

Short Communication

Marketing Skin-To-Skin-Contact in the Kangaroo Position as a Frugal Technology: A No-Cost Way to Support Improved Maternal-Child Health Outcomes across Global Contexts

Nikki L. Rogers^{1,2}, Cristina Redko^{1,3}, Linda J. Smith^{1,2,4}

¹Department of Population and Public Health Sciences, Wright State University Boonshoft School of Medicine, Dayton, Ohio. (3123 Research Blvd., Suite 200, Dayton, Ohio 45420)

²Breastfeeding Institute at Wright State University, ³Center for Global Health, Wright State University, A unit within the Department of Population and Public Health Sciences, Wright State University Boonshoft School of Medicine.

⁴Bright Future Lactation Resource Centre, Ltd., Dayton, Ohio. <http://www.bflrc.com/> 6540 Cedarview Court, Dayton OH 45459-1214. This is Linda Smith's personal business, a domestic limited liability company incorporated in the State of Ohio.

Corresponding Author: Nikki L. Rogers

ABSTRACT

Background: Long before the 21st century frugal innovation movement, the practice of skin-to-skin contact achieved through the Kangaroo Position described in Kangaroo Mother Care was introduced as a strategy to thermostabilize low birthweight infants without electric incubators and avoid separating mothers and babies.

Discussion: We explain the spectrum of skin-to-skin contact interventions (hospital-based and community-based Kangaroo Mother Care, the Baby Friendly Hospital Initiative) to show skin-to-skin contact achieved by the Kangaroo Position as a pioneering frugal solution to address the global health problems of infant mortality and morbidity. We have found no literature formally describing these methods as frugal technologies/innovations. The need to actively promote maternal-infant contact is necessary because separating the mother and baby plus the medicalization and technological focus of birth is the current accepted medical norm. Skin-to-skin contact is an evidence-based best practice that should be promoted as a lower cost, sustainable medical intervention suitable for all newborns and their families across low-, middle-, and high-resource countries. This provides new marketing opportunities for maternal and child health interventions within the framework of frugal technology, fitting skin-to-skin contact and Kangaroo Mother Care within a popular, fundable, 21st century movement.

Conclusion: Adding the concept of frugal technology to discussions of skin-to-skin contact-based interventions is a no-cost way to reach additional stakeholders and address medicine's cultural bias against low-technology and natural solutions. This reframing can be used to address healthcare system barriers to increase skin-to-skin contact intervention coverage, which is necessary to achieve global goals for infant and maternal health improvement.

Keywords: breastfeeding; infant morbidity; infant mortality; frugal technology; maternal-child health; mother-baby dyad.

INTRODUCTION

The concept of 'frugal technology' challenges the traditional global health approach that adopts technical solutions

from high-resource countries to meet the medical needs of poorer countries. ⁽¹⁾ Instead of retro-fitting existing technological solutions to meet local needs

in a resource-poor environment, frugal innovators design new, reproducible, lower-cost solutions using local resources. Long before the frugal innovation movement, the practice of skin-to-skin contact and its specialized form of Kangaroo Mother Care (KMC) were introduced as strategies to thermostabilize low birthweight infants without electric incubators and keep mothers and babies together. ⁽²⁻⁴⁾ We have found no literature formally describing these two methods as frugal technologies/innovations and offer this work as evidence that skin-to-skin contact and KMC are frugal interventions applicable and beneficial in all settings, from home birth in under-resourced countries to the technologically equipped hospitals in wealthy countries.

We explain the spectrum of skin-to-skin contact (SSC) across hospital-based and community-based KMC ^(5,6) and the Baby Friendly Hospital Initiative ⁽⁷⁾ to show SSC as an pioneering *frugal solution* to address the global health problems of infant mortality and morbidity. SSC is an evidence-based best practice that should be promoted as a lower cost, sustainable medical intervention suitable for *all newborns* and their families across low-, middle-, and high-resource countries. This approach provides new marketing opportunities for maternal and child health interventions within the framework of frugal technology, fitting SSC and KMC within a popular and fundable 21st century movement. Adding the concept of frugal technology to discussions of SSC-based interventions is a no-cost way to reach additional stakeholders and address medicine's cultural bias against low-technology and natural solutions. This may be a beneficial perspective to promote maternal-child bonding in high-income

countries enamored of technology and in low-income countries where medical professionals view technology as a symbol of modernity or medical necessity even when electricity service is inconsistent. We recommend promoting SSC for full-term infants in addition to low birthweight infants, traditionally the primary targets for hospital-based ⁽²⁾ and community-based KMC. ⁽⁵⁾ We cite and promote the 1998 Bogota Declaration ⁽⁸⁾ for reduced infant mortality and morbidity:

Kangaroo Mother Care should be a basic right of the newborn, and should be an integral part of the management of low birth weight [sic] and full-term newborns, in all settings and at all levels of care in all countries” ⁽⁸⁾ [p, 1-11].

The Global Burden of Infant Mortality and Morbidity

Neonatal deaths represent the global majority of all child deaths under 5 years of age (Figure 1). More than 80% of newborn deaths are preventable and due to neonatal infections, pre-term birth and its consequences (e.g., hypothermia), and intrapartum risks. ⁽⁹⁾ By implementing evidence-based practices, the UNICEF/WHO *Every Newborn* action plan aspires to save 3 million lives ⁽⁹⁾ through core components including KMC and feeding support (p. 7). As many as 450,000 deaths could be avoided in pre-term infants alone by “near-universal” uptake of KMC. ^(10,11) SSC's positive effects on breastfeeding outcomes ⁽¹²⁾ would prevent deaths in both pre-term/low birthweight and full-term/normal-weight infants because increased rates of early and exclusive breastfeeding are associated with lower infant morbidity and mortality, ⁽¹³⁻¹⁵⁾ even in resource-rich countries. ⁽¹⁶⁾

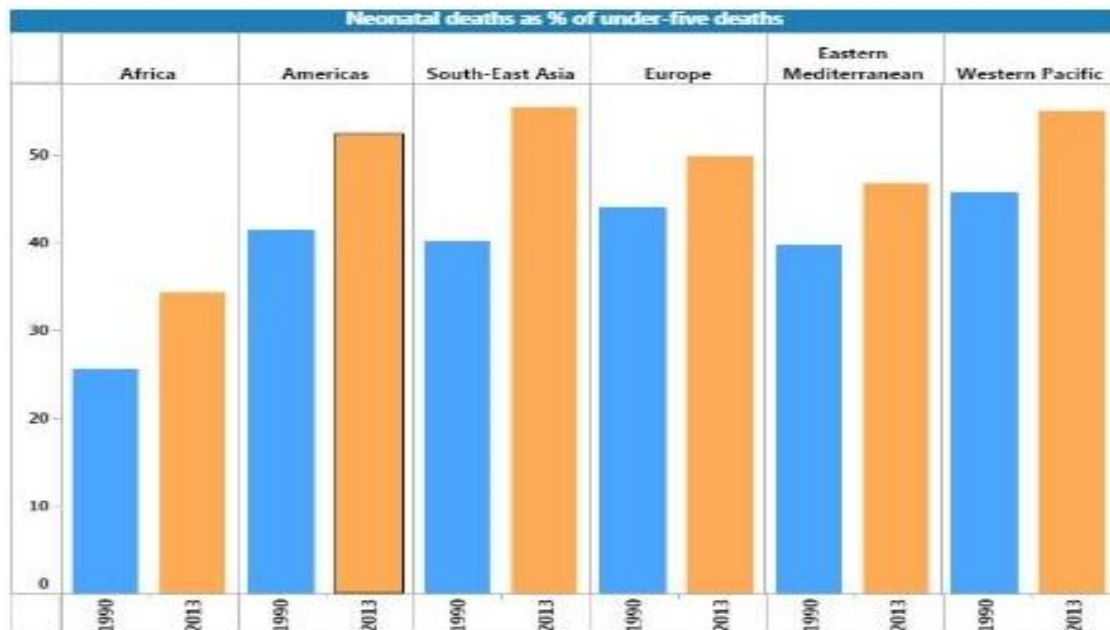


Figure1: Child mortality: Neonatal Deaths as a Percentage of Under-five deaths. From WHO. Global Health Observatory Data Repository: Visualizations: Mortality and global health estimates; Child mortality, neonatal deaths and mortality rate, 2015 (17,18).

The Spectrum of Skin-to-Skin Contact methods

SSC is “placing the dried, naked baby prone on the mother’s bare chest” (12) p. 1; This chest-to-chest contact is achieved by the Kangaroo Position of mother and infant (Figure 2). Conde-Aguedelo and Díaz-Rossello state that Kangaroo care was “originally defined as skin-to-skin contact between a mother and her newborn” (2), p. 1). Bergman and Bergman (19) define SSC as a *place of care* defined by the Kangaroo Position: they differentiate the Kangaroo Position/SSC from the comprehensive protocols of KMC that take place once the mother-infant dyad are in Kangaroo Position. Usage in the current Cochrane reviews (2,12) suggests that the term KMC is more likely to be applied to pre-term births (< 35 weeks), while SSC is more likely applied to full-term (≥ 35 weeks) infant

care. The evidence shows that SSC in the first two hours after birth programs infant self-regulation that is detectable in 12-month follow-up. (20) SSC is a central feature of and facilitates Step 4 of the WHO-UNICEF Ten Steps to Successful Breastfeeding, (21) part of the Baby-Friendly Hospital Initiative (BFHI)(Table 1).



Figure 2: The Kangaroo Position achieves Skin-to-Skin Contact (SSC) (Photo by author #3; mother’s consent was received.)

Table 1. Definitions of Skin-to-Skin Contact Methodologies used in this Manuscript

| Method | Definition | Notes |
|-------------------------------|--|--|
| Skin-to-Skin Contact (SSC) | “...placing the dried, naked baby prone on the mother’s bare chest” (12) p. 1) for a specified period; Bare chest-to-chest contact is required. | Does not include contact not supported by the literature, e.g., leaving mother’s brassiere on; involving an infant dressed in a diaper; cheek/cheek contact (22) |
| Hospital-Based Kangaroo Care | Achieving chest-to-chest SSC under specific protocols described by the World Health Organization and recommended for low birthweight infants; performed in a hospital setting on low birthweight infants (2) | |
| Community-Based Kangaroo Care | Designed to provide SSC to <i>all</i> infants to establish a community norm and ensure coverage for all low birthweight regardless of accurate birthweight identification. (5,23) | |

Kangaroo Mother Care (KMC) is a method for achieving chest-to-chest SSC under specific protocols described by the World Health Organization for preterm infants. ⁽²⁾ We call it ‘hospital-based’ KMC in this work to distinguish these institutional protocols for low birthweight infants from ‘community-based KMC’ protocols designed to provide SSC to *all* infants to

establish a community norm and ensure coverage for all infants regardless of accurate birth weight identification ⁽⁵⁾ (see Table 2). Community-based KMC is designed for the millions of children born outside of hospitals. ⁽²³⁾ We do not use the definition of Kangaroo Care used in the United States because it applies only to low birthweight infants *after stabilization*. ^(19,24)

Table 2: The WHO/UNICEF Ten Steps to Successful Breastfeeding. From ^(7,25)

| |
|--|
| 1. Have a written breastfeeding policy that is routinely communicated to all health care staff. |
| 2. Train all health care staff in skills necessary to implement this policy. |
| 3. Inform all pregnant women about the benefits and management of breastfeeding. |
| 4. Help mothers initiate breastfeeding within a half-hour of birth. |
| 5. Show mothers how to breastfeed, and how to maintain lactation even if they should be separated from their infants. |
| 6. Give newborn infants no food or drink other than breastmilk, unless <i>medically</i> indicated. |
| 7. Practice rooming-in -- allow mothers and infants to remain together -- 24 hours a day. |
| 8. Encourage breastfeeding on demand. |
| 9. Give no artificial teats or pacifiers (also called dummies or soothers) to breastfeeding infants. |
| 10. Foster the establishment of breastfeeding support groups and refer mothers to them on discharge from the hospital or clinic. |

Evidence Base for KMC/SSC

The current Cochrane review of KMC⁽²⁾ specifically addresses evidence concerning morbidity and mortality in *low birthweight infants* (LBW, <2500 g), excluding evidence for normal weight infants. It does, however, consider the two studies of KMC before complete stabilization. The review categorizes much of the current evidence as “moderate quality”, indicating room for scientific growth in this area. Data from 21 randomized clinical trials (total infant n=3042) were compared with “conventional neonatal care” (incubator). Mother-newborn

SSC was identified as “the major component of KMC” (p. 2) and search terms included “skin-to-skin” (p. 9). The strongest documented outcomes (Table 3) for stabilized LBW infants (n=19 studies) included significantly reduced infant mortality and infection at discharge/40-41 weeks postmenstrual age, greater linear and head growth, and better exclusive breastfeeding measures. Significant outcomes supported by “moderate-quality evidence” include decreased infant hypothermia, reduced infection or mortality at follow-up, and increased weight gain (data not shown).

Table 3: Summary of KMC Outcomes with the Strongest Evidence Support ⁽²⁾

| Intervention | Outcome | (Statistic; 95% CI) | Number of trials/participants |
|--------------|--|------------------------------|-------------------------------|
| KMC | mortality at discharge/40-41 weeks postmenstrual age | (RR 0.60; 0.39-0.92) | 8 trials/ 1736 infants |
| KMC | nosocomial infections/ sepsis | (RR 0.35; 0.22-0.54) | 5 trials/ 1239 infants |
| KMC | Length gain at latest follow-up | (MD 0.21 cm/week; 0.03-0.38) | 3 trials/377 infants |
| KMC | Head circumference gain at latest follow-up | (MD 0.14 cm/week; 0.06-0.22) | 4 trials/495 infants |
| KMC | Exclusive breastfeeding at discharge/40-41 weeks postmenstrual age | (RR 1.16; 1.07-1.25) | 6 studies/1453 mothers |
| KMC | Exclusive breastfeeding at 1 to 3 months follow-up | (RR 1.20; 1.01-1.43) | 5 studies/600 mothers |

Note: Results characterized as supported by “moderate-” or “low-quality evidence” are not presented.

Because 19 of the 21 trials included only stabilized LBW infants, the authors recommend KMC for this subgroup and limit recommended KMC “mainly in resource-limited settings” (p. 2). This recommendation will necessarily remain

limited unless and until the more well-controlled studies comparing SSC to standard care in full-term infants are conducted and disseminated. The review does not discuss complications associated with the use of incubators in resource-poor

settings, such as unstable electricity source and the likelihood of using older technology in these settings, with concerns of the increased unreliability often associated with aged machines.

The evidence for SSC in healthy newborns (≥ 35 weeks gestation) was recently updated, ⁽¹²⁾ covering 46 trials with almost 4000 women. Most studies suffered from low sample sizes and high heterogeneity, and the authors recommend better quality studies be conducted. They conclude that “moderate quality” evidence SSC effectively promotes breastfeeding (p. 2) and recommend that SSC be “normal practice for healthy newborns including those born by cesarean and babies born early at 35 weeks or more” (p. 3) given the promising nature of the studies and no negative outcomes. The Cochrane Review of interventions to promote breastfeeding ⁽²⁶⁾ included only two studies of “early mother-infant contact” vs. standard care. While the outcomes slightly favor the early contact, the small sample size made the test for overall effect (p. 96) non-significant ($Z=1.48, p=0.14$).

The Frugal Technology Movement

Christensen’s ‘disruptive innovation’ ⁽²⁷⁾ is often cited as the start of the frugal technology/frugal innovation movement. He describes disruptive innovation as change in technology that substantially changes a product’s market expectations and trajectories or that creates or capitalizes on emerging markets. ⁽²⁷⁾ Important parts of this concept are that disruptive innovation: introduces products into markets where such products “had not been technologically or economically feasible” (p. 23); involves widely available components or processes adapted to new use (pp.18, 43); and is simpler in design, cheaper, more reliable or convenient than other options (pp. 15, 172).

Radjou and Praha ⁽²⁸⁾ write about *jugaad*, a Hindi concept that means “an innovative fix; an improvised solution born from ingenuity and cleverness” (p. 4). They elucidate six principles of jugaad innovation

that show socioeconomic, environmental, and practical sense as integral to frugal innovation (Table 4). They claim that the West’s traditional approach to innovation is “too expensive and resource consuming, lacks flexibility, and ...is elitist and insular” (p. 8) compared with jugaad innovation.

Table 4: The Six Principles of Jugaad/Frugal Technology ⁽²⁸⁾

| |
|----------------------------------|
| 1. Seek opportunity in adversity |
| 2. Do more with less |
| 3. Think and act flexibly |
| 4. Keep it simple |
| 5. Include the margin |
| 6. Follow your heart |

The frugal technology movement continues to gain momentum given its quick dissemination of helpful products and practices, suitability, and sustainable solutions for low-resource contexts. It is the basis for *The Journal of Frugal Innovation* (ISSN: 2197-7917, Springer) ⁽²⁹⁾ and some schools of engineering now offer specialty training (e.g., Santa Clara (California) University’s Frugal Innovation Laboratory). ⁽³⁰⁾ Using the frugal innovation framework to describe SSC interventions can harness the positive momentum of the frugal technology movement to benefit the mother-baby dyad.

The War against Natural Mother Care

The neonatal incubator has saved millions of lives since its invention 1880. However, it was, and continues to be, symbolic of a struggle between proponents of the medicalization of birth and infant care and those promoting natural mother care. Baker’s socio cultural history ⁽³¹⁾ provides an insightful description of the incubator’s initial impact:

In the wake of French claims that the incubator could lower premature infant mortality by nearly 50 percent, the device became a symbol of the promise of modern medicine and technology... public fairs and expositions began promoting so-called incubator baby shows complete with live infants. Yet a backlash soon followed, construing the device as a symbol of well-intentioned medicine gone awry,

encroaching on a realm better left to mothers than doctors, ⁽³¹⁾ p. 3.

This quote remains disturbingly accurate, as proponents of natural birthing, postnatal care methods, and breastfeeding decry the medicalization of birth and ‘authoritative knowledge’ that takes power from mothers. ⁽³²⁻³⁴⁾ For women in low resource countries, there are still unmet needs for ‘appropriate technology for birth’ ⁽³⁵⁾ recommended over 30 years ago: “good health and nutrition labor, a hygienic environment for the birth, and ready access to medical assistance in labor should need arise”, ⁽³⁶⁾ p. 787. It is perplexing to see low-resource settings like Rwanda describing incubators and Western-style hospital services as ‘conventional neonatal services’ ^(37,38) when 80% of its 12 million citizens live in rural settings with little to no access to electricity or clinical services. ⁽³⁹⁾ In such settings, high-tech care may be an inappropriate use of scarce funds and could be dangerous if the technology is unstable due to unpredictable electricity supply or unreliable infrastructure.

In 2012, a *Lancet* Commission reported on ways that medical technology “should best be used” in low- and middle-income countries, ⁽⁴⁰⁾ first paragraph. Its *Executive Summary* notes that: “Instead of relying on hand-me-down technologies from wealthier countries, which can be costly, inappropriate for local conditions, and even dangerous, the authors urge a renewed effort towards developing what they call ‘frugal technologies’... ” ⁽⁴⁰⁾ second paragraph. Despite this statement, the Commission’s report ⁽⁴⁰⁾, Panel 10, p. 522) summarizes a project that recycled neonatal incubators in Nigeria using generic parts ordered via the internet. ^(41,42) Its inclusion encourages the very ‘hand-me-down’ technologies the manuscript argues against. Further, it failed to mention KMC/SSC as a *frugal technology* that is far more ‘frugal’ than recycling obsolete incubators. The fact that the article reached publication without even marginal mention of SSC reflects the widespread lack of knowledge and/or

acceptance of this evidence-based practice. We hope that this manuscript introduces the benefits of SSC and KMC to a wider audience and encourages their framing as frugal technologies.

DISCUSSION

While some frugal innovations are simply ‘good enough’, ^(28,43) this characteristic of frugal technology *does not* apply to SSC. Rather, the literature indicates that SSC is *at least as good as* incubation ^(12,44) and KMC is *superior to* incubators with regard to infant temperature regulation, ⁽⁴⁴⁾ psychological outcomes, and cost. ⁽⁴⁵⁾ Recent research has also documented significantly better outcomes at for a range of social and neuro-cognitive behavioral measures in a 20-year longitudinal study of 264 young Colombian adults (South America) who weighed ≤ 1800 g and received KMC at birth vs. those who did not. ⁽⁴⁶⁾

Western medicine has long ascribed to the ‘technological imperative’, which Baker ⁽³¹⁾, p. 1) describes as... “The idea that any technology that *can* be used *must* be used”. However, it is not alone in its affinity for shiny, new machines. People in poor and low-resource countries are may also be enamored of technology and wish to participate in its use, especially when it represents modernity and perceptions of progress. This shared human desire to use the newest technology despite its potential inappropriateness is associated with both assumed superiority of technological interventions and social implications of technological change. ⁽³¹⁾ An unintended consequence of the poor rate of immediate KMC/SSC uptake in wealthy countries ⁽⁴⁷⁾ and in hospitals in low-resource countries alike ⁽³⁷⁾ is sustaining the false idea that technology and medicalization of birth is superior to mothers and natural/lower-technology interventions, ⁽⁴⁸⁾ or that natural or lower-technology interventions have no place in modern healthcare.

The evidence supporting KMC’s outcomes is limited to LBW infants after

stabilization; 90% of the trials identified by the Cochrane Review team included only these infants. ⁽¹²⁾ There is a major barrier to carrying out research on KMC prior to stabilization in countries such as the United States, where the standard of care prohibits KMC in unstabilized infants; without extant evidence that it is safe, ethical review boards are unlikely to approve research involving LBW infants. This circular reasoning means that much of the research necessary to improve the data in this area must be developed by healthcare professionals in countries without such mandates and then built upon when the assumptions of the danger of immediate KMC can be addressed by valid data.

RECOMMENDATIONS & CONCLUSION

SSC and the Kangaroo position are evidence-based frugal technologies that should be promoted as effective, lower cost medical interventions suitable for all newborns and their families across low-, middle-, and high-resource countries. This recommendation is in line with evidence from the literature ⁽⁴⁸⁻⁵¹⁾ and policy promoting maternal and child health. ⁽²¹⁾ Marketing SSC as frugal technology can increase its uptake, which is necessary to achieve the goals of the *Every Newborn* action plan. ⁽⁹⁾

The need for frugal technology is intensifying with environmental degradation, climate change, and increasing wealth and health disparities. ⁽⁴⁾ In countries where political and infrastructural stability is a concern, frugal technologies have the added benefit of being sustainable at the local level and locally produced. ⁽⁵²⁾ Some cultural practices and preferences are barriers for KMC implementation by families, including concerns for modesty and reluctance for fathers to be involved with childcare. ⁽⁴⁵⁾ However, the majority of documented barriers to SSC implementation lie within the healthcare system and its workers, including policy, program, and practice barriers. ^(25,45) The need to actively

promote maternal-infant contact is necessary because the medicalization and technological focus of birth is the current accepted medical norm. ⁽¹²⁾ Invoking the frugal technology movement can help reduce bias and stigma toward “low-tech” and human-centric solutions in medical culture. We recommend that healthcare professionals who advocate for evidence-based SSC interventions frame their discussions of policy, practice and training using the concept of frugal technology.

REFERENCES

1. Winter A. Tech buzz: Engineering for global development. Research for development. Mech Eng [Internet]. 2013;(May):2013. Available from: <http://gear.mit.edu/Publications/Popular Press/0513MEMp020.pdf>
2. Conde-agudelo A, Díaz-Rossello JL. Kangaroo mother care to reduce morbidity and mortality in low birthweight infants. Cochrane Review, Neonatal Group. Cochrane Database Syst Rev [Internet]. 2016;CD002771(8). Available from: <http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD002771.pub4/abstract>
3. Heidarzadeh M, Hosseini MB, Ershadmanesh M, Gholamitabar Tabari M, Khazaei S. The Effect of Kangaroo Mother Care (KMC) on Breast Feeding at the Time of NICU Discharge. Iran Red Crescent Med J [Internet]. 2013 Apr [cited 2014 Oct 23];15(4):302–6. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3785903&tool=pmc-entrez&rendertype=abstract>
4. Rey ES, Martinez HB. Manejo racional de niño primario. Bogota, Columbia; 1983.
5. Quasem I, Sloan NL, Chowdhury A, Ahmed S, Winikoff B, Chowdhury AMR. Adaptation of kangaroo mother care for community-based application. J Perinatol [Internet]. 2003 Dec [cited 2014 Dec 1];23(8):646–51. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/14647161>
6. Quasem I, Ahmed S, Winikoff B. Adaptation of Kangaroo Mother Care

- for Community-Based Application January 2003 [Internet]. 2003. Available from: http://r.search.yahoo.com/_ylt=A0LEVj_hN35UMJ0APYQPxQt.;_ylu=X3oDMTByMG04Z2o2BHNIYwNzcgRwb3MDMQRjb2xvA2JmMQR2dGIkAw--/RV=2/RE=1417586785/RO=10/RU=ht tp%253a%252f%252fresearch.brac.net %252freports%252f2003_KMC_Pilot_Report.pdf/RK=0/RS=DRT5nmE4zGM fYrQxUAiIjysA1I-
7. WHO U. Baby-Friendly Hospital Initiative: Revised, updated and expanded for integrated care [Internet]. Geneva; 2009. Available from: http://www.who.int/nutrition/publications/infantfeeding/bfhi_trainingcourse/en/
 8. Charpak N, Calume ZF, Ruiz J. “The Bogotá Declaration on Kangaroo Mother Care”: conclusions at the second international workshop on the method. *Acta Paediatr* [Internet]. 2000 Jan 2 [cited 2015 Sep 3];89(9):1137–40. Available from: <http://doi.wiley.com/10.1111/j.1651-2227.2000.tb03365.x>
 9. WHO U. Every newborn: Executive summary [Internet]. Geneva; 2014. Available from: http://apps.who.int/iris/bitstream/10665/127938/1/9789241507448_eng.pdf?ua=1
 10. Engmann C, Wall S, Darmstadt G, Valsangkar B, Claeson M. Consensus on kangaroo mother care acceleration. *Lancet* [Internet]. Elsevier Ltd; 2013 Nov 30 [cited 2014 Dec 2];382(9907):e26-7. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/24246562>
 11. James J. In Ethiopian hospitals, keeping babies alive through skin-to-skin contact. *Impatient Optimists* [Internet]. 2013; Available from: <http://www.impatientoptimists.org/Posts/2013/01/Kangaroo-Mother-Care-Units-in-Ethiopian-Hospitals>
 12. Moore E, Anderson G, Bergman N, Dowswell T. Early skin-to-skin contact for mothers and their healthy newborn infants. *Cochrane Review, Pregnancy and Childbirth Group. Cochrane Database Syst Rev* [Internet]. 2016;CD003519(11). Available from: http://www.cochrane.org/CD003519/PR EG_early-skin-skin-contact-mothers-and-their-healthy-newborn-infants
 13. Debes AK, Kohli A, Walker N, Edmond K, Mullany LC. Time to initiation of breastfeeding and neonatal mortality and morbidity: a systematic review. *BMC Public Health* [Internet]. 2013 Jan [cited 2014 Nov 4];13 Suppl 3:S19. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3847227&tool=pmc-entrez&rendertype=abstract>
 14. The Lancet Maternal and Child Nutrition Study Group. Maternal and child nutrition: Executive summary of the Lancet maternal and child nutrition series [Internet]. *Lancet*. 2013 [cited 2014 Dec 30]. Available from: <http://download.thelancet.com/flatcontentassets/pdfs/nutrition-eng.pdf>
 15. Turin CG, Ochoa TJ. The Role of Maternal Breast Milk in Preventing Infantile Diarrhea in the Developing World. *Curr Trop Med reports* [Internet]. 2014 Jun 1 [cited 2014 Dec 30];1(2):97–105. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/24883263>
 16. Chen A, Rogan WJ. Breastfeeding and the risk of postneonatal death in the United States. *Pediatrics* [Internet]. 2004 May [cited 2014 Dec 30];113(5):e435-9. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/15121986>
 17. United Nations Interagency Group for Child Mortality Estimation. Levels & trends in child mortality. Report 2015. [Internet]. New York, NY; 2015. Available from: http://www.who.int/maternal_child_adolescent/documents/levels_trends_child_mortality_2015/en/
 18. WHO. Global Health Observatory Data Repository: Visualizations: Mortality and global health estimates; Child mortality, neonatal deaths and mortality rate [Internet]. Geneva; 2016. Available from: <http://apps.who.int/gho/data/node.wrapper.MORT-1?lang=en&menu=hide>
 19. Bergman N, Bergman J. Kangaroo Mother Care [Internet]. [cited 2014 Jun

- 19]. Available from: www.kangaroomothercare.com
20. Bystrova K, Ivanova V, Edhborg M. Early Contact versus Separation : Effects on Mother – Infant Interaction. 2009;(June):97–109.
21. Centers for Disease Control & Prevention. The CDC Guide to Breastfeeding Interventions: Maternity Care Practices [Internet]. Atlanta, GA: Centers for Disease Control & Prevention; p. 1–6. Available from: http://www.cdc.gov/breastfeeding/pdf/bf_guide_1.pdf
22. Ludington-Hoe SM, Morgan K, Morrison B, Anderson GC. Module 1: Origins. In: The 9th Intensive Kangaroo Care Certification Program Learner’s Manual. 2015. p. 1–17.
23. Darmstadt GL, Lee ACC, Cousens S, Sibley L, Bhutta ZA, Donnay F, et al. 60 Million non-facility births: who can deliver in community settings to reduce intrapartum-related deaths? *Int J Gynaecol Obstet* [Internet]. Europe PMC Funders; 2009 Oct 1 [cited 2014 Dec 26];107 Suppl(Suppl 1):S89-112. Available from: [/pmc/articles/PMC3428830/?report=abstract](http://pmc/articles/PMC3428830/?report=abstract)
24. Bergman J, Bergman N. What is KMC? [Internet]. Kangaroo Mother Care: Support for parents & staff of premature babies. Available from: <http://kangaroomothercare.com/what-kmc-is.aspx>
25. Charpak N, Figueroa de Calume Z, Ruiz J. Problems and solutions for the implementation of Kangaroo Mother Care (KMC) according to the level of care and country’s development [Internet]. Bogata, Columbia; 1998 [cited 2014 Dec 4]. Available from: http://fundacioncanguero.co/descargas/reportefinal_ingles.pdf
26. Balogun OO, O’Sullivan EJ, Mcfadden A, Ota E, Gavine A, Garner CD, et al. Interventions for promoting the initiation of breastfeeding. *Cochrane Review, Pregnancy and Childbirth Group. Cochrane Database Syst Rev* [Internet]. 2016;CD001688(11). Available from: <http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD001688.pub3/abstract;jsessionid=3DBA8F8A42E3784E3B704146307CBD49.f02t03>
27. Christensen CM. The Innovator’s Dilemma: when new technologies cause great firms to fail [Internet]. Boston, Massachussets: Harvard Business School Papers; 1997 [cited 2014 Apr 11]. 225 p. Available from: <http://www.claytonchristensen.com/books/the-innovators-dilemma/>
28. N. Radjou, J. Prabhu SA. Jugaad Innovation: Think Frugal, Be Flexible, Generate Breakthrough Growth: : 9781118249741: Amazon.com: Books [Internet]. 1st ed. Jossey-Bass; 2012 [cited 2014 Apr 18]. Available from: <http://www.amazon.com/exec/obidos/A/SIN/1118249747/stansociinn09-20>
29. Vadakkepat P, Garg H, editors. *Journal of Frugal Innovation* [Internet]. SpringerOpen; Available from: <http://www.springer.com/engineering/journal/40669>
30. Engineering SCUS of. About us: History of the frugal innovation lab [Internet]. 2014. Available from: <https://www.scu.edu/engineering/frugal/about/>
31. Baker JP. The Machine in the Nursery: Incubator Technology and the Origins of Newborn Intensive Care [Internet]. JHU Press; 1996 [cited 2014 Apr 8]. 247 p. Available from: http://books.google.com/books/about/The_Machine_in_the_Nursery.html?id=jJjXh3euw6cC&pgis=1
32. Johanson R, Newburn M, Macfarlane A. Has the medicalisation of childbirth gone too far ? 2002;324(April):11–4.
33. Browner C, Press N. The Production of Authoritative Knowledge in American Prenatal Care. *Med Anthropol Q.* 1996;10(2):141–56.
34. Righard L. Helping to maintain natural behavior at birth. *Birth* [Internet]. 2010 Mar [cited 2014 Jul 1];37(1):84. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/20402732>
35. WHO 1985 Appropriate technology for birth summary.pdf [Internet]. Fortaleza, Brazil: World Health Organization; 1985. Available from: [http://whqlibdoc.who.int/hq/1985-86/ICP_MCH_102_m02\(s\).pdf](http://whqlibdoc.who.int/hq/1985-86/ICP_MCH_102_m02(s).pdf)

36. Moore B. Letter: Appropriate technology for birth. *Lancet*. 1985;326(8458):787.
37. Bergh A-M, Manu R, Davy K, van Rooyen E, Asare GQ, Williams JKA, et al. Translating research findings into practice--the implementation of kangaroo mother care in Ghana. *Implement Sci* [Internet]. 2012 Jan [cited 2014 Dec 30];7(1):75. Available from: <http://www.implementationscience.com/content/7/1/75>
38. Bergh A, Sayinzoga F, Mukarugwiro B, Zoungrana J, Abayisenga G, Karera C, et al. Republic Of Rwanda Ministry Of Health Evaluation Of Kangaroo Mother Care Services In May 2012 Report compiled by [Internet]. Kigali; 2012. Available from: http://www.mchip.net/sites/default/files/Rwanda_KMC_Evaluation_Report_0.pdf
39. RWANDA [Internet]. June 201,. The World Factbook. Central Intelligence Agency (CIA); 2014. Available from: <https://www.cia.gov/library/publications/the-world-factbook/geos/rw.html>
40. Howitt P, Darzi A, Yang G-Z, Ashrafian H, Atun R, Barlow J, et al. Technologies for global health. *Lancet* [Internet]. 2012 Aug 4 [cited 2014 Mar 21];380(9840):507–35. Available from: <http://www.thelancet.com/journals/a/article/PIIS0140-6736%252812%252961127-1/fulltext>
41. Amadi HO, Mokuolu OA, Adimora GN, Pam SD, Etawo US, Ohadugha CO, et al. Digitally recycled incubators: better economic alternatives to modern systems in low-income countries. *Ann Trop Paediatr* [Internet]. Maney; 2007 Sep 18 [cited 2014 Apr 16];27(3):207–14. Available from: <http://www.maneyonline.com/doi/abs/10.1179/146532807X220325?token=00561ea619cdf7f197d9ab573d2570257050236e6c53406a4d386b5f7c4e75477e4324576b6427381c1758>
42. Amadi HO, Azubuike JC, Etawo US, Offiong UR, Ezeaka C, Olateju E, et al. The impact of recycled neonatal incubators in Nigeria: a 6-year follow-up study. *Int J Pediatr* [Internet]. 2010 Jan [cited 2014 Apr 16];2010:269293. Available from:
- <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3038574&tool=pmc-entrez&rendertype=abstract>
43. Shaw W. Frugal innovation: adapting local tech where top-of-the-range is out of reach. *Wired* (UK) [Internet]. 2013 Apr [cited 2014 Jun 19]; Available from: <http://www.wired.co.uk/magazine/archive/2013/05/features/frugal-innovation>
44. Bergman NJ, Linley LL, Fawcus SR. Randomized controlled trial of skin-to-skin contact from birth versus conventional incubator for physiological stabilization in 1200- to 2199-gram newborns. *Acta Paediatr* [Internet]. 2004 Jun [cited 2014 Mar 22];93(6):779–85. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/15244227>
45. Charpak N, Gabriel Ruiz-Peláez J. Resistance to implementing Kangaroo Mother Care in developing countries, and proposed solutions. *Acta Paediatr* [Internet]. 2007 Jan 2 [cited 2014 Jul 2];95(5):529–34. Available from: <http://doi.wiley.com/10.1111/j.1651-2227.2006.tb02279.x>
46. Charpak N, Tessier R, Ruiz JG, Hernandez JT, Uriza F, Villegas J, et al. Twenty-year Follow-up of Kangaroo Mother Care Versus Traditional Care. *Pediatrics*. 2016;139(1).
47. Save the Children. Healthy Newborn Network: Kangaroo Mother Care (KMC) [Internet]. 2009 [cited 2014 Dec 30]. Available from: <http://www.healthynewbornnetwork.org/topic/kangaroo-mother-care-kmc>
48. Claeson M, Darmstadt G, Engmann C. Busting myths: Taking kangaroo mother care to the next level. *Impatient Optimists* [Internet]. 2014; Available from: <http://www.impatientoptimists.org/Posts/2014/01/Busting-Myths-Taking-Kangaroo-Mother-Care-to-the-Next-Level>
49. Nyqvist KH, Anderson GC, Bergman N, Cattaneo A, Charpak N, Davanzo R, et al. Towards universal Kangaroo Mother Care: recommendations and report from the First European conference and Seventh International Workshop on Kangaroo Mother Care.

- Acta Paediatr [Internet]. 2010 Jun [cited 2014 Mar 22];99(6):820–6. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/20219044>
50. Ruiz-Peláez JG, Charpak N, Cuervo LG. Kangaroo Mother Care, an example to follow from developing countries. *BMJ* [Internet]. 2004 Nov 13 [cited 2014 Dec 30];329(7475):1179–81. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=527708&tool=pmcentrez&rendertype=abstract>
51. Kumar V, Shearer JC, Kumar A, Darmstadt GL. Neonatal hypothermia in low resource settings: a review. *J Perinatol* [Internet]. Nature Publishing Group; 2009 Jun 22 [cited 2014 Dec 13];29(6):401–12. Available from: <http://dx.doi.org/10.1038/jp.2008.233>
52. Zeschky M, Widenmayer B, Gassmann O. FRUGAL INNOVATION IN EMERGING MARKETS. *Res Manag* [Internet]. Industrial Research Institute, Inc; 2011 Jul 1 [cited 2014 Mar 22];54(4):38–45. Available from: <http://www.ingentaconnect.com/content/iri/rtm/2011/00000054/00000004/art00008>

How to cite this article: Rogers NL, Redko C, Smith LJ. Marketing skin-to-skin-contact in the kangaroo position as a frugal technology: a no-cost way to support improved maternal-child health outcomes across global contexts. *Int J Health Sci Res.* 2017; 7(8):364-374.
