The Turkish Journal of Pediatrics 2024; 66: 275-286
https://doi.org/10.24953/turkjpediatr.2024.4551

Original Article

Has the COVID-19 pandemic negatively impacted children's development? An assessment of the neurodevelopment of premature babies born during the pandemic

Emel Ömercioğlu[1], Ece Naz Mert Karakaya[1], Gökçenur Özdemir[1], Buse Şencan Karakuş[1], Şeyma Kılınç[1], H. Ceren İskender[1], Ebru Cihan Çam[1], Ayşe Mete Yeşil[1], Hasan Tolga Çelik[2], Sevilay Karahan[3], Elif N. Özmert[1]

[1]*Division of Developmental Pediatrics, Department of Pediatrics, Faculty of Medicine, Hacettepe University, Ankara;* [2]*Division of Neonatology, Department of Pediatrics, Faculty of Medicine, Hacettepe University, Ankara;* [3]*Department of Biostatistics, Faculty of Medicine, Hacettepe University, Ankara, Türkiye.*

ABSTRACT

Background. Pandemics, such as COVID-19, have the potential to adversely affect children's development due to a variety of negative factors at the level of children, families, and services. In this study the effect of the pandemic on the cognitive, language and motor development of premature babies who are among the most vulnerable group, were evaluated.

Methods. The study included 236 premature infants who were followed at Hacettepe University Department of Developmental Pediatrics. The Bayley-Third Edition Developmental Assessment (Bayley III) was used to evaluate the neurodevelopment of 152 premature infants from the pre-pandemic group and 84 from the post-pandemic group at the corrected age of 18–24 months. The perinatal and sociodemographic risks were also evaluated.

Results. No difference in Bayley III scores (cognitive, language, and motor) was found between the pre- and post-pandemic groups. Furthermore, the multivariate covariance analysis displayed that regardless of the pandemic, infants with higher maternal education consistently scored higher in the cognitive, language, and motor domains; and the motor area scores of infants with moderate perinatal risk were also significantly higher than infants with high perinatal risk.

Conclusions. It is crucial to monitor the development of vulnerable children who encounter developmental risks, such as premature babies. Fortunately, no significant effect was encountered during the COVID-19 pandemic. However, this does not underweigh the need for close supervision in extraordinary circumstances. Additionally, it should be noted that severe postnatal comorbidities, perinatal risks, and social factors, such as maternal education level, interact to influence the neurodevelopmental outcomes of preterm infants.

Key words: COVID-19, premature babies, neurodevelopment, impacts.

The World Health Organization declared the COVID-19 outbreak as a pandemic on March 11, 2020, after the detection of the first case in early December 2019 in Wuhan, China.[1] Stress caused by isolation measures; school closures; restricted access to health and rehabilitation services; changes in daily routines, increased screen time, fewer physical activities; parent job losses, and increased domestic stress could be listed as negative factors at the level of children, families, and services, particularly for the health and development of the children, who are among the most vulnerable groups in a

✉ Emel Ömercioğlu
emelomercioglu@gmail.com

Received 20th Mar 2024, revised 8th May 2024, 18th May 2024, accepted 22nd May 2024.

pandemic.[2,3] In fact, this process has been more challenging for children with special needs and their families.[4]

Restrictions caused by the pandemic have reduced access to primary healthcare and interrupted the follow-up of healthy children and pregnant women.[5] Research conducted at the beginning of the outbreak indicated that High-Risk Infant Follow-Up (HRIF) programs also needed to be enhanced since they were unable to provide effective treatment during the pandemic.[6] Furthermore, stress, anxiety, and depression symptoms were more prevalent both during the prenatal and postpartum periods in women who were pregnant during the pandemic.[7,8] On the other hand, several studies have shown that, due to pandemic measures like closures and working from home, the amount of time children spend with their parents has increased. Whereas some research suggests that children who spent more time with their parents exhibited positive learning behaviors and experienced fewer anxiety symptoms, other studies indicate that the reverse may be true due to the increased stress and chaos in the home.[9] Consequently, in the light of the bioecological framework, the pandemic processes have the potential to influence children's development with changes in the context of the parents' mental health, the home environment, family relationships, social environment, and community characteristics.[10] The COVID-19 pandemic and child development studies have resulted in a range of findings. Shuffrey et al. found that 6-month-old term infants had lower scores in gross motor, fine motor, and personal social domains compared to the historical cohort group, and it was presumed that this could be due to pandemic-related stressors or maternal anxiety during pregnancy.[11,12] In another study, comparing 6-month-old and 1-year-old term birth children who participated in neurodevelopment assessments between March 1 and May 15, 2020, in China, and a historical cohort of the same ages found that infants' development at 6 months did not differ from that of the pre-pandemic group, but that delays in communication and fine motor skills were present in the post-pandemic group of 1 year old infants.[13] In the study by Lau et al., it was discovered that there was no difference in the neurodevelopmental outcomes of premature infants at 2 years of age prior to and following the COVID-19 pandemic.[14] Nevertheless, the literature on this topic contends that long-term follow-up may reveal different developmental patterns and that initial findings do not always indicate long-term outcomes.[11,15]

There is a lack of research on the effects of the COVID-19 pandemic's altered social and environmental circumstances on the neurodevelopmental traits of premature infants. Environmental and social factors can play a protective role in preterms' neurodevelopmental trajectories; some studies show that the impact of perinatal risk factors fade over time.[16,17] However, it was found in a study comparing the influence of biological and social factors on the long-term outcomes of extremely preterm children that early neonatal complications continued to predict outcomes into adolescence and some social variables assumed increasing importance in later years, but most of them did not diminish or exceed the significant biological associations.[18] As with all the families of all the risky children monitored in our developmental pediatrics clinic throughout the pandemic, the parents of premature babies reported they reduced hospital visits due to concerns about possible COVID-19 transmission. Patient administrations were limited for the first six months, from March 2020 until October 2020, as a result of the COVID-19 cases that started to appear in Türkiye and the implementation of strict restrictions. In the first year of the pandemic, the referral pattern had caught up to the pre-pandemic period.[19] It is critical to add to the body of literature to evaluate the neurodevelopmental status of premature infants who already have developmental risks in the long-term follow-up after the pandemic. The present study aimed to evaluate the cognitive, language, and motor development of preterm infants at 18-24 months of age born and raised during the pandemic restrictions in comparison to their counterparts born and assessed prior to the pandemic.

Materials and Methods

Participants

This retrospective study was conducted at the Hacettepe University Division of Developmental Pediatrics and the Ethics Committee of Hacettepe University approved this study (GO 22/828). The study included all 236 infants with gestational age below 37 weeks who were followed at the Developmental Pediatrics outpatient clinic between January 2018 and August 2022 and whose developmental assessments were performed using the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley III) when their corrected age was between 18-24 months. The study excluded premature infants with visual and hearing impairments, as well as those who had a diagnosis or suspicion of autism spectrum disorder (Figure 1). The focus of the study was the effect of the pandemic scenario on development, instead of the consequences of the virus and disease, therefore premature babies who had intrauterine exposure to COVID-19 were not included in the study.

Republic of Türkiye Ministry of Health reported its first case of the COVID-19, on March 11, 2020. As was the case around the globe, numerous closure measures, lockdowns, and school closings were also implemented. Gradual normalization began as of May 2021, and many restrictions had been removed as of July 2021.[20] In a study in which we investigated the referral trends during the COVID-19 pandemic at the Hacettepe University Division of Developmental Pediatrics, as of July 2021, our referral trend had caught up to the pre-pandemic period.[19]

The Department of Developmental Pediatrics provides services to families and children based on family-centered strategies. The primary patient group is children aged between 0 and 6 years who have developmental risks and delays, genetic syndromes, and chronic diseases. A multidisciplinary, structured high-risk infant

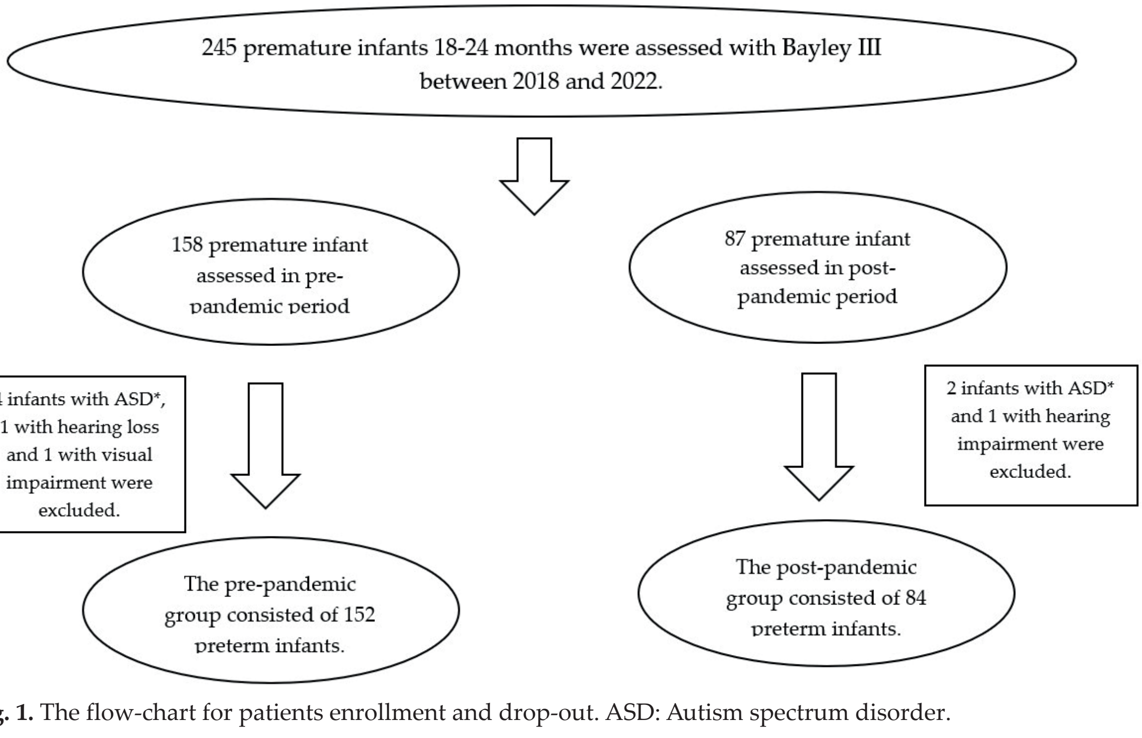

Fig. 1. The flow-chart for patients enrollment and drop-out. ASD: Autism spectrum disorder.

follow-up program is carried out by specialists from neonatology, physical therapy and rehabilitation, and developmental pediatrics for preterm infants, which constitute a sizable portion of our patient population. Based on the perinatal and social risks, patients are evaluated every three to six months with their parents. At each visit, developmental tests are carried out, risk and protective factors for development are discussed, and the necessary interventions are implemented.

While the difference between the pre- and post-pandemic groups was taken to have an effect size of 0.4, it was determined that, with 80% power and 5% type 1 error levels, 149 premature cases should be included in the pre-pandemic group and 75 premature cases in the post-pandemic group to detect a change of 5 points in Bayley III scores. The pre-pandemic group consisted of 152 premature babies evaluated between January 2018 and December 2019, whereas the post-pandemic group consisted of 84 premature babies born between March 2020 and December 2020 who had not been exposed to intrauterine COVID-19 and whose developmental evaluation was completed by August 2022. After this date we did not include any more premature babies, as the pandemic restrictions had become minimal after this date.

Evaluation tools

The sociodemographic data and the mothers' Edinburgh Postnatal Depression Scale (EPDS) results were obtained from the patient files. Child health status including infant gestational age, birthweight, multiple birth, Apgar score, duration of Neonatal Intensive Care Unit (NICU) stay, severe hyperbilirubinemia, small for gestational age (SGA) or large for gestational age (LGA), additional systemic illness including congenital heart diseases and metabolic, neurological or genetic disorders, bronchopulmonary dysplasia (BPD), retinopathy of prematurity (ROP), intraventricular hemorrhage (IVH), periventricular leukomalacia (PVL), respiratory distress syndrome (RDS), necrotizing enterocolitis (NEC), mechanical ventilation during NICU stay, mechanical ventilation duration, and presence of severe sepsis were all reviewed from the patient files and medical records. Infants' health status were classified as high moderate or low risk according to the Turkish Neonatal Society (Supplementary Table I) guidelines.[21]

The Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III)

The Bayley III is one of the most widely used and reliable developmental assessment tool in the world, evaluating cognitive, language, and motor development in children aged 1–42 months. The Bayley-III has acceptable levels of reliability (test-retest reliability > 0.67; internal consistency > 0.86) and concurrent validity compared to numerous developmental diagnostic tests for American children.[22] It is age-normed and has a standard deviation (SD). Each case's distribution for the sum of scaled scores is converted to composite scores (mean = 100, SD = 15). The developmental evaluation of all infants was conducted by the same experienced child development specialist.

Statistical analysis

IBM SPSS Version 22.0 was used to perform the statistical analysis. The numerical variables were summarized as mean, SD or median [min-max], whereas categorical variables were reported as frequencies and percentages. In continuous variables, the differences between the groups were determined by an independent samples t-test or Mann-Whitney U test as appropriate. The Pearson chi-square test was used to determine these differences for categorical variables. A multivariate analysis of covariance (MANCOVA) is a statistical procedure used to analyze the relationship between multiple dependent variables and one or more independent variables while controlling for the influence of covariates. The Bayley III composite scores were utilized for this covariance analysis. The effect of groups (preterm infants born pre-pandemic vs. during pandemic) on child development domains assessed by Bayley III was examined using the MANCOVA, which controlled the covariance of biological (child's age, birth weight, gestational age, and perinatal risk) and environmental (mother's working status and maternal educational level) variables. The homogeneity of variance-covariance matrices and multivariate normality were satisfied, which is a prerequisite for the MANCOVA. A p-value of less than 0.05 was considered significant.

Results

The demographic features of the two groups (pre-pandemic and post-pandemic born premature infants) are presented in Table I. The post-pandemic group had higher birth weight, gestational age, and child age at developmental assesments. In terms of perinatal risk factors, premature infants in both groups were comparable. Except for maternal employment status, there was no difference between the two groups' sociodemographic traits (Table I). Table II provides a detailed breakdown of the Bayley III results, which were applied in both groups when the corrected ages of the prematures were between 18 to 24 months.

Table I. Sociodemographic and clinical characteristics of the pre-pandemic and post-pandemic groups.

	Pre-pandemic group (n=152)	Post-pandemic group (n=84)	p value
	Median (min-max) / n (%)	Median (min-max) / n (%)	
Child age (months)[a]	18.55 (17.50-22.30)	20.00 (17.50-24.00)	**0.000**
Gestational age (weeks)	32 (23-36)	32.82 (24-36)	**0.004**
Birth weight (gram)	1755 (620-4430)	1895 (600-4100)	**0.024**
Infants' perinatal risk			0.163
Low risk	15 (9.8)	14 (16.6)	
Moderate risk	55 (36.1)	34 (40.4)	
High risk	82 (53.9)	36 (42.8)	
Maternal age	32 (21-50)	22 (22-50)	0.552
Maternal education			0.111
≤High school	61 (42.7)	44 (53.7)	
>High school	82 (57.3)	38 (46.3)	
Paternal age	34 (25-51)	35 (26-50)	0.752
Paternal education			0.630
≤High school	65 (45.5)	40 (48.8)	
>High school	78 (54.5	42 (51.2)	
Maternal Edinburg postpartum depressive symptoms score	7 (1-25)	6 (1-20)	0.062
Number of children at home	2 (1-4)	2 (1-4)	0.417
Number of family members	4 (1-7)	4 (3-6)	0.573
Birth order of the child	1 (1-4)	2 (1-4)	0.126
Mother's working status			**0.002**
Employed	54 (37.8)	15 (18.3)	
Unemployed	89 (62.2)	67 (81.7)	
Father's working status			0.689
Employed	142 (99.3)	81 (98.8)	
Unemployed	1 (0.7)	1 (1.2)	

[a]:Corrected age at which developmental assessment was performed were given

Table II. Bayley III scores in the pre-pandemic and post-pandemic groups.

	Pre-pandemic group (n=152)	Post-pandemic group (n=84)
	Mean ± SD (range)	Mean ± SD (range)
Cognitive composite score	93.61±10.72 (60-125)	93.98±11.18 (55-115)
Language composite score	88.31±11.35 (56-118)	88.76±12.95 (53-121)
Motor composite score	90.02±9.75 (46-110)	93.48±12.27 (46-124)
Cognitive scale score	8.72±2.14 (2-15)	8.79±2.23 (1-13)
Language scale score	15.93±3.89 (5-26)	16.09±4.43 (4-27)
Receptive language scale score	8.36±2.20 (2-14)	8.32±2.65 (1-15)
Expressive language scale score	7.57±1.99 (1-13)	7.76±2.03 (2-13)
Motor scale score	16.69±3.22 (2-23)	17.81±4.07 (2-28)
Fine motor scale score	9.04±1.85 (1-13)	9.54±2.14 (1-13)
Gross motor scale score	7.62±1.76 (1-10)	8.24±2.26 (1-16)

In order to accurately interpret the differences in neurodevelopment scores between premature infants following the pre-pandemic period and those born during the pandemic, covariance analysis was performed by controlling group differences (mean birth weight, age at assessment, gestational age, maternal employment status). The first model included the statistically significant factors described in Table I. As one of the strongest predictors of development, the perinatal risk status was also incorporated into the model. The perinatal risk level x group interaction effect was also added to the model to examine its significance. Finally, Model 1 (Supplementary Table IIa) included the following variables: group (pre-post pandemic), mean birth weight, age at assessment, gestational age, maternal employment status, perinatal risk level, and perinatal risk level x group interaction effect; and it revealed that, regardless of the pandemic, the mother's employment status had a positive impact on the cognitive development of premature infants (p=0.002, Supplementary Table IIa, IIb). Since the mother's employment status could be related to her education level and its protective effect on the development of the children was already known, Model 2 was then created by including maternal educational level (Supplementary Table IIIa). According to the analysis's Model 2, which was similar to Model 1 except for maternal employment status substituted with maternal education Bayley scores in the cognitive, language, and motor domains were found to be significantly higher in infants born to mothers with a high school or higher education level (respectively; p=0.000, p=0.000, p=0.000, Supplementary Table IIIa, IIIb). In the final model, birth weight and gestational age (Supplementary Table I), which have previously been used to assess perinatal risk status, were excluded. The final model's findings, presented in Table III, indicate that maternal education level has a positive impact on the neurodevelopmental outcome of infants (Table III, Supplementary Table IVa). The perinatal risk status was only associated with motor outcome (p = 0.043) (Table III, Supplementary Table IVb), and motor area scores of infants with moderate perinatal risk were significantly higher than those of infants with high perinatal risk (p = 0.037) (Supplementary Table IVc).

Discussion

The fact that the majority of studies on the early developmental effects of the COVID-19 pandemic have mostly been based on parent reporting has commonly drawn criticism.[7,11,15]

Shuffrey et al. revealed that they had more delays in gross motor, fine motor, and personal social development in the Ages and Stages Questionnaire (ASQ) filled out by parents compared to the pre-pandemic period.[11] According to Huang et al., there was no difference in the development of 6-month-old term-born infants who were assessed by clinic staff using the ASQ compared to the pre-pandemic period. Besides that, delays in fine motor and communication areas were found in children at one year of age in the study's follow up.[13] A recent meta-analysis investigating the neurodevelopmental effects of COVID-19 in infancy reported that overall neurodevelopment in the first year of life was not changed by either being born or raised during the SARS-CoV-2 pandemic or by gestational exposure to SARS-CoV-2. The limitations of the research, as stated by the authors, include the use of the ASQ for developmental evaluation, which was mainly filled out with parental reports, and the focus on the pandemic's impacts exclusively in the first year of life.[23] This study, using an objective tool, Bayley III, for the developmental assessment of children aged 18-24 months and constituting a pure group of premature infants, will provide an important contribution to a yet not much studied area. No significant difference in neurodevelopment was detected compared with the pre-pandemic period. The neurodevelopmental results of two-year-old

Table III. Covariance analysis of the factors effecting Bayley III composite scores.

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	cognitive scores	3282.866a	7	468.981	4.779	0.000
	language scores	3032.084b	7	433.155	3.472	0.002
	motor scores	2388,413c	7	341.202	3.478	0.002
Groups (pre-post pandemic)	cognitive scores	22.372	1	22.372	0.228	0.634
	language scores	35.921	1	35.921	0.288	0.592
	motor scores	217.144	1	217.144	2.214	0.138
Perinatal risk level	cognitive scores	348.693	2	174.346	1.777	0.172
	language scores	124.664	2	62.332	0.500	0.608
	motor scores	626.219	2	313.110	3.192	**0.043**
Age at assessment	cognitive scores	179.222	1	179.222	1.826	0.178
	language scores	16.990	1	16.990	0.136	0.712
	motor scores	129.942	1	129.942	1.325	0.251
Perinatal risk level x group interaction effect	cognitive scores	282.811	2	141.406	1.441	0.239
	language scores	247.281	2	123.640	0.991	0.373
	motor scores	93.506	2	46.753	0.477	0.622
Maternal education level	cognitive scores	2684.902	1	2684.902	27.360	**0.000**
	language scores	2701.255	1	2701.255	21.650	**0.000**
	motor scores	1212.617	1	1212.617	12.362	**0.001**

a: R Squared = 0.140 (Adjusted R Squared = 0.110), b: R Squared = 0.106 (Adjusted R Squared = 0.075), c: R Squared = 0.106 (Adjusted R Squared = 0.075), p<0.05 is significant infants born before and after the pandemic weren't distinct, according to a current investigation that only examined preterm babies.[14]

The relationship between modifications in the neurodevelopment of premature babies and environmental factors, including maternal education, the number of children living at home, parents' stable union, the knowledge and experience of parents, parent-child interaction, and parental mental health, has been demonstrated in recent research.[16,24,25] The pandemic raised stress levels among parents, and especially in women who were pregnant during the pandemic, stress, anxiety, and depression symptoms were more prevalent in both the prenatal and postpartum periods.[7,8] In a study conducted following a previous disaster, it was found that these effects, which were associated with parental stress in children's development at 6 months of age in problem solving and personal social skills, vanished with responsive parental care at 30 months.[26] The maternal Edinburgh postpartum depressive symptoms scores in this study did not significantly differ between the groups. This could be attributable to the mothers in the study not having COVID-19 during pregnancy, the fact that they gave birth in a tertiary hospital and were monitored, or other protective factors. On the other hand, research conducted throughout the pandemic period has indicated an increase in the amount of time parents spend with their kids, which may have given rise to opportunities to improve parent-child interactions.[9] Despite the enormous difficulties the pandemic brought, social changes like having older siblings at home, parents working from home, and the opportunity to spend more time with the family may have lessened the effects of pandemic-induced stressors on young children.[7,27]

Another issue is that the pandemic reduced access to healthcare services and interrupted well-child follow-up. This precludes the diagnosis of developmental delays and referral to early intervention programs for children.[28] However at Hacettepe University Divison of Developmental Pediatrics where the study was conducted developmental pediatricians continued developmental evaluations of the premature babies and gave recommendations based on those assessments. Although early intervention services were unavailable during closures and strict social restrictions, families were informed of developmentally urgent situations throughout the visits and home based development promotion activities. Follow-up care for premature infants in a developmental pediatric outpatient clinic may have been a protective factor that could have had a positive impact on the infants' development. The detrimental effects of this process on children can be mitigated by improving health care services that were interrupted during the pandemic.

The protective effect of maternal education level on the neurodevelopment of premature infants at 18 to 24 months, regardless of the pandemic, is one of the study's key findings. Children of highly educated mothers tend to benefit from greater exposure to stimulating learning opportunities; education can enhance mothers' ability to be sensitive and nurturing with their children as well as increase the likelihood that mothers enroll their young children in early childhood education programs.[29] The high biological risks associated with preterm birth, however, may mitigate the beneficial effects of environmental factors on developmental outcomes. It is now widely known that brain injury and neurodevelopmental problems are related, but less is known about how experiences and the environment affect these relationships.[30,31] In the study by Joseph et al., it was demonstrated that, regardless of the gestational age of extremely preterm infants, a high maternal education level is significantly correlated with neurocognitive skills at the age of 10 years.[30] Another comprehensive study found that preschool-aged premature children with higher maternal education had better cognitive and motor skills. Furthermore, the link between brain injury and poor cognitive outcomes in children born preterm was attenuated in children born to mothers of higher education level.[31] In contrast, Doyle et al. found that among extremely preterm survivors, perinatal biological risks persisted with negative associations with cognitive and academic outcomes until adolescence, and some social variables, like maternal education, assumed increasing importance in later years but mostly did not diminish or exceed the significant biological associations.[18] Despite these variations in studies, it is widely accepted that social and biological factors interact to influence how premature infants develop.

The long-term neurodevelopmental outcomes of preterm infants are known to be adversely impacted by postnatal comorbidities like infections, low arterial pH of umbilical cord blood, prolonged mechanical ventilation, ROP, BPD, severe IVH, PVL, and brain injury. As the gestational week and birth weight decrease, these risks rise.[16,18,31,32] The majority of the comorbidities mentioned in the literature are included in the high-risk group of the perinatal risk classification used in this study, and as a result, the motor development scores of high-risk premature infants were significantly lower than those of moderate-risk infants. Furthermore, the cognitive and language developmental scores fell as the perinatal risk level increased, though this trend was not statistically significant. In a current study that was similar to our study, the perinatal risks of premature babies born at 25–35 weeks of gestation and the results of the Bayley III evaluation at 36 months were assessed, and it was found that high-risk perinatal circumstances were associated with lower motor scale scores.[33] In the study by Lean et al., it was demonstrated that among very preterm children, medical risk was related to motor outcome at 5 years, and neonatal white matter abnormalities predicted worsening cognitive and motor development. The neural networks that support the development of motor skills mature in infancy, making them more susceptible to biological insults during the neonatal period compared to later developing cognitive and language networks. This may explain how medical risks of infants affect motor skills.[25] The motor scores of the low-risk infant group, on the other hand, were not significantly higher than those of the moderate and high perinatal risk groups in the study. The small number of infants at mild risk may be responsible for this. It could also be because mild motor delays in these infants go unnoticed or are not referred to services for early intervention. It has been emphasized in the literature that the rate of referral of late-term and low-risk preterm infants to early intervention services is lower than that of low gestational weeks and that these infants' developmental risks and delays should be closely monitored.[34,35]

One of our study's strength is that, unlike previous research, we focused on the pandemic's impact exclusively on the development of premature infants. Furthermore the study addressed significant risk and protective factors that may influence the developmental evaluation results of babies, such as perinatal risks, sociodemographic characteristics, and maternal postpartum depression. A confounding factor was also removed as the babies were not exposed to intrauterine COVID-19. Another strength is that we assessed children between the ages of 18 and 24 months, which will produce more reliable results in terms of developmental outcomes than the studies in the literature that look at the effects of the pandemic on younger children's development. Additionally, this study is valuable in that it eliminates biased results based on parental reports as the developmental assessments were conducted by skilled specialists using the Bayley III, a dependable and objective tool.

The most significant limitation of our study is the lack of data on other family dynamics, such as parental stress and anxiety levels, self-efficacy, effective stress-coping techniques, time spent with the child at home, and financial hardships, aside from maternal postpartum depression. The study included all premature infants (except for premature infants with visual and hearing impairments and infants with an autism spectrum disorder diagnosis or suspicion) born between March 2020 and December 2020 and followed up in our developmental pediatrics clinic. However the study's single-center design and inclusion of premature babies born during the pandemic limited the number of cases included in the study. Given these limitations, it is not appropriate to generalize the research findings to all premature infants, but this study contributes to the lack of literature on this topic and highlights the need for multicenter or cohort studies.

Conclusion

Although children's developmental surveillance is always important, it becomes crucial during pandemics. Premature infants should be handled separately throughout this process, and their long-term follow-up should be maintained, as they are one of the most vulnerable groups in terms of developmental delay due to their biological and environmental risks. Additionally, it can be hypothesized that severe postnatal comorbidities, perinatal risks, and social factors, such as maternal education level, interact to affect the long-term neurodevelopmental outcomes of preterm infants.

Supplementary materials

Supplementary materials for this article are available online at https://doi.org/10.24953/turkjpediatr.2024.4551

Ethical approval

This study was approved by the Ethics Committee of Hacettepe University Faculty of Medicine (GO 22/828).

Author contribution

The authors confirm contribution to the paper as follows: study conception and design: EO, ENMK , GÖ, BSK, SK, HCİ, ECC, AMY, HTÇ, SK, ENÖ; data collection: EO, ENMK , GÖ, BSK, SK, HCİ, ECC, AMY ; analysis and interpretation of results: EO, SK; draft manuscript preparation: EO, ENMK , GÖ, BSK, SK, HCİ, ECC, AMY, ENÖ, HTÇ, SK. All authors reviewed the results and approved the final version of the manuscript.

Source of funding

The authors declare the study received no funding.

Conflict of interest

The authors declare that there is no conflict of interest.

REFERENCES

1. World Health Organization (WHO). WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. Geneva, Switzerland; March 11, 2020. Available at: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (Accessed on September 28, 2021).
2. Goldfeld S, O'Connor E, Sung V, et al. Potential indirect impacts of the COVID-19 pandemic on children: a narrative review using a community child health lens. Med J Aust 2022; 216: 364-372. https://doi.org/10.5694/mja2.51368
3. Wang G, Zhang Y, Zhao J, Zhang J, Jiang F. Mitigate the effects of home confinement on children during the COVID-19 outbreak. Lancet 2020; 395: 945-947. https://doi.org/10.1016/S0140-6736(20)30547-X
4. Mete Yesil A, Sencan B, Omercioglu E, Ozmert EN. The Impact of the COVID-19 pandemic on children with special needs: a descriptive study. Clin Pediatr (Phila) 2022; 61: 141-149. https://doi.org/10.1177/00099228211050223
5. Santoli JM, Lindley MC, DeSilva MB, et al. Effects of the COVID-19 pandemic on routine pediatric vaccine ordering and administration - United States, 2020. MMWR Morb Mortal Wkly Rep 2020; 69: 591-593. https://doi.org/10.15585/mmwr.mm6919e2
6. Panda S, Somu R, Maitre N, Levin G, Singh AP. Impact of the Coronavirus pandemic on High-Risk Infant Follow-Up (HRIF) programs: a survey of academic programs. Children (Basel) 2021; 8: 889. https://doi.org/10.3390/children8100889

7. Firestein MR, Dumitriu D, Marsh R, Monk C. Maternal mental health and infant development during the COVID-19 pandemic. JAMA Psychiatry 2022; 79: 1040-1045. https://doi.org/10.1001/jamapsychiatry.2022.2591

8. Shuffrey LC, Thomason ME, Brito NH. Improving perinatal maternal mental health starts with addressing structural inequities. JAMA Psychiatry 2022; 79: 387-388. https://doi.org/10.1001/jamapsychiatry.2022.0097

9. Zhang X. Caregivers' perceived changes in engaged time with preschool-aged children during COVID-19: familial correlates and relations to children's learning behavior and emotional distress. Early Child Res Q 2022; 60: 319-331. https://doi.org/10.1016/j.ecresq.2022.03.001

10. Bronfenbrenner U. Ecology of the family as a context for human development: research perspectives. Dev Psychol 1986; 22: 723–742. https://doi.org/10.1037/0012-1649.22.6.723

11. Shuffrey LC, Firestein MR, Kyle MH, et al. Association of birth during the COVID-19 pandemic with neurodevelopmental status at 6 months in infants with and without in utero exposure to maternal SARS-CoV-2 infection. JAMA Pediatr 2022; 176: e215563. https://doi.org/10.1001/jamapediatrics.2021.5563

12. Wood ME, Delgado M, Jonsson Funk M. Understanding the effects of the COVID-19 pandemic on infant development-the preterm problem. JAMA Pediatr 2022; 176: e215570. https://doi.org/10.1001/jamapediatrics.2021.5570

13. Huang P, Zhou F, Guo Y, et al. Association between the COVID-19 pandemic and infant neurodevelopment: a comparison before and during COVID-19. Front Pediatr 2021; 9: 662165. https://doi.org/10.3389/fped.2021.662165

14. Lau M, Kraus V, Schulze AF, Rausch TK, Krüger M, Göpel W. Observational study on the neonatal outcome during the COVID-19 pandemic in Germany. Acta Paediatr 2023; 112: 1892-1897. https://doi.org/10.1111/apa.16873

15. Wenner Moyer M. The COVID generation: how is the pandemic affecting kids' brains? Nature 2022; 601: 180-183. https://doi.org/10.1038/d41586-022-00027-4

16. Valentini NC, de Borba LS, Panceri C, Smith BA, Procianoy RS, Silveira RC. Early detection of cognitive, language, and motor delays for low-income preterm infants: a brazilian cohort longitudinal study on infant neurodevelopment and maternal practice. Front Psychol 2021; 12: 753551. https://doi.org/10.3389/fpsyg.2021.753551

17. Linsell L, Malouf R, Morris J, Kurinczuk JJ, Marlow N. Prognostic factors for poor cognitive development in children born very preterm or with very low birth weight: a systematic review. JAMA Pediatr 2015; 169: 1162-1172. https://doi.org/10.1001/jamapediatrics.2015.2175

18. Doyle LW, Cheong JL, Burnett A, et al. Biological and social influences on outcomes of extreme-preterm/low-birth weight adolescents. Pediatrics 2015; 136: e1513-e1520. https://doi.org/10.1542/peds.2015-2006

19. Omercioglu E, Mete Yeşil A, Avcı H, Ozmert EN. Gelişimsel pediatri bilim dalina yönlendirilme eğilimlerinin incelenmesi ve Covid-19 pandemisinin etkisi. Poster session presented at: 66. Türkiye Milli Pediatri Derneği Kongresi; 2022 Oct 5-9; Turkish Republic of North Cyprus.

20. Republic of Türkiye Ministry of Interior. A circular on gradual normalization measures was sent to 81 governorship. February 20, 2023. Available at: https://www.icisleri.gov.tr/81-il-valiligine-kademeli-normallesme-tedbirleri-genelgesi-gonderildi (Accessed on February 27, 2023).

21. Acunaş B, Uslu S, Baş AY. Turkish Neonatal Society guideline for the follow-up of high-risk newborn infants. Turk Pediatri Ars 2018; 53: S180-S195. https://doi.org/10.5152/TurkPediatriArs.2018.01817

22. Bayley N, Infant S. Bayley Scales of Infant and Toddler Development, Third Edition. APA PsycTests; 2005. https://doi.org/10.1037/t14978-000

23. Hessami K, Norooznezhad AH, Monteiro S, et al. COVID-19 pandemic and infant neurodevelopmental impairment: a systematic review and meta-analysis. JAMA Netw Open 2022; 5: e2238941. https://doi.org/10.1001/jamanetworkopen.2022.38941

24. Bills SE, Johnston JD, Shi D, Bradshaw J. Social-environmental moderators of neurodevelopmental outcomes in youth born preterm: a systematic review. Child Neuropsychol 2021; 27: 351-370. https://doi.org/10.1080/09297049.2020.1861229

25. Lean RE, Paul RA, Smyser TA, Smyser CD, Rogers CE. Social adversity and cognitive, language, and motor development of very preterm children from 2 to 5 years of age. J Pediatr 2018; 203: 177-184.e1. https://doi.org/10.1016/j.jpeds.2018.07.110

26. Austin MP, Christl B, McMahon C, et al. Moderating effects of maternal emotional availability on language and cognitive development in toddlers of mothers exposed to a natural disaster in pregnancy: the QF2011 queensland flood study. Infant Behav Dev 2017; 49: 296-309. https://doi.org/10.1016/j.infbeh.2017.10.005

27. Thomason ME. Standards for objectivity and reproducibility in high-impact developmental studies-the COVID-19 pandemic and beyond. JAMA Pediatr 2022; 176: 227-228. https://doi.org/10.1001/jamapediatrics.2021.5168

28. Irwin M, Lazarevic B, Soled D, Adesman A. The COVID-19 pandemic and its potential enduring impact on children. Curr Opin Pediatr 2022; 34: 107-115. https://doi.org/10.1097/MOP.0000000000001097

29. Cuartas J. The effect of maternal education on parenting and early childhood development: an instrumental variables approach. J Fam Psychol 2022; 36: 280-290. https://doi.org/10.1037/fam0000886

30. Joseph RM, O'Shea TM, Allred EN, Heeren T, Kuban KK. Maternal educational status at birth, maternal educational advancement, and neurocognitive outcomes at age 10 years among children born extremely preterm. Pediatr Res 2018; 83: 767-777. https://doi.org/10.1038/pr.2017.267

31. Benavente-Fernández I, Synnes A, Grunau RE, et al. Association of socioeconomic status and brain injury with neurodevelopmental outcomes of very preterm children. JAMA Netw Open 2019; 2: e192914. https://doi.org/10.1001/jamanetworkopen.2019.2914

32. Hee Chung E, Chou J, Brown KA. Neurodevelopmental outcomes of preterm infants: a recent literature review. Transl Pediatr 2020; 9: S3-S8. https://doi.org/10.21037/tp.2019.09.10

33. López-Hernández ÁM, Padilla-Muñoz EM, Duque-Sánchez C, Lanzarote-Fernández MD. Influence of perinatal complications on the development of a sample of 36-month-old premature infants. Infant Behav Dev 2021; 62: 101507. https://doi.org/10.1016/j.infbeh.2020.101507

34. Kalia JL, Visintainer P, Brumberg HL, Pici M, Kase J. Comparison of enrollment in interventional therapies between late-preterm and very preterm infants at 12 months' corrected age. Pediatrics 2009; 123: 804-809. https://doi.org/10.1542/peds.2008-0928

35. Woythaler M. Neurodevelopmental outcomes of the late preterm infant. Semin Fetal Neonatal Med 2019; 24: 54-59. https://doi.org/10.1016/j.siny.2018.10.002