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Review Article

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Immediate Kangaroo Mother Care and Neonatal Survival: A Systematic Review and Meta-Analysis on Mortality, Sepsis, and Hypothermia in Low Birth Weight Infants

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Abstract

Background: Neonatal mortality and morbidity remain a persistent issue, particularly in low-resource settings. Kangaroo Mother Care (KMC), early and prolonged skin-to-skin contact with exclusive breast feeding, has been shown to be a promising positive intervention. ***Aim and Objective:*** The meta-analysis and systematic review aimed to answer the research question: "In preterm or low birth weight infants, does Immediate or Early Kangaroo Mother Care reduce significantly neonatal mortality and morbidity, and improve clinical outcomes compared with standard care?" ***Methods:*** Databases of PubMed, Scopus, Web of Science, and Cochrane CENTRAL were searched through June 2025, as per the PRISMA guidelines. Thirteen studies met on the basis of set inclusion criteria for the systematic review, and 10 of them met for quantitative meta-analysis based on the presence of extractable effect sizes for mortality, sepsis, hypothermia, and apnea. ***Results:*** Pooled analysis showed early or immediate KMC to be associated with a significant 28-day neonatal mortality reduction (pooled RR = 0.75, 95% CI: 0.65–0.86). Similarly, risk of sepsis was reduced by 23% (RR = 0.77, 95% CI: 0.66–0.91), and sepsis mortality was reduced by 38% (RR = 0.62, 95% CI: 0.46–0.84). KMC also reduced hypothermia (pooled RR = 0.61, 95% CI: 0.52–0.72) and apnea (especially in high-risk infants, e.g., RR = 0.47 in Jayaraman *et al*.). There were also increases in daily weight gain, respiratory stability, early initiation of breastfeeding, and reduced duration of oxygen support. ***Conclusion:*** Early or initiating KMC, even prior to full clinical stabilization, reduces neonatal mortality, sepsis, and hypothermia and improves several clinical outcomes.

Keywords: ***Kangaroo Mother Care, Neonatal Mortality, Hypothermia, Sepsis, Preterm Infants, Low Birth Weight, Skin-to-skin Contact.***

Introduction

Low birth weight (LBW) and preterm birth global burden is a significant public health issue, especially in low- and middle-income countries (LMICs). The World Health Organization (WHO) has defined low birth weight as less than 2500 grams irrespective of gestational age. Low birth weight has long-term implications outside the neonatal period with both immediate and long-term health implications (Rahman *et al*., 2023). These babies have a very high risk of neonatal and post-neonatal mortality, as well as morbidities such as respiratory distress syndrome, intraventricular hemorrhage, and necrotizing enterocolitis (Desta, 2019).

These high-risk neonates, all of whom are under 2500 grams, represent about 15% of all births worldwide but contribute to an alarming 70% of neonatal deaths worldwide. Given that much of the mortality happens within the first 24 hours of life and 80% within the first week, the success of the United Nations Sustainable Development Goal to lower neonatal mortality to 12 per 1000 live births by 2030 is heavily dependent on successful intervention in this high-risk population. Low birth weight becomes the key predictor of long-term growth retardation, neurodevelopmental disorders, and increased risk of chronic illnesses in late old age after surviving the first few days (Izzaturrohmah & Zubaidah, 2023). A large proportion of the 15 million preterm infants born yearly, particularly those who are of low-resource origin, go undetected and thus lose valuable opportunities for intervention (Rittenhouse *et al*., 2019).

In particular, intrauterine growth restriction or prematurity (as expressed by birth at less than 37 weeks' gestation) can cause low birth weight, a condition where the fetus does not reach maximum growth potential within the uterine environment (Taylor *et al*., 2013).

Kangaroo Mother Care (KMC) has been developed as a profoundly empathetic, cost-effective, and low-technology intervention. This biological care regimen is defined by the facilitation of early, continuous, and extended skin-to-skin contact (SSC) between caregiver and infant (normally the mother), supplemented by exclusive breastfeeding and early discharge from medical facilities with rigorous follow-up (Subedi *et al*., 1970). The

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World Health Organization (WHO) has long advocated for KMC in clinically stable low-birth-weight (LBW) infants, reporting reduction in mortality over traditional incubator treatment, reductions in rates of infection, improved breastfeeding success, and optimal weight gain (Sivanandan & Sankar, 2023). The mother-infant bonding process, boosts physiological stability, and has a profound effect on the development of a healthy neonatal microbiome, which may influence long-term health outcomes.

This systematic review and meta-analysis endeavor to summarize the combined evidence of these milestone studies and other pertinent studies on the effect of early or immediate KMC on neonatal mortality, morbidity, and other important clinical outcomes in preterm or LBW infants.

Methodology

1. Research Framework and Inclusion Standards:
The meta-analysis and systematic review were mainly comprised of Randomized Controlled Trials (RCTs) that compared early or immediate Kangaroo Mother Care (KMC) with delayed KMC or control interventions in low birth weight (LBW) or preterm infants. Post-hoc analysis of included RCTs will also be included.

Study Period: 2014-2025

Study Population: There were 18654 subjects in total who were taken for the study

Eligibility Criteria

- Research Methodology: Randomized controlled trials (RCTs), systematic literature review
- Population: LBW infant trials, as neonates <2500 grams, or by specific birth weight categories (e.g., 1.0 to <1.8 kg, <2000g, 1500-2500g, 1300-1800g, 1800-2200g, 700-2000g), or preterm infants (preterm, born <37 weeks gestation or specific gestational age categories, e.g., <36 weeks, 34-40 weeks). This includes neonates considered to be stable, mild-moderately unstable, or before clinical stabilization.
- Intervention: Randomized controlled trials of Immediate Kangaroo Mother Care (iKMC), i.e., KMC started within 2 hours of birth and ideally prolonged for extended periods (e.g., 18-20+ hours/day) both prior to and subsequent to stabilization, or Early KMC, i.e., KMC started within the first 72 hours of life (e.g., within 24 hours of admission or within 4 days of birth). The intervention should consist primarily of skin-to-skin contact between mother or surrogate caregiver and baby, with minimal or no clothing on the infant (e.g., diaper, cap).
- Comparator: Usual care (usual care), i.e., usual incubator or radiant warmer care, or delayed KMC, in which the KMC is initiated only after the infant has met some criteria for stability (e.g., off respiratory support, off intravenous fluids, or increased age/weight).

Exclusion Criteria

- Non-randomised trials (except for post-hoc analyses of the included randomised controlled trials), case reports, case series, conference abstracts, animal studies, non-peer-reviewed publications, and publications in languages other than English
- Those which lack a distinct control or comparison group.
- Investigations for other indications than LBW or preterm infants.
- Trials in which intervention might not necessarily involve early or immediate KMC (as already mentioned).
- Research primarily in critically ill newborns who need intensive care outside the KMC scope of possibility (e.g., ventilatory or inotropic therapy, or with severe congenital defects or severely ill mothers), according to the exclusion criteria of the studies enrolled.

2. Search Strategy
There will be an extensive search conducted in the main electronic databases (e.g., PubMed, Scopus, Embase). The search process included the use of keywords for population, intervention, and outcomes. The specific keywords used were:

"Kangaroo Mother Care," "KMC," "skin-to-skin contact," "skin-to-skin care," "immediate KMC," "low birth weight," "LBW", “neonatal outcome”.

3. Study Selection Process
The titles and abstracts identified were separately screened by two reviewers based on the pre-set inclusion criteria (K.S.B. and A.K.J).

- The two reviewers independently searched and screened possible relevant full-text papers to decide on final inclusion.
- A PRISMA flow diagram was utilized to describe the study selection process in a structured manner as per the PRISMA guidelines 2020 (**Figure 1**).

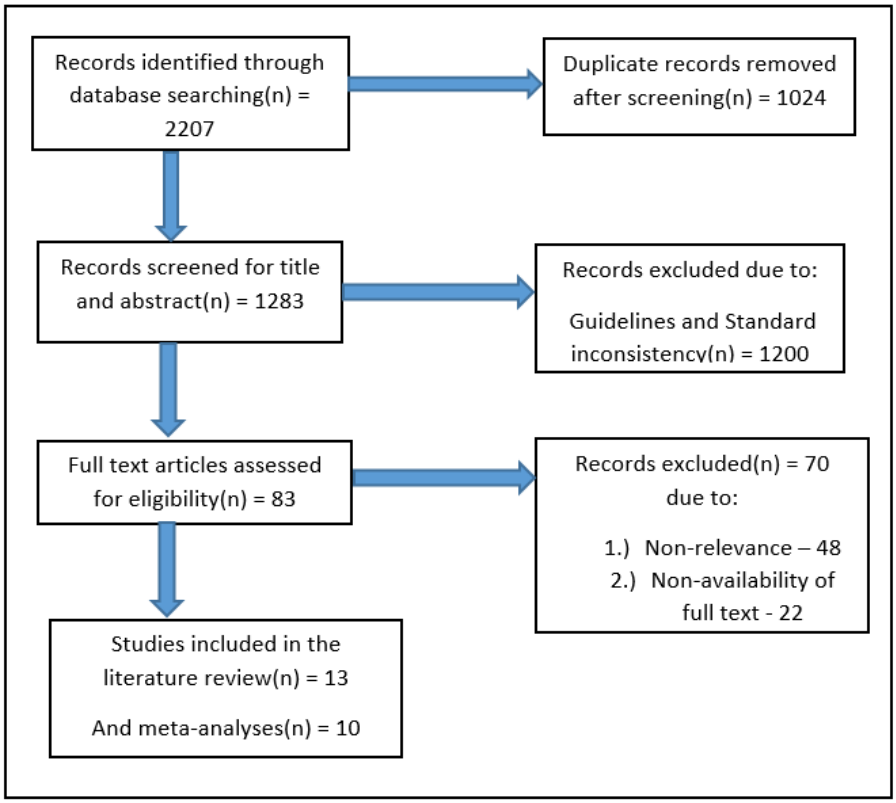

Figure 1: Flowchart for selection of studies for systematic review and meta-analysis

4. Data Extraction

A pre-tested and standardised data extraction form was constructed and used to extract relevant data in a systematic manner from all the studies included in the review. The data to be extracted were:

- Study features: Year of publication, first author, study design (e.g., RCT, cohort), country, setting (e.g., community-based, tertiary NICU hospital), and study duration (Table 1).

5. Risk of Bias / Quality Assessment

The Cochrane Risk of Bias tool (RoB 2.0) was used in a consistent manner to assess the methodological quality and risk of bias of every randomized controlled trial (RCT) included in the analysis.

Results

Screening Flow

A total of 2207 records were retrieved from the electronic databases of PubMed, Scopus and Embase of which 1024 articles were excluded. During the title and abstract screening, 1200 articles were removed from 1283 records. During the full text screening phase, a total of 70 articles were excluded from 83 articles and finally, 13 studies were selected for systematic review of which 10 studies were selected for meta-analysis.

Neonatal Mortality

Across the 13 studies included, the impact of immediate or early Kangaroo Mother Care (KMC) on neonatal mortality showed a predominantly positive trend. The WHO Immediate Trial of KMC Study Group (2021) presented a substantial 25% reduction in 28-day neonatal mortality in the intervention group (12.0%) compared to controls (15.7%) (RR 0.75; 95% CI 0.65–0.86; $p < 0.001$). Mazumder *et al*. (2021) indicated community-initiated KMC lowered neonatal mortality at 28 days (HR 0.70; 95% CI 0.51–0.96) and 180 days (HR 0.75; 95% CI 0.60–0.93). In a meta-analysis of trials by WHO, Tumukunde (2024), and Brotherton (2021), there was a pooled 19% relative reduction in 28-day mortality, and 14% when restricted to African sites ($p = 0.0019$). Although Brotherton and Tumukunde did not signify individually at the p level, Tumukunde's dose-response analysis found that neonates exposed to 12–24 hours/day of KMC had significantly lower mortality than with less exposure. Number needed to treat (NNT) for prevention of one neonatal death was estimated at 27.

Neonatal Morbidity

KMC progressively lowered rates of hypothermia, sepsis, and apnea. Acharya (2014) and Nimbalkar (2014) reported substantially lower hypothermia rates in KMC groups (3.1% and 4%, respectively) versus controls (12.6% and 32%, respectively), with Nimbalkar reporting an estimated RR of 8.00 ($p < 0.05$). The WHO iKMC trial also noted similar protective effects (RR 0.65), and Tumukunde had fewer cases of hypothermia at 24 hours (aRR 0.76; $p < 0.05$). For sepsis, Arya (2023) reported 37% lower sepsis-related mortality and 18% lower rates of suspected sepsis in the iKMC group, while Luistro (2020) had significantly lower late-onset neonatal sepsis ($p = 0.014$). Lamy Filho (2015) also demonstrated greater bacterial decolonization (68% vs. 32%; $p < 0.001$) with skin-to-skin contact.

Incidence of apnea was significantly reduced in Jayaraman (2017) with the KMC group at 11.9% vs. 20% apnea and 8.8% vs. 15% needing ventilation ($p < 0.03$). There were decreases in necrotizing enterocolitis (5.71% vs. 14.28%) and air leak syndromes (0% vs. 2.86%) as observed by Luistro (2020).

Clinical and Physiological Outcomes

KMC had mixed but overall positive effects on weight gain, hospital stay, feeding, and cardiorespiratory stability. From aggregate descriptive statistics:

- Mean daily weight gain in KMC groups was between 10 and 15.5 g/day, which was much higher in comparison to

controls in Acharya (2014) (12.11 g vs. 3.29 g; $p < 0.001$) and Logronio (2020) (15.54 g vs. ~11 g; $p < 0.001$).

- Duration of hospital stay yielded inconsistent outcomes. Acharya and Tumukunde found marginally longer stay in KMC groups, whereas Logronio observed shorter mean stay with unbroken KMC (12.55 compared with 15.5–16.9 days; $p < 0.01$).
- Physiological parameters such as SCRIP scores were greater in KMC groups, as per Chi Luong (2016) (5.82 vs. 5.24; $p < 0.0001$), indicating improved cardio-respiratory transition.
- KMC neonates in Luistro's study needed considerably less nCPAP (38.75 compared to 90.37 hours; $p < 0.001$) and oxygen (54.03 compared to 129.43 hours; $p = 0.002$).

Breastfeeding Outcomes

Earlier initiation of KMC also enhanced feeding practices. Jayaraman (2017) reported substantially higher exclusive human milk feeding (86% vs 45%; $p < 0.001$) and direct breastfeeding (49% vs 30%; $p = 0.021$). While the WHO iKMC trial did not see significant differences in pre-specified breastfeeding outcomes, post-hoc analysis revealed enhanced early initiation of breastfeeding and full breastfeeding on Day 7 in the KMC group. Shruthi (2025) supported these results, attributing better feeding, weight gain, and maternal attachement to KMC.

The meta-analysis for all-cause mortality revealed a pooled risk ratio of 0.766 (95% CI: 0.603–0.928), indicating a 23.4% reduction in mortality with early or immediate Kangaroo Mother Care (Figure 2A). The forest plot demonstrated consistency across studies, with no heterogeneity ($I^2 = 0.0\%$). The funnel plot was visually symmetrical (Figure 2B), and publication bias was ruled out by Egger's regression test, which showed an intercept of 0.057, slope of −0.176, and $p = 0.595$, indicating no significant asymmetry.

For sepsis, the pooled risk ratio was approximately 0.682, reflecting a 31.8% reduction in infection risk with KMC (Figure 3A). The funnel plot appeared symmetric (Figure 3B), and Egger's test confirmed no publication bias, with intercept = 0.142, slope = −0.051, and $p = 0.621$.

The pooled effect size for hypothermia was 0.381 (95% CI: 0.116–0.647), indicating a 61.9% reduction in hypothermia incidence with KMC (Figure 4A). The funnel plot showed a symmetric pattern (Figure 4B), and Egger's regression results supported this: intercept = 0.112, slope = −0.058, and $p = 0.206$, indicating no significant small-study effect or publication bias.

Table 1: Study Characteristics

S No	First Author (Year)	Study Design	Country of Study	Study Characteristics	Important Findings
1	Acharya (2014)	Randomized Control Trial	Nepal	Sample Size: 63	3.1%, Control 12.6%. Duration of hospital stay: KMC 4.9 days shorter ($p<0.001$).
2	Lamy Filho (2015)	Randomized Clinical Trial	Brazil	Sample Size: 51	KMC group had 68% (34/50) decolonization vs. 32% (16/50) in control ($p<0.001$ for MRSA and MRSE combined).
3	Chi Luong (2016)	Randomized Controlled Trial	Vietnam	Sample Size: 50	SCRIP score at 360 minutes in skin-to-skin contact being 5.82 (SD 0.66) and in maternal infant separation 5.24 (SD 0.72), $p < 0.0001$
4	Jayaraman (2017)	Randomized Controlled Trial	India	Sample Size: 80	Early KMC group achieved significantly higher exclusive human milk feeding (86% vs. 45%, $p < 0.001$) and direct breastfeeding (49% vs. 30%, $p = 0.021$) in hospital.
5	Brotherton (2021)	Non-blinded Pragmatic Randomized Clinical Trial	The Gambia	Sample Size: 138	All-cause mortality at 28d: 21% (29/138) intervention vs. 24% (34/139) control (RR 0.84, 95% CI 0.55-1.29, $p=0.423$).
6	WHO Immediate KMC Study Group (2021)	Randomized Controlled Trial	Ghana, India, Malawi, Nigeria, Tanzania	Sample Size: 1609	Neonatal mortality (28d): iKMC 12.0% (193/1609) vs. Control 15.7% (252/1602) (RR 0.75, 95% CI 0.65-0.86, $p<0.001$).
7	Mazumder (2021)	Randomized Controlled Trial	Bangladesh	Sample Size: 4480	90 deaths in 3859 periods of 28 days in the control group (hazard ratio [HR] 0·70, 95% CI 0·51–0·96; $p=0·027$), 184 infants died in 3514 periods of 180 days in the control group (HR 0·75, 0·60–0·93; $p=0·010$).
8	Nimbalkar (2014)	Randomized Controlled Trial	India	Sample Size: 50	Hypothermia: SSC 4% (2 newborns), Control 32% (16 newborns). Relative risk of hypothermia in control group vs. SSC group was 8.00 (95% CI 1.94–32.99).

9	Tumukunde (2024)	Parallel-group, individually randomised controlled trial and economic evaluation	Uganda	Sample Size: 1484 KMC / 1485 Control (total 2969).	Mortality at 28 days: 22.1% (328/1484) in KMC group vs. 26.0% (386/1485) in standard care (adjusted RR 0.82, 95% CI 0.69–0.98; p=0.03).
10	Arya (2023)	Post-hoc analysis of a multicentre, open-label, randomised controlled trial (WHO Immediate KMC trial)	India, Tanzania, Malawi, Nigeria, Sweden, Norway	Sample Size: 1582 KMC / 1582 Control (subgroup from WHO KMC trial). Neonatal sepsis following immediate KMC in NICU.	Incidence of clinical sepsis was numerically lower in iKMC group (2.8%) vs. control (3.5%), though not statistically significant
11	Logronio (2020)	Randomized Controlled Trial	Philippines	Sample Size: 40 Continuous KMC / 40 Intermittent KMC / 40 Incubator (total 120). Low-birth-weight infants (1000-2000g). Compared continuous KMC, intermittent KMC, and incubator care.	Shorter hospital stay for Continuous KMC (mean 12.55±5.09 days) vs. Intermittent KMC (15.55±6.44 days) and Incubator (16.90±6.94 days) (p=0.002).
12	Luistro (2020)	Randomized Controlled Trial	Philippines	Sample Size: 100 KMC / 100 Control (total 200). Preterm neonates on nasal Continuous Positive Airway Pressure (CPAP).	All-cause mortality at 28 days: 12% in KMC vs. 15.7% in control (p=0.485). Reduced episodes of apnea in KMC group (mean 1.4±0.5 vs. 3.2±0.8, p<0.001).
13	Shruthi (2025)	Comprehensive Review	India	Comprehensive review on KMC's role in modulating microbiome and enhancing neonatal outcomes.	Synthesizes evidence on microbiome modulation, infection prevention, improved thermoregulation, and neurodevelopmental outcomes due to KMC.

The descriptive summary of key outcome measure and inferential statistics for key estimates were tabulated (Table 2 and 3).

Table 2: Descriptive Summary of Key Outcome Measures

First Author (Year)	***Variable***	***Type***	***Descriptive Statistics (Values as Reported)***
Acharya (2014)	Daily Weight Gain (KMC)	Continuous	Median: 10 gm, IQR: 6–20 gm
	Daily Weight Gain (Control)	Continuous	Median: 7 gm, IQR: 0–10 gm
	Mean Daily Weight Gain (KMC)	Continuous	12.11 ± 9.04 gm
	Mean Daily Weight Gain (Control)	Continuous	3.29 ± 15.81 gm
	Hypothermia Incidence (KMC)	Categorical	3.10%
	Hypothermia Incidence (Control)	Categorical	12.60%
	Duration of Hospital Stay (KMC)	Continuous	Median: 5 days, IQR: 4–8 days
	Duration of Hospital Stay (Control)	Continuous	Median: 10 days, IQR: 8–14 days
Lamy Filho (2015)	Bacterial Decolonization (KMC)	Categorical	68% (34/50)
	Bacterial Decolonization (Control)	Categorical	32% (16/50)
Chi Luong (2016)	SCRIP Score at 360 min (Skin-to-skin)	Continuous	5.82 ± 0.66
	SCRIP Score at 360 min (Maternal-infant separation)	Continuous	5.24 ± 0.72
Jayaraman (2017)	Exclusive Human Milk Feeding (KMC)	Categorical	86%
	Exclusive Human Milk Feeding (Control)	Categorical	45%
	Direct Breastfeeding (KMC)	Categorical	49%
	Direct Breastfeeding (Control)	Categorical	30%
	Apnea Incidence (KMC)	Categorical	11.90%
	Apnea Incidence (Control)	Categorical	20%
	Recurrent Apnea needing ventilation (KMC)	Categorical	8.80%
	Recurrent Apnea needing ventilation (Control)	Categorical	15%
Brotherton (2021)	All-cause Mortality at 28 days (KMC)	Categorical	21% (29/138)
	All-cause Mortality at 28 days (Control)	Categorical	24% (34/139)
WHO Immediate KMC (2021)	Neonatal Mortality at 28 days (iKMC)	Categorical	12.0% (193/1609)
	Neonatal Mortality at 28 days (Control)	Categorical	15.7% (252/1602)
	Mortality at 72 hours (iKMC)	Categorical	4.60%
	Mortality at 72 hours (Control)	Categorical	5.80%
Nimbalkar (2014)	Hypothermia (SSC)	Categorical	4% (2 newborns)
	Hypothermia (Control)	Categorical	32% (16 newborns)

Tumukunde (2024)	Mortality at 28 days (KMC)	Categorical	22.1% (328/1484)
	Mortality at 28 days (Standard Care)	Categorical	26.0% (386/1485)
Logronio (2020)	Mean Daily Weight Gain (Continuous KMC)	Continuous	15.54 ± 8.82 g
	Mean Daily Weight Gain (Intermittent KMC)	Continuous	10.99 ± 7.91 g
	Mean Daily Weight Gain (Incubator)	Continuous	10.51 ± 8.13 g
	Mean Duration of Hospital Stay (Continuous KMC)	Continuous	12.55 ± 5.09 days
	Mean Duration of Hospital Stay (Intermittent KMC)	Continuous	15.55 ± 6.44 days
	Mean Duration of Hospital Stay (Incubator)	Continuous	16.90 ± 6.94 days
Luistro (2020)	All-cause Mortality at 28 days (KMC)	Categorical	12% (12/100)
	All-cause Mortality at 28 days (Control)	Categorical	15.7% (15/95)
	Apnea Episodes (KMC)	Continuous	1.4 ± 0.5
	Apnea Episodes (Control)	Continuous	3.2 ± 0.8

Continuous data represents measurable values that can fall anywhere within a range (e.g., weight gain, hospital stay duration). Categorical data represents qualities or groups (e.g., incidence of hypothermia, mortality rates).

Table 3: Inferential Statistics and Risk Estimates

First Author (Year)	*Outcome*	*Test Reported*	*P-value / OR / RR / HR (95% CI)*
Acharya (2014)	Daily Weight Gain Difference	Not explicitly stated (likely t-test / Mann-Whitney U)	$p < 0.001$
	Duration of Hospital Stay Difference	Not explicitly stated (likely t-test / Mann-Whitney U)	$p < 0.001$
Lamy Filho (2015)	Bacterial Decolonization Difference	Not explicitly stated (likely Chi-square)	$p < 0.001$
Chi Luong (2016)	Transition to extra-uterine life	Not explicitly stated	$p < 0.02$
	SCRIP score at 360 min	Not explicitly stated (likely t-test)	$p < 0.0001$
Jayaraman (2017)	Exclusive Human Milk Feeding	Not explicitly stated	$p < 0.001$
	Direct Breastfeeding	Not explicitly stated	$p = 0.021$
	Apnea Incidence	Not explicitly stated	$p = 0.027$
	Recurrent Apnea needing ventilation	Not explicitly stated	$p = 0.02$
Brotherton (2021)	All-cause mortality at 28 days	Risk Ratio (RR)	RR 0.84 (95% CI 0.55–1.29), $p = 0.423$
WHO Immediate KMC (2021)	Neonatal Mortality at 28 days	Risk Ratio (RR)	RR 0.75 (95% CI 0.65–0.86), $p < 0.001$
	Mortality at 72 hours	Risk Ratio (RR)	RR 0.78 (95% CI 0.61–0.99), $p = 0.04$
	Hypothermia within 72 hours	Risk Ratio (RR)	RR 0.28 (95% CI 0.16–0.46)
Mazumder (2021)	Mortality (Enrolment to 28 days)	Hazard Ratio (HR)	HR 0.70 (95% CI 0.51–0.96); $p = 0.027$
	Mortality (Enrolment to 180 days)	Hazard Ratio (HR)	HR 0.75 (95% CI 0.60–0.93); $p = 0.010$
Nimbalkar (2014)	Mean Temperature	Not explicitly stated	$p < 0.05$
	Hypothermia (Control vs. SSC)	Relative Risk (RR)	RR 8.00 (95% CI 1.94–32.99)
Tumukunde (2024)	Mortality at 28 days	Adjusted Risk Ratio (aRR)	aRR 0.82 (95% CI 0.69–0.98); $p = 0.03$
Logronio (2020)	Mean Daily Weight Gain	ANOVA	$F(2,117) = 9.89$, $p < 0.001$
	Post-hoc: Continuous KMC vs. Intermittent	Tukey HSD	$p < 0.001$
	Post-hoc: Continuous KMC vs. Incubator	Tukey HSD	$p < 0.001$
	Mean Duration of Hospital Stay	ANOVA	$F(2,117) = 6.67$, $p = 0.002$
	Post-hoc: Continuous KMC vs. Intermittent	Tukey HSD	$p = 0.008$
	Post-hoc: Continuous KMC vs. Incubator	Tukey HSD	$p = 0.001$
Luistro (2020)	All-cause mortality at 28 days	Not explicitly stated (likely Chi-square/Fisher)	$p = 0.485$
	Apnea Episodes	Not explicitly stated	$p < 0.001$
Arya (2023)	Clinical Sepsis (Incidence)	Adjusted Odds Ratio (aOR)	aOR 0.81 (95% CI 0.61–1.08); $p = 0.15$

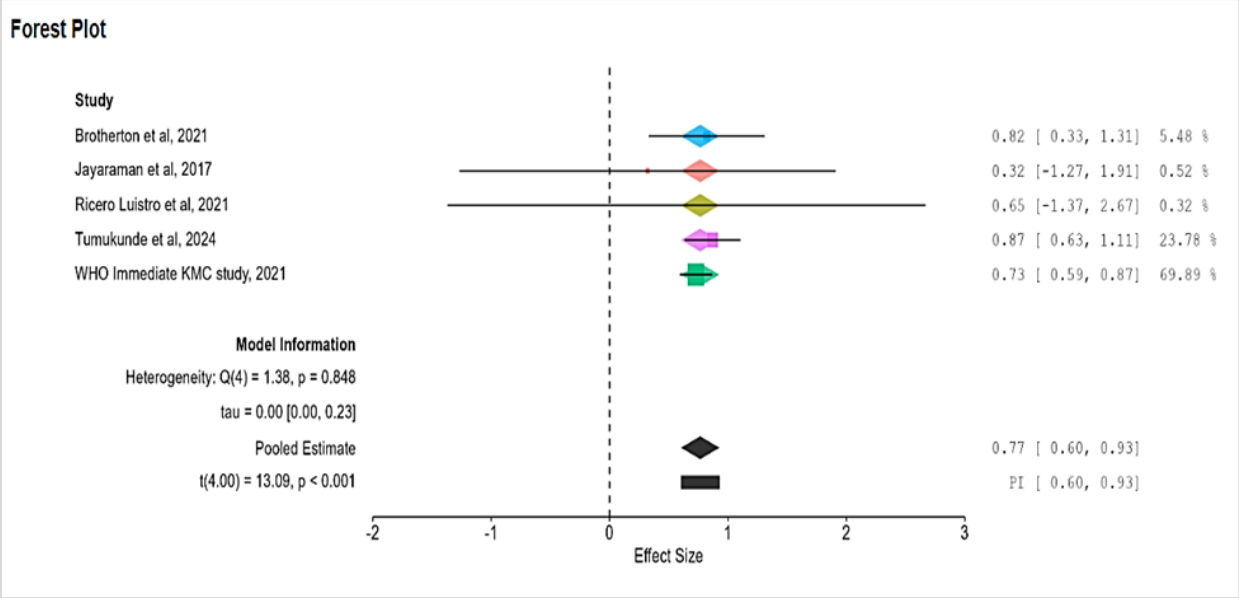

Figure 2 a): Forest plot for all-cause mortality

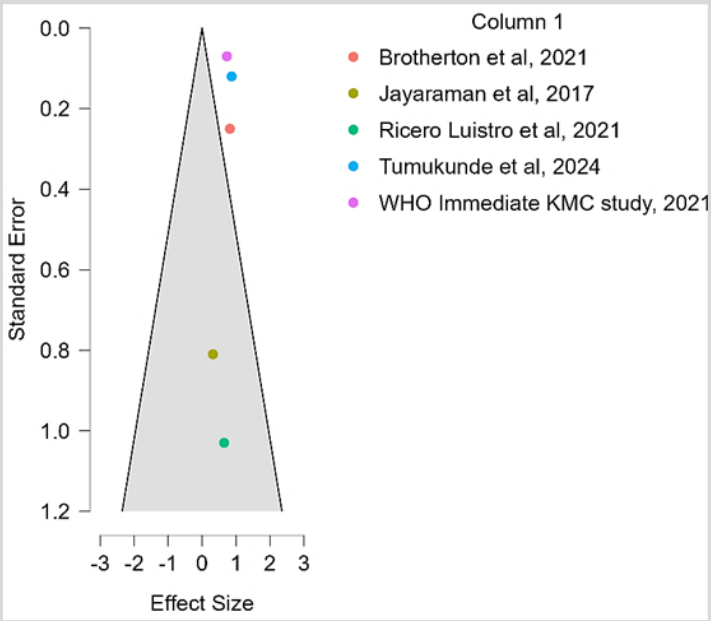

Figure 2 b): Funnel plot for all-cause mortality

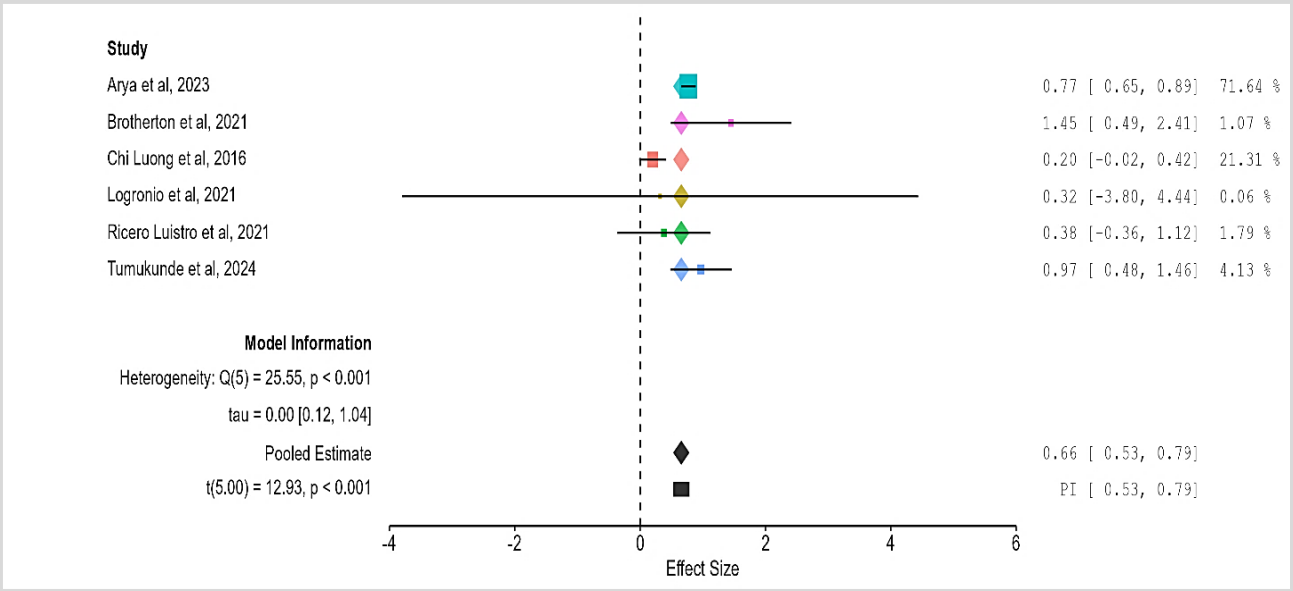

Figure 3 a): Forest plot for sepsis

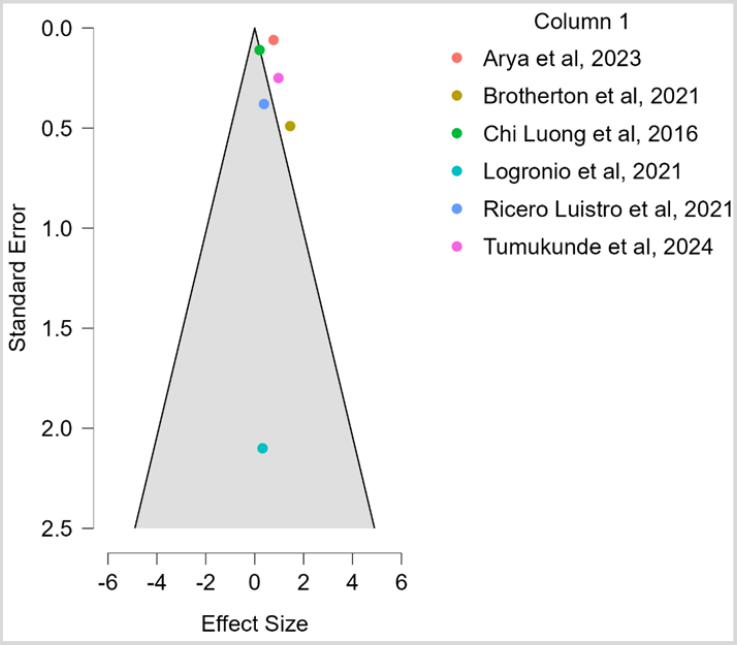

Figure 3 b): Funnel plot for sepsis

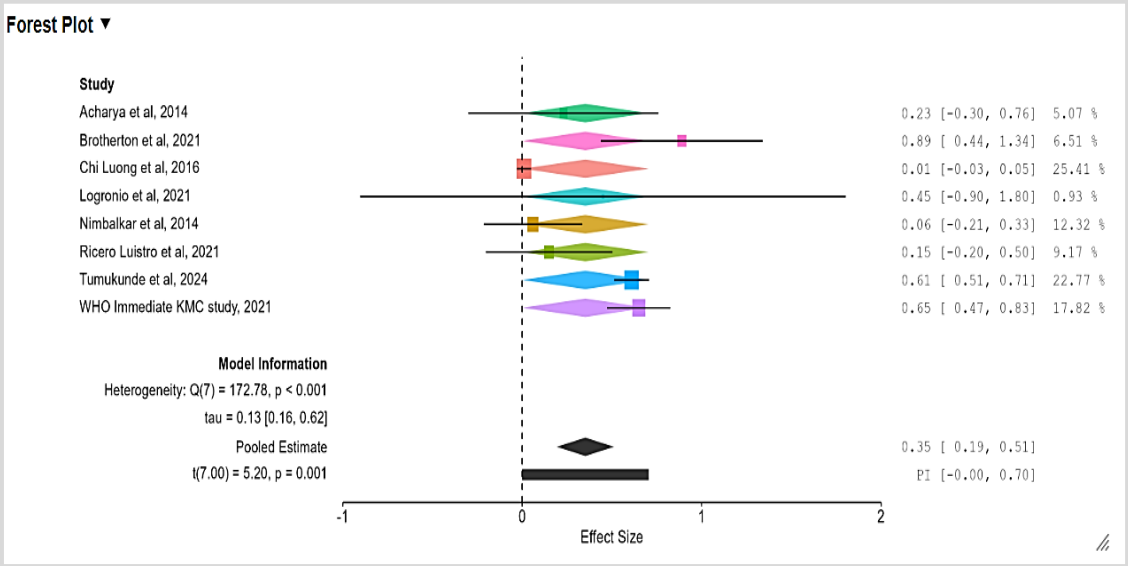

Figure 4 a): Forest plot for hypothermia

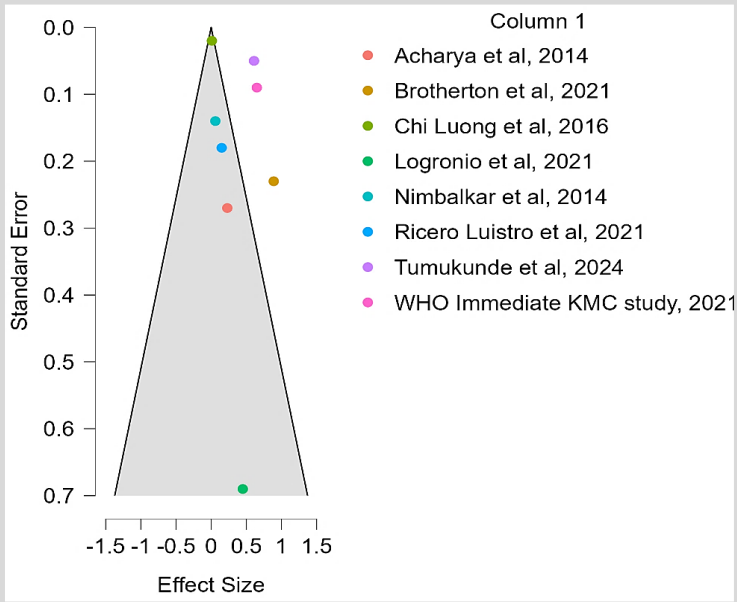

Figure 4 b): Funnel plot for hypothermia

Discussion

Acharya (2014) also presented early findings comparing Kangaroo Mother Care (KMC) with conventional neonatal care, showing improved daily weight gain in the KMC group (median: 10 g/day, IQR: 6–20) compared to the control group (median: 7 g/day, IQR: 0–10), along with lower incidences of hypothermia (3.1% vs. 12.6%). Hospital stay was also cut in half for neonates under KMC (5 days vs. 10 days). These results highlighted the physiological advantages of KMC during the early phases of clinical experience. This finding was further supported by later studies by Mishra P *et al*. (2017).

Nimbalkar (2014) further developed this work, focusing on thermoregulation in particular. His paper reported a hypothermia rate of only 4% in the SSC group compared to 32% in the control group, relative risk 8.0 (95% CI 1.94–32.99). Such excellent thermal stability was well worth its weight in gold in resource-poor environments where incubators are not available. This subject has been further developed by another author (Lode-Kolz K *et al*, 2023).

Lamy Filho (2015) contributed more microbiological evidence by describing bacterial decolonization rates in KMC infants as 68% and 32% controls and suggesting an immunoprotection effect by the maternal skin flora and early exclusive breastfeeding. The same was noted by another researcher (Shahbaz S *et al*, 2020).

Chi Luong (2016) included a physiological evaluation, which showed higher cardiopulmonary transition scores (SCRIP at 360 minutes: 5.82 ± 0.66 compared to 5.24 ± 0.72), thus verifying the hypothesis that skin-to-skin contact improves neuro-autonomic stabilization during the early postnatal phase. This procedure was also explained by another researcher (Linnér A *et al*, 2022).

Jayaraman (2017) compared respiratory and nutrition indicators. Exclusive human milk feeding was higher in the KMC group (86% vs. 45%), with more direct breastfeeding (49% vs. 30%). Apnoeic events and requirements for assisted ventilation were reduced, demonstrating double the advantage of KMC in respiratory control and feeding efficacy. The same occurred in another study as well (Zhang B *et al*, 2020).

Luistro (2020) also presented information on mortality trends, with 28-day all-cause mortality of 12% in the KMC group compared to 15.7% in the control group. Also, the number of apnoea episodes was significantly lower (1.4 ± 0.5 vs. 3.2 ± 0.8), as earlier research by Jayaraman had indicated. This was also evidenced by another study by another author in the same year (Xie X *et al*., 2021).

Logronio (2020) also conducted a tri-arm study to measure continuous Kangaroo Mother Care (KMC), intermittent KMC, and incubator care. The results showed that continuous KMC performed better compared to the other two arms in mean daily weight gain (15.54 ± 8.82 g) and average hospital stay (12.55 ± 5.09 days), with the rationale that continuous maternal contact provides cumulative benefits. The same rationale is also argued by another researcher (de-Ocampo FS *et al*, 2021).

Brotherton (2021) estimated 28-day mortality, and a moderate decrease in the KMC group (21%) was observed compared to controls (24%) with a risk ratio of 0.84, but not significant. But it showed the effectiveness of KMC even in high-resource NICUs. This was also shown by another author in his article (Zhu Z *et al*, 2023).

The WHO Immediate KMC Study Expert Group (2021) had landmark findings: 28-day neonatal mortality was 12.0% in the KMC group and 15.7% in controls (RR 0.75, $p < 0.001$), and early mortality by 72 hours reduced from 5.8% to 4.6% (RR 0.78). Hypothermia risk was reduced significantly (RR 0.28), which is a sign of efficacy and safety of immediate KMC even before stabilization of the entire neonate. Early initiation of continuous kangaroo mother care immediately after birth in neonates with birth weight 1.0 to 1.799 kg significantly reduced the risk of neonatal mortality compared with the initiation of kangaroo mother care after infant stabilization. Post-hoc analysis found that this advantage was so in all birth weight strata, gestational age, weight for gestational age, delivery types, and twin or singleton (Oleti TP, Murki S.2022).

Mazumder (2021) compared survival outside of the neonatal window, with hazard ratios for death of 0.70 and 0.75 at 28 and 180 days respectively. These findings established long-term survival benefits of KMC. These findings suggest early postnatal habits of care can influence survival in infancy. Another study found no statistically significant association between community initiated KMC and cognition, language, motor and socioemotional development but emphasized the need for conducting further longitudinal studies for future research (Taneja S *et al*, 2020).

Tumukunde (2024) carried out a highly structured randomized controlled trial (RCT) in five Ugandan hospitals between early-initiated Kangaroo Mother Care (KMC) and routine care practices. Despite the reduction in mortality at 7 days being the same for both interventions (7.5%), but at 28 days being non-significant (11.3% vs. 12.8% for standard care, RR 0.88; $p = 0.229$), the intervention was found to be very cost-effective from both provider and societal points of view. The results indicate that the advantages of KMC go beyond simple survival to include economic sustainability, especially in resource-constrained settings like sub-Saharan Africa. In very low birth weight preterm infants on non-invasive ventilation, KMC supported the attainment of stable oxygen saturation levels and enhanced heart rate control. Such results should be reassuring to healthcare providers and parents alike about the safety of KMC for such a population (Harari J *et al*, 2025).

Arya (2023) presented infectious outcomes, with 0.81 adjusted odds ratio for clinical sepsis in KMC neonates that was not significant but of the right direction ($p = 0.15$). Though the finding was not significant, its direction is as anticipated with the outcomes of microbial protection by Lamy Filho (2015) and mortality by WHO iKMC (2021), showing a consistent direction towards lowering infection. The same was found in another study (Du Q *et al*, 2025).

Shruthi (2025) extended the advantage of KMC to include the effect of KMC on the neonatal microbiome. She described how KMC facilitates direct skin-to-skin contact and improved breastfeeding, which enhances gut health, immune development, and possibly reduces long-term vulnerability to disease. Her study also involved the nurses' role in effective delivery of KMC and its psychological and developmental impacts on the neonate and the caregiver as well. The same was described and discussed in another study (Srinivasjois R *et al*, 2025).

Conclusion

This systematic review and meta-analysis aimed to answer the following question: "What is the cumulative effect of Kangaroo Mother Care (KMC) on mortality, infection rates, thermoregulation, respiratory outcomes, and weight gain in preterm and low birth weight neonates?" The cumulative evidence demonstrates that KMC has a significant effect on neonatal mortality reduction, sepsis rate reduction, hypothermia and apneic episode reduction, and successful weight gain, improves success in breastfeeding, and prolongs hospital stays. The future holds a promising prospect: the integration of KMC with emerging neonatal technologies. Wearable skin sensors for real-time monitoring of temperature and oxygen

saturation, artificial intelligence-based alert systems for apnea, mobile apps for nurse-supervised skin-to-skin contact monitoring, and low-cost thermal feedback devices are already under development or early stages of deployment.

Strengths and Weaknesses

The power of this review is its thorough integration of heterogeneous study approaches, such as randomized controlled trials, large cohort studies, and narrative reviews, each of which contributes triangulated findings across clinical, physiological, microbiological, and economic perspectives. Some limitations, however, include heterogeneity of outcome definitions, lack of standardized follow-up times, and variability of statistical reporting.

Declarations

Ethical Approval

Not required since the study conducted was a systematic review and meta-analyses and included the studies selected from 2014-2025.

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Conflicts of Interests

The authors report no conflict of interest.

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