EVALUATING THE EFFECTIVENESS OF KANGAROO MOTHER CARE: A CAMEROON PERSPECTIVE

By

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Abstract

The purpose of this study is to understand and measure the impact of introducing a cost-effective intervention in a developing country like Cameroon, Africa. Preterm birth and low-birth weight are the global leading causes for neonatal complications and mortality (Lawn et al., 2005). The intervention under study in this paper is kangaroo mother care. Ex-ante research shows that kangaroo mother care is associated with reduced mortality and morbidity. Impacts on mortality and morbidity can be aggregated using quality-adjusted life years (QALYs), healthy-year equivalents (HYEs) and disability adjusted life years (DALYs). This paper uses a modified DALYs formula to aggregate the number of disabled years averted across neonatal and post-natal mortality, lower incidence of mild and moderate infections, and low post-neonatal weight. Effectiveness is usually represented in monetary terms using a value transfer method, as shown in this paper. These benefits in monetary terms have been compared with the costs to understand the cost-effectiveness of kangaroo mother care. Finally, a probabilistic analysis – Monte Carlo simulation – has been conducted using the standard errors associated with inputs. The results include a simulation that shows a probabilistic range of DALYs averted and sensitivity analysis.

Introduction

Almost four million infants die each year within the first four weeks of their life (Lawn et al., 2005). This early mortality is attributable to being preterm and having a low birth-weight. Preterm infants are defined as being born before 37 weeks of gestational age. Each year, over 20 million infants are born below the weight of 2.5kgs (Conde-Agudelo & Belizán, 2003). These infants are classified as low-birth-weight (LBW) and are at an increased risk of early growth retardation, infectious disease, development delay and death during infancy and childhood. 96% of low-birthweight infants are born in developing countries (Conde-Agudelo & Belizán, 2003). An immediate explanation for this is inadequate healthcare systems, inadequate prenatal education amongst mothers, socioeconomic and cultural factors that make it difficult for mothers to seek medical help.

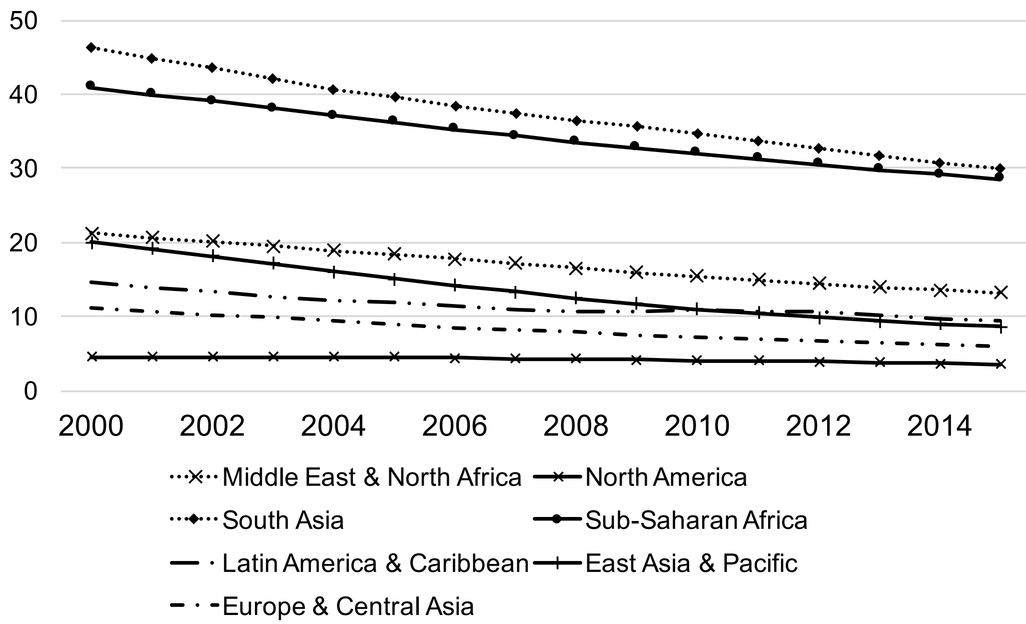

Figure 1 – Global neonatal mortality rates comparison (The World Bank, 2017a)

Reduced neonatal mortality is one of the goals outlined in the Millennium and Sustainable Development Goals by the UN. The Millennium Development Goals (MDGs), by the UN, outlined eight goals, several of which covered global health scenarios. These goals have been revised as of 2015, with a new time target of 2030. The Sustainable Development Goals (SDGs) by the WHO address health priorities such as universal health coverage, financial protection, health risk reduction and management fronts. Maternal and child health are a key component of the SDGs. Health coverage looks at eight core tracer indicators such as family planning, antenatal care, skilled birth attendance, child immunization, infectious diseases, water sources, and sanitary facilities. These are all factors that affect national progress towards SDG goals.

As a part of maternal and child health, SDGs use under-five mortality, maternal mortality, neonatal mortality, adolescent birth rate, and mortality due to unsafe water, hygiene, and sanitation. Besides mortality rates, SDGs also analyze health risks by observing child stunting, and wasting. Risk indicators include access to resources that reduce the health impacts. Examples of risk factor indicators include access to a safely managed drinking-water source and access to clean household energy. Global progress towards these goals has included a 49% decline in under-five mortality between 1990 and 2013. However, this decline does not meet the goal of two-third reduction in under-five mortality (The World Health Organization, 2015). Therefore, this is reason enough to investigate interventions that can help countries attain the Millennium and Sustainable Development Goals.

This paper evaluates the effectiveness of Kangaroo Mother Care (KMC), a intervention that aims at reducing infant and neonatal mortality through skin-to-skin neonatal care and promotion of exclusive breastfeeding. The quantitative analysis is conducted in the context of Cameroon.

Cameroon

Cameroon is composed of eight Francophone and two Anglophone provinces. 40% of Cameroonians identify with Christianity, 20% identify with Islam, and 40% ascribe to indigenous African beliefs (U.S. Department of State, 2006). In all, there are over 200 ethnic groups living in the ten provinces, totaling to a population of 23.1 million (The World Bank, 2017a). The differences in religions between Islam in the North, and Christianity and traditional African religions in the South, have brought about a significant cultural divide between the north and the south (U.S. Department of State, 2006). Cameroon's ethnically diverse population is also amongst the most urban in Western Africa, with 54.4% of the population living in urban areas. This proportion has been steadily increasing over the last 10 years, with the lowest population density in the southeast interior (Central Intelligence Agency, 2016).

Cameroon ranks 150th worldwide and 34th regionally on the Heritage Foundation's Economic Freedom scale. Therefore, the country is categorized as "mostly unfree". It also ranks 153 on the UNDP's Human Development Index (HDI) (UNDP, 2016) and has a relatively low average life expectancy of 58 years, with 57 years for males and 59 years for females (Central Intelligence Agency, 2017). The Gender Development Index (GDI) for Cameroon, which is calculated using the ratio of female to male HDI values, is 0.853 (UNDP, 2016). The GDI level for Cameroon has been consistent since the year 2000, indicating that gender-based inequality has persisted. Cameroon's overall unemployment rate of 4.6% and youth unemployment rate at 7% have been consistent since 1995 (UNDP, 2016). This may be attributed to the high dropout rate from school – only 31.8% of the population has attempted secondary education. This leads to a high proportion of low-skilled workers and high participation in the informal sector. In terms of human security, the homicide rate per 100,000 people is 2.7 which, is lower than the Sub-Saharan average of 9.5 (UNDP, 2016; World Bank Database). Figure 2 shows these rankings and some other important background indicators in a snapshot.

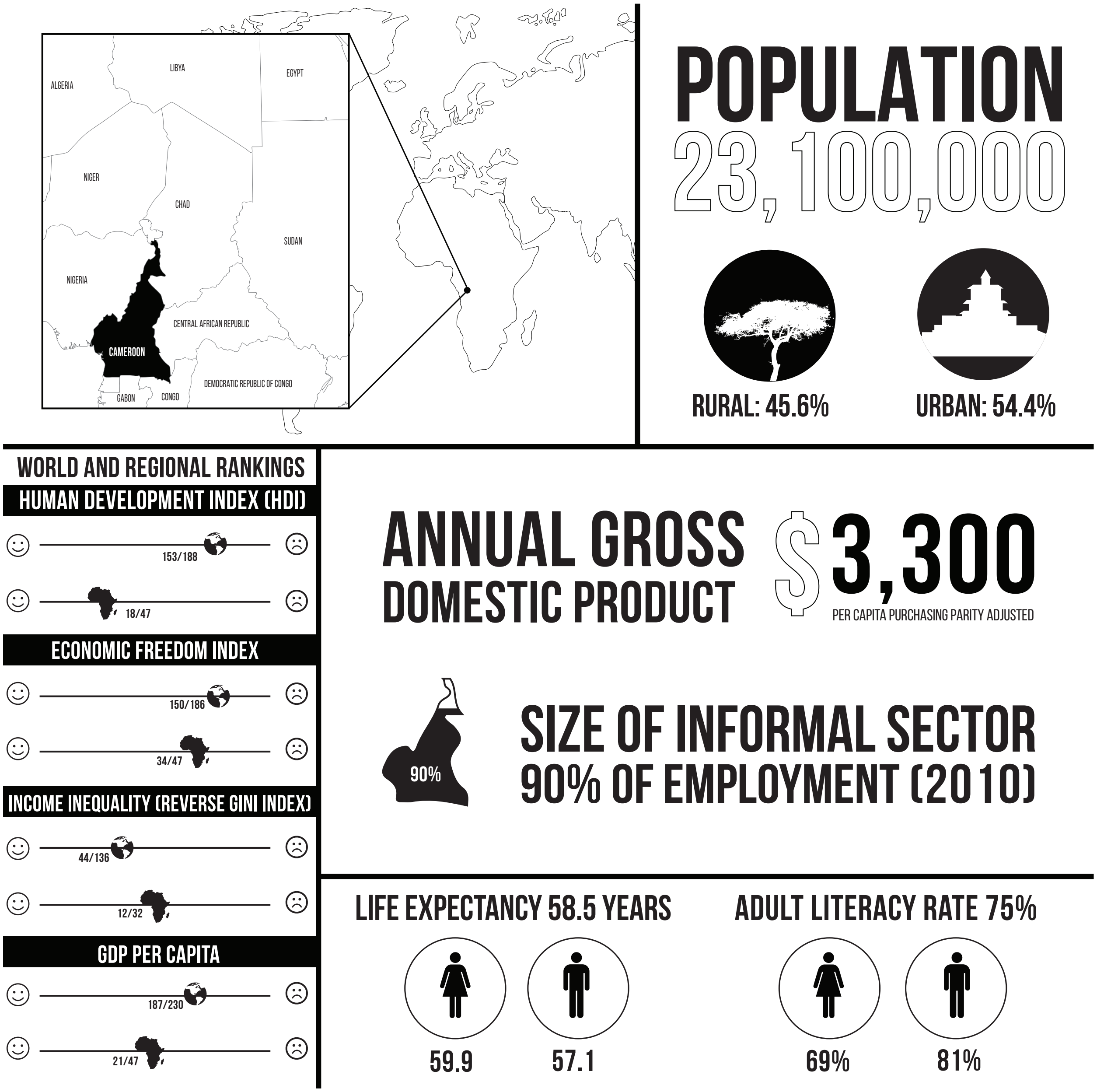

Figure 2 – Country snapshot of Cameroon (Central Intelligence Agency Fact book, 2017)

Cameroon has 178 health districts with 150 operational district hospitals, 17 provincial hospitals and 9 regional hospitals, 141 health centers and 1,653 health posts (WHO, Cameroon, Global atlas of medical devices). Cameroon has public and private healthcare facilities, each offering various levels of quality depending on the region. Within Cameroon, 40% of the country's doctors practice medicine within the Center region. By 2030, the MDGs stipulate that neonatal mortality rate and under-5 mortality rate needs to be reduced to below 12 per 1,000 live births. Table 1 reflects Cameroon's before and after levels with respect to some MDG goals over time.

Table 1 – Cameroon status on MDG goals: before and after comparison (MDG Country Progress Snapshot: Cameroon, 2015; The World Bank, 2017 d-n)[1]

Indicators	First Year Value	Latest Year Value	Percentage Change
Under-five mortality rates (per 1,000 births)	138	87.9	-36%
Maternal mortality ratio (100,000 live births)	720	590	-18%
Children under-5 moderately or severely underweight (%)	18.1	14.8	-18%
Contraceptive prevalence rate (% of women aged 15-49, married or in union, using contraception)	16.1	34.4	113%
Unmet need for family planning (% of women aged 15-49, married or in a union, with unmet need for family planning)	22.4	23.5	5%
HIV Incidence rate (number of new HIV infections per year per 100 people aged 15-49	0.76	0.4	-47%
Number of new cases of tuberculosis per 100,000 population	110	212	93%
Number of deaths associated with tuberculosis per 100,000 population	22	35	59%
Proportion of population using an improved drinking water source (%)	51%	76%	49%
Proportion of population using improved sanitation facility (%)	40%	46%	15%
Proportion of urban population living in slums (%)	51%	38%	-25%

[1] The year of the data varies according to the indicator. All data presented is according to the latest year estimates. Data has been combined between the World bank database and the UN country report for Cameroon. For details on the UN report, visit https://mdgs.un.org/unsd/mdg/Resources/Static/Products/Progress2015/Snapshots/CMR.pdf.

Kangaroo Mother Care

Kangaroo Mother Care (KMC) was initiated in 1979 by Dr. Edgar Rey and Dr. Hector Martinez in Bogota, Columbia, as a cost-effective alternative to conventional neonatal care in developing countries. Conventional neonatal care has resulted in a global decrease in perinatal mortality over the last 40 years because of its rigorous precautions against sepsis. Perspex incubators are commonly used in conventional neonatal care units. Infants are placed in these incubators for weeks or months. However, conventional neonatal care is expensive and requires highly skilled personnel and permanent logistic support. This is not easily accessible in developing countries like Cameroon. Further, there have been concerns about the barrier between parents and the baby that conventional neonatal care units bring about. The concerns from using an incubator are derived from the psychological consequences of prolonged separation between babies and their mothers (Conde-Agudelo & Belizán, 2003). Further, conventional neonatal care units require a constant monitoring by skilled medical staff. While this is not a barrier in developed countries, developing countries such as Cameroon have very limited access to skilled medical staff.

Lack of access to medical staff can be explained over two fronts: inability to afford medical services and overall low doctor to population ratio. According to the World Health Organization, over 100 million people worldwide become impoverished as a direct result of the prohibitive cost of providing welfare services (World Health Organization 2008: 16). According to the WHO, the critical level of minimum healthcare workforce density is 2.5 physicians and medical staff per 1,000 population (The World Health Report, 2006). This worldwide ideal requirement would achieve an 80% coverage rate for deliveries by skilled birth attendants. The WHO estimates that over 4.3 million more health workers are needed worldwide, out of which, 1.5 million workers are needed in Africa alone (World Health

Organization 2008: 16). Further, out of the 57 countries identified by the World Health Organization as having critical shortages of health workers, 36 are in Africa, including Cameroon (Tandi, et al., 2015).

Cameroon's physician and medical staff per 1,000 population is at 1.3 physicians and medical staff per 1,000 population (Tandi et al., 2015). This is lower than the African average of 2.3 physicians and support workers per 1,000 population (The World Health Report, 2006). A comparison of health personnel density between Africa and other global regions has been shown in Figure 3. Regionally, a physician in Central Cameroon caters to an average of 5,449 persons. In comparison, one physician in the Adamawa region caters to an average of 26,726 persons (Tandi, et al., 2015). Six out of the ten regions in Cameroon have fewer than 2 doctors per 10,000 population, three provinces have an average of less than 1 doctor per 10,000 population and one province has exactly 2 doctors per 10,000 population (Tandi, et al., 2015).

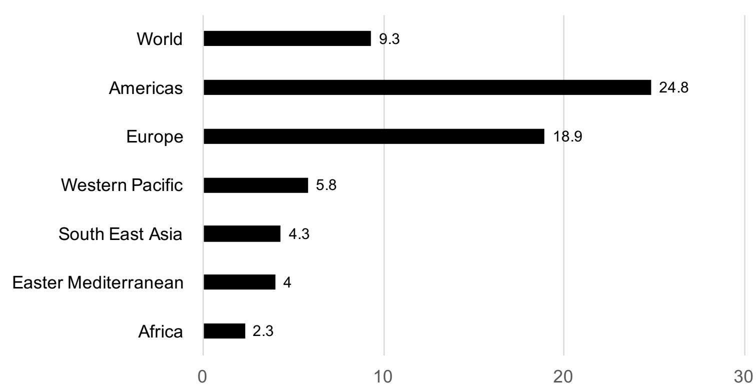

Figure 3 – Health personnel density (per 1,000 population), regional comparison. (The World Health Organization, 2006a)

Table 2 – Health worker density per 1,000 population (Tandi et al., 2015)

Region	Total density	Physician density	Nurse density
Cameroon	1.29	0.07	0.67
Adamawa	0.84	0.04	0.59
Centre	1.97	0.18	0.92
East	1.35	0.06	0.85
Extreme North	0.78	0.02	0.4
Littoral	1.29	0.1	0.66
North	0.5	0.01	0.31
North west	1.05	0.04	0.5
West	1.72	0.05	0.97
South	1.36	0.08	0.8
South west	1.69	0.05	0.87

Besides the low-density of medical workforce, the public-sector workforce is aging with 53% of healthcare workers between the age of 40-51, and 31% over the age of 51. Given that the retirement age within the public sector is 51-60, the World Health Organization used the HRH (2011) census to estimate that 15% of existing public-sector health workers were lost to retirement in 2010-2012 and this pattern is expected to persist (World Health Organization, 2011). This has caused problems with stability of available health personnel. Further, the centralized form of recruitment after training takes 36 months or more to complete when including the integration of personnel at healthcare facilities (Tandi, et al., 2015). Therefore, there will be a critical shortage of medical personnel in Cameroon. Interventions such as kangaroo mother care that require minimal effort and supervision from doctors are therefore advantageous to Cameroon.

Due to the shortage of doctors in Cameroon, nurses are often responsible for basic medical treatment. These nurses are therefore trained in basic healthcare programs, disease prevention programs and education programs on hygiene, nutrition, and infection (The World Bank, 2013). In KMC literature, nurses are the ones that train and supervise mothers (Conde-Agudelo & Belizán, 2003). The disparity of available healthcare personnel across Cameroon has affected the government's ability to work towards the Millennium Development Goals (MDGs). The Cameroonian government aims to achieve universal healthcare by 2035 (Tandi, et al., 2015). In order to do this, policies must be implemented that target the training, recruitment, and retention of healthcare personnel.

Kangaroo mother care has been viewed as a successful alternative to conventional neonatal care to reduce neonatal mortality and morbidity. It has addressed the shortage of incubators in neonatal units and the incidence of severe hospital infections in developing countries. It was developed because of high neonatal death rates and abandonment in large maternity hospitals (Conde-Agudelo & Belizán, 2003). KMC was developed as an option that encouraged mothers to nurse their babies thereby, increasing mother-infant attachment and interaction (Conde-Agudelo & Belizán, 2003).

Mother’s skin-to-skin contact and unique interaction with the infant has been discussed as providing sensory stimulation that includes proprioceptive, emotional, vestibular, tactile, olfactory visual, auditory, and thermal stimulation (Cong, Ludington-Hoe, McCain & Fu, 2009). Chiu and Anderson (2009) discuss that KMC promotes beneficial physiological conditions such as increasing quiet sleep state, alert wakefulness, shorter periods of active sleep, more organized sleep-wake cycles in the short-term, stable thermoregulation, oxygen saturation, heart rate, and respiratory rate. KMC can be divided into two key components - kangaroo nutrition and skin-to-skin contact.

Early and exclusive breastfeeding forms the kangaroo nutrition component of KMC. It is very beneficial in developing countries because of limited nutrition sources for infants. Low birth-weight infants are very prone health issues related to nutritional deficiencies. Health issues from health issues include stunting and wasting. The Institute for Health Metrics in Cameroon has listed low childhood weight and suboptimal breastfeeding as two out of the three risk factors that account for the most disease burden (GBD: Cameroon

Profile). Since baby formula is not always affordable in developing countries, exclusive and early breastfeeding is used as an attempt to increase post-birth neonatal weight. Term neonates have been reported as losing almost 3-5 percent of their birth weight within the first 3-6 days (Doherty & Simmons, 2008). This weight is usually regained by the tenth day. Preterm infants lost 5-15 percent of their birth weight within the first 5-6 days, because of immature and underdeveloped skin and kidneys. Preterm infants also take a longer time to regain their body weight (Ellard & Anderson, 2008).

Skin-to-skin contact has been used in KMC to regulate the infant's body temperature. Mothers are taught to hold the infant in an upright position so as to prevent neonatal aspiration (Venancio & Almeida, 2004). Further, Tourneux et al. (2009) discuss that the thermoregulation through skin-to-skin contact helps the infant redirect energy towards body growth. Newborns usually direct energy towards three things: metabolism, body temperature, and body growth. KMC reduces the energy needed for basic metabolism and body temperature regulation. The duration of skin-to-skin contact depends on the type of KMC being implemented.

KMC implementation can be segregated on two bases: duration of KMC per day and onset of KMC. Duration of KMC can be divided into continuous and intermittent. Continuous KMC is defined as having skin-to-skin contact for longer than twenty hours in a day. Intermittent KMC as described by studies as either implementing KMC for less than two hours a day or six to fifteen hours a day. Early-onset KMC is undertaken within 24 hours post-birth and late-onset KMC is undertaken after stabilization of the infant, which often occurs later than 24 hours post-birth. Quality KMC implementation includes early, continuous and prolonged thermal care through skin-to-skin contact between a mother and her newborn, frequent and exclusive breastfeeding and early discharge from the hospital (Conde-Agudelo & Belizán, 2003).

Pilot studies have shown that as long as the infant is stable, skin-to-skin contact could be initiated for babies as small as 700g (Boundy et al., 2016). Skin-to-skin contact improves communication between the mothers and full-time infants. Mothers also report being more confident and feeling more positive towards her baby at the six-month follow-up. The first set of randomized controlled trials were initiated in the 1980's by Whitelaw et al. (1998) among babies less than 1500g. Seventy-one infants were randomized, and mothers were given varied instructions on whether to hold her baby in skin-to-skin contact or handle her baby without skin-to-skin contact. At 6 months of age, the infants who had skin-to-skin contact cried significantly less than the control group. Mothers that used skin-to-skin contact also lactated for four weeks longer than the control group. These mothers have also made positive comments about child-maternal bonding while using KMC.

Effectiveness of Kangaroo Mother Care

Introducing Kangaroo Mother Care to neonatal facilities can have a wide range of benefits to infants, parents and other stakeholders such as the hospital and insurance companies. The intervention specifics and results can be categorized using the theory of change components: input, output, impact, and outcome.

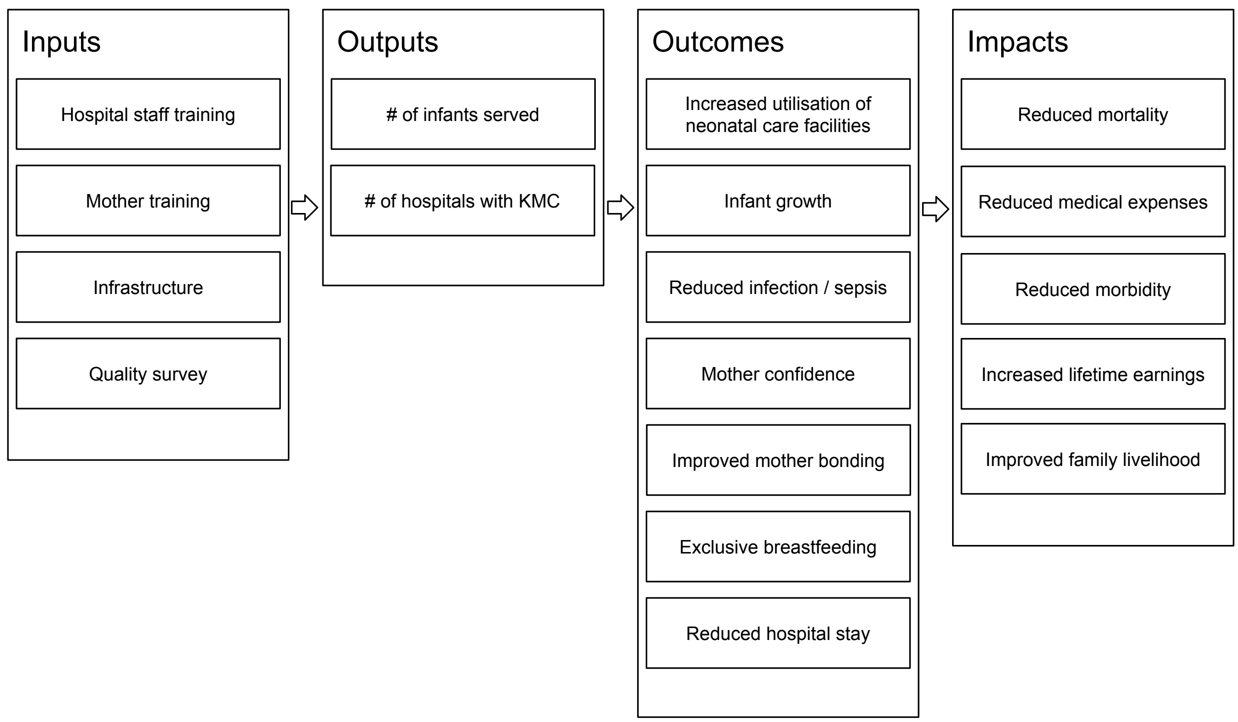

Figure 4 – KMC theory of change

Infants are the ones that receive the main benefits from the program, followed by parents, the hospitals, and the insurance agencies. These are, therefore, the key stakeholders impacted by the intervention. It can also be helpful to group outcomes in terms of their representativeness of intervention effectiveness. To this end, Conde-Agudelo, Díaz-Rossello, and Belizan (2014) have grouped possible outcomes into primary and secondary outcomes, where primary outcomes are relatively more representative of effectiveness.

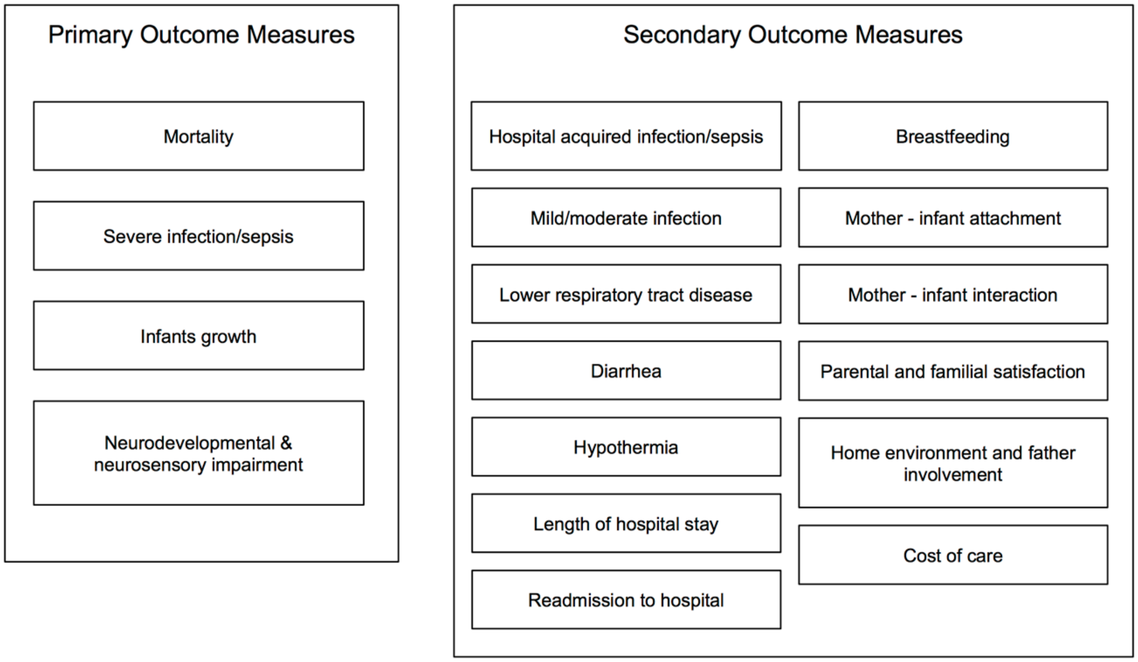

Figure 5 – Primary, Secondary Outcome Measures (Conde-Agudelo et al., 2014)

Mortality vs Morbidity

Health impacts of KMC that can be aggregated intro reduced mortality and reduced morbidity. Because the target population of this intervention is infants at early stages of life, health problems such as severe infections or illnesses, hypothermia are classified as causes of mortality. Severe infections or illnesses are classified as those that always require that the neonate is readmitted to the hospital or stay at the hospital for a longer time. Severe infections can include sepsis and meningitis. On average global deaths from neonatal sepsis and other infections were estimated at 328,000 and 342,000 in 1990 and 2013 (Vergnano et al., 2016). Therefore, despite the fall in global neonatal mortality as seen before, the incidence of infections is increasing.

As discussed in the figures above, systematic reviews by Conde-Agudelo et al. (2014) have shown that KMC can have impacts on averting mild or moderate infections, diarrhea, increasing weight gain, head circumference, increased height, and increased exclusive or any breastfeeding. These health outcomes are responsible for reducing morbidities. Morbidities are associated with disabilities that result from a negative health outcome. Morbidities can, therefore, have short or long term effects. These effects, however, do not result in immediate mortality. In the KMC perspective, when the infant gains weight such that it is no longer in the low-weight category, morbidities such as stunting, nutritional deficiencies, and wasting can be avoided. There has been controversial evidence that surrounds the impacts of exclusive breastfeeding. While breastfeeding in the low-income setting is beneficial because it provides nutrition, the long-term benefits on IQ and psycho-development has been inconclusive. More details have been specified in the section that looks at long-term impacts of KMC.

When accounting for morbidities in KMC, there can be an overlap between mortality and morbidity outcomes. Infants are only able to get benefits from reduced morbidities if they don’t die during the intervention. Therefore, analysis of benefits from reduced morbidities only looks at a section of infant population in Cameroon. This is referred to as double counting as benefits are counted from mortality and morbidity, and it can have significant biases in results. However, both mortality and morbidity need to be considered while estimating impacts to get a clearer picture on benefits of KMC.

Impacts on Infants

The most direct beneficiaries from Kangaroo Mother Care (KMC) are the low-birth weight, preterm infants. As discussed above, impacts on infants can be segregated into averted mortalities and morbidities. Mortalities can be segregated in neonatal and post-neonatal. Neonatal mortality is defined by the World Bank as infant deaths within the first month of life. Within hospital deliveries, the first month of an infant’s life is quite commonly spent at the hospital. The first month includes time spent in stabilization and KMC. Post-neonatal mortality is defined as the period between the first month and the end of the infant's first life year. The post-neonatal period is, therefore, usually the period after discharge, spent at home. The causes of mortality between these two periods are quite different. Mortalities in hospitals are caused due to hospital acquired infections, neonatal asphyxia, hypothermia, and congenital malformations (Ndombo et al., 2017). Infections in hospitals are mainly caused due to the lack of cleanliness and hygiene.

During the post-neonatal period, infant mortality is a result of lack of cleanliness and hygiene at home, HIV transmission, infections from other family members (Monebenimp, F. et al, 2011). These negative outcomes are observed in infants in addition to the higher risk of morbidity, inhibited growth and development, disruptions in the neonate's neurobehavioral development, and chronic disease faced by low birth-weight and preterm infants. Disruptions in neurobehavioral development in particular can result in disorganization of the neonate's nervous system in the form of physiological functioning disturbances, stress and behavior disturbances (Jefferies, 2012). Keeping infants at the hospital and limiting contact with individuals excluding the mother also reduces the chance of exposure to surrounding infectious outbreaks (Boundy et al., 2016). Jeffries et al. (2012) has observed improvements in cardiorespiratory stability and improved responses to procedural pain in KMC infants.

Systematic reviews have linked Kangaroo Mother Care with an increase in exclusive breastfeeding, breastfeeding in early stages has been linked with reducing long-term disabilities. During KMC, infants experience maternal heart sounds, rhythmic breathing, and warmth, all of which may have an impact on long-term infant neurodevelopment. Researchers hypothesize that there may be long-term impacts such as improvements in neurodevelopment outcome, higher scores on Mental Development Index and Psychomotor Development Index of the Bayley Scales of Infant Development at six months and within one year. There have only been two cohort studies that have identified these results in the short-term (Conde-Agudelo et al., 2014). There is therefore inadequate evidence that KMC improves outcomes through these mechanisms (Boundy et al., 2016). Research that has been conducted on the long-term impacts of KMC has been discussed in the following section.

Long-term Impacts

Charpak N, Tessier R, Ruiz JG, et al., (2016) tested the long-term implications of KMC treatment on the first cohort of KMC infants twenty years after the intervention has ceased in Columbia. Out of the 716 original participants, 494 were identified, 441 were re-enrolled in an evaluation program. Comparisons were made across KMC and control groups to identify the differences in health statuses, and neurologic, cognitive and social functioning. KMC did not protect infants from sensorial (visual and hearing) and motor (cerebral palsy) morbidity. Researchers have also been unable to explain the differences in mathematical and language skills between the KMC and control group twenty years after the original trial. Within mathematical tests, the lower scores seen in the KMC groups were found only in the most immature children. The academic challenges faced by both groups are in line with the challenges faced by children born prematurely elsewhere. On average very preterm or low birth weight infants have a lower IQ and these effects are seen up o 20 years after birth.

Within the KMC group, a smaller effect of lower IQ is seen and is focused on groups that were more fragile within their first year of life (Charpak N, Tessier R, Ruiz JG, et al., 2016). Behaviorally, KMC participants from the poorest families have had lesser tendencies towards aggression, impulsiveness, and hyperactivity. They have also shown more social behavior traits. KMC families have been more supportive and child-oriented. This has helped with child development by exposing the child to a wider array of experiences. Paternal involvement in neonatal care has had positive impacts on the family environment and ultimately the child's cognitive capacity.

The second avenue of long-term research was on wages and productivity. Darwin Cortés and some other researchers conducted two avenues of research in consecutive years of 2015 and 206. The first paper looked at evaluating the long-term effects of KMC on labor and education outcomes twenty years after the intervention was conducted in Bogota, Columbia. It was observed that KMC children had longer enrollment in preschool and had a lesser temporary absence from school. These results were then analyzed to understand the effect of KMC on wages. The primary outcome observed was log wage changes per hour. In order to correct for selection biases, they have controlled for decisions to study and work. The status of studying was defined as currently studying or having previously studied at a university. The decision to work reflects on whether the individual is currently working or has worked in the previous year. Given that the study was conducted twenty years after KMC ended, some of the individuals under review may not have even entered the labor market yet. The individuals already in the labor market may be less able, poorer, or a combination of both as compared to those that are still pursuing studies at universities.

Charpak et al. (2016) published another paper to highlight the reasoning and pathway behind KMC infants earning more wages than the control group. KMC is already known to impact family bonding. This results in positive cognitive and socio-emotional skills. Their working hypothesis was that KMC also impacts household investments. Increased household investments may be impactful in the accumulation of human capital and individual productivity both in the short and long run. They assume that skill sets that design a pathway of earning profiles should be identified for an individual over the course of his/her life.

Their research uses three steps: a factor analysis to identify latent variables, a structural analysis to connect childhood skills and adulthood skills and outcomes and decompose the effects of KMC on the skills and outcomes discussed in the first two steps. The decomposition is undertaken using the Blinder-Oaxaca technique. This technique decomposes wage differentials between the treatment and control group into two components: the explained and unexplained components. The explained component looks at the mean change in outcomes, given that individuals in the treatment and control group have the same skill sets. The unexplained component looks at the mean change in outcomes given that there is variation between the treatment and control in unrelated skill sets.

Estimates of skills and investments are gathered from a pool of measurements that include cognitive, academic, personality, and behavioral characteristics. These measures are calculated at an individual level. Structural models look at the health statuses, parental education, hereditary traits and other environmental factors at birth as childhood skills. These skills are combined with parental investments to produce adulthood skills and final outcomes. At adulthood, KMC has shown a significant negative mean difference between the treatment and control group in working memory. When KMC is analyzed with respect to childhood skills, it is estimated that on average, infants from the treatment group spend more years in pre-school as compared to control group infants. The authors conclude that wage changes between the treated and control group remain unexplained because the number of pre-school years attended by an infant is the only measurement variable significantly impacted by KMC.

Their results on whether KMC has impacted and changed the level of skills during adulthood are inconclusive. The significant results shown by Charpak et al. (2016) only suggest that there is an impact on working memory. However, this impact is negative. Charpak et al. (2016) have recognized that while KMC has not had a direct impact on their chosen adulthood skills that impact wages, there is a possibility that KMC has affected skills not outlined by the authors or that KMC affects a production function that maps skills and investments into outcomes. This is an important area for future research. With the availability of a data collection system, it would be an interesting research avenue after the intervention ceases. Long-term impacts may influence stakeholder buy-in in the program. Therefore, while there is no current evidence on long-term impacts, it is an important consideration.

Impacts on Other Stakeholders

Impacts of Kangaroo Mother Care also extend to the mother and the hospital. Early kangaroo care increases the probability of the infant being reliant on the mother as compared to nursery's surroundings, or more commonly known as nursey flora (Jefferies, 2012). An infant increased reliance on the mother as compared to the nursery surroundings is beneficial because the nurseries often have plenty antibody-resistant organisms and coagulase-negative Staphylococcus. Mothers enrolled in the KMC program have shown more attachment behaviors and describe an increased understanding of motherly roles. They report feelings of increased confidence and describe a feeling of being needed by their baby (Conde-Agudelo et al., 2014). Jefferies (2012) reports that post-discharge, mothers were more attuned to their child's needs and signals as compared to mothers that did not go through KMC.

Hospitals are another key stakeholder within the KMC intervention. The implementation of KMC would result in a range of financial impacts on hospitals. Neonates would have a lower risk of sepsis, hypothermia, and hypoglycemia (Conde-Agudelo et al., 2014). Advanced technologies that generate higher revenue would therefore not be used as often. As discussed before, most hospitals in Cameroon, especially in the north and extreme north region, have restrictions on capacity and personnel. Introducing KMC, which does not require intensive supervision and specialized personnel will allow hospitals to reallocate resources such as advanced personnel and equipment to unstable infants in need to immediate attention. As a part of the intervention, infrastructure improvements would also be undertaken that would be accessible to the hospital during and after the intervention. Overall, depending on the financial arrangements of the intervention, hospitals may experience a reduction in revenue per infant, but an overall increase in net profits.

The reduction in medical expenses per infant has the potential to provide significant respite to low-income parents that ordinarily would not be able to afford the high costs associated with advanced procedures for neonatal care (Conde-Agudelo et al., 2014). Evidence from KMC studies conducted in Ethiopia, Indonesia, Mexico and Ecuador by Cattaneo et al. (2007) and Sloan et al. (2008) show that there is an overall lower cost of care for mothers and hospitals. Mothers have a lower cost because of lower readmissions and hospitals have lower costs because of lower salaries and lower running costs (Cattaneo et al., 2007; Sloan et al., 2008).

It is important to avoid double counting while identifying the financial impacts of KMC on medical expenses. Reduced readmissions count towards reduced medical expenses as well. Therefore, if a clear distinction is provided wherein the reasoning of readmission is noted, impact analysis can be conducted on whether KMC was successful in averting the incidence of infections after discharge. There are some cases such as HIV transmission where the infant is admitted within a year of discharge, this would not be a result of KMC not working. All these results require a strong baseline analysis at a regional level.

Impact Measurements

A quantitative measure of impact for assessing Kangaroo Mother Care needs to capture benefits arising from reducing mortality and morbidity. Quality-adjusted life years (QALYs), health year equivalents (HYEs), and disability-adjusted life years (DALYs) are measures of health that show how years lost due to premature mortality and years of life lived with disease or disability are impacted by an intervention.

QALYs

Quality-adjusted life years (QALYs) are used to correct life expectancy based on the health-related quality of life that the individual is predicted to have given any disability. It adds an indicator that reflects the quality of life among survivors, making it a more elaborate calculation. It can be referred to as “the number of years lived in perfect health.” The term ‘quality-adjusted life years’ was first used in 1976 by Zeckhauser and Shepard as a health outcome measurement that combines quantity and quality of life (Sassi, 2006). The calculation framework employed in QALY is the basis for the development of multiple outcome measures, including disability-adjusted life years (DALYs). QALYs can be identified per year for better interpretation (Sassi, 2006).

$$\text{QALYs lived in one year} = 1 \times \text{Q}, \text{with Q} \leq 1$$

Here, Q refers to the health-related quality of life weight attached to the relevant life year. This gives rise to the concept of quality-adjusted life expectancy (QALE) which is the summation of QALYs over a period of time:

$$\text{QALE} = \sum_{t=a}^{a+L} Q_t$$

Here, L refers to the residual life expectancy of the individual at age a, and t refers to the individual years within that life expectancy range. When t is defined as a shorter time period than one year, L has to be consistently redefined. Accounting for time preference and discounting rate r, the discounted QALE can be written as,

$$\text{Discounted QALE} = \sum_{t=a}^{a+L} \frac{Q_t}{(1+r)^{t-a}}$$

QALYs are mainly used to analyze the cost-effectiveness of an intervention. It, therefore, analyses the improvement in the quality adjusted life expectancy obtained from a particular intervention i and allows comparisons of results when no intervention or standard alternative intervention takes place. This then allows researchers to calculate QALYs gained as positive health outcomes.

$$\text{QALYs gained} = \sum_{t=a}^{a+L^i} \frac{Q_t^i}{(1+r)^{t-a}} - \sum_{t=a}^{a+L} \frac{Q_t}{(1+r)^{t-a}}$$

Here, Q^i represents a vector of health-related quality of life weights predicted over a time period t after the intervention has ceased, L is defined as the duration of the disease, L^i is the period over which the benefits from the treatment are enjoyed by an individual (or suffers from adverse consequences of the treatment). L^i exceeds L when the treatment exceeds the life expectancy of the individual (Sassi, 2006).

Each QALY is measured on a scale of 0-1, where 0 represents death, and 1 represents full or perfect health. The quality of life weights used in QALYs differ from the disability weights used in DALYs. The quality of life weights in QALYs are used to represent variations in quality of life enjoyed by patients in different health states. Information on quality of life is collected by getting ex-ante information on the potential utility of various health states from the entire patient population or a sample. QALYs therefore also tests the risk-averseness of patients in various health states. The most common techniques used in QALY calculations to identify the quality of life weights are the standard gamble and the time trade-off (Prieto & Sacristán, 2003) QALYs are therefore also used towards a cost-utility analysis as well because they cover intervention impacts on two fronts, quality (morbidity) and quantity (mortality).

Most challenges faced by QALYs revolve around defining perfect health. Researchers have debated about including negative values for some health state, thereby expanding the weights beyond zero and one (Weinstein, Torrance, & Mcguire, 2009). Some arguments addressed by researchers include discounting QALYs at a lower rate than the cost, and not discounting QALYs at all if risk neutrality holds. Further, ethical considerations suggest that QALYs should not be used as they undervalue treatments that benefit elderly or others with a low life expectancy. It, therefore, does not take into account equity issues such as the overall distribution of health states (Weinstein, Torrance, & Mcguire, 2009). Young and healthier cohorts would have a more QALYs than sicker, older cohorts. Choosing interventions that impact healthier cohorts is contradictory to the fundamental reasons for healthcare interventions. Fundamentally, cohorts that suffer from severe illness should be prioritized over those suffering from less severe illness.

QALY calculations also face difficulties when making interpersonal comparisons between patients who have the same disability, and aggregating individual utilities. QALY calculations often rely on preference based quality of life measures that are drawn from general population samples or groups of patients that vary across patients. This data is not always consistent with assumptions as outlined by Pliskin, Shepard & Weinstein's study (1980): independence of utility for life years and health, risk neutrality, and constant proportional tradeoff behavior. QALYs also do not incorporate an age-weighting function; one QALY has the same value regardless of age at which it is lived. DALYs on the other hand, have weights that are assigned by the WHO or a region-specific expert panel. DALY weights are widely used by researchers; they can be modified to account for age-weights, discount factors, and they do not face ethical problems where they prioritize interventions affecting young, healthy individuals over older, sicker individuals (Weinstein, Torrance, & Mcguire, 2009). Finally, QALYs may be more appropriately used in scenarios where the target population is middle-aged, and has an extensive range of pre-existing morbidities. KMC targets new-borns, therefore, QALYs has not been used.

HYEs

Healthy-year equivalents (HYE) is another measure of health outcome that combines two results of interest: quality of life and quantity of life. It is similar to QALYs but has more in-depth data collection. HYE represent patient interests and as a result, are calculated using individual utility functions. According to Mehrez and Gafni (1991), unlike QALYs, HYE methodology allows for a fuller representation of patients' preferences. Getting a complete representation of patients' preferences involves a lengthy questioning process and therefore, increases costs, and is severely impacted by the patient's willingness to participate in lengthy studies. Therefore, concerns regarding lengthy interview times, financial feasibility and performance have been raised (Mehrez & Gafni, 1991). Performance feasibility questions can be fixed by incorporating the standard gamble method, a method that incorporates cardinal preferences.

For a given lifetime health profile, Mehrez and Gafni have devised an algorithm based on the standard gamble method. They also use Q and T as used in QALYs. Q represents the health state of an individual, T represents life years. $\bar{\mathrm{Q}}$ represents a state of full health and $\underline{\mathrm{Q}}$ represents death (Mehrez & Gafni, 1993). T is defined with an interval of [0, $\bar{\mathrm{T}}$], where, $\bar{\mathrm{T}}$ is the maximum survival possible. If the individual is currently in health state Q, and has T more years to live, and H represents years in full health, H would represent healthy years that are equivalent to the combination of (Q, T). Towers, Spencer & Brazier (2005) define H^* such that

$$\mathrm{U}(\bar{\mathrm{Q}}, \mathrm{H}^*) = \mathrm{U}(\mathrm{Q}, \mathrm{T}), \text{where U represents the utility level}$$

This equation will yield H^* years of full health ($\bar{\mathrm{Q}}$) such that it is equivalent to living T years in health state Q. Lottery style questions are asked to determine the indifference level of P between

$$\{[\mathrm{P}, (\bar{\mathrm{Q}}, \bar{\mathrm{T}})];\ [(1-\mathrm{P}), (\underline{\mathrm{Q}}, 0)]\} \text{ and } (\mathrm{Q}, \mathrm{T})$$

Q can be represented as a vector of all health statuses at different periods during their lifetime. The complications with such derivation arise when trying to define H^*. Interview questions may not always be able get answers that can help researchers derive a value for H^*. Further, capabilities in effectively communicating the differences between the outcomes can differ between interviews. As mentioned before, interview questions can be simplified to simply outline three or four outcomes. However, this has been recognized by Mehrez and Gafni (1991) as having the potential to cause more problems than solve. DALYs averted are therefore, a better option for evaluating the success of an intervention as they use more readily available data, and do not depend on patient utility functions, resulting in a smaller bias.

DALYs

The measure that is commonly used to analyze the impact of health interventions is Disability Adjusted Life Years (DALYs). They were first used in the Global Burden of Diseases and Injury (GBD) study, jointly conducted by the World Bank, the Harvard School of Public Health and World Health Organization (GBD Profile: Cameroon, 2010). DALYs are the years of healthy life that are lost due to mortality or morbidity risk. The aggregate of DALYs across a target population, which can be referred to as the burden of disease, is the gap measurement between a current health status and the ideal health situation. The ideal health situation is one where the entire population lives to an advanced age, free of disease and disability. The WHO defines DALYs using years of life lost and years lived with disability.

The usage of DALYs is consistent with welfare maximization under three conditions. The first one is separability of individuals over time (Gold et al., 2006). The aggregate health impact of an intervention is the summation of health impacts over the period of the intervention. Therefore, using a time-based measure of the target population health leads to years being additively separable. The second condition is separability across people. This condition stipulates that welfare impact of an intervention on a given member of the target population is independent of the rest of the population. Separability across individuals allows DALYs to be constructed and assessed from overall measures of individual health while keeping inequality across the population in mind. Therefore, DALYs measure the average level of population health. The third condition is that health and non-health components of welfare are separable and that welfare is a linear function of years of healthy life.

Researchers have discussed the use of age-weights and discounting factors to form a modified DALY (Larson, 2013). However, the use of modified DALYs leads to questions such as, is a year of healthy life more valuable to the society now as compared to the future, and are healthy years of life more valuable at some ages as compared to others. On the societal front, the third question that can be asked is given the heterogeneity across individuals regarding sub-regional life expectancy, should all population groups be regarded as equal. There have been studies conducted by Murray and Acharya (1996) that show that people would, in general, prefer a healthy year of life immediately as compared to in the future. This preference can be used as a reason to use discounting factors when aggregating DALYs over a period. The Global Burden of Disease (GBD), US Panel on Cost-Effectiveness in health and medicine, and the World Bank Diseases Control Priorities study recommends the use of three percent real discount rate to adjust costs and health outcomes (Tan-Torres, et al.).

However, there have also been additional studies that debate the differentiated use of discount rates in developing and developed countries (Tan-Torres, et al.). This paper will not use age-weights or discount rates. Age weights tend to favor target populations that are younger. This would give us a potential upward bias of DALYs averted. Using discount weights would not be beneficial in this paper for two reasons. Firstly, since KMC implementation and follow-up is completed within a little over a year of time, this is a very small time-frame. Secondly, exclusive breastfeeding will not be used towards DALYs averted calculations. This is because exclusive breastfeeding averts infections that result in mortality and facilitates weight gain. From a developing country perspective, it is more valuable to directly evaluate mortalities averted and infant weight gain. Therefore, to avoid double counting, exclusive breastfeeding will not be included. As discussed before there has been inconclusive evidence on the impacts of exclusive breastfeeding on long-term benefits. If further research is conducted to provide more evidence and answer this question, then discounting could be used as calculations could span up to 15-20 years.

The Global Burden of Diseases also reports changes in Cameroon's rankings of leading age-standardized rates of DALYs relative to comparison countries in 1990 and 2010. The fifteen comparison countries include Nigeria, Uzbekistan, Senegal, Côte d'Ivoire, Mauritania, Solomon Islands, Sudan, etc. Cameroon ranks on the higher end for most diseases including malaria, pre-term birth complications, meningitis, measles, neonatal sepsis and maternal disorders. Between 1990 and 2010, Cameroon has seen an increase in age-standardized rates of DALYs within diarrheal diseases, respiratory infection, meningitis, neonatal sepsis and maternal disorders. In Cameroon, the top three leading causes of DALYs in 2010 were malaria, HIV or AIDs, and lower respiratory infections. Neonatal sepsis, preterm birth complications are ranked fifth and seventh on the top 25 leading causes of DALYs. They conclude that overall, suboptimal breastfeeding counts as one of the three factors that account for most diseases burden in Cameroon (GBD Profile: Cameroon).

Ex-ante assumptions: Cochrane systematic review analysis

To accurately study the impacts of Kangaroo Mother Care on neonates, the length of gestation and age need to be consistently defined. Infant ages are commonly classified into gestational age, postmenstrual age, corrected age, and chronological age. Gestational age refers to the elapsed time between the first day of the last menstrual period and the day the delivery. It is commonly used by gynecologists to estimate the delivery date. Chronological age is calculated after the day of delivery, and postmenstrual age refers the aggregation of gestational and chronological age. In the case of preterm infants, the babies are born before the expected date. Therefore, a corrected age estimates the period between the expected date of delivery and the day of assessment.

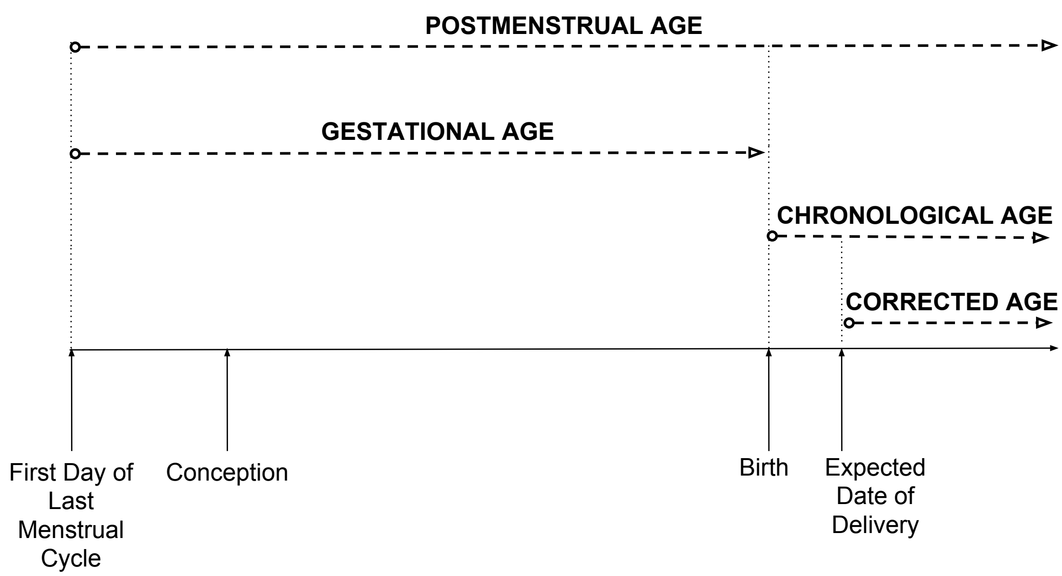

Figure 6 – Neonate age classifications

Table 3 – Statistically Significant Health Outcomes from the Cochrane systematic review

Health outcome	Control	Treatment	When	Relative risk	CI
Mortality	5.3%	3.2%	Discharge or 40-41 weeks' postmenstrual age	0.60	(0.38,0.88)
Mortality	6.0%	4.0%	Latest follow-up	0.67	(0.46, 0.98)
Severe infection[†] or sepsis	13.1%	6.6%	Latest follow-up	0.38	(0.24,0.6)
Severe illness	17.8%	5.3%	6 months follow-up	0.30	(0.3,0.14)
Hospital acquired infection or sepsis	11.4%	4.0%	Discharge or 40-41 weeks' postmenstrual age	0.49	(0.25, 0.93)
Respiratory tract disease	12.5%	4.6%	6 months follow-up	0.37	(0.15,0.89)
Hypothermia[†]	27.1%	7.6%	Discharge or 40-41 weeks' postmenstrual age	0.28	(0.16, 0.49)
Exclusive Breastfeeding	56.3%	66.3%	Discharge or 40-41 weeks' postmenstrual age	1.16	(1,1.24)
Any Breastfeeding[†]	36.8%	54.7%	6-month follow up	1.50	(1.08, 2.08)
Exclusive breastfeeding[†]	55.6%	84.6%	6-12 months' follow-up	1.52	(1.1,2.1)

[†]Sub-group intermittent KMC because continuous KMC did not show statistical significance beyond 3 months.

Within epidemiology and health economics, relative risk is widely used to understand the difference between treatment and control group outcomes. Relative risk is the probability ratio of particular outcomes occurring in the treatment and control group. The relative risk in Table 3 identifies how many times more likely an outcome occurs amongst low-birthweight and preterm infants that are subject to KMC as compared to those that are not.

$$\mathrm{RR} = \frac{\text{Probability of a health outcome in the treatment group}}{\text{Probability of a health outcome in the control group}}$$

As can be seen in Table 3, there are risk ratios lesser than and greater than one. In the instance that relative risk is greater than one, there is a percentage increase in health outcome. When there is a relative risk lesser than one, there is a percentage decrease in health outcomes.

$$\text{When RR} > 1, \%\ \text{increase} = (\text{RR} - 1) \times 100$$

$$\text{When RR} < 1, \%\ \text{decrease} = (1 - \text{RR}) \times 100$$

For example, hypothermia at discharge or 40-41 weeks' postmenstrual age has a relative risk of 0.28. The interpretation of this number is that low-birthweight and preterm infants treated with KMC have a 72 percent reduction in risk of hypothermia at discharge or 40-41 weeks postmenstrual age. The relative risk for exclusive breastfeeding is 1.16. The interpretation of this estimate is that low-birthweight and preterm infants treated with KMC are 16 percent increase in the likelihood of exclusive breastfeeding.

Mortality rate, the incidence of hospital acquired illnesses and growth rate are the two indicators that can reflect the short-term impacts of KMC. The Cochrane systematic review by Conde-Agudelo et al. (2014) has conducted a systematic review of KMC studies to identify significant health outcomes. Table 3 shows the statistically significant summaries of reduced negative outcomes from this study. Mortality is measured at discharge or at 40-41 weeks' postmenstrual age, six months of age, one year of age. Infant growth is characterized by the change in weight, length, head circumference between discharge time and latest follow-up. The Cochrane review classifies KMC programs by continuity, the period of initiation and country income-level.

As discussed before, KMC can be segregated into continuous and intermittent care. Continuous care can be defined as having 20 hours or more of treatment in a day. Period of initiation can be defined as having KMC initiated within ten days post birth. Country income-level is segmented into low, middle and high income (Conde-Agudelo et al., 2014). Continuous care initiated within ten days of birth in low or middle-income countries have shown the most statistically significant beneficial effect on mortality at discharge (or 40-41 weeks' postmenstrual age) and at latest follow-up (Conde-Agudelo et al., 2014). Studies that analyzed intermittent KMC initiation after ten days post birth in high-income countries, using stabilized infants did not show statistically significant effects on averted mortality. Intermittent KMC also did not show evidence of differentiated risk of mortality at six months of age or follow-up between the treatment and control group. Continuous KMC however, showed evidence of reduced mortality in the treatment group at the latest follow-up (Conde-Agudelo et al., 2014).

The Cochrane review has shown a significant reduction in incidence of severe infection or sepsis at latest follow-up, severe illness at the six-month follow-up, hospital acquired infection or sepsis at discharge or 40-41 weeks postmenstrual age, respiratory tract disease at six-month follow-up, and hypothermia at discharge or 40-41 weeks' postmenstrual age (Conde-Agudelo et al., 2014). Positive health outcomes of reduced severe infection or sepsis at latest follow-up and reduced hypothermia at discharge or at 40-41 weeks' postmenstrual weeks are statistically significant only for intermittent KMC trials. As discussed before since our target population is neonates, the incidence of sepsis or severe infections and hypothermia result in mortality. Therefore, while aggregating the impacts of KMC, results of reduced incidence of severe infections and illnesses cannot be used alongside mortality. This is done to avoid double-counting and overlapping impacts, in a lot of cases, infants that have severe infection may also have a reduced immune system and therefore contract hypothermia and other diseases.

There have been no statistically significant changes between KMC infants and control infants in risks of mild or moderate infection or illness after discharge, at the latest follow-up. Mild or moderate infection and diarrhea are associated with morbidity in the short-term. They do not affect mortality and can therefore be included while aggregating KMC impacts. While statistically there have not been any significant impacts, it is important to analyze the overall effect regardless. The insignificance is attributable to the heterogeneity of KMC results across studies. Heterogeneity has been discussed in detail in the following section. Therefore, KMC does not have impacts on reducing morbidities caused by mild infection or illness. The Cochrane review has also recorded a statistically insignificant 1.6 days reduction in the length of hospital stay. On average, randomized hospital stay was recorded as 5.6 days for the control group and 4.5 days for KMC infants (Conde-Agudelo et al., 2014).

Infant growth through KMC is segregated into weight gain, length increase, and head circumference increase. Within the Cochrane systematic review, statistically significant results were reported infant weight gain after enrollment in the KMC program. The change in weight gain recorded between KMC and the control group was 4.1 grams (Conde-Agudelo et al., 2014). However, there has once again been significant evidence of heterogeneity amongst trials reporting changes in infant growth. Therefore, further investigation was conducted that did not result in significant weight gain, head circumference, length changes between the treatment and control groups. Mothers from the KMC group are also more likely to breastfeed at discharge or 40-41 weeks' postmenstrual age, and at 1-3 months than mothers from the control group. There has been significant heterogeneity observed among trials that study increased breastfeeding (Conde-Agudelo et al., 2014).

With regards to neurodevelopmental and neuro sensory impairment, researchers analyzed the Griffith quotients for psychomotor development. No statistically significant differences were identified between the treated and control infants (Conde-Agudelo et al., 2014). Within the systematic review, Cattaneo (1998) is the only study that has evaluated parental and familial satisfaction. Cattaneo (1998) also identified that KMC group mothers were more satisfied (91%) with the method of care as compared to the control group (78%). The evidence available is, however, low-quality, and the Cochrane review has concluded that further experiments would lead to significantly different estimates. Investigators also did not find significant differences in family satisfaction between the two methods of care (Conde-Agudelo et al., 2014).

Mother-infant interaction and attachment have been assessed by three studies. Charpak tested mother's feelings using the Likert scale within the "mother's perception of premature birth questionnaire" (Charpak, Ruiz-Peláez, & Calume, 1996). This questionnaire was used 24 hours after birth and when the infant reached 41 weeks' postmenstrual age. Further, mother-infant responsiveness to each other during breastfeeding was also observed using a "nursing child assessment feeding scale." Other papers used frameworks similar to Charpak and found that the KMC mother-infant dyad scored better on attachment. Charpak also evaluated the father's involvement and home environment at 12 months corrected age. The study used structured interviews and developed a Home Observation for Measurement of the Environment (HOME) score. Families that had been selected for KMC treatment scored better than families that had undertaken conventional neonatal care.

The Cochrane review shows expected changes in health outcomes after implementing KMC in low, medium and high-income countries. Therefore, adjustments need to be made for Cameroon when analyzing the expected health outcomes. There are several ways in which this can be approached. The methodology that will be used here is to first to identify the results from low and middle-income countries in Cochrane and secondly, use Cameroon based rates of diseases prevalence and mortality. The second methodology directly applies country-specific focus to a global result. More details on this will be provided in the section for impact calculation

Ex-post considerations: minimum detectable effect

A minimum detectable effect (MDE) is the minimum required true difference between the treatment and control group that would be statistically significant at the 0.05 confidence level using a power of 80 percent. This is normally calculated after a baseline survey to help researchers design a scale-up. In the KMC perspective, this would involve conducting a baseline at one or two hospitals, maybe one urban and one rural. The baseline can then be used to set the minimum number of hospitals needed to get our aimed effect in DALYs averted, mortality and morbidity reduction. The power used in an MDE can be defined as the probability that, given an effect size and a confidence level, we will be able to reject the null hypothesis of the treatment having a zero effect. Power calculations can be illustrated using a simple linear regression framework where the OLS coefficient is the estimate of the average treatment effect (the difference in sample means for the treatment and control group) (Duflo, Glennerster, & Kremer, 2006).

$$Y_i = \alpha + \beta T + \epsilon_i$$

The null hypothesis can be written as KMC having zero effect on reducing infant mortality and morbiditywith a significance level of 0.05. Assuming that only a proportion P of the sample hospitals are within the KMC treatment group and that they are randomly sampled with a variance of σ^2, the variance of $\widehat{\beta}$, the OLS estimator of β, can be written as

$$\text{variance of } \widehat{\beta} = \frac{1}{P(1-P)}\frac{\sigma^2}{N}$$

Given a test statistic t_α and the distribution of $\widehat{\beta}$, the power of the test(κ) is the probability that the null is rejected when it is, in fact, false, i.e. correctly rejecting the null hypothesis that the treatment has zero effects. κ is therefore defined such that,

$$\beta > (t_{1-\kappa} + t_\alpha)SE(\widehat{\beta})$$

$$MDE = (t_{1-\kappa} + t_\alpha)\sqrt{\frac{1}{P(1-P)}}\sqrt{\frac{\sigma^2}{N}}$$

Using the power (κ), significance level (α), sample size (N), MDE can be calculated as shown above. An effective baseline data collection across hospitals in Cameroon can allow us to derive an estimate for the variance. Dividing the sample of hospitals into treated and controlled hospitals is dependent on the cost of evaluation. If for example, for every individual treatment, the primary cost of evaluation is simply data collection, an equal division of hospitals between the treated and control group may be optimal. Therefore, $P = 0.5$. An alternative to equal distribution of treatment and control proportions is to minimize MDE subject to a budget constraint (Duflo, Glennerster, & Kremer, 2006).

$$Nc_c + NPc_t \leq B$$

Here, N is the total sample size, $c_c$is the unit cost per comparison hospital, and c_t is the unit cost of data collection and the treatment per treated hospital. This allows for an optimization rule that can define P

$$\frac{P}{1-P} = \sqrt{\frac{c_c}{c_t}}$$

The ratio of hospitals in the treatment group to number of hospitals in the control group is proportional to the inverse of the square root of unit costs per group. For example, Systematic reviews in low and middle-income countries have allowed us to conclude that a 30 percent reduction in mortality can be attributable to KMC in Cameroon. Therefore, MDE, when set at 30 percent, can be used to identify the number of hospitals that need to be in the program to attain the target reduced mortality, given the proportion of treated versus controlled, variance and optimal power.

Aggregating health impacts: DALYs averted by KMC

DALYs are calculated using years of life lost (YLLs) and years lived with disability (YLDs). The Global Burden of Diseases Study in 2010 (GBD 2010), led by the Institute for Health Metrics and Evaluation (IHME), quantifies levels and trends of health loss due to diseases, injuries, and risk factors. In Cameroon, the number of years of life lost (YLLs) due to premature death, malaria, HIV or AIDS, and respiratory infections are amongst the highest-ranking causes. The GBD ranks childhood underweight as a leading risk factor in Cameroon. Between 1990 – 2010, under-five female infants have reported the highest in mortality rates by 33%. Table 4 shows the rank changes and aggregates in some KMC relevant health outcomes that result in YLLs between the year 1990 and 2010 from the GBD study (“GBD Profile: Cameroon”).

Table 4 – Years of life lost (in thousands) per disease in Cameroon ("GBD Profile: Cameroon")

Disorders	YLLs in '000s (1990)	% of total YLLs (1990)	Rank (1990)	YLLs in '000s (2010)	% of total YLLs (2010)	Rank (2010)
Lower respiratory infections (pneumonia)	972	12%	2	1,021	9.3%	3
Preterm birth complications	354	4%	4	451	4%	6
Neonatal sepsis	328	4%	8	490	5%	5
Neonatal encephalopathy	219	3%	10	306	3%	10
Maternal disorders	123	2%	14	189	2%	12

The second component of DALYs is Years Lived with Disability (YLDs). YLDs can be estimated in two ways. The original WHO calculation used incidence, disability weights, and average duration of the case until remission. The new formula as of 2010 uses prevalence and disability weights. In Cameroon, the top five leading causes of YLDs are iron-deficiency anemia, low back pain, malaria, major depressive disorder, and chronic obstructive pulmonary disease. The more interesting methodology that combines YLLs and YLDs and can, therefore, effectively assess KMC is Disability-Adjusted Life Years (DALYs).

DALYs are the summation of the years of life lost (YLL) and the years lost due to disability (YLD). It therefore accounts for years lost from premature mortality and years of live lived with a health disability or its consequences. Numerically, the basic formula for DALYs as defined by the WHO is,

$$D\mathrm{ALY} = \mathrm{YLL} + \mathrm{YLD}$$

$$\mathrm{YLL} = \mathrm{N} \times \mathrm{LE}$$

$$\mathrm{N} = \text{Rate of incidence (i)} \times \text{ target population (n)}$$

$$\mathrm{YLD} = \mathrm{P} \times \mathrm{DW} \quad \text{or} \quad \mathrm{YLD} = \mathrm{I} \times \mathrm{DW} \times \mathrm{L}$$

The years of life lost (YLL) is calculated by multiplying the number of affected individuals N by the standard life expectancy LE at the age at which the diseases occur. The number of affected individuals can be estimated by multiplying the existing rate of disease incidence or mortality rate by the target population affected by it. YLL therefore measures the incident stream of lost years of life due to deaths or diseases. As an example, in the KMC context, baseline DALYs for neonatal mortality can be estimated by multiplying the pre-existing neonatal mortality rate by the number of infants targeted by KMC. The life expectancy for the YLL formula would be the average number of life years we would expect an individual to live given that mortalities or morbidities are averted. In the case of Cameroon, the average life expectancy for males and females is 56 years. Since KMC averts mortalities and morbidities within the first year of the infant's life, the life expectancy for these infants can be estimated at 56 years.

Years lost due to disability (YLD) uses two formulas. The incidence I based formula looks at the currently expected onset of a diseases or mortality. The prevalence P based formula looks at the pre-existing onset of diseases or mortality. Both formulas weight the number of incident/prevalent morbidity and mortality cases by disability weights DW for a particular health risk. Since KMC looks at reducing the pre-existing mortality rate and reducing the incidence of diseases at the neonatal and post-neonatal stage, a combination of the two equations can be used to fit the KMC perspective.

The incidence or prevalence of mortality can be calculated by using the pre-existing neonatal and infant mortality in Cameroon. The incidence or prevalence of an infection or positive health outcomes such as weight gain can be sourced from Cameroonian hospital based studies. These studies report the incidence or prevalence of health outcomes during infant admission and/or at discharge. This rate is then multiplied by the number of infants that KMC targets to get a numerical estimate of the prevalence or incidence of a health outcome in Cameroon. the can use the same formula as number of infants affected.

The Cameroon DHS survey estimates the average national neonatal mortality rate at 14.7%. The World Bank estimates that neonatal mortality in Cameroon is 25.7 deaths per 1,000 live births which is lower than the Sub-Saharan Africa average of 28.5 (The World Bank, 2015, c). Figure 11 shows the neonatal and post-neonatal mortality rate over a period of time in Cameroon. This has been compared to the Sub-Saharan Africa average and South Africa. There has been a decline in the neonatal mortality globally and in Cameroon. The number of neonatal deaths is recorded at 21,071 as of 2015 (The World Bank, 2015, b). The neonatal mortality rate has also been influenced by the fact that there were over 61% unattended births in the Northern region of Cameroon (Tandi, et al., 2015).

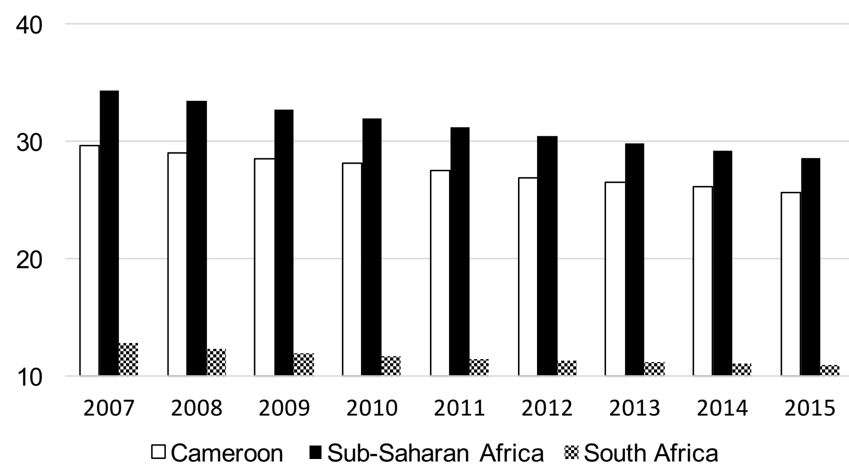

Figure 7 – Neonatal mortality rate (Per 1,000 live births) comparison (The World Bank, 2017e)

As discussed previously, neonatal mortality is heavily impacted by the conditions of hospital for in-hospital births and homes for in-home births. A study based out of a referral hospital in Cameroon by Mungyeh et al. (2011) showed a decline in hospital based mortality over a seven-year period. They attribute this decline to improving working conditions in the hospital. Improving working conditions have included hiring more personnel, having more supplies and materials, regular refresher courses on neonatology

(Mungyeh et al., 2011). Further, hospitals have now started to implement a minimum package of diagnostic tests that are run on infants when admitted. These tests are run before the parents are billed for medical services. Medical bills in the neonatal unit are now only provided at discharge. Therefore, all tests are run regardless of whether the parents were in a position to pay for extensive medical services when they admitted their infants.

The disability weights assigned to each health outcome weight the remaining expected life years for an individual. The weights range from zero to one, with zero representing perfect health and one representing death. For example, when calculating DALYs for mortalities averted, the disability weight assigned to it would be one. A lower weight reduces the impact that KMC has on DALYs averted. Within KMC, infants are only able to take advantage of reduced morbidities such as reduced incidence of diarrheal infections, mild infections, lower respiratory distress, and increased weight after they avert mortality at the neonatal and post-neonatal stage. The disability weights used in this paper have been sourced from the updated 2010 Global Burden of Diseases repository. The values for prevalence have been sourced from Cameroon based studies on the incidence of disease and mortality in urban hospitals. These studies also report specific mortality rates.

Specific mortality rates can be defined as the number of infants that have died due to a specific disease, for example sepsis or meningitis, divided by the number of neonates admitted for that pathology over a given period of time. As discussed previously, in order to avoid double counting, DALY calculations for kangaroo mother care will incorporate benefits from overall mortalities averted, and not the specific diseases that result in mortalities. DALYs from mortality and morbidity averted include overall neonatal mortality, overall post-neonatal mortality, increase in weight, and reduced incidence of diarrhea, mild or moderate infections, and lower respiratory tract infections.

The number of infants used within this paper has been sourced from Mungyeh et al. (2011). The referred study analyzed neonatal and infant mortality in Cameroon over a period of seven years and studied 5,828 infants. Within this time period, 58 percent of infants admitted were born pre-term and had low birth-weight. Since KMC is only used on pre-term and low birth-weight infants, as a baseline, the target number of infants has been set at 483 infants. Changes in this number will have an impact on the DALY calculations.

The final component of the incidence based YLD formula is L, the average duration of the case until remission or death. In the case of mortalities associated with KMC, a modification to the definition of L has been made to use the average life expectancy. This is because of the early nature of this intervention in the infant's life. Morbidities such as low-weight have long-term sequelae, that is conditions such as stunting or wasting in the long-term that is a consequence of the infant losing more weight than usual after birth (Taylor et al. 2001). Therefore, the L associated with this has been selected at 56 as well to reflect the life-long consequences of low infant weight. Finally, the remaining morbidities of lower respiratory tract infection and diarrhea have immediate consequences and remedies and are therefore treated in a similar fashion as mortalities, their L is also set at 56.

Results from each of these individual health outcomes and the time periods of neonatal and post-neonatal periods are aggregated to get a sum total baseline DALYs estimate in Cameroon. Here x refers to the time period, y refers to the health outcomes under review.

$$\text{Aggregate DALYs} = \text{YLLs} + \text{YLDs}$$

$$\text{YLLs} = \sum_{\text{x,y}} \text{i}_{\text{x,y}} \times \text{n}_{\text{x,y}} \times \text{LE}_{\text{x,y}}$$

$$\text{YLDs} = \sum_{x,y} i_{x,y} \times n_{x,y} \times LE_{x,y} \times DW_{x,y}$$

Introducing KMC has shifted the incidence of mortality and morbidity by $1 - \mathit{Risk\ Ratio}$ as discussed in previous sections. A risk ratio below one shows a decrease in the incidence of mortality or morbidity. A risk ratio over one shows an increase in incidence, the interpretations depend on the health outcome under review. To estimate this effect in DALYs, $1 - \mathit{Risk\ Ratio}$ should be multiplied to the baseline DALY calculations. This gives us DALYs averted, that is, the number of aggregate life years saved from reduction in incidence of mortality and morbidity. The calculations are as follows:

$$\text{Aggregate DALYs averted} = \text{YLLs averted} + \text{YLDs averted}$$

$$\text{YLLs averted} = \sum_{x,y} i_{x,y} \times n_{x,y} \times LE_{x,y} \times (1 - RR)_{x,y}$$

$$\text{YLDs averted} = \sum_{x,y} i_{x,y} \times n_{x,y} \times L_{x,y} \times DW_{x,y} \times (1 - RR)_{x,y}$$

The results from this calculation have been reported below. As can be seen, intermittent KMC does not use lower respiratory tract infection and diarrhea in the DALY calculations. This is because, in all previous studies that have implemented KMC intermittently, changes in the incidence of lower respiratory tract infection and diarrhea have not been reported. Therefore, there are no risk ratios available that can be used. Overall, there have generally been more studies that report continuous KMC than intermittent. It is important to note that there may be some overlap between the health outcomes listed under morbidities as discussed before. Higher infant weight ca be associated with a lower onset of other diseases because the infant is stringer overall.

Table 5: Continuous KMC: DALYS

Categ.	Outcome	Time period	I	N	LE/L	DW	RR	Std. error	YLL	YLD	Total DALYs averted
Mortality		Neo-natal	0.025	483	56	1	0.6	0.11	278	278	556
		Post-neonatal	0.031	483	56	1	0.67	0.10	280	280	560
Morbidity	Lower respiratory tract infection	Post-neonatal	0.048	483	56	0.28	0.37	0.11	818	229	1,047
	Mild or moderate infection	Post-neonatal	0.35	483	56	0.006	1.42	0.45	(3,975)	(24)	(3,999)
	Diarrhea	Post-neonatal	0.238	483	56	0.105	0.65	0.15	2,253	237	2,489
	Weight gain	Post-neonatal	0.13	483	56	0.106	3.6	1.43	9,140	969	10,109
Total DALYs averted									**8,794**	**1,969**	**10,762**

Table 6: Intermittent KMC: DALYs averted

Categ	Outcome	Time period	I	N	LE/L	DW	RR	Std. error	YLL	YLD	Total DALYs averted
Mortality		Neo-natal	0.0257	483	56	1	0.59	0.20	285	285	570
		Post-neonatal	0.03137	483	56	1	0.68	0.21	271	271	543
Morbidity	Mild or moderate infection	Post-neonatal	0.35	483	56	0.006	1.52	0.56	(4,922)	(30)	(4,951)
	Weight gain	Post-neonatal	0.13	483	56	0.106	4.13	0.99	11,003	1,166	12,170
Total DALYs averted									**6,638**	**1,693**	**8,331**

Probablistic analysis of KMC components

KMC consists of various components within the program such as skin-to-skin, kangaroo nutrition, duration of implementation, early vs late onset, the age of follow-up, and area of implementation. This section attempts to visually analyze every outcome discussed above regardless of statistically significant using density plots. Each outcome has comparisons made such as neonatal and post-neonatal, and continuous and intermittent.

Mortality, in particular, has multiple available risk ratios from Cochrane that compare when and where KMC is initiated. As mentioned above, risk ratio compares the likelihood of mortality between KMC and non-KMC infants. Mortality aversion is an important outcome for both continuous and intermittent implementation within the first year of the infant's life. KMC is used for different reasons in developed countries vs developing countries. Developing countries such as Cameroon need KMC to primarily avert mortality whereas, in developing countries, KMC is generally used for qualitative outcomes such as mother-child interaction and affection.

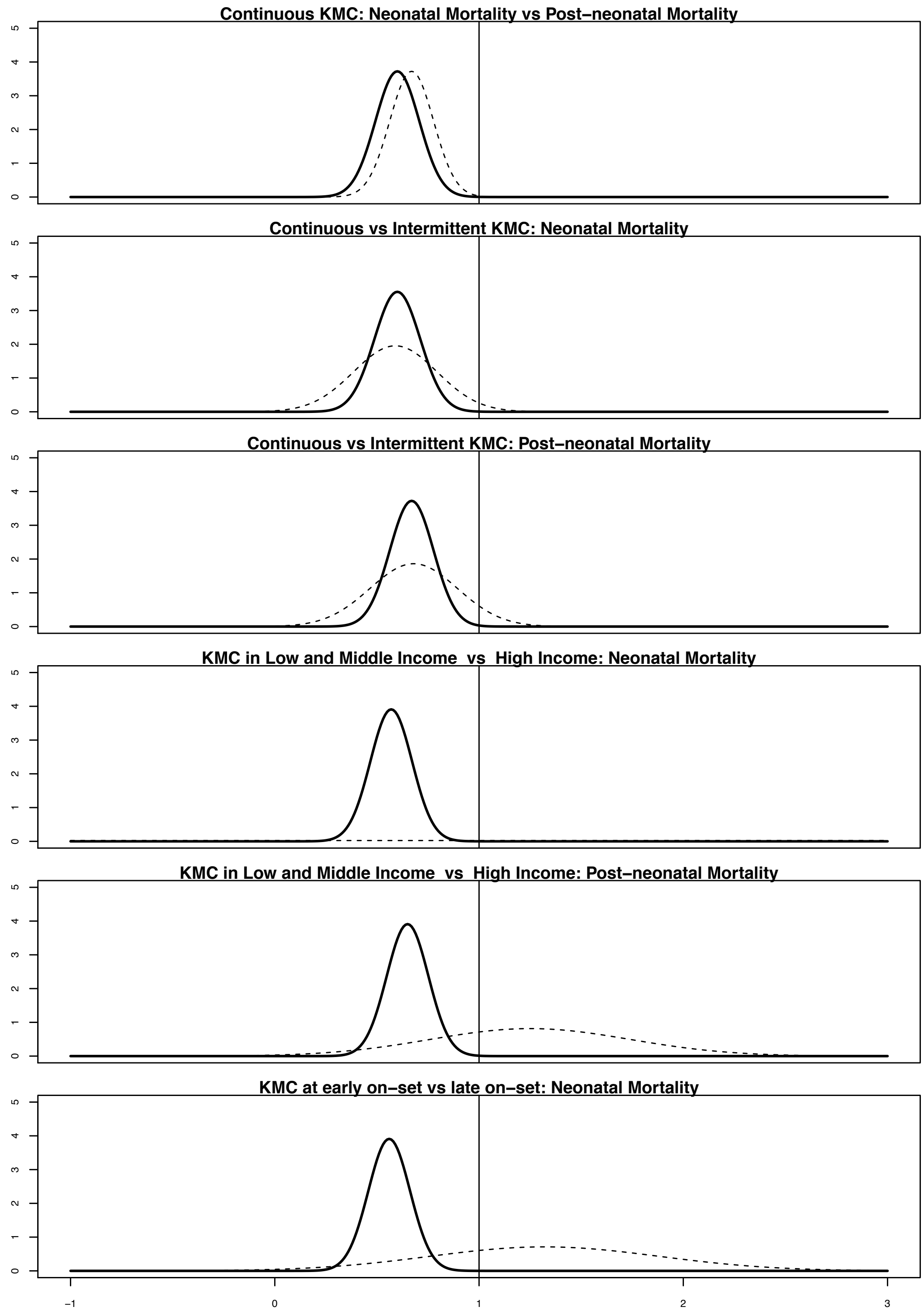

Figure 8 – Risk ratio density plots for mortality incidence

Late on-set KMC shows a wide range of risk ratios. Late on-set KMC may be attributed to birth complications. Infant stabilization is challenging when there are more complications. Developed countries have enough resources to constantly attempt to help unstable neonates. Therefore, they may be more likely to have a late on-set of KMC i.e., the infant is over 10 days old at KMC initiation.

Figure 8 analyses risk ratios associated with severe infections such as sepsis, mild infections, diarrhea, and lower respiratory tract infection. The solid line shows overall KMC results, the dashed line shows continuous KMC, and the dotted line shows intermittent KMC. Hospital acquired infection affects neonatal health outcomes. Sepsis and severe infection have been used by studies in Cochrane to discuss the onset of infections after discharge, i.e. during the post-neonatal period. Diarrhea has only been analyzed by some small studies during the post-neonatal period. These studies have only implemented continuous KMC. Therefore, there is no comparison available. As a part of KMC implementation, studies have shown that hospitals are required to improve the cleanliness and quality standard in the neonatal unit (KMC India Network, 2004). Therefore, there may be a lower incidence of diarrheal infections at the hospital. Diarrheal infections are commonly caused in developing countries by lack of cleanliness. Therefore, it is intuitive that reduced diarrheal infections may be observed after discharge in family homes that may not have the same level of hygiene.

Similarly, lower respiratory tract infection has only been surveyed by studies that have implemented intermittent KMC. Therefore, there aren't comparison risk ratios. The next group of comparisons is made across exclusive breastfeeding at different time periods of discharge, 1-3 months, and 6-12 months. Exclusive breastfeeding is a very important component of KMC because it is responsible for weight gain. Further, it allows for antibody transmission between the mother and the infant. This plays a very important role in reducing infections. In order to avoid double counting, exclusive breastfeeding is often excluded from impact calculations. The final piece of Figure 9 shows impacts of skin-to-skin contact with and without breastfeeding on mortality risk ratio. This has been sourced from a different meta-analysis by Boundy et al. (2016). The solid line shows skin-to-skin contact and breastfeeding combined, the dotted line shows only skin-to-skin contact.

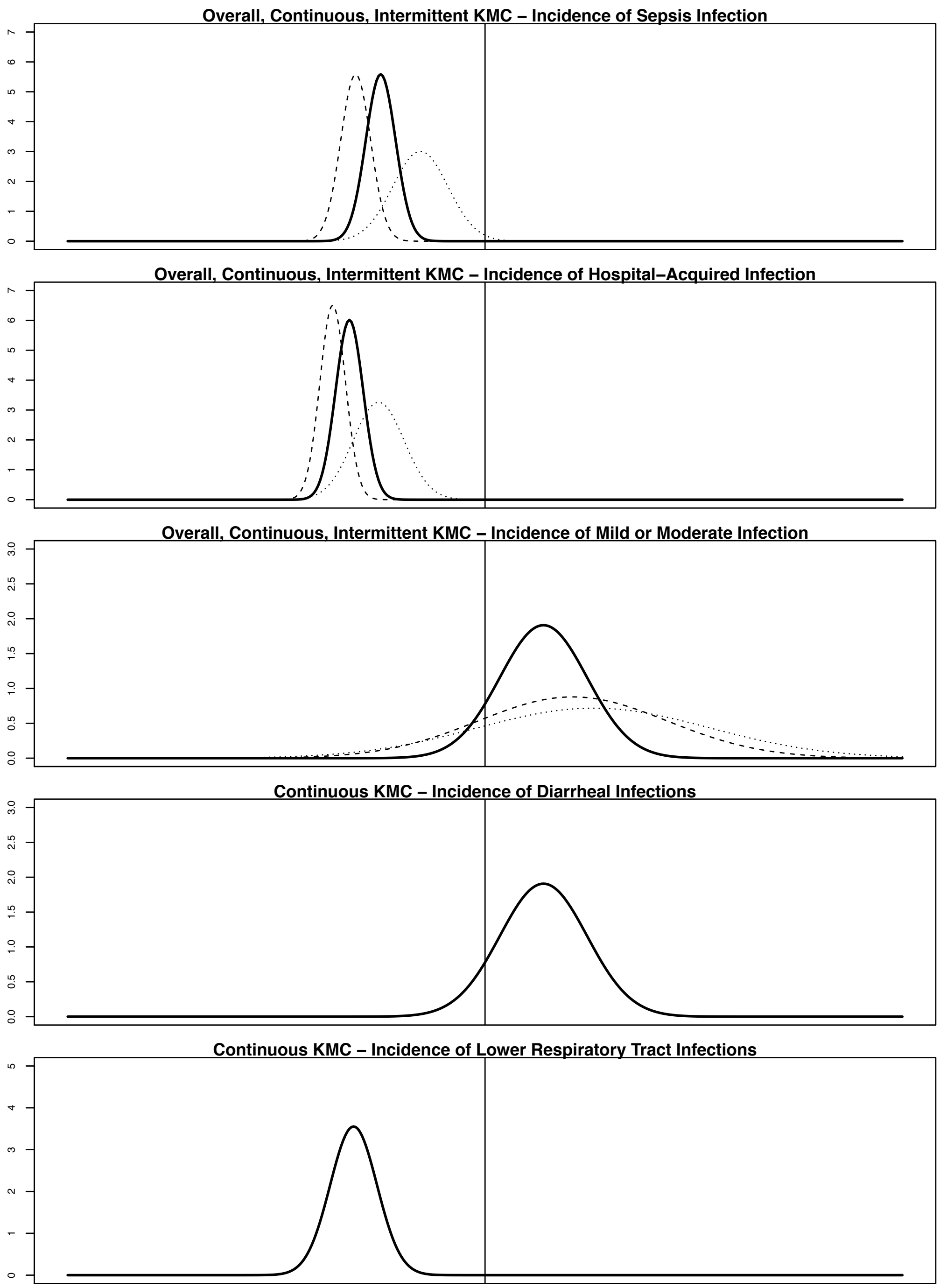

Figure 9 - Risk ratio density plots for incidence of infection

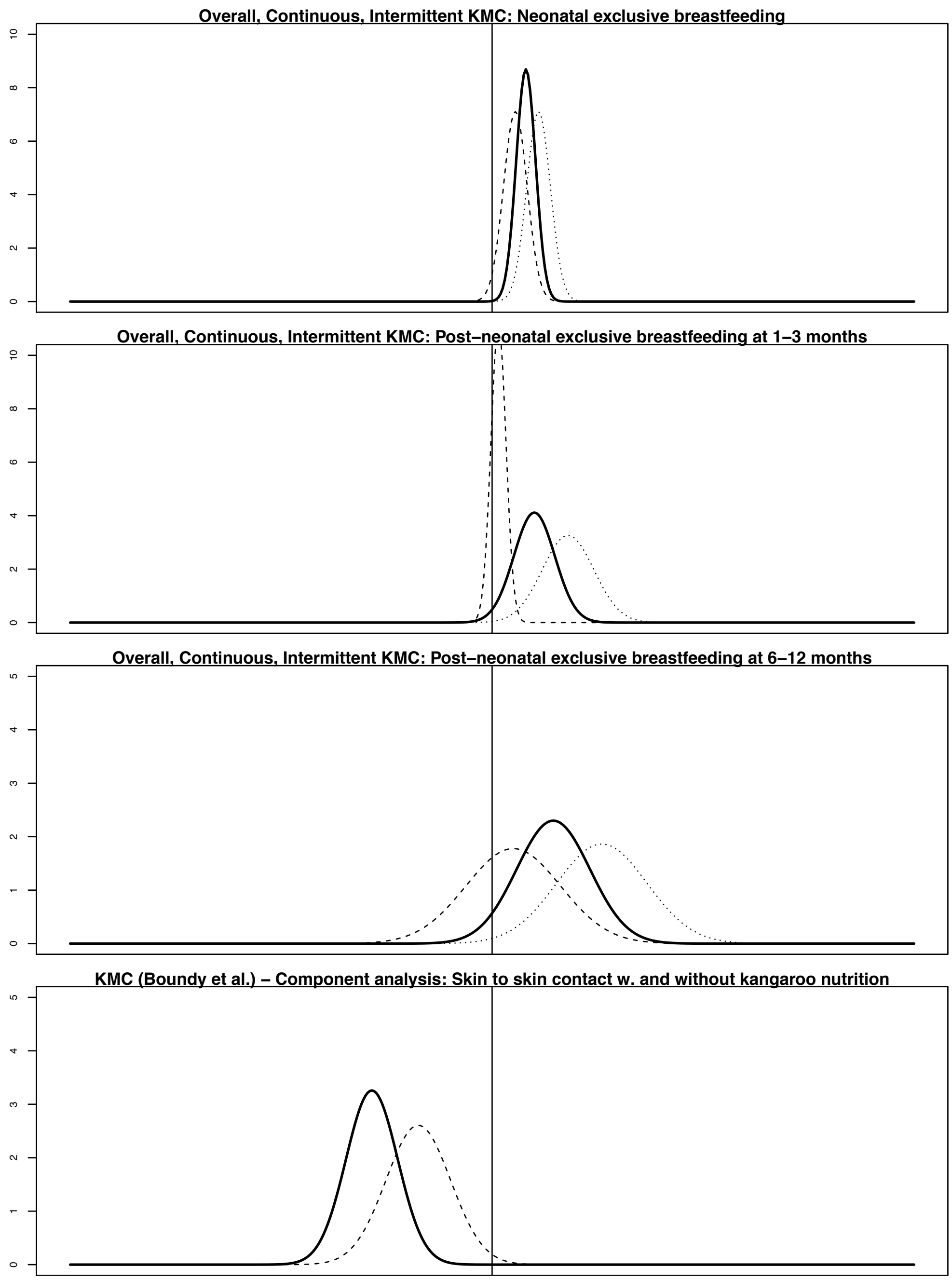

Figure 10 - Risk ratio density plots for incidence exclusive breastfeeding

The final plot compares results from Cochrane with results from different meta-analysis. The Meta-analysis used are Boundy et al. (2016), Lawn et al. (2005), and Jeffries et al. (2012). These meta-analyses have made study selections based on their specific area of research. Boundy et al. (2016) focus primarily on mortality and exclusive breastfeeding, Lawn et al. (2005) focuses only on low and middle-income countries, and Jeffries et al. (2012) segregate KMC's impact on mortality by showing results from high quality and low-quality studies.

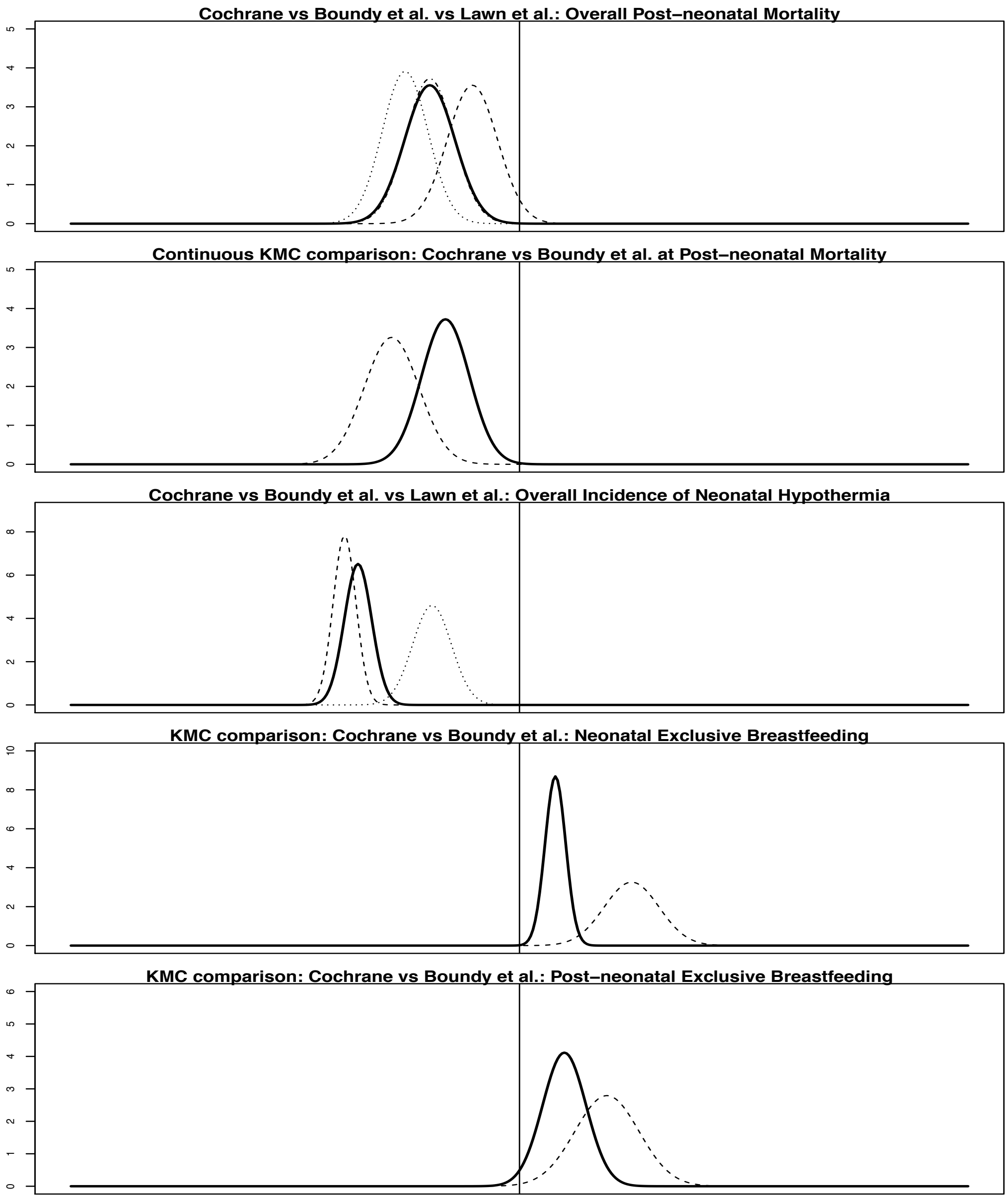

Figure 11 - Systematic review comparison of mortality and exclusive breastfeeding outcomes

Probabilistic analysis - Monte Carlo Simulation

Contingencies can be defined as events, circumstances, or risk factors within input assumptions that can affect the estimated effectiveness of KMC. Contingencies within KMC's effectiveness can be derived from the risk ratios chosen. As seen in earlier sections, systematic reviews such as Cochrane report risk ratios that define all health outcomes that KMC can potentially affect. Due to extensive heterogeneity between studies, some estimates lose their external validity. Some estimates are also reported as statistically insignificant because of the standard errors associated with studies measuring those particular outcomes. This paper seeks to conduct an ex-ante analysis of all the possible benefits associated with KMC in terms of DALYs averted. As has been seen in the DALYs averted calculations, all health outcomes that can be quantified have been used regardless of statically significance or heterogeneity. The immediate concern with this approach is that the estimated DALYs averted for Cameroon could be very different from true values.

A Monte-Carlo simulation has been conducted to account for the risk factors associated with variability in risk ratio estimates. Monte Carlo methods rely on randomness to solve problems that are deterministic in principle. It uses random samples values from the input probability distribution to generate a probability distribution of all outcomes. Each sample set is an iteration that records the resulting outcome from that particular sample set. This methodology, therefore, uses multiple simulation trials where each trial is an independent event and thereby assigns an independent probability to each trial. Having multiple trials allows us to develop a frequency distribution of effectiveness of KMC; this is then used to determine the mean and median DALYs averted (central DALYs averted). Further, 95 percent confidence intervals can also be generated to systematically show the combined effects of multiple risk sources. The first step in conducting a Monte Carlo simulation is specifying the underlying probability distribution of each parameter as random, and a 95 percent confidence interval for each input.

Cochrane's risk-ratios are reported in a logarithmic transformation, along with the corresponding confidence intervals. Therefore, the inputs have a normal distribution. The output chosen is DALYs averted. The standard errors for each risk ratio input used towards DALY calculations have been shown in Table 5 and 6. The next step is to take random draws from the distribution and use these values to generate estimated DALYs averted. The final step is to repeat the trial – usually 200,000 times – to compute estimated DALYs averted per trial. These estimates are then graphically representable to show the mean, median, spread and range values. The graphical representation has been shown in Figure 12 and 13 for continuous and intermittent KMC. The two figures show a large differential between the means calculated from a probabilistic analysis and means calculated from a deterministic analysis. Deterministic analysis refers to DALYs calculated in Tables 5 and 6. The difference may be explained by the statistically insignificant estimates included. The insignificant estimates result in a range of positive and negative range of (1-RRs).

Figures 14 and 15 show a tornado plot that assesses the variation in DALYs averted for continuous and intermittent KMC by each input. The inputs selected here are the health outcomes associated with KMC. As can be seen in Table 7 and 8, weight gain and mild or moderate infection are the two top health outcomes that can affect DALYs averted for continuous and intermittent KMC. This is interesting as mild or moderate infections showed a statistically insignificant outcome, that is an RR over one, and weight gain had substantial heterogeneity associated with its estimates. Having an RR over one negatively affects the DALYs averted calculations, as has been seen in Table 5 and 6. Having substantial heterogeneity means that the estimate can have large variations in its estimates and if often very distant from the expected estimate.

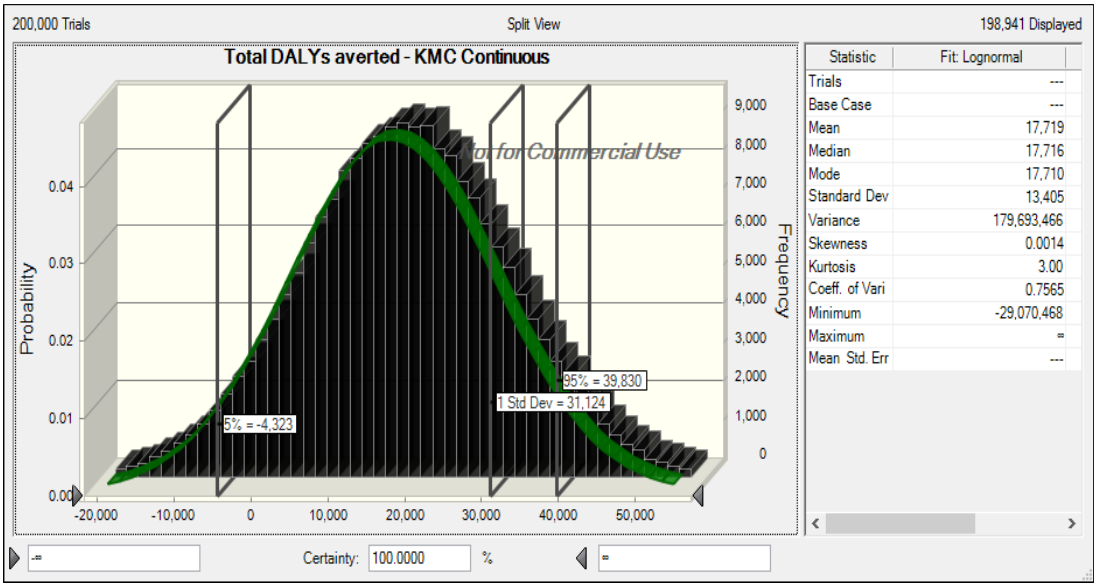

Figure 12 – Monte Carlo simulation: Continuous KMC

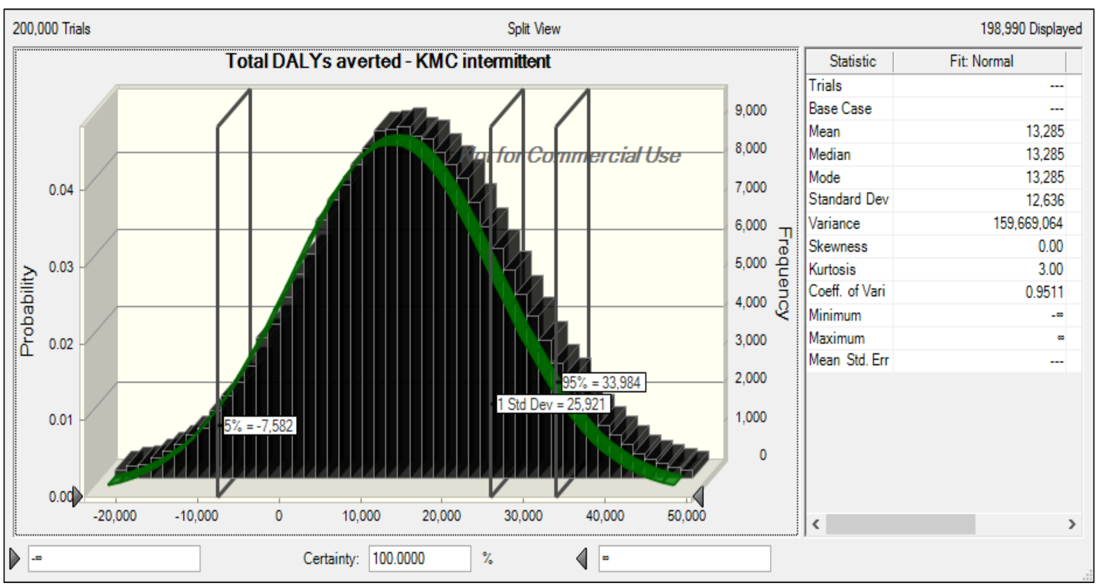

Figure 13 – Monte Carlo simulation: Intermittent KMC

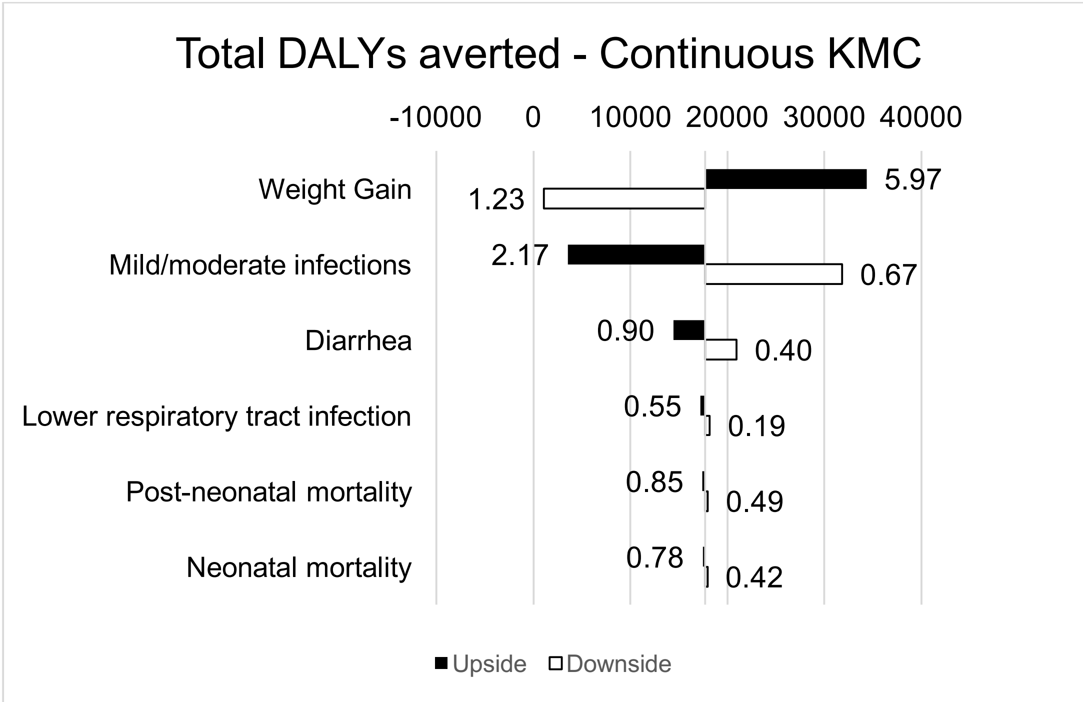

Figure 14 – Tornado plot – Continuous KMC

Table 7:Tornado plot – explained variation - Continuous

	Total DALYs averted · Continuous KMC				Input		
Input Variable	Downside	Upside	Range	Explained Variation†	Downside	Upside	Case
Weight Gain	1,053	34,332	33,278	56.75%	1.23	5.97	3.60
Mild/ moderate infections	31,831	3,554	28,277	97.73%	0.67	2.17	1.42
Diarrhea	20,960	14,425	6,536	99.92%	0.40	0.90	0.65
Lower respiratory tract infection	18,192	17,193	999	99.97%	0.19	0.55	0.37
Post- neonatal mortality	17,992	17,394	598	99.99%	0.49	0.85	0.67
Neonatal mortality	17,949	17,436	513	100.00%	0.42	0.78	0.60

† Explained Variation is cumulative

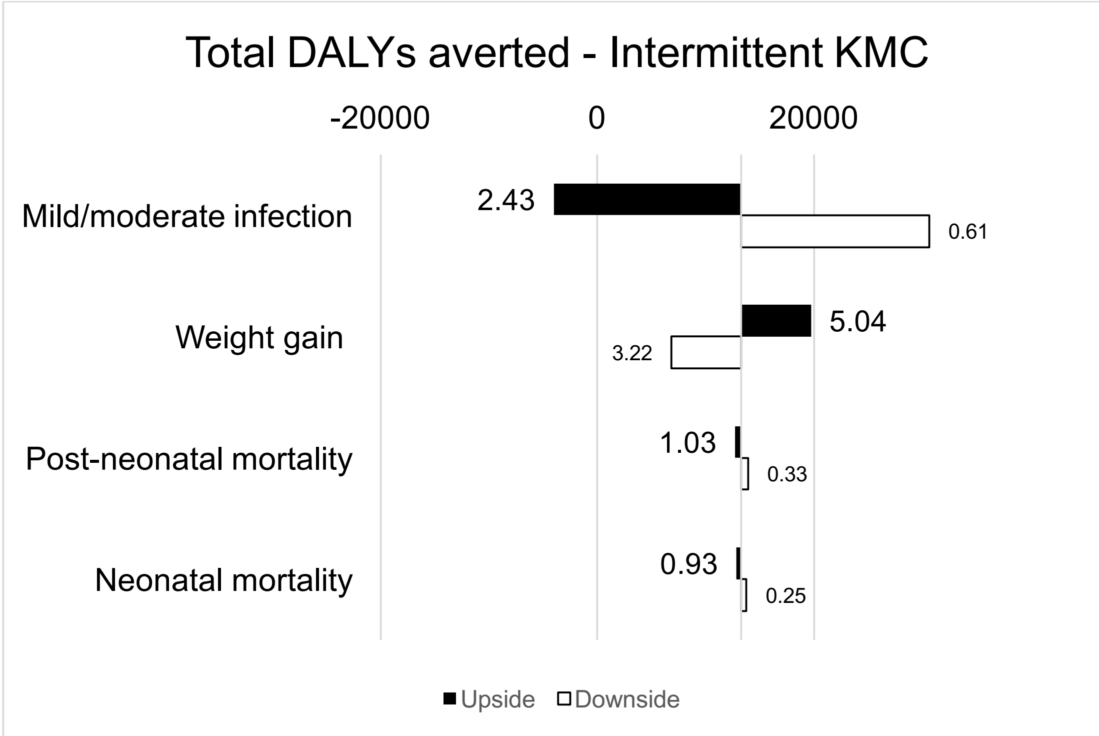

Figure 15 – Tornado plot – Intermittent KMC

Table 8: Tornado plot – explained variation - Intermittent

	Total DALYs averted · Intermittent KMC				Input		
Input Variable	Downside	Upside	Range	Explained Variation†	Downside	Upside	Base Case
Mild/ moderate infection	30,592	-4,039	34,631	87.73%	0.61	2.43	1.52
Weight gain	6,845	19,708	12,863	99.83%	3.22	5.04	4.13
Post-neonatal mortality	13,874	12,678	1,196	99.94%	0.33	1.03	0.68
Neonatal mortality	13,743	12,810	933	100.00%	0.25	0.93	0.59

† Explained Variation is cumulative

Monetization

There are several approaches to valuing mortality and morbidity risk reductions. The OECD discusses several methodologies that can be utilized by policy makers towards assessing the Value of a Statistical Life (VSL) which used alongside DALYs (Lindhjem, Navrud, & Biausque, 2011). A VSL identifies a monetary value on reductions in the risk of dying. A VSL is eventually used towards a cost-benefit analysis (CBA). CBA is usually undertaken within impact assessment and regulatory impact assessment. Non-market valuations suggested by the OECD that use a VSL include Revealed and Stated Preference methods.

Revealed preference (RP) methods cover markets where prices reflect mortality risk and assess individual behaviors in those markets. This approach, however, faces constraints while evaluating health policies and interventions because it is focused on the specific preference of a small population group facing specific risks. Therefore, it is not flexible enough to be applied to the general population (Lindhjem, Navrud, & Biausque, 2011). In this case, the general population would refer to all pre-term, underweight neonates. A revealed preference would be ideal when measuring whether mothers would prefer using KMC, given a particular sub-regional background and not on a national scale.

Stated preference (SP) methods derive VSL estimates by constructing a hypothetical market for mortality risk and ask respondents for their willingness-to-pay (WTP) to reduce their mortality risk. Surveys from SP methods identify different income levels between countries and assess whether VSL can be adjusted to account for differences in mortality risk magnitude, context and, population characteristics. WTP estimates for reductions in mortality risks are determined using data from studies on people's risk trade-off preferences.

These estimates are not independent of valuation context or individual circumstances. Therefore, the WTP reflects the contextual value an individual is willing to pay to reduce mortality risk by 1 in 100,000. The VSLs are then calculated by summing up the individual WTP values over the 100,000 individuals. VSL is, therefore, not the identified value of a person's life, but the aggregation of individual values from small changes in the risk of premature death (Lindhjem, Navrud, & Biausque, 2011). VSL is used in CBA calculations using the following methodology:

1. Multiplying the annual average risk reduction with the number of people affected by the program gives the number of deaths that are expected to be prevented.
2. Either a single or a range of VSLs are applied to each death prevented in that year to estimate the annual benefit.
3. Annual benefits are then discounted using the national social discount rate and then summed over the lifetime of the policy to achieve a present value.

There have been multiple arguments that discuss the usage of one common VSL as compared to a range of VSL values depending on social groups. A common VSL value is often used to be coherent across policy areas. The unit transfer with income adjustments approach is sometimes used to transfer the VSL values across countries while accounting for different income and cost of living levels. The equation commonly used is

$$\mathrm{VSL}'_{\mathrm{P}} = \mathrm{VSL}_{\mathrm{S}} \times \left(\frac{\mathrm{Y}_{\mathrm{P}}}{\mathrm{Y}_{\mathrm{S}}}\right)^{\beta}$$

VSL'_P represents the adjusted VSL estimate for the policy site, VSL_S represents the original VSL estimate from the study context and Y_P, Y_S represent the income levels at the study country and the comparison country. β represents the income elasticity. There have been some arguments on the value of income elasticity as it is dependent on the age spectrum covered within the study. However, the standardized income elasticity used by health researchers is valued at 1 (Lindhjem, Navrud, & Biausque, 2011).

While transferring VSL values, variations across sub-regional income levels need to be considered, especially in developing countries. GDP per capita is also used as an alternative when benefit transfers are applied internationally. Another important consideration while transferring VSL across two countries is the population and risk characteristics of the study and policy site have to be similar to avoid having to correct for differences in individual preferences, baseline levels of risk and magnitude of risk changes, risk contexts, and cultural and institutional conditions between countries.

Once the VSL has been transferred from the base country to the policy country, it can be converted into a value of a life year(VOLY) using the country average life expectancy.

$$\text{VOLY} = \frac{\text{VSL}}{\text{Average Life Expectancy}}$$

$$\text{Value of DALE} = \text{VOLY} \times \text{number of DALYs averted}$$

The calculations have been shown in Table 8. As a next step, weights can be assigned to selected base countries. We have used a ratio of observations to pooled observations reported in the meta-analysis conducted by OECD to account for study size differences (Biausque, 2012).

Table 9 – Calculating the weighted value of DALE (Cont. KMC) (Base VSL estimates from Biausque, V., 2012)

Base country	VSL (base)	GDP per capita (2015 USD)	Adjust. factor (Cameroon GDP in 2015/Base GDP 2015)	VSL	VOLY	Value of DALE	Wt.	Wt. value of DALE
Bangladesh	5,248	1,212	1.032	5,416	100.3	2,235	0.034	$76.00
Thailand	1,555,256	5,816	0.215	334,380	6192.2	138,007	0.034	$4,692
China	562,225	7,925	0.158	88,832	1645.0	36,663	0.932	$34,169
Cameroon (per infant)								$38,938
Cameroon (all infants)								$18,802,848.49

Table 10 – Calculating the weighted value of DALE (Int. KMC) (Base VSL estimates from Biausque, V., 2012)

Base country	VSL (base)	GDP per capita (2015 USD)	Adjust. factor (Cameroon GDP in 2015/Base GDP 2015)	VSL	VOLY	Value of DALE	Wt.	Wt. value of DALE
Bangladesh	5,248	1,212	1.032	5,416	100.3	1,730	0.034	$58.83
Thailand	1,555,256	5,816	0.215	334,380	6192.2	106,835	0.034	$3,632
China	562,225	7,925	0.158	88,832	1645.0	28,382	0.932	$26,451
Cameroon (per infant)								$30,143
Cameroon (all infants)								$14,555,805

The DALE values across Bangladesh, Thailand, and China can be aggregated to obtain a weighted DALE for Cameroon at $18,802,848 or $38,938 per infant for continuous KMC and $30,143 per infant using intermittent KMC. The weighted value of benefits per DALY can then be compared to the cost per DALY to assess the effectiveness of the intervention.

Costs associated with KMC

There have been multiple studies that look at the cost effectiveness and the cost utility of implementing kangaroo mother care in developing countries. A study in Nicaragua analyzed the costs of implementing KMC in a referral hospital. The costs discussed cover training, implementing, and ongoing operating costs (Broughton et al., 2013). They concluded that on average KMC infants had a shorter hospital stay by 4.64 days. The entire cost of KMC as an intervention was estimated at US$23,133. They estimated that the benefits from KMC elimination of incubator use, lower antibiotic and formula costs covered the cost of KMC within 1-2 months of initiation. When KMC was extended to 12 facilities, KMC was projected to save US$ 166,000 – US$ 233,000 within the first year of use.

Another study observed the costs of KMC implementation as compared to conventional neonatal care in three developing countries: Ethiopia, Indonesia, and Mexico (Cattaneo et al., 2007). The salaries paid to hospital staff for implementing KMC and including training showed that KMC at US$11,788 was less costly than conventional neonatal care at US$29,888. Other implementation and operating costs also followed a similar trend, where KMC had a lower cost of US$7,501 as compared to conventional neonatal care cost of US$9,876. Therefore, for low-income countries, KMC offers a cost-effective alternative that efficiently utilizes scarce resources, and increases the prevalence of benefits from exclusive breastfeeding, infant growth, and lower infections.

Cost effectiveness of kangaroo mother care

Cost effectiveness can be defined as the ratio between the costs associated with an intervention and the benefits associated with it. It is used as an alternative to a cost-benefit analysis. CEA is often used when there is an established need for an intervention, but there is uncertainty over the method of achieving it. The benefits are defined as the DALYs averted by kangaroo mother care. Since, there are two types of kangaroo care discussed, continuous and intermittent, cost effectiveness can be conducted for both scenarios. The costs associated with KMC have been outlined in the preceding section. Costs from both studies have been assigned weights using ratios of observations to pooled observations. The same weighting methodology has been applied within the second study as it covers three cities: Ethiopia, Mexico, and Indonesia. Therefore Ethiopia, Mexico, and Indonesia have a weight of 27, 48, and 25 percent respectively. The benefits, costs, weights, and weighted costs are shown in Table 10. Just for reference, the monetary value of benefits associated with Cameroon have also been reported in Table 10. The cost effectiveness has been shown in Table 11.

Table 11 – Calculating the weighted value of costs associated with KMC (regardless of continuous or intermittent)

Base study country	Cost (base) (USD)	GDP per capita (2015 USD)	Adjust. factor (Cameroon GDP in 2015/Base GDP 2015)	Cost in Cameroon	Wt.	Wt. value of cost
Nicaragua	$23,133	$2,151	0.58	$13,417	0.023	$309
Ethiopia, Mexico, Indonesia	$24,101	$4,961	0.25	$6,025	0.977	$5,886
Cameroon						**$6,195**
Benefits (KMC Continuous - $) per infant						**$38,938**
Benefits (KMC Intermittent - $) per infant						**$30,143**

Table 12 – Calculating the cost effectiveness of KMC (continuous and intermittent)

Weighted costs	Continuous KMC DALYs averted	Intermittent KMC DALYs averted)	Cost-effectiveness Cont. KMC	Cost-effectiveness Cont. KMC
$6,195	10,762	8,331	0.58	0.74

As can be seen in Table 11, regardless of the type of KMC implemented, the benefits in terms of lives saved significantly outweighs the costs associated with it. The next point of concern is whether the benefits associated with KMC can persist over time.

Effect Persistence

Some factors affect the persistence of benefits of a health intervention and need to be considered and accounted for when analyzing impacts. The primary cause for concern at the end of this intervention is derived from whether or not hospitals have the incentive to continue KMC after the intervention has ended. Cameroon has public and private hospitals. Services at both hospitals are paid for either by the patient or an insurance company. Private hospitals in general, have a higher cost per medical service provided and are therefore only accessed by the relatively wealthier population groups in Cameroon. This population group is more likely to not default on their hospital bills. Therefore, private hospitals have a lower incentive to take on a cost-effective neonatal approach for patients that can afford the higher costing NICU service.

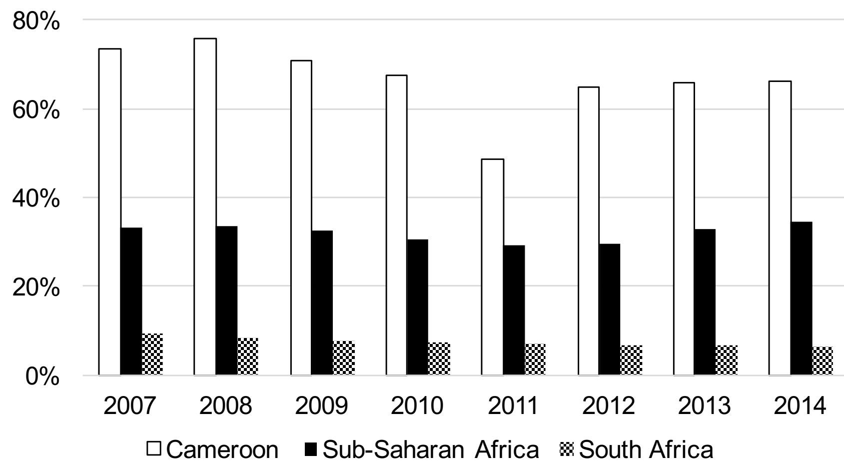

Figure 16 - Share of out of pocket expenses for healthcare (The World Bank, 2017s).

Public hospitals, however, have more low and middle-income groups of the population as patients. These groups are more likely to default on their medical payments, especially when they have minimal to no insurance coverage. Cameroonians in general also suffer from a higher out-of-pocket medical expenditure because of the lack of accessibility to risk sharing structures. Public hospitals may, therefore, be more willing to continue the KMC program after the intervention ceases. By continuing the KMC program, they would have lower income per infant, but, they would have a lower risk of payment default per infant. They may also be able to resolve capacity constraints and therefore, earn on the margin.

A convenient way to look at long-term sustainability is the presence of "trifecta" learnings or skills that are malleable, fundamental to intervention success and skills that would not have been developed within the counterfactual. These skills can also be emphasized on during the preliminary stages of the intervention. From the perspective of KMC, hospital staff and mothers need to be trained. KMC interventions in the past have been heterogeneous to fit the requirements and the capacities of the hospitals. Therefore, the skills sets are inherently malleable and can be applied to varied forms of the intervention. Within the counterfactual setting, intensive neonatal care would not involve training mothers at the hospital; there would be a significant separation of infant and mother until the infant is discharged. Identifying these “trifecta” characteristics of an intervention allows the emphasis on benefits derived from them during intervention design and implementation.

Another concept discussed by researchers is fade out patterns. Ex-post evaluation of the intervention is an avenue that allows learning from the fade out of benefits from the intervention. Such learnings allow researchers to ask questions about scaling up the intervention through duration, the number of hospitals that are needed to participate, hospital qualities that are impactful, regional focus, longer training periods, etc. The number of hospitals needed to participate can be calculated using the formula for Minimum Detectable Effect after a baseline survey is conducted. Concerning KMC specifically, a staggered approach to the KMC training and implementation period across hospitals would allow learnings within healthcare accessibility, quality control, uptake, etc. These learnings can be to other hospitals. Hospitals with earlier starting periods can also be used for a baseline analysis to test for the need of randomized controlled trials in the future.

Other Considerations

When assigning a value to the health outcomes from KMC, a review can be conducted on KMC implementations in similar countries and pre-existing KMC knowledge. A similar KMC implementation in Mali faced problems in data collection. The nonexistent record-keeping infrastructure affected the analysis of the before and after effects of KMC. In Mali, only two hospitals were able to show evidence of guidelines, policies, or procedures related to KMC; only one hospital was able to gather some evidence-based data but, it was not enough (Bergh, Sylla, Kante, Bengaly, & Kaba, 2012). The records of the type of KMC (continuous or intermittent) were not backed by evidence. Data gaps also made it difficult to assess the quality of KMC offered in most facilities. They were only able to conduct analysis on the number of infants enrolled in the program and overall program uptake. These data gaps would have a significant impact on an ex-ante analysis of health outcomes. Therefore, it is imperative to have systematic, periodic data collection method that analyzes health outcome impacts. A baseline data collection is commonly used as the first step towards analyzing preliminary before and after effects.

Another factor that will impact health outcomes in Cameroon is the already existing KMC training facility and kangaroo unit in Laquintinie hospital. Doctors and nurses that participated KMC in Mali were trained in Cameroon in 2007 (Bergh et al.,2012). Further, accreditation of the KMC training unit in Mali was undertaken by trainers from Cameroon and Colombia. Therefore, there has been pre-existing training knowledge in Laquintinie Hospital, Cameroon. This would have a positive impact on intervention results because there is a potential for fewer implementation errors, shorter training periods and pre-existing knowledge about KMC amongst the locals.

Barriers and Enablers of KMC

Mothers and nurses

Studies that have analyzed mother and nurse responses to KMC have identified barriers and enablers (Seidman G et al., 2015). Mothers in low and middle-income countries have stated physical and emotional difficulties as one of the key barriers to taking up continuous KMC. These difficulties are aggravated by the lack of family support, issues with the facility environment, lack of resources, negative staff attitudes, fear of harming the infant, and lack of help with KMC practice. Most hospitals in Cameroon have a deficit of medical personnel. Therefore, mothers are required to take initiative to learn their role within KMC quickly. Family members also do not always support mothers when undertaking KMC because of the gendered roles in households in Cameroon; they may be required to resume household responsibilities soon after childbirth. Such gendered roles and lack of empowerment in decision-making affects the willingness of mothers to spend time at the hospital after delivery and family responsiveness and acceptance towards KMC.

A more flexible program that accounts for such cultural norms may be beneficial to increase uptake. Tailoring the program to cultural needs and societal expectations can increase support and acceptance from the community. Lack of support and acceptance from the community is often derived from a misperception and a lack of awareness of KMC benefits within the community. This lack of awareness affects community buy-in and can lead to community disapproval because of the low perceived value of KMC (Seidman G et al., 2015). Therefore, a support system needs to be set up at the hospital to help mothers through the stress that they go through while undertaking continuous KMC. This support system needs to address the fact that mothers may require more training, supervision and emotional support. A support system also needs to be an intermediary between the mother and the family, especially in the case when families are not supportive of mothers undertaking KMC. A support system would also help when medical staff has a negative outlook in KMC. Overall, support systems for mothers would affect their willingness to participate in the intervention.

Staffing Considerations

Implementing KMC involves an investment of time and energy by hospital staff that is already stretched thin. The scarcity of doctors is a reason to expect some push-back from doctors in terms of learning KMC (Seidman G et al., 2015). This is a reason to take measures to promote engagement activities that increase doctor buy-in. Doctors should be aware that KMC reduces complications and has the potential to decrease per patient workload. When workload spent on preventable infections is decreased, doctors can reinvest their time savings into caring for other patients or expanding their skill-set. From the hospital side, decreased per patient workload may help hospitals retain doctors as high workload in rural hospitals has been cited as a reason for migration to urban centers (Tandi et al., 2015).

Nurses have identified resourcing and sociocultural factors as lead barriers to KMC adoption. A study by Seidman et al. (2015) shows that resourcing barriers faced by nurses can be classified into increased workload, lack of clear guidelines/training, issues with facility environment, low awareness or misinformation about practice, and logistical issues with implementing a new practice. These barriers are aggravated by the fact that due to the scarcity of doctors, nurses in Cameroon have a large set of responsibilities and may already be providing services within disease prevention programs, primary health care, and education programs. One solution is to provide monetary incentives for nurses to take KMC training. More direct solutions reduce barriers—for example, establishing clear guidelines for KMC before training.

Nurses have similar socio-cultural beliefs like those of mothers. Nurses' beliefs include a lack of buy-in or belief in the efficacy of KMC, other gendered beliefs that the mothers are not supposed to spend time at the hospital after delivery. Further, KMC requires that mothers be present in the neonatal unit for extended periods of time. This can be perceived by nurses as interference with daily work. Experiential factors such level of experience, and handoff issues with other nurses have been reported as additional factors that affect nurses' willingness to enthusiastically participate within KMC.

As a part of KMC, the medical staff is required to undergo training. Centers of excellence such as Laquintinie hospital can be used as a training ground for nurses and doctors prior to implementation. During training, supportive skills need to be focused on so that nurses can eventually be the second source of support for mothers. Experiences from previous studies and experiences during the intervention can, therefore, be leveraged to constantly improve KMC delivery. KMC delivery can only be successful if there are behavioral changes amongst mothers, families and medical staff.

Community Engagement

One avenue for community engagement is recruiting KMC champions at hospitals. A KMC champion is a health worker that actively participates in training sessions and enthusiastically motivates mothers to initiate KMC (Soni et al., 2016). Parental involvement is a key aspect of KMC. KMC champions can help parents that are overwhelmed and thereby, reduce parental nervousness. They are also responsible for training nurses to record KMC data as standard care in hospital medical records, and providing weekly or twice-weekly KMC sessions that illustrate proper KMC methodology. A study conducted by Soni et al. (2016) on KMC in India separates impacts on infants from KMC when champions are present as compared to when they are not present to quantify the quality improvement efforts of KMC champions. They have observed that withdrawing KMC champions from the staff reduces the practice of skin-to-skin care practice, but no effects are seen in breastfeeding practices. Overall use and initiation rate of skin-to-skin care in the absence of KMC champions is half of that of when champions are present.

UNICEF has had multiple public health partnerships in Cameroon to address mortality and morbidity issues among women and children. Preventative interventions that increase routine vaccination against childhood diseases such as Hepatitis B, measles, meningitis, polio, yellow fever have been successfully undertaken. They have also successfully trained health staff in nine district hospitals and distributed vitamin A supplements, emergency drugs, and equipment including maternal and obstetric kits to ensure safe deliveries. As a part of their nutritional interventions, they have taken measures to prevent early childhood malnutrition by promoting child feeding, caregiving, and care seeking practices at the facility, family, and community levels. The Ministry of Health, WHO and UNICEF have also worked together to organize Maternal and Child Health and Nutrition Action Weeks (MCHNAW) (UNICEF, 2013). Such campaigns have had a wide reach into Northern regions. KMC community engagement programs can be conducted in collaboration with such campaigns to cast a wider net in terms of mothers reached and educated.

Rural or Urban

KMC impacts can be segmented geographically into rural and urban impacts. Rural areas have lower access to health care. Lack of accessibility to medical facilities would affect the uptake of the KMC program. The Adamawa, Northern and Extreme Northern region has the highest percentage of respondents that have not utilized any hospital services in the past year (DHS, 2011). In addition to this low uptake, hospitals in the rural areas are not well equipped with medical facilities and amenities. Therefore, measures would have to be taken to have more community engagement in rural areas. More awareness of KMC programs would help mothers actively seek out medical help.

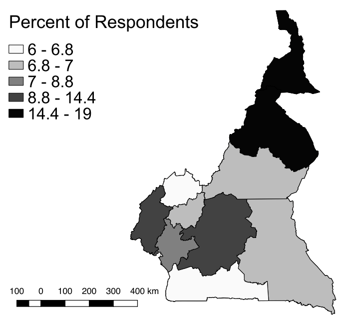

Figure 17 – Respondents that identify the distance to the hospital as a reason for not getting medical aid. (Cameroon Demographic and Health Survey 2011)

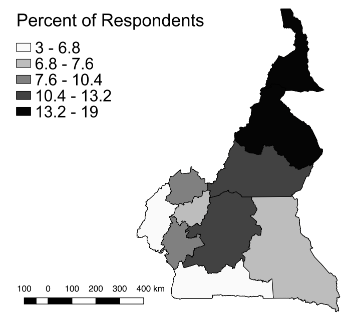

Figure 18 – Respondents that have not utilized hospital services in the past year. (Cameroon Demographic and Health Survey 2011)

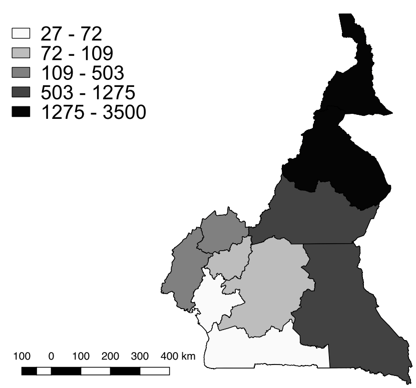

Figure 19 – Number of people reported as “poorest” on the Wealth Index (Cameroon Demographic and Health Survey 2011)

At-home deliveries are more prevalent in rural communities as compared to urban communities. This is because of lack of easy access to hospitals, and cultural norms where women may not feel comfortable asking for medical help. In the latter case, women may also not feel comfortable staying at the hospital for extended periods for KMC treatments. Therefore, an at-home KMC or community-level KMC would be an alternative design that could provide better results in uptake in rural areas. In the past, the Federal Ministry of Health in Ethiopia in partnership with USAID's Maternal and Child Health Integration Program have evaluated the feasibility of implementing community-based KMC and at-home skin-to-skin care with support from Health Extension Workers (HEW) at health posts (cite). The main challenge they identified was recruiting enough health workers to incorporate home visits. Similar designs could be implemented in Cameroon with support from mutual health organizations (MHOs). The government has provided significant support to developing sustainable MHOs and aim at having one MHO in every health district. MHOs could prove to be an effective alternative in rural areas where there are few hospitals, and non-existent neonatal care units.

Developed countries such as Germany have implemented Kangaroo transport, a mechanism that allows for the transport of neonates between neonatal care units and homes. Since rural areas have a high at-home birth rate, Kangaroo transport has been suggested as an effective means of transport between the home and hospital. Rural hospitals in Cameroon do not have neonatal care units so that patients must travel to urban areas to public hospitals. It has been suggested that antenatal training be provided to mothers so that they can use skin-to-skin contact and appropriately position the infant to reduce mortality while traveling. This higher chance of infant survival may provide enough incentive for mothers to participate in KMC.

The lack of medical amenities and low salary structure in rural areas has been a significant factor in the rural-urban migration of doctors. Therefore, the absence of sufficient medical professionals is a reason that rural areas have a lot more to gain from a cost-effective intervention such as KMC. Another factor that would have to be considered as a part of the intervention would be an outbreak of infections in hospitals. Since quality control and management is a key input of KMC, rural hospitals would benefit significantly with lower infection outbreaks. Another factor that affects the design of the intervention is its sustainability. Hospital incentives to continue KMC once the intervention ends are a significant contributor to sustainability.

Political Considerations

Cameroon follows a unitary presidential republic political system. Paul Biya took over the presidency in 1982 and has been the president ever since. He represents the head of the state whereas Philemon Yang, the Prime Minister, represents the head of the government. Cameroon will be hosting presidential elections in 2018. Paul Biya's successor may have a significant impact on the continuation of KMC because of potential shifts in government subsidies and support. In recent years, the North region of Cameroon has also been drawn into the local insurgency of Boko Haram. This has been exacerbated by the spillover crisis from neighboring countries. There has also been instability within public services because of corruption. Bribery, abuse of office and embezzlement is widespread among public service officials. This has been a fundamental the problem that companies have faced while investing in Cameroon (EIU, 2015).

The success of an intervention is contingent on a favorable regulatory environment, institutional framework, operational and financial facilities, and past successes. The Infrascope Index, by the Economic Intelligence Unit (EIU), is a country-based index that evaluates the potential for future public-private partnerships using six categories. These six categories represent the various aspects of a country that needs to be considered by investors and international organizations as background research. A detailed description of each category had been shown in Figure 20 along with the weight assigned to it while calculating the Infrascope Index. Cameroon's rank and score on the Infrascope Index in comparison to South Africa has been shown in Table 9.

The Infrascope Index is primarily used for public-private partnerships within infrastructure based projects. However, the country-aspects that are considered while calculating the Infrascope Index have implications within the health sector as well. Within an intervention such as KMC where key stakeholders include the general population, hospitals and Ministry of Health, it is important to have harmonization and transparency across all stakeholders. On the governmental front, it is important to have communication and procedural stability between horizontal, vertical, national and subnational levels of the government. In the absence of regulatory frameworks and transparency, there is a risk of projects and their subsidies falling into distress or cancellation.

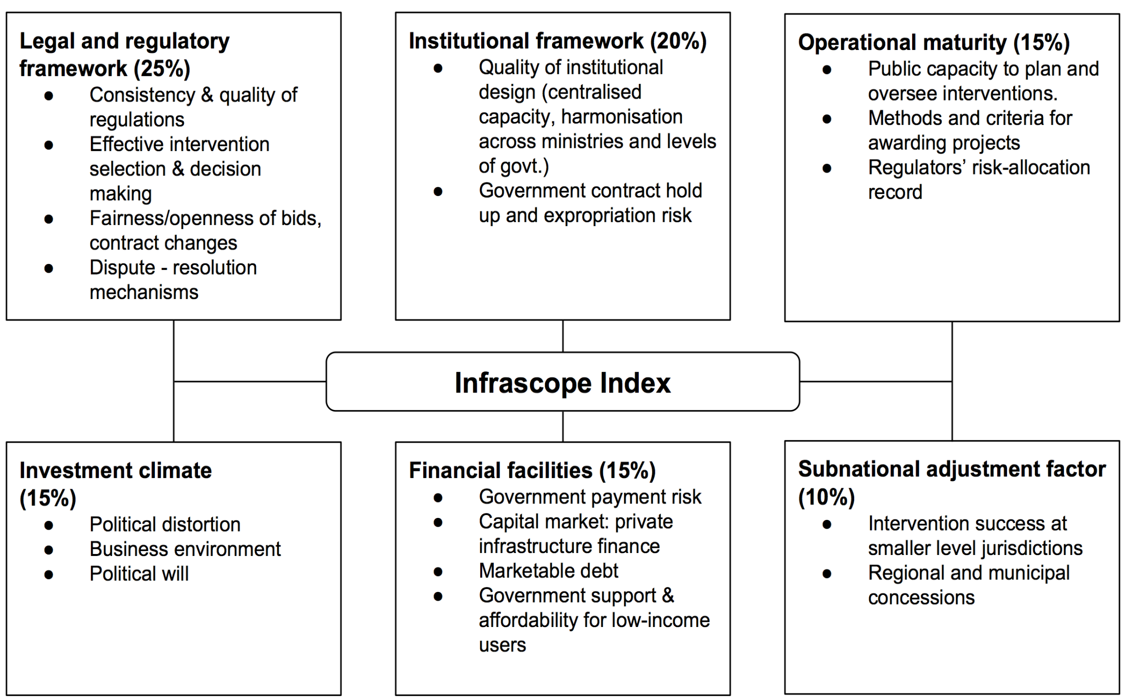

Figure 20 – Qualitative and Quantitative considerations while analyzing country risk

Table 13 – Cameroon's score on six categories within the African Infrascope Index. (EIU, 2015)

Category	Score	Rank	South Africa Score	South Africa Rank
Overall Score	38.2	11/15	70.7	1/15
Regulatory Framework	43.8	11/15	75.0	1/15
Institutional Framework	25.0	11/15	75.0	1/15
Operational Maturity	31.3	11/15	75.0	1/15
Investment Climate	55.8	7/15	46.4	14/15
Financial Facilities	27.8	14/15	91.7	1/15
Subnational Adjustment	50.0	1/15	50.0	1/15

Appendix

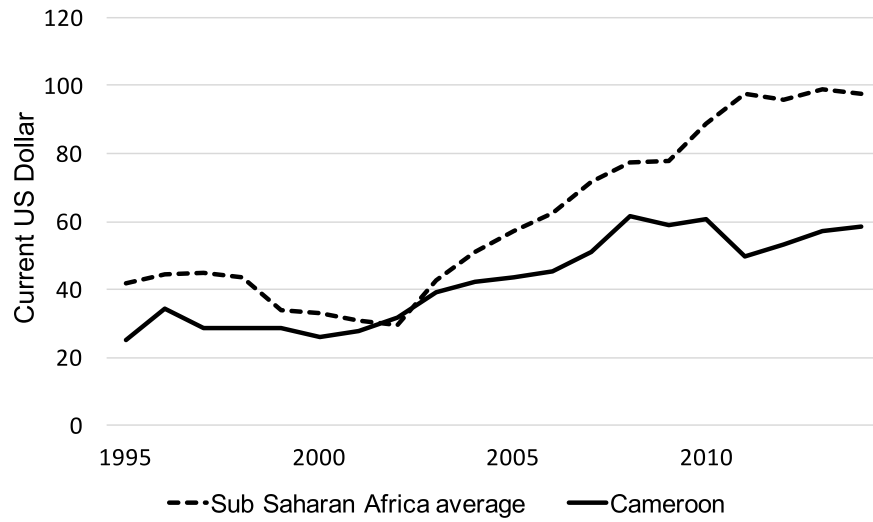

Figure 21 – Per capita health expenditure, regional comparison. (The World Bank, 2017o).

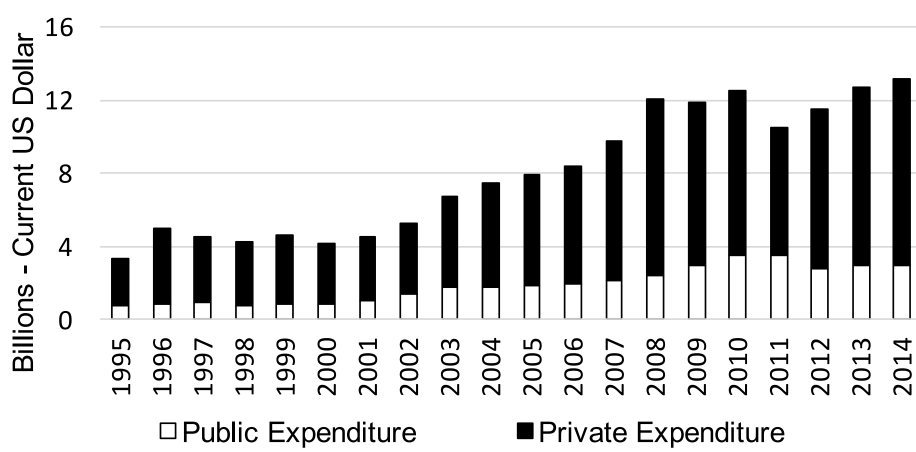

Figure 22 – Public and private healthcare expenditure (The World Bank, 2017 p-r)

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