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# Follow-up of Kangaroo Mother Care programmes in the last 28 years: results from a cohort of 57 154 low-birth-weight infants in Colombia

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## ABSTRACT

**Background** Kangaroo Mother Care (KMC) is an evidence-based intervention focused on premature and low-birth-weight (LBW) infants. In different healthcare systems, outpatient KMC programmes (KMCPs) have been pioneers in the follow-up of these high-risk newborns. Here, we describe an overview analysis performed in an unprecedented data set comprising Colombian infants and spanning 28 years.

**Methods** Cohort study of 57 154 infants discharged home in kangaroo position (KP) for follow-up in four KMCPs between 1993 and 2021.

**Results** At birth and at hospital discharge to a KMCP, median gestational age and weight were 34.5 and 36 weeks, 2000 g and 2200 g, respectively. Chronological age at admission was 8 days. Over time, anthropometric measures at birth and somatic growth during follow-up improved; on the other hand, percentages of mechanical ventilation, intraventricular haemorrhage and need for intensive care decreased as neuropsychomotor, sensory disorders and bronchopulmonary dysplasia incidence at 40 weeks. Risk of cerebral palsy and teenage mothers' frequency was higher in the poorest population. Early home discharge in KP in less than 72 hours was possible in 19% of the cohort. During the COVID-19 pandemic, we observed a more than twofold increase in exclusive breast feeding at 6 months and a reduction in readmission rates.

**Conclusion** This study provides a general overview of KMCPs follow-up during the last 28 years within the Colombian healthcare system. These descriptive analyses have allowed us to structure KMC as an evidence-based method. KMCPs allow close monitoring with regular feedback about preterm or LBW infants' perinatal care, quality of care over time and health status during their first year of life. Monitoring these outcomes is challenging but guarantees access to high-risk infants' care with equity.

### WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The Kangaroo Mother Care Method is an evidence-based intervention that impacts morbidity and mortality of preterm or low-birth-weight infants.

### WHAT THIS STUDY ADDS

⇒ Kangaroo Mother Care ambulatory programmes allow strict 1-year follow-up of high-risk infants enabling early detection and intervention of growth problems and developmental disorders.

### HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Monitoring high-risk infants' outcomes in Kangaroo Mother Care ambulatory programmes guarantees access to integral care with equity and quality, and it is an opportunity for feedback and research.

## BACKGROUND

Kangaroo Mother Care (KMC) is an evidence-based intervention, suitable for both developed and developing countries, focused on premature (<37 weeks) and low-birth-weight (LBW) newborns (<2500 g) with mothers acting as the primary provider of heat and stimulation. This method has three main components. First, the continuous skin-to-skin contact between mother and infant (Kangaroo position (KP)) which provides appropriate thermal regulation, among other benefits. Second, exclusive breast feeding whenever possible (kangaroo nutrition). Third, close monitoring after early discharge at home in KP and high-risk follow-up until 1 year of corrected age (CA) in outpatient KMC programmes (KMCPs).[1 2] Early discharge at home in KP is impossible if transportation is unavailable. In this case, early discharge is done to a kangaroo ward.

Between 1978 and 1994, the original KMC intervention created by Dr Rey-Sanabria corresponded to early discharge in KP with a short empirical follow-up without data.[3]

Since 1994, the Kangaroo Foundation (KF) in Colombia has implemented further guidance, including early home discharge in KP as soon as possible when the baby is stabilised. The mother is trained in KMC and discharged home with the baby in KP under close monitoring until 40 weeks to guarantee the survival, followed by high-risk follow-up until 12 months of CA to ensure the quality of survival.[2 4]

In Colombia, KMCPs have been pioneers in follow-up and systematic management of these high-risk newborns, at least during their first year of life. In 1998, KMC started to be implemented in delivery rooms and neonatal intensive care units because of its evidence-based benefits.[2 5]

Follow-up of Kangaroo babies is a valuable technique to assess KMC performance of clinical outcomes. Indeed, this continuous monitoring has allowed studying short and long-term benefits since the first randomised control trial (RCT) conducted by KF in 1994.[6] Following this RCT, the KF team has conducted multiple studies on preterm infants' feeding patterns, breastmilk composition according to gestational age (GA), predictor models for breastmilk supplementation, oxygen dependency, neurodevelopmental assessment, KMC brain protection effect and enhancement of bonding between mother, infant and family.[7–16]

The strict 1-year follow-up of high-risk infants in low and middle-income countries (LMIC) constitutes a milestone in achieving sustainable development goals 3 and 4 (SDG 3, 4). SDGs are built on the experience of the millennium development goals (MDGs). They reflect a comprehensive perspective of global development being uniformly applicable to all countries of the world, removing the 'developing' versus 'developed' dichotomy that left the MDGs open to criticism. KMC is a strategy to diminish preventable deaths and to improve the quality of survival in children by early detection and intervention of any disabilities related to prematurity and LBW during the first year.[17] We could assimilate KMCPs follow-up as a strategy for 'early child development'.

The objective of this paper is to describe the main results of the monitoring of KMCPs 1-year follow-up from 1993 to 2021 in Colombia. This includes somatic growth, neuropsychomotor development, sensorial alterations and certain aspects of morbidity and mortality.

## METHODS

### Study design and participants

Descriptive cohort study of 57154 premature or LBW infants followed until 1year of CA in four outpatient KMCPs. Infants were included initially from 'Casita Canguro' (1994–2001), then from three Integral KMCPs in San Ignacio University Hospital, San Jose Children's University Hospital (2001–2021) and Medellin KMCP (2008–2021).

### Patient and public involvement

The families of patients were not involved in the KMCPs' follow-up structure. They signed a consent agreeing that the follow-up data could be used by the KF for research and improvement of KMC.

### General procedures

During follow-up in the KMCP, paediatricians can detect deviations in somatic growth, psychomotor development (Griffiths test),[18] neuromotor development (INFANIB test),[19] vision and hearing (any deafness uni or bilateral greater than 60dB indicating a neurosensorial loss have been considered as abnormal hearing. Both otoacoustic emissions and auditory brainstem evoked auditory potentials are used to determine the degree of deafness).

The first set of data collected in the 1994 RTC recorded different anthropometric measures.[6] Then, baseline information was collected through interviews and data analysis of clinical records according to socioeconomic status. Health professionals in each KMCP collected clinical and laboratory data. Additional data from psychological evaluations have been registered in pre-encoded forms. Between 1994 and 2008, all infants <37 weeks or ≦2000g at birth were included. From 2008, term infants between 2000 and 2500g were added. Since 2015, data on in-hospital KMC have been collected through a survey answered by parents. KMCPs monitored by the KF receive infants from more than 35 neonatal care units (NCUs) in Medellín and Bogotá.

### Data processing and analysis

Data were recorded in standardised formats on paper and online and entered into computerised databases designed explicitly for the KMCPs, following accepted good practices for data recording and management. In 2019, a new electronic health record named KAREN was developed to collect systematically data from birth up to 1year.

After performing manual and computerised data cleaning, every 6months, the data set was monitored to evaluate the quality of KMCPs' practice and to generate questions and answers in face of results.

Exploratory analysis included a general description of interest variables concerning different topics as anthropometric measures and nutrition, neurodevelopment, audition and vision, hospitalisation characteristics, health insurance as a proxy of socioeconomic status and immediate KMC with early home discharge, oxygen dependency at KMCP entry and bronchopulmonary dysplasia (BPD) (defined as need of respiratory support at 40 weeks GA according to the study of Isayama and cols; this operative definition has demonstrated to be a good predictor for respiratory and neurosensory morbidity at 18 to 21 months[20]). We have performed the analyses according to GA groups (≤32 weeks, 33–36 weeks, ≥37 weeks), and time periods (periods of 5 years between 1993 and 2017, pre-COVID-19 pandemic 2018 and 2019 and in COVID-19 pandemic, 2020 and 2021).

Qualitative data were described as percentages, and quantitative data as means with SD or medians with maximum and minimum values or IQR, according to its distribution. The bivariate analysis compared baseline characteristics, antenatal, perinatal and follow-up outcomes according to different groups up to 1year CA. The analysis was conducted using SPSS V.21 and Stata V.14.

**Table 1** Nutrition index

| Year period | Nutrition index at 40 weeks | | Nutrition index at 12 months | |
|---|---|---|---|---|
| | Harmonious growth (%) | Non-harmonious growth (%) | Harmonious growth (%) | Non-harmonious growth (%) |
| 1993–1997 | 2142/3820 (56.1) | 1679/3820 (43.9) | 1030/2839 (36.3) | 1809/2839 (63.7) |
| 1998–2002 | 2395/3724 (64.3) | 1329/3724 (35.7) | 1371/1901 (72.1) | 530/1901 (27.9) |
| 2003–2007 | 2893/4308 (67.2) | 1415/4308 (32.8) | 1637/2474 (66.2) | 837/2474 (33.8) |
| 2008–2012* | 6168/7928 (77.8) | 1763/7928 (22.2) | 3432/4710 (72.9) | 1278/4710 (27.1) |
| 2013–2017 | 12281/14 463 (84.9) | 2182/14 463 (15.1) | 7815/9921 (78.8) | 2106/9,921 (21.2) |
| 2018–2019 | 4823/5,671 (85.1) | 847/5671 (14.9) | 3003/3714 (80.9) | 711/3714 (19.1) |
| 2020–2021** | 2908/3,340 (87.1) | 432/3340 (12.9) | 537/657 (81.7) | 120/657 (18.3) |

**2020 up to 30 June 2021 (SARS-Cov-2 pandemic).
*Since 2008, at term-LBW infants were included in KMCP.
KMCPs, KMC programmes; LBW, low-birth weight.

## RESULTS

### Overall health outcomes 1994–2021

During these years, median GA and weight at birth were 34.5 weeks with minimum and maximum values (23–43) and 2000 g (470–4987), respectively. The median postnatal age at hospital discharge to the ambulatory KMCPs was 8 days (1–121) with a median GA and weight of 36 weeks (31–43) and 2200 g (885–6000). At KP discharge, average GA was 38.5 weeks (SD 1.7 weeks) and weight 2500 g (SD 287 g).

General compliance with monitoring visits up to term was 43 250/52 249 (83%), and loss to follow-up between 40 weeks and 12 months CA was 6993/45 483 (15%). The main reasons were loss of health insurance, financial problems, advice from doctors and change of residence.

### Nutrition and growth 1994–2021

A nutrition index was created according to WHO growth charts. Harmonious growth was defined as patients with all anthropometric measures above the range of −2 SD, and non-harmonious growth as patients with any measure below this range. There was an increase in the harmonic nutrition index at both 40 weeks (56%–87%) and 12 months (36%–82%) during the follow-up periods (table 1).

Comparing the first period, 1993/1997 and 2020/2021 period, we found that in the ≤32 weeks of GA groups, there were no significant differences in any of the three anthropometric measures at birth; on the other hand, in the 33–36-week and ≥37-week groups, there was a difference in weights up to 480 g as well as 2.8 cm in height and 1.4 cm in head circumference in favour of the last periods.

At 40 weeks, 6 months and 12 months of CA, weights in the three GA groups are between 490 and 767 g higher, and there was a difference in length in average of 2 cm and in head circumference of 1 cm, in favour of the last years (online supplementary material 1).

Between 1993 and 2007, most patients entered KMCP weighing between 1500 and 2000 g (52%–67%); from 2008 onwards, the majority of patients were >2000 g at entry (70%–88%). More than half of patients entering KMCP are preterm appropriate for GA, followed by preterm patients with intrauterine growth restriction (IUGR) and at term with IUGR, according to the Fenton-2013 classification[21] (table 2).

### Neurodevelopment 1993–2021

Between 1993 and 2007, altered neuromotor development at 3 and 6 months, assessed by INFANIB, was found in 18%–39% of patients, with a decrease from 2008 onwards (9%–31%). At 9 and 12 months, the non-normal evaluations' percentage continued to decrease to 4% in the last 2 years (2020–2021). Regarding neurodevelopment assessed with the Griffiths scale, scores of developmental quotient (DQ) decreased notably from 2008, when LBW patients ≧37 weeks GA were included, and the tool to evaluate neurodevelopment was changed to Griffiths II (table 3).

Rates of hearing impairment showed a steady downward trend from 7%–8% to 1%. Rates of retinopathy of prematurity (ROP) have remained between 3%–8%, and up to 1% required surgery. Cases of blindness were a maximum of 0.3% in 2003–2007 and a minimum of 0.03% between 2018 and 2019. The primary refractive defect was hyperopic astigmatism (up to 73%). Proportions of myopic astigmatism were between 1% and 1.4%, with a decrease in the last 4 years (Supplementary material 2 and 3).

### Clinical characteristics 1994–2021

Regarding characteristics of hospital care over different periods, total hospital stays remain similar in the three GA groups. On the other hand, Neonatal Intensive Care Unit (NICU) stays started with a value of 12 days in 1993/1997 for infants ≤32 weeks, then decreased to a median minimum value of 7 days in 1998/2002 and 2003/2007 and rose to a maximum median value of 14 days in 2018/2019 and 2020/2021. In the 33–36 weeks and ≥37 weeks groups, a decreasing trend in NICU stay is

**Table 2** Mean weight at KMCP entry and Lubchenco-Fenton ponderal classification at birth

| Year period | Weight at KMCP entry—N (%) | | | |
|---|---|---|---|---|
| | <1000 g | 1000 to <1500 g | 1500 to <2000 g | ≥2000 g |
| 1993–1997 | 39/4225 (0.9) | 711/4225 (16.8) | 2843/4255 (67.3) | 632/4225 (15.0) |
| 1998–2002 | – | 233/4334 (5.4) | 2252/4334 (52.0) | 1849/4334 (42.7) |
| 2003–2007 | 1/4717 (0.02) | 183/4717 (3.9) | 2617/4717 (55.5) | 1916/4717 (40.6) |
| 2008–2012 | – | 22/9837 (0.2) | 2902/9837 (29.5) | 6913/9837 (70.3) |
| 2013–2017 | – | 6/18 860 (0.03) | 3620/18 860 (19.2) | 15 234/18 860 (80.8) |
| 2018–2021 | – | – | 1554/12 989 (12.0) | 11 435/12 989 (88.0) |
| Lubchenco-Fenton Ponderal Classification at birth N (%) | | | | |
| PT-SGA* | | | | 11 325/56 414 (20.1) |
| PT-AGA† | | | | 32 352/56 414 (57.4) |
| AT-SGA‡ | | | | 11 167/56 414 (19.8) |
| AT- AGA and LBW§ | | | | 1570/56 414 (2.8) |

*Preterm small for GA (SGA).
†Preterm adequate for GA (AGA).
‡At term small for GA (SGA).
§At term Adequate for GA (AGA) and LBW.
AGA, appropriate for gestational age; LBW, low-birth weight.

observed, with medians from 11 and 13 days, respectively, in 1993/1997 to 2–4 days for both GA groups between 2003 and 2021. Concerning median days of invasive mechanical ventilation, a decrease from 4 days IQR (2–7) in 1993/1997 to 3 days IQR (1–9) in 2020/2021 was observed for infants ≤32 weeks; in the group of 33–36 weeks, the days fell from 3 IQR (2–4) in 1993/1997 to 1 IQR (1–3) in 2020/2021. Finally, in the group, ≧37 weeks duration of mechanical ventilation remained similar, from 2 days IQR (1–2) in 1993/1997 to 2 days IQR (1–5) in 2020/2021.

In terms of nutrition, the proportion of infants with exclusive breast feeding (EBF) at discharge since 2003 remains between 34% and 42% for the ≤32 weeks group, 63%–73% for the 33–36 weeks group and 70%–83% for those ≧37 weeks.

Considering IUGR, percentages between 2003 and 2021 in≤32 weeks GA were low and have remained

**Table 3** Neurodevelopment

| Year period | Non-normal INFANIB N (%) | | | | At least one non-normal INFANIB during follow-up | Griffiths DQ Mean (SD) | |
|---|---|---|---|---|---|---|---|
| | 3 months | 6 months | 9 months | 12 months | | 6 months | 12 months |
| 1993–1997 | 626/3251 (17.8) | 601/3278 (18.3) | 279/3098 (9.0) | 129/2824 (4.6) | | 97 (12.7) | 103.3 (9.8) |
| 1998–2002 | 560/2894 (19.4) | 570/2438 (23.4) | 336/2825 (11.9) | 127/2606 (4.9) | | 95.7 (12.9) | 103.6 (11.8) |
| 2003–2007 | 1079/3146 (34.3) | 1118/2893 (38.6) | 375/2555 (14.7) | 166/2412 (6.9) | 1974/3098 (63,7) | 98.2 (10.7) | 99.4 (11.0) |
| 2008–2012* | 1942/6768 (28.7) | 1,752/5721 (30.6) | 732/4809 (15.2) | 365/4641 (7.9) | 3974/7670 (51,8) | 93.6 (19.3) | 92.8 (14.0) |
| 2013–2017† | 3857/13 715 (28.1) | 1771/11 789 (15.0) | 522/10 211 (5.1) | 358/9893 (3.6) | 6414/15 110 (42,5) | 87.3 (18.5) | 92.2 (12.2) |
| 2018–2019 | 1091/5668 (19.3) | 495/4722 (10.5) | 144/3921 (3.7) | 114/3700 (3.0) | 1792/4397 (40,8) | 90.0 (9.8) | 94.8 (11.3) |
| 2020†* | 445/2.310 (19.3) | 156/1720 (9.1) | 38/1054 (3.6) | – | 672/1163 (56,8) | 91.2 (10.4) | – |

*Introduction of term-LBW infants in 2008 and Griffiths II scale in 2011.
†Physical therapy access in public insurance since 2014.
‡Patients followed up until May/2021.
LBW, low-birth weight.

between 8 and 12%. In the 33–36 weeks GA group, there has been a gradual reduction to half of the cases in the last 2 years (40 to 22%). The highest proportion is in ≧37 weeks GA group, which decreased from 95 to 83%. Additionally, Extra Uterine Growth Restriction (EUGR) frequency at KMCP entry has decreased from 48% (2003–2007) to 20% (2020–2021) in preterm infants ≤32 weeks GA and from 45% (2003–2007) to 19% (2020–2021) in those with 33–36 weeks GA. Concerning parenteral nutrition, patients ≤32 weeks had a median between 6 and 10 days in the last four time periods (2008–2021); on the other hand, in those >32 weeks, the median days was 0 (table 4). Regarding intraventricular haemorrhage, there was a sustained decrease in all GA groups (online supplementary material 4).

### Impact of SARS-Cov-2 pandemic on breast feeding and readmissions

Follow-up shows that through pandemic years, the proportion of EBF at 40 weeks did not change significantly in any GA group. Conversely, an increase in EBF at three and 6 months was found in all groups; ≤32 weeks group (from 16 to 22% at 3 months and from 8% to 18% at 6 months), 33–36 weeks (from 27% to 43% at 3 months and from 14% to 32% at 6 months), ≧37 weeks (LBW) (from 30% to 49% at 3 months and from 16% to 38% at 6 months). For all patients, readmissions at 40 weeks decreased from 7% to 1%, and after 40 weeks until 12 months, decreasing was from 18% to 2% (online supplementary material 5).

### Special groups 1994–2021

#### Ambulatory oxygen and bronchopulmonary dysplasia (BPD) incidence in a high-altitude city

From 1998 to 2021, 15%–43% of patients in the KMCPs at Bogotá, Colombia, were oxygen dependent (OD) at entry (need supplemental oxygen) and between 2% and 20% had BPD-confirmed diagnosis at 40 weeks GA follow-up.

The KMC method encourages early home discharge in KP once OD infants regulate temperature. When discharge criteria are met, parents are empowered to care for their baby. This is followed by ambulatory KMCP sessions with strict monitoring through dynamic oximetry. Sessions are initially daily and later weekly until 40 weeks GA, then every 2 weeks until oxygen weaning.[22]

With the KMCP database, we aimed to evaluate the health, and nutritional status of infants with confirmed BPD. Additionally, we intended to know if there is a higher incidence of BDP in Bogotá (located at 2600 metres above sea level) compared with other cities worldwide.

This cohort included 11 953 oxygen-dependent infants sampled between January 1998 and the first semester of 2021. There was a decrease in the percentage of OD infants at ambulatory KMCPs entry from 1998 to 2021. Moreover, patients with BPD at 40 weeks follow-up decreased in Bogotá from 20% in 2008 to 6% in 2020–2021 (figure 1). Patients born ≤32 weeks GA were between 41% and 62% of all OD groups.

We conducted a descriptive and bivariate analysis of BPD incidence, feeding patterns, growth and readmission up to 12 months, DQ at 6 and 12 months, incidence of ROP, abnormal audiometry and mortality.

There were no significant differences in anthropometric measures follow-up comparing babies with and without BPD. By contrast, at 12 months, there was a difference of 1.6 points in the mean value of the DQ. In very LBW infants (<1500 g), there were no significant differences neither in anthropometric measures between 40 weeks GA and 12 months CA nor in the mean value of DQ at 6 months or 12 months.

Infants with BPD had 5.3 times more ROP. They underwent surgery for ROP 9.7 times more than the general population. In addition, they had two times more abnormal audiometry. Mortality at 40 weeks was quite similar, but at 12 months was three times superior among the group with BPD. Readmission at 12 months was 1.7 times higher in those with BPD; on the other hand, patients with BPD received less breast milk at 12 months CA (online supplementary material 6).

#### Outcomes according to the three types of health insurance

Colombia is a country with three different systems of health insurance and growing disparities between social classes. We evaluated high-risk infants' follow-up from 1994 to 2021, according to the three types of health insurance, to investigate if there were differences in the primary outcomes of morbidity, development and mortality.

The three types of health insurance are private insurance (PI) (high income), worker insurance (WI) (middle and low income) and government-subsidised insurance (GI) (very low income).

Among the total population of our cohort, 67% (38 072) had WI, 24% (13 509) GI and 9.5% (5433) PI.

Teenage mothers in GI were 28% contrasting with 9% in WI (three times more) and 4% in PI (seven times more). The average weight at birth was approximately 130 g more in babies from GI. On the other hand, the body length and head circumference did not show considerable variations. Hospitalisation in NICU was 38% for WI, 43% for PI and 42% for GI, with ventilation required in 32%, 29% and 15%, respectively. The frequencies of nosocomial infection were higher in the GI group; 6.4% (WI), 8.5% (PI) and 8.7% (GI).

Postnatal median age at KMCP entry was 10 days in WI infants, IQR (6–21), 15 days in PI infants IQR (8–29) and 19 days in those with GI IQR (9–48). We detected ROP in 5% of children in WI, 4% in PI and 3% in GI. More than half of WI and GI patients received EBM until term (59 and 57%) in contrast to 49% of PI infants. We observed breast feeding increase during COVID-19 pandemic only in the WI group.

**Table 4** Hospitalisation characteristics

| Year period | Gestational age at birth | Total hospital stay in days Median (IQR) | NICU days Median (IQR) | Mechanical ventilation days Median (IQR) | Days of parenteral nutrition Median (IQR) | EBF* at hospital discharge N (%) | IUGR N (%) | EUGR at KMCP entry N (%) |
|---|---|---|---|---|---|---|---|---|
| 1993–1997 | ≤32 weeks | 27(15-40) | 12(8-20) | 4 (2–7) | No data available | No data available | No data available | No data available |
| | 33–36 weeks | 7 (3–14) | 11(7-20) | 3 (2–4) | | | | |
| | ≥37 weeks | 3 (3–6) | 13 (6–21) | 2 (1–2) | | | | |
| 1998–2002 | ≤32 weeks | 36(25-51) | 7 (4–16) | 4 (2–8) | | | | |
| | 33–36 weeks | 9 (4–15) | 6 (2–12) | 3 (2–5) | | | | |
| | ≥37 weeks | 5 (3–10) | 14(3-19) | 6 (1–11) | | | | |
| 2003–2007 | ≤32 weeks | 30(18-44) | 7 (3–18) | 4 (2–9) | | 594/1433 (42.0) | 177/1433 (12.0) | 594/1250 (48.0) |
| | 33–36 weeks | 8 (5–13) | 4 (2–7) | 2 (1–4) | | 1868/2551 (73.0) | 1036/2551 (40.6) | 670/1507 (45.0) |
| | ≥37 weeks | 5 (3–9) | 4 (2–9) | 3 (2–5) | | 274/331 (83.0) | 315/331 (95.0) | – |
| 2008–2012 | ≤32 weeks | 32(20-48) | 10(4-20) | 3 (1–8) | 6 (0–13) | 838/2295 (37.0) | 239/2294 (10.0) | 584/2005 (29.0) |
| | 33–36 weeks | 8 (4–12) | 3 (2–6) | 2 (1–5) | 0 | 3951/5883 (67.0) | 1635/5884 (28.0) | 1234/4207 (29.0) |
| | ≥37 weeks | 4 (1–7) | 2 (1–5) | 3 (1–5) | 0 | 1195/1665 (71.8) | 1530/1668 (92.0) | – |
| 2013–2017 | ≤32 weeks | 35(23-54) | 10(4-25) | 3 (1–8) | 8 (0–15) | 1173/3165 (37.0) | 265/3165 (8.0) | 829/2749 (30.0) |
| | 33–36 weeks | 7 (3–12) | 3 (1–6) | 2 (1–3) | 0 | 7085/10 698 (66.0) | 2489/10 709 (23.0) | 1886/7862 (24.0) |
| | ≥37 weeks | 3 (1–6) | 3 (1–5) | 2 (1–4) | 0 | 3506/4830 (73.0) | 4246/4839 (88.0) | – |
| 2018–2019 | ≤32 weeks | 35(24-53) | 14(4-30) | 3 (1–10) | 10 (0–15) | 336/1000 (34.0) | 89/998 (9.0) | 203/878 (23.0) |
| | 33–36 weeks | 7 (3–12) | 3 (2–7) | 1 (1–3) | 0 | 2715/4148 (66.0) | 1037/4139 (25.0) | 683/3064 (22.0) |
| | ≥37 weeks | 2 (1–5) | 3 (1–8) | 2 (1–5) | 0 | 2071/2874 (72.0) | 2429/2874 (84.5) | – |
| 2020–2021 | ≤32 weeks | 37(25-51) | 14(5-28) | 3 (1–9) | 10(4-15) | 188/532 (35.0) | 62/536 (12.0) | 93/471 (20.0) |
| | 33–36 weeks | 7 (4–13) | 4 (2–7) | 1 (1–3) | 0 | 1588/2503 (63.0) | 556/2511 (22.0) | 364/1949 (19.0) |
| | ≥37 weeks | 3 (2–7) | 4 (2–8) | 2 (1–5) | 0 | 1332/1895 (70.0) | 1571/1899 (83.0) | – |

EBF, exclusive breast feeding; EUGR, Extra Uterine Growth Restriction; NICU, Neonatal Intensive Care Unit.

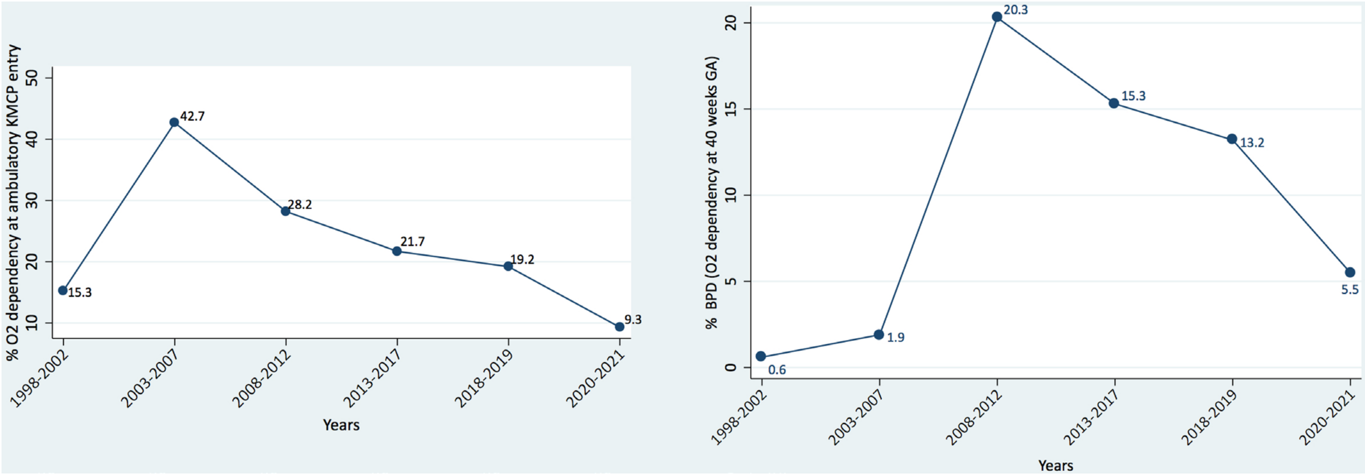


**Figure 1** Oxygen dependency and BPD at 40 weeks in Bogota 1998–2021. BPD, bronchopulmonary dysplasia; KMCP, KMC programme.

There was a significant difference in DQ at 12 months between groups, WI 97(SD12), PI 95(SD11) and GI 92(SD14) (Analysis of variance (ANOVA) p<0.001). The risk of cerebral palsy at 1 year was 2.5% in the GI group versus 1.0% in PI and 1.3% in WI.

Finally, mortality during follow-up was 1.4% for WI, 0.4% for PI and 1.0% for GI. Most deaths were in hospitals.

### Early hospital home discharge (<72 hours) with early KMC

Early KMC is an intervention where a newborn is placed skin-to-skin on the mother's chest to promote thermoregulation, breast feeding and bonding from birth. There has been an increasing interest in early KMC, usually initiated at birth after stabilisation of the preterm/LBW baby, allowing home discharge <72 hours. We followed 10891 premature and LBW infants (19% of the total cohort) who were in KMC in the delivery room with early discharge <72 hours and close ambulatory follow-up in a KMCP.

Concerning mothers' characteristics, 16% (1732) were teenagers, and 13% (1369) were >35 years; 21% (2059) were alone with support, 10% (953) did not have any support and the others were a stable couplet. Regarding education, 32% (3137) had primary school, 38% (3731) had high school, 13% (1300) had a degree in technical education and 18% (1792) went to university. In fathers, education was very similar; 89% (7598 fathers) were employed (formal or not). More than half of pregnancies were not desired or planned (57%=5492). Additionally, 1.6% of mothers (145) had alcohol consumption, 1.2% (59) had drug consumption and 2.3% (203) smoked during pregnancy.

We found that 81% (7142) of mothers had complete prenatal control. Anaemia was reported in 7% (561); additionally, 16% had toxaemia (1656) and 13% premature membrane rupture (1129). Delivery by C-section was 43% (3822).

Anthropometric measures remained a steady increase at 40 weeks, 3 months and 1 year of CA. At 40 weeks, 72% (4833) received EBF, 27% (1804) breastmilk+artificial milk and 2% (108) only artificial milk. At 12 months: 12% (556) had EBF, 51% (2273) breastmilk+artificial milk and 37% (1656) artificial milk only.

In relation with neurodevelopment, at 6 months, 89% infants (4838) were normal, 11% (587) had transient anomaly and 0.8% (45) abnormal examination; at 12 months: 98% (4330) were normal, 1.6% (71) had transient anomaly and 0.9% (40) abnormal examination. Regarding sensorial development, 1.6% infants (106) had ROP of any degree, and only one remained blind.

Lost to follow-up at 12 months CA was 21%. Finally, mortality relative risk (RR) in the first year between the cohort of kangaroo babies hospitalised in the NCU and the cohort of kangaroo babies immediately stabilised and not hospitalised with early discharge (<72 hours) was not significant. RR 1.21. 95% CI (0.99 to 1.48) p=0.06.

## DISCUSSION

This study provides the first general overview of KMCPs follow-up during the last 28 years within the Colombian healthcare system.

These descriptive analyses have allowed us to structure the KMC as an evidence-based method. Furthermore, it has been developed as a public health tool for the best care of premature and LBW infants in LMIC and even high-income settings. The experience in Colombia showed that KMCP is cost-effective and can be included in the health system of similar countries.[23]

Results from different subdatabases allowed us to monitor KMC quality closely and improve KMC methods based on evidence. These outcomes are steps forward in achieving MDG 3.[17,24] The results presented are strong evidence of the imperative need for a strict and multidisciplinary follow-up such as the KMCP, at least up to 1-year CA, given preterms' high morbidity and mortality.

We believe that changes in anthropometric measures at birth are effect of factors such as improvement in prenatal control, timely management of IUGR, nutritional management of pregnant women and the addition of nutritional supplements in public health programmes.[25] It is important to note that when the mother-nutrition questionnaire was filled, more than 80% of the mothers had more than three meals and two snacks per day. However, during the pandemic, inadequate nutrition increased, especially in mothers with economic difficulties (GI). In this group, anaemia during gestation was 11% in 2021, probably associated with a nutritional deficit.

The improvement of anthropometric measures at KMCP entry is probably related not only to better quality of prenatal control but also to a progress of the in-hospital nutrition. The opening of neonatal units to mothers, the availability of colostrum, then of breast milk and the KP as early as possible and for as long as possible for increasingly small and critical children as the staff experience increased, played a major role. In addition, EUGR progressively decreased since the first period; that is why children <1500 g receiving direct breast feeding and with average 35 weeks GA at KMCP entry currently are scarce.

The improvement in babies' somatic growth during the 1-year CA follow-up could result from rigorous KMCP protocols and monitoring that allows paediatricians to take timely actions. For example, supplementing breast milk when growth problems are detected and emphasising when and how is the introduction of food between 4 and 6 months CA according to the growth curves. The KMCP is a place to educate parents on not only the introduction of foods but also the quality and quantity of nutrients and the impact of growth on neurodevelopment,[12] especially in a poor population with little education.

Regarding neurodevelopment, we found a gradual improvement in neuromotor evaluation results from 2008 onwards. KMCP educational campaigns may explain this progress by encouraging stimulation at home by parents and facilitating access to physical therapy. On the contrary, in the population with fewer resources (GI), problems in access to these interventions persist; as a result, we found higher deviations in neuropsychomotor development at the end of follow-up. These results were an opportunity to work with policymakers in order to guarantee equity in the timeliness of access to these services and to develop educational sheets with simple exercises of stimulation accompanied by small practical workshops.

We observed a decrease in the overall Griffiths scale score from 2008. We believe those results could be explained by the inclusion of infants with IUGR, and the updating of the scale to more demanding scores. LBW in a newborn is the most significant factor contributing to neonatal morbidity and mortality because these infants are at higher risk of asphyxia, sepsis, hypothermia and feeding problems.[26–28] As a consequence, LBW neonates are prone to long-term disorders such as malnutrition and neurodevelopmental problems with low IQ.[29–33] Altogether, these facts are the reason why actions to improve short-term and long-term health, such as KMC, have a significant impact on neonatal and infant mortality in these infants.[34]

The variations in neurodevelopment results during follow-up show the importance of closely monitoring, at least during the first year of life, taking into account that the brain development is a continuous process that goes even further than 1 year CA.

Concerning the initial low percentage of ROP between 1993 and 1997, it could be due to the high mortality of extremely preterm infants; therefore, they did not reach the ambulatory KMCP assessment. Conversely, the increase in the proportion of autoregressive ROP can be explained by an increase in the survival of the most immature children over the years. Currently, there has been a general reduction in severe cases (surgery or blindness) probably due to improved oxygen therapy in NICUs.

Frequencies of refractive defects indicate how premature children show variations in their refractive development. As the ocular cavity grows, refractive defects are corrected. Nonetheless, some children will require correction with lenses. It is clear that an uncorrected myopic child will be delayed in processes such as crawling and walking. There is evidence that underweight, prematurity and ROP are associated with refractive errors, particularly myopia and astigmatism.[35–38]

In recent years, we have achieved a decrease to 1% in hearing deficits. This has been probably accomplished by improving prenatal screening for early TORCH detection (Toxoplasmosis, rubella, cytomegalovirus, herpes simplex and other congenital infections), better use of aminoglycosides and timely treatment of hyperbilirubinemia.

It is interesting to see how duration of the neonatal stays in the NCUs, especially for the youngest (≤32 weeks GA), has not changed much over the years. We believe that this is because they reflect the time necessary for the baby to mature and be ready for discharge. On the other hand, aspects such as the shorter stay in the NICU for those ≧33 weeks GA, the reduction in the use of invasive ventilation and IVH in all GAs, but mostly in the ≤32 weeks GA group (18.7% to 3.1%) show an improvement in the Colombian kangaroo babies' neonatal care.

Regarding nutrition, infants ≤32 weeks GA continue with a low proportion of EBF at discharge. This particular aspect of the NCUs could be improved by keeping units and lactation centres open 24×7 and the promotion of breast milk banks.

In general, IUGR percentages have been reduced over the years. Specifically, the 33–36 weeks GA group dropped by 50%. This also reflects an improvement in mothers' prenatal controls and nutrition, in addition to the timely decision of the moment of delivery, when the fetus stops growing, thus avoiding health and neurodevelopment risks associated with IUGR. For EUGR, we observed a decrease by more than half, both in those ≤32 weeks GA, the group most susceptible to present this entity, and in those between 33 and 36 weeks. There has been a sustained median of 6–10 days of parenteral nutrition in the most immature group since 2008 (≤32 weeks), which reflects the possibility of improving nutrition for these more vulnerable infants. More work remains to be done on monitoring aspects such as trophic nutrition initiation and enteral progression.

The high rate of OD infants at KMCP entry in Bogotá could be related to early home discharge in KP with oxygen and perhaps, the city's altitude (2600 m above sea level).

In Colombia the mortality of the most immature children has changed between 1998 and 2021. The KMCPs started to receive in 1998 infants with early discharge in KP with ambulatory oxygen due to the confidence of the professionals in the follow-up performed in these programs and at the same time the most immature children started to survive but with a more aggressive handling which was reflected in the peak of BPD in 2008 which went down progressively because of therapeutic advances (eg, less mechanical ventilation and fewer perinatal infections). Additionally, with the nutritional strategy of promoting and supplementing breast feeding when necessary, even the most immature Kangaroo babies with BPD, followed up in the three KMCPs of excellence, achieved an anthropometric growth similar to patients without BPD.[22]

The KMC follow-up strategy, applied rigorously and consistently, provides the same benefits for preterm or LBW infants, regardless of their socioeconomic status. We inferred this from the analysis performed according to Colombia's multiple health insurance systems. Although it is demanding for families and healthcare providers, compliance with KMC guidelines is high, and the results are gratifying.

Our different descriptive analyses allowed the creation of the KMC guidelines published by the Colombian Ministry of Health in 2014 and then updated in 2017.[4 39] These guidelines contain the minimum activities required in a KMCP. In Colombia, the KF trained more than 60 KMCPs throughout the country, including three KMC centres of excellence (two in Bogotá and one in Medellin). In Bogotá, there are 17 KMCPs, which offer 98% access to KMC in a city of more than 8 million inhabitants. As described in the Ministry of Health guidelines, health insurances are responsible to support the minimum set of KMC activities and, so far, for the sustainability of the KMCPs.[2]

Twenty years after the first RCT on the KMC method, we conducted another study with the re-enrolled sample to evaluate the persistence of benefits in adolescence and young adulthood. This study showed that KMC participants had fewer severe neurological abnormalities, were less aggressive, impulsive and hyperactive. Brain volumes were higher in the KMC group, correlated with the duration of KP. Additionally, family changes were a noticeable effect of KMC, which appear to reduce contextual disparities and increase the chance that a child would be stimulated.[12 16]

The data obtained on immediate KMC at home show that the eligible population is made up of 87% of babies ≧35 weeks GA with fewer risk factors; this may make them suitable for a faster discharge because of immediate stabilisation. It is essential to insist that despite these facts, these are late preterm and term infants with IUGR that require strict follow-up. With the multidisciplinary follow-up performed in the KMCPs, this group had similar growth and neurodevelopment to those who remain hospitalised but with the benefit of 72% of EBF at 40 weeks GA.

Associated with the COVID-19 pandemic, we observed an increase in the proportion of EBF after the discharge of kangaroo babies, more than doubling at 6 months CA in all groups. Additionally, there was a decrease in readmission, probably related to the home isolation measure, the feeling of mothers about protection through EBF and the use of protective measures for respiratory infections.

This study has the limitation of being a general description of the patients followed, where definitive conclusions on the effects of some interventions cannot be drawn, but it does allow us to generate hypotheses to be confirmed with analytical studies over time, as mentioned above.

## CONCLUSION

We created a broad database, which allowed periodic analysis of the quality of prenatal control, the preterm or LBW infants' health status during hospital stay and the quality of KMC over time, based on a Colombian population. We show that progress in perinatal care and KMCPs strict follow-up could explain the improvement observed in infants' overall health. Monitoring these outcomes is challenging but guarantees high-risk infants' care with equity and quality in this healthcare system. Colombian's experience in KMCPs follow-up is an example for other LMICs, and we believe its replication could bring these benefits to all KMC candidate infants worldwide.

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