patients might not reach advanced care settings. In this poster we continue to work with the bottom up approach.
- Within the transfused cohort a mortality rate of 3% is expected or 22 births out of a 100 000 and research states that the mortality risk without transfusion is 6,5 times higher than with blood transfusion[24,27,69,72-75].
- Together PPH would result in 455 deaths per 100 000 births within the SSA region.
- Literature also suggests that 50 in 100 000 patients with severe PPH would not be saved even with massive blood transfusion[24,27,69,72-75].
- Hence out of the 433 patients (0,43%), 383 are potentially avoidable with massive blood transfusion (see figure 1: Impact of PPH on maternal mortality rates).

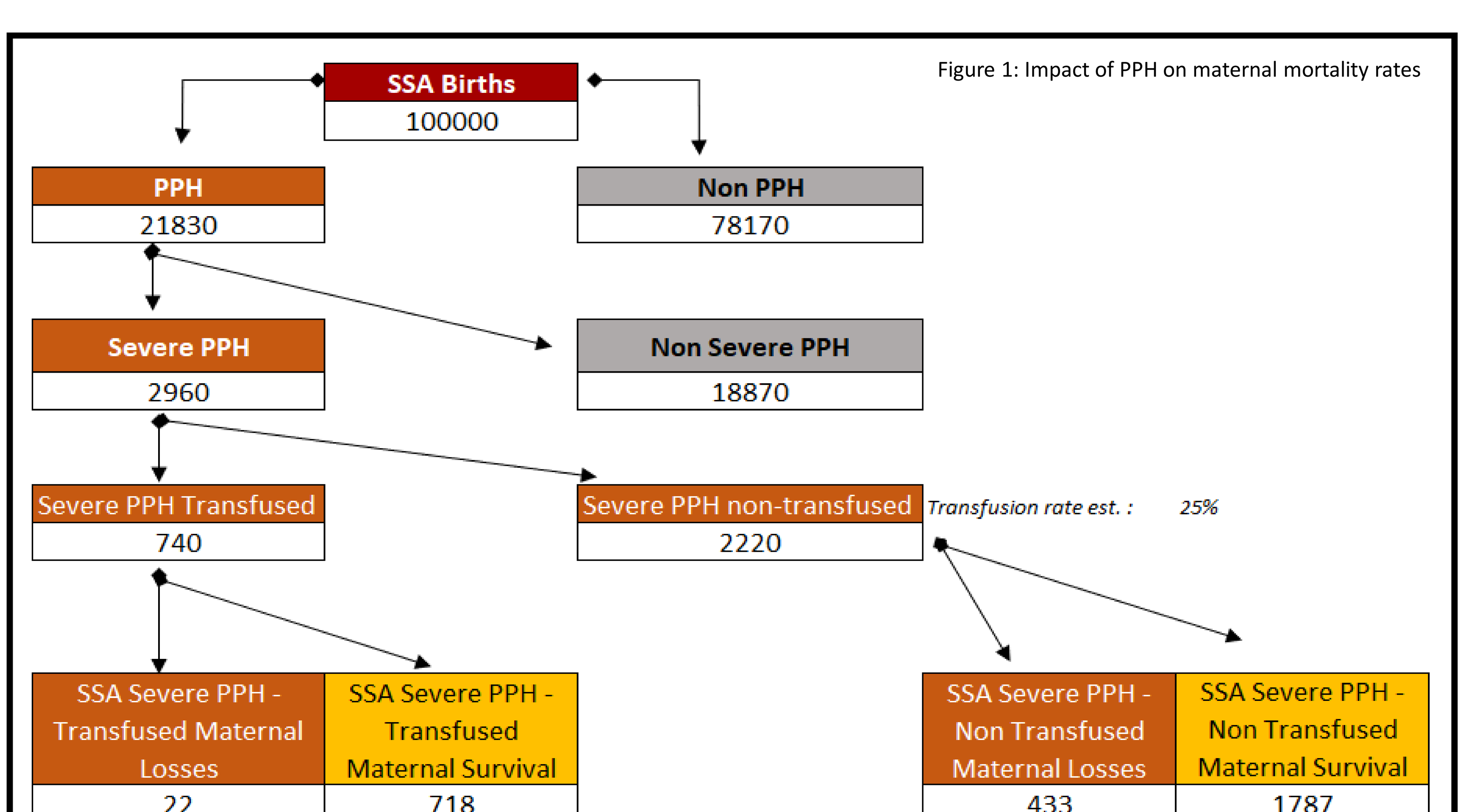


Figure 1: Impact of PPH on maternal mortality rates

RESULTS

Economic relevance of blood transfusion in PPH

Applying a simplified and undiscounted human capital method[78], we estimated the net economic benefit of blood transfusion in PPH for Kenya, Ghana and Ivory Coast. The model was constructed as follows (See table 1: Economic Impact of Blood Transfusion in PPH).

(A) Considering the births per year in the countries of investigation[79,80,82].

(B) Not all PPH cases will be severe and result in a life lost, we considered 0,43% of PPH cases to be severe and mortal[24,27,69,72-75].

(C) As discussed above, not all deaths due to PPH are avoidable, there is a group of 0,05% of females that can not be saved with massive blood transfusion upon severe PPH[24,27,69,72-75].

(D) Life expectancy varied between the countries of investigation[79,81,83], in combination with the assumed age at deliver of 20-27 years old[89] **(E)** this results in the amount of life years lost per woman **(F = D-E)** that dies of severe PPH.

(G = F*C) The total life years lost per countries is calculated based on the amount of life years lost per woman (F), multiplied with the avoidable deaths (C).

(H) To estimate the financial impact of these life years lost, the first parameter to take into account is the labor rate, this is the amount of females that are employed. Employment rates of females in the countries of investigation varied between 48% and 64%[90].

(I) The labor rate needs to be combined with the financial value of a single life year lost, in this case the yearly net income of an individual in the country of investigation[84,85,86].

(J = G*I*H) The total value of life years lost due to severe PPH was estimated as the total amount of avoidable life years lost (G) multiplied with the yearly net income of an individual (I) and adjusted for the labor rate. We estimated that the total loss of value for Kenya, Ghana and Ivory Coast combined is close to 1,8 billion USD over a period of 43 years.

(K) To assess the yearly financial impact of severe PPH, the total value lost (J) is divided by the life years lost per woman that dies due to severe PPH (F). Taking this step is required to be able to compare the yearly investments to collect, manage and transfuse a unit of blood with the cost of a life lost.

(L) The first driver to estimate the cost of blood transfusion are the units of blood transfused. For severe PPH, massive blood transfusion is required. In our literature[12,33,62,66,72] review we found that the average units of blood transfused during massive blood transfusion is 13.

(M) Secondly the cost to collect, test and store a unit of blood was estimated to be 100 USD[87].

(N) The cost of providing a unit of blood to the patient was estimated to be 50 USD.

(O) As a consequence, the total cost of providing a unit of blood to **O = N+M**.

(P) Not only women that survive severe PPH are transfused, we should consider that also women that do not survive are transfused. Hence the total cost of required PPH blood transfusion per year is **P = B*O*L**

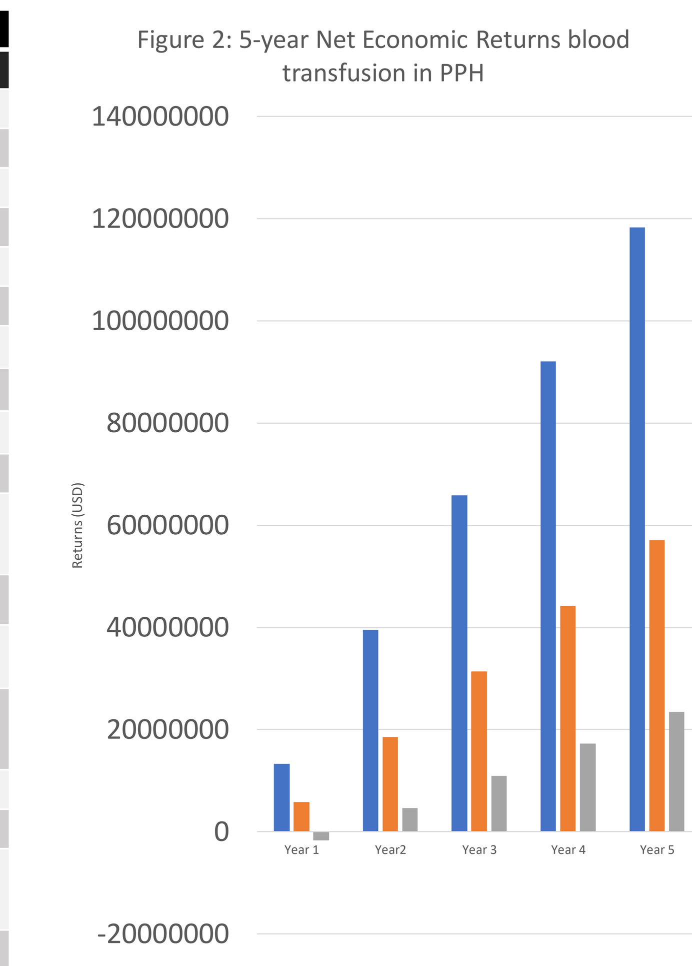
(Q) To come to the net economic benefit of blood transfusion in case of severe PPH we confronted the yearly value of life lost (K) with the total cost of required PPH blood transfusion (P). **Q = K – P.**

In Kenya and Ghana, this results in positive financial returns within the first year. In Ivory Coast (due to the lower identified level of income per inhabitant), the first year returns a negative financial output. However as from the second year, also for Ivory Coast positive financial returns can be expected (see Figure 2: 5-year Net Economic Returns for blood transfusion in PPH).

Table 1: Economic impact of blood transfusion in PPH

Country	Kenya	Ghana	Ivory Coast
Yearly births (A)	1 534 900	836 005	944 778
PPH related mortality (B)	0,433%	0,433%	0,433%
PPH related mortality (cases) (#) (B)	6646	3620	4091
Avoidable deaths with transfusion (#) (C)	5879	3202	3618
Life expectancy (D)	61,1	63	54
Median age at delivery (E)	20,3	22,3	27
Life years lost F (= D-E)	41,1	43	27
Total life years lost (G =C*F)	241 613	137 682	123 029
Employment rate females (est. 50%) (H)	64%	64%	48%
Value of a life year lost per year (USD) (I)	6979	6259	3626
Total value of life years lost due to avoidable PPH deaths (USD) (J = G*H*I)	1 079 179 916	551 519 700	214 129 499
Yearly value of life years lost (USD) (K = J/F)	26 257 419	12 826 040	6 297 926
Blood Units required for massive blood transfusion (L)	13	13	13
Cost of collection, test, storage of a unit of blood (USD) (M)	100	100	100
Cost of providing blood to the patient (USD) (N)	50	50	50
Total cost of blood transfusion per unit (O = N+M)	150	150	150
Total cost of required PPH blood transfusion per year (USD) (P)	12 959 928	7 058 808	7 977 233
Net Economic Impact of blood transfusion (USD) (Q = K - P)	13 297 491	5 767 231	-1 679 307

Figure 2: 5-year Net Economic Returns blood transfusion in PPH



CONCLUSION

Our research suggests that an increased in investment in SSA's safe blood supply chain is likely to provide large positive economic and societal returns in less than 5 years. Even considering the relatively low-income levels, the cost of lives saved outweighs the investments in the supply of blood with positive economic returns. Since there are gaps in the available data in the countries of investigation related to the impact of PPH on mortality figures we recommend to partner with local medical communities to assess this locally.

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