

# Cost-Effectiveness Comparison of the ReMiND program and the NewHints Program for Reducing Neonatal Mortality Rates in the Muchinga Province of Zambia



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## Abstract

As of 2018, 2.5 million children globally died in their first month of life [1]. With lack of resources and low performing healthcare systems, developing countries are likely to encounter neonatal deaths. The perception of the necessity of expensive and advanced care is an obstacle to the reduction of neonatal mortality rates because it ignores inexpensive preventative measures that could also be effective. Preventative measures such as education about the benefits of breastfeeding, training programs for healthcare professionals to identify warning signs at early stages, close follow-up during pregnancy etc. can play a major role in averting neonatal mortality. In Zambia, a southern African country, 84,000 babies are born prematurely each year [2]. Intrapartum-related events and preterm birth complications are two leading causes of neonatal deaths in Zambia.

Within India, the state of Uttar Pradesh provided the Accredited Social Health Activists (ASHAs), a governmental program consisting of community health workers, with extensive technological training used to monitor participants from pregnancy to the child's second birthday [3]. Data tracked through the ReMiND (Reducing Maternal and Newborn Deaths) program, introduced in 2012, identified vital danger signs of expecting patients, culminating in a 5.3% reduction of neonatal deaths [3]. Within Ghana, seven rural districts in the Brong Afoho region received the NewHints intervention program, consisting of home visits to pregnant women by a trained group of community-based surveillance volunteers. This program aimed to improve delivery and newborn care practices, leading to an 8% reduction of neonatal mortality rate [4]. Rather than using disability adjusted life years, or DALYs, to examine the cost-effectiveness of each program, this cost-effective analysis utilizes deaths averted to calculate the effectiveness of interventions when applied to Muchinga, Zambia.

## Background

### *Past Attempts and Challenges*

The Millennium Development Goals (MDG) final progress report in 2015 showed that goals 4 and 5, addressing child mortality and maternal health, respectively, were not fulfilled [5]. Goal 4 called for a two thirds reduction in the under-five mortality rate. Globally, under-five years mortality rates radically dropped from 90 deaths per 1,000 live births to 43 deaths per 1,000 live births [6]. Although there was a major reduction observed, disparities within a population generated insufficient trends that prevented the proper fulfillment of the Millennium Development Goals 4 and 5 (MDGs) until 2025 [7]. Some of these disparities include socioeconomic status and wealth gaps, educational inequities for women and girls, and geographic differences between rural and urban areas. [7]. These disparities are indicative of the need for urgent program interventions devoted to closing these gaps. Another urgent disparity gap to address is

widespread access to reproductive care, including antenatal care (ANC). Although the WHO recommends a minimum of four antenatal visits a year, the percentage of women who fulfill this recommendation in Sub Saharan Africa was less than 50% in 2014. Antenatal visits are essential in detecting early warning signs indicative of possible delivery complications and providing proper support for a safe delivery [7].

At the conclusion of 2015, lack of impact was supported by a high 94% of neonatal deaths remaining in low-and-middle countries [5]. Although it is important to address the range of causes of child mortality, it can be divided into even more specific rates, such as perinatal, neonatal and postnatal mortality rates, further increasing the probability of reducing overall child mortality. Neonatal death refers to the first 28 days of life and constitutes the most vulnerable period of a child's life with the highest risk of dying globally [8]. Globally, 2.5 million children died within the first 28 days of life, with an average of 7,000 neonatal deaths a day, implying an urgent call for

international attention in neonatal health programs. Shockingly, of neonatal deaths in 2018, one third occurred within the first day [8]. The probability of dying dramatically decreases after this vulnerable neonatal period, indicating the importance of devising interventions aimed to address neonatal illnesses and deaths.

### **Disparities in Neonatal Mortality Rates in Zambia**

The urgency regarding reduction of neonatal mortality rate is even more dire in sub-Saharan African countries. Most neonatal deaths that occur in African countries still remain unreported in country wide statistics as they typically occur at home [9]. Neonatal deaths are only counted in hospitals. In Zambia, a southern African country divided into ten provinces, the neonatal mortality rate averaged to 23.5 (CI 17.6, 31.7) deaths per 1,000 live births [10]. The wide range between the upper and lower bounds can be attributed to socioeconomic and geographic disparities. In the poorest households, the neonatal mortality rate was 31 deaths per 1,000 live births, while it was 22 deaths per 1,000 live births in the richest households [1]. In addition, in rural Zambia, the neonatal mortality rate was 27 deaths per 1,000 live births, while it was 22 deaths per 1,000 live births in urban areas [1].

Muchinga is one of Zambia's provinces. It is subdivided into seven districts. 82.99% of the population live in rural areas, while only 17.01% live in urban areas [11]. Therefore, Muchinga will be used as the target region for implementing programs aiming to reduce neonatal mortality in this cost-effective analysis.

### **Program 1: ReMiND Program in the Uttar Pradesh State of India**

#### *ReMiND Intervention*

Mobile Health (mHealth) technologies have broadened the effectiveness of community health workers within India's Uttar Pradesh, targeting insufficient maternal, neonatal, and child health services in the region. With 366 maternal deaths per 100,000 live births and 80 neonatal deaths per 1,000 live births, the region of Kaushambi contributes to Uttar Pradesh's staggering maternal and neonatal death rates. To combat these numbers, mHealth interventions were implemented in a two-block radius with a target population size of 387,030 people [12].

Mobile tech utilization in developing countries has become one of the most effective healthcare interventions because of its proven growth in supplemental support of healthcare workers, substantially improving services. In

2012, the ReMiND (Reducing Maternal and Neonatal Death) project, was devised to be utilized by Accredited Social Health Activists (ASHAs), community volunteers who complete extensive healthcare training focused on community level intervention. ASHAs' main priorities aimed to increase healthcare services by acting as community mobilizers. ReMiND was used to enhance ASHAs' knowledge and skills to recognize danger signs during pregnancy and post-delivery. ASHAs managed ReMiND through Java-based mobile phones to track participants' antenatal home care visits and usage of healthcare services postpartum, tackling MDG goal five [12]. Additionally, newborn immunization was tracked throughout the first two years of life. Therefore, the mHealth intervention was able to follow-up and track patient progressive health attendance.

#### *ReMiND Data*

ASHAs reported better knowledge retention regarding threatening circumstances during pregnancy, throughout delivery, and postpartum. They were able to suggest abdominal examinations during ANC visits and encouraged women to self-report complications during pregnancy. By continuing to increase maternity and child health services, the ReMiND program would allow MDG goals four and five to be reached by 2025. Additionally, primary health benefit reductions recorded ASHA counseling education services, with the use of ReMiND, resulted in a reduction of 3.1 million maternal illnesses and 37,337 neonatal illnesses [12]. ReMiND is estimated to result in a total maternal deaths reduction rate of 312 and 149,468 neonatal deaths or 0.2% and 5.3% respectively [12]. An estimated 4,127,529 Disability-adjusted life years (DALYs) would be averted by 2020 with continuous ReMiND use, at an incremental cost of 982 million USD. Deconstructed, the ten-year incremental cost for maternal and child health combined sums 205 USD per DALY avoided. From a societal perspective, a scale up for the entire population of Uttar Pradesh, would be cost effective with 5,865 USD per death averted [12].

### **Program 2: NewHints Program in the Brong Ahafo Region of Ghana**

According to the United Nations Children Fund (UNICEF) [13], a newborn in Ghana dies every 15 minutes, with approximately 30,000 newborn deaths occurring annually. The causes of neonatal deaths have been associated with infections, preterm births, low birth weights, and hypothermia [14]. Out of all the causes, infections were the largest factor. Infections could be averted through preventive measures, such as training programs for

volunteers to identify signs at early stages, and follow-up during and pregnancy. Four studies in South Asia demonstrated a reduction in neonatal mortality rates by up to 60% through community-based approaches [15]. Based on the findings of these four studies, the WHO and UNICEF issued a joint statement encouraging all low-and-middle income countries to implement “home visits for the newborn child: a strategy to improve survival,” nicknamed the NewHints program [15]. In contrast to the studies in South Asia, the feasibility and effectiveness of community approaches to reduce newborn mortality were not evaluated in Africa, specifically in Ghana where there was a high neonatal mortality rate [15].

With the urgency to develop community-based interventions to increase neonatal survival in Ghana, the NewHints Program was implemented in rural Ghana. The target population expanded to seven districts in the Brong Ahafo region, including Kintampo North, Kintampo South, Wenchi, Tain, Techiman, Nkoranza North, and Nkoranza South [15]. The NewHints program was evaluated through a cluster randomized controlled trial design with a target population of 385,000 [4]. The intervention was integrated and developed in close collaboration with the District Health Management Teams

(DHMTs), national neonatal policy makers and coordinators, experts in neonatal health, community-based surveillance volunteers (CBSV), and many more [4]. The intervention culminated in an 8% reduction in neonatal mortality rate in Ghana and an even greater reduction of neonatal mortality of 12%, after conducting a meta-analysis of Ghana’s program and four other studies of NewHints’ program in South Asia [15]. In 2009, the economic cost of implementation was estimated to be 203,998 USD. With respect to Ghana’s GDP per capita, it had a 78% of being cost-effective [4]. The findings also revealed that the home-visit strategy had more than a 95% chance of being highly cost-effective in settings with a neonatal mortality rate of 30 or more per 1,000 deaths [4].

### Target Population in the Muchinga Province of Zambia

As of 2010, Muchinga had a population of 711,657 people accounting for 5.2% of the total Zambian population, with a 4.60% population growth projection. The 2019 population was projected to be 1,052,996 [11]. The target population chosen for intervention only includes high fertility age groups: 10-40-year-olds.

Table 1. Total population and different age distributions of Muchinga province in 2010 and total population projection for 2019

Muchinga Province	Population size (persons)
2010 Census	711,657
2019 Projection	1,052,996
Age distribution from 2010 Census	Population size (persons)
10-19 years old	177,370
20-29 years old	112,786
30-39 years old	73,650
Total	363,806

Assuming the same growth rate for different age distribution groups, the 2019 target population was projected using the calculations below:

*Sample calculation for 10 – 19 years old:*

$$\text{Ratio of 10 – 19 year old to total population} = \frac{177,370}{711,675} = 0.249$$

$$\text{Projection of 10 – 19 years old population in 2019} = 1,052,996 \times 0.249 = 262,443.7$$

Table 2. Calculated projections of the difference age distributions of Muchinga province in 2019

Age distribution in 2019	Projected target population (persons)
10-19 years old	262,444
20-29 years old	166,883
30-39 years old	108,975
Total	538,302

Table 3. Annual Costs for the ReMiND and NewHints Program

Annual Cost of ReMiND and NewHints Program		
ReMiND Program (Annual implementation cost of program in 2015-USD amount)	Human resources	\$109,032
	Travel expenses	\$26,921
	Training, equipment (mobiles), etc. for startup	\$17,526
	Supplies and other costs	\$15,700
	Overheads - management	\$22,713
	<b>Total</b>	<b>\$191,894</b>
	<b>Target population</b>	<b>\$387,030</b>
NewHints Program (Annual implementation cost of program in 2009-USD amount)	Human Resources	\$149,870
	Capital- cars and equipment	\$30,225
	Meetings and Training	\$6,835
	Supplies for CBSVs	\$12,926
	Overheads- management	\$4,143
	<b>Total</b>	<b>\$203,998</b>
<b>Target population</b>	<b>\$385,000</b>	

Costs obtained from [12] and [15]

The majority of the costs for both the ReMiND and NewHints Program are allocated towards human resources. This is because of community health workers in NewHints. ASHAs in ReMiND, and healthcare workers in hospitals, are an essential part of the implementation plans. Therefore, it is important that funds are allocated towards human resources.

### Cost Adjustment to Muchinga's Target Population

#### ReMiND Program

$$\text{Cost per capita: } \frac{\text{total cost}}{\text{target population}}$$

$$\text{Cost per capita: } \frac{\$191,894}{387,030}$$

$$\text{Cost per capita: } \$0.49/\text{capita}$$

$$\text{Projected total cost in Muchinga Zambia} = \text{target population} \times \text{cost per capita}$$

$$\text{Projected total cost} = 538,302 \times \$0.49$$

$$\text{Projected total cost} = \$263,768$$

$$\text{Projected total cost} = \$263,768$$

Using an average yearly inflation rate of 2.04% and a cumulative inflation rate of 8.43%, the projected total annual cost is adjusted for inflation from 2015 and translated into 2019 dollars.

$$\text{Total cost adjusted for inflation} = \$286,006$$

Therefore, for the ReMiND program to be implemented in Muchinga in 2019, the total cost needed will be \$286,006.

## NewHints Program

$$\begin{aligned} \text{Cost per capita: } & \frac{\$203,998}{385,000} \\ \text{Cost per capita: } & \$0.53/\text{capita} \\ \text{Projected total cost} & = 538,302 \times \$0.53 \\ \text{Projected total cost} & = \$295,253 \end{aligned}$$

Using an average yearly inflation rate of 1.82% and a cumulative inflation rate of 19.79%, the projected total annual cost is adjusted for inflation from 2009 and translated into 2019 U.S. dollars.

$$\text{Total cost adjusted for inflation} = \$341,786$$

Therefore, for the NewHints program to be implemented in Muchinga in 2019, the total cost needed will be \$341,786.

### Ghana and India as Proxy Countries for Zambia

The cost per capita of the two programs was used to linearly scale up to Muchinga's target population because the three countries have similar indicators such as target population, rural geographic areas. Regions were strategically chosen, based on the indicators previously discussed, in order to ease the estimation of cost directly from cost per capita. The GDP per capita of Ghana, India, and Zambia in 2016 were similar, which indicates comparability. As of 2017, the three countries' GDP per capita only changed slightly with Zambia's GDP per capita being 1,509.80 USD while Ghana's was 1,641.49 USD and India's was 1,939.61 USD (World Bank). The three countries also have similar healthcare expenditures. As of 2016, India's current health expenditure (CHE) as a percent of the GDP was 3.66%, while Ghana's was 4.45% and Zambia's was 4.48%. In addition, India's CHE per capita was \$62.72, Ghana's was \$67.51, and Zambia's was \$56.54, indicating further comparability [16]. Furthermore, the overall Human Development Index (HDI) for the regions are similar. The target area of Uttar Pradesh in India has an HDI of 0.590, while the target

region of Brong Ahafo in Ghana has an HDI of 0.581, and Muchinga has an HDI of 0.538 [17]. With similarities in health expenditure and overall in HDI, we assume the functionality of the health infrastructures and resources are interchangeable in Zambia. Thus, the cost for implementing the two programs in Muchinga was calculated by scaling up the cost directly from the cost per capita.

### Neonatal Mortality in Muchinga, Zambia

The neonatal mortality rates between Ghana, India and Zambia are very similar. Therefore, we can assume the reduction percentages reported from the two programs will have similar effects in Muchinga as well. Therefore, neonatal deaths averted will be calculated assuming a similar reduction trend. According to the Central Statistics office of Zambia in 2020, there is a projection of 48,148 live births in the Muchinga province. Assuming the neonatal mortality rate is 29 deaths per 1,000 live births in Muchinga, the neonatal deaths averted can be estimated using the percentage reduction stated above from the two programs.

$$\text{Annual neonatal deaths} = \text{annual live birth} \times \text{neonatal mortality rate}$$

$$\begin{aligned} \text{Annual neonatal deaths} & = \frac{48,184 \text{ live births} \times 29 \text{ neonatal deaths}}{1,000 \text{ live births}} \\ \text{Annual neonatal deaths} & = 1,397 \text{ deaths} \end{aligned}$$

### Neonatal Deaths Averted in Muchinga

#### ReMiND Program

Assuming the previously stated 5.3% neonatal mortality rate reduction

$$\text{Neonatal deaths averted} = \text{total neonatal deaths} \times \text{percentage reduction}$$

$$\text{Neonatal deaths averted} = 1,397 \text{ neonatal deaths} \times 0.053$$

$$\text{Neonatal deaths averted} = 74 \text{ neonatal deaths averted}$$

## NewHints Program

Assuming the previously stated 8.0% neonatal mortality reduction

$$\text{Neonatal deaths averted} = 1,397 \text{ neonatal deaths} \times 0.08$$

$$\text{Neonatal deaths averted} = 112 \text{ neonatal deaths averted}$$

### Cost-effectiveness Comparison

#### ReMiND Program

$$\text{Cost effectiveness} = \frac{\text{total cost}}{\text{outcome}}$$

$$\text{Cost effectiveness} = \frac{\$286,006}{74 \text{ neonatal deaths averted}}$$

$$\text{Cost effectiveness} = \$3,865 \text{ per neonatal death averted}$$

#### NewHints Program

$$\text{Cost effectiveness} = \frac{\$341,769}{112 \text{ neonatal deaths averted}}$$

$$\text{Cost effectiveness} = \$3,052 \text{ per neonatal death averted}$$

Table 4.

Cost-effectiveness	
ReMiND Program	\$3865/death averted
NewHints Program	\$3052/death averted

According to the calculations, NewHints is more cost effective than the ReMiND program.

## Discussion

### Threshold for Cost Effectiveness

The World Health Organization (WHO), recommends a threshold within the range of one to three times the GDP per capita for determining cost-effectiveness of a program, with less than 1 times the GDP per capita being highly cost efficient and 3 times the GDP per capita being the threshold for cost-efficiency [18]. As of 2017, Zambia's GDP per capita was \$1,509.80.

$$\text{Threshold} = \$1,509.80 \times 3 = \$4,529.4$$

Therefore, according to WHO's recommendation, both programs are cost-effective, as they are both under \$4,529.4. Conditionally, if the rate of inflation does not exceed Zambia's GDP growth per capita; the programs may become even more cost-effective. Nevertheless, the NewHints program is more cost-effective compared to the ReMiND program, as it costs \$813 less per death averted.

### Policy Implications

Implementing the NewHints home visit program in Muchinga would represent only a small percentage of Zambia's budget in primary healthcare. As of 2016, 79% of the current health expenditure is allocated towards primary health care expenditure [19]. In addition, there is 33 million USD of external funding allocated towards reproductive health. Therefore, with the appropriate political will and advocacy, funds can be allocated towards this new program with Muchinga serving as the target region. Depending on the impact of a one-year implementation period, the program can be scaled up to the entire country. To create a profound impact, the implementation process should integrate incentivization schemes for the community-based surveillance volunteers, such as monthly awards for number of home visits, performance etc.

The use of preventative measures has been shown to be cost-effective in reducing neonatal deaths in India's ReMiND program and Ghana's NewHints program. Each program indicates strong reduction rates of neonatal health in their prospective countries with the potential to be

equally effective when applied to Zambia. Although the total costs of implementation for ReMiND narrowly outweighed the total cost of NewHints, when applied to the cost per capita and death averted, NewHints was the more cost-effective intervention. It is important to note, maternal and child health services are traditionally tethered interventions. NewHints disassociated child health services from maternal services while ReMiND combined services. This juxtaposition indicates a possible need for distinguishable interventions specifically for maternal or neonatal health.

In conclusion, service delivery is one of the key determinants transforming a broken healthcare system into a well-functioning one. Targeted service delivery, such as home health visits by community health workers, is essential in addressing inequality and inequity regarding accessibility to healthcare services. Data indicates inequalities are visible across borders, but there is an immediate need to address hidden inequalities, which may result in dire healthcare consequences. Although the ideal, long-term solution to close the gap within countries is providing universal coverage, current political and economic situations impede most countries' ability to provide the fiscal capacity or the governance necessary to achieve that. Thus, for now, direct targeting of vulnerable and disadvantaged communities is necessary.

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