



## Has the COVID-19 pandemic influenced the neurological development of children?

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### Key words:

- Behavioural disorder
- COVID-19
- Developmental language disorders
- Neurodevelopmental disorders
- Psychomotor disorder

### Abstract

The COVID-19 pandemic caused a change in social interactions that may have had an impact on children's neurodevelopment. We carried out a cohort study including all children born in the years 2017 and 2020 in the Autonomous Community of Aragón (Spain), with a sample of 21 484 patients; comparing the neurodevelopmental disorder diagnoses coded in two groups of patients (born pre- and post-pandemic). We found an increased risk of neurodevelopmental disorder in children born in 2020 compared to children born in 2017, which was statistically significant in the areas of language and behaviour.

### Palabras clave:

- COVID-19
- Trastorno de la conducta
- Trastorno de la psicomotricidad
- Trastorno del lenguaje
- Trastorno del neurodesarrollo

### Resumen

La pandemia por COVID-19 ha provocado un cambio en las interacciones sociales que puede tener repercusión en el neurodesarrollo de los niños. Se realiza un estudio de cohortes en el que se incluye a todos los niños nacidos en los años 2017 y 2020 en la Comunidad Autónoma de Aragón (España), siendo la muestra de 21 484 pacientes; y se realiza una comparativa de los diagnósticos de trastorno del neurodesarrollo codificados en los dos grupos de pacientes, nacidos pre y pospandemia. Se observa un aumento de riesgo de padecer un trastorno del neurodesarrollo en los nacidos en el año 2020 frente a los nacidos en el año 2017, siendo estadísticamente significativo en las áreas del lenguaje y de la conducta.

## ¿Ha influido la pandemia por COVID-19 en el desarrollo neurológico de los niños?

### INTRODUCTION

The recent COVID-19 pandemic brought a change to social life, limiting interpersonal contact and changing the shape of social interactions. This social isolation applied to all subsets of the popula-

tion, and vulnerable groups were most affected. Childhood, especially in the first years of life, is characterised by rapid psychomotor and neurologic development that may be affected by changes in social interaction; if social interaction decreases, so do the stimuli that facilitate

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development, thereby limiting it, and delays in development that may or may not be clinically significant may ensue.

The growth and development of the nervous system can be divided in 4 main areas:

1. Fine and gross motor skills.
2. Language.
3. Social interaction and activities of daily living.
4. Cognition.

The preschool period of childhood (<5 years) is a highly sensitive period for the development of cognitive ability, characterised by rapid social, psychomotor and language development.<sup>1</sup> Developmental disorder is a broad concept defined as any deviation in neurodevelopment below  $-1.5$  standard deviations from the mean expected for the age.<sup>2</sup> The prevalence in the paediatric population is estimated at 16%. Neurodevelopment must be assessed in routine paediatric check-ups by qualified providers. The opinions and concerns of parents should be taken into account in the assessment of neurodevelopmental disorders, as in 60% of cases, the problem is first suspected by the family.<sup>3</sup>

The most frequently identified neurodevelopmental disorder in early childhood is language delay, with a described prevalence greater than 15%.<sup>4</sup> Language development is influenced by a variety of factors: anatomical, cognitive, affective and social, among others. A decrease in interpersonal interaction and stimuli in early childhood, both in the preverbal and the verbal stage, can contribute to the development of expressive language delay. It is believed that language delay is due to slow development of expressive language skills, probably due to a maturational delay.

The literature on the trends in the risk of neurodevelopmental disorders in children born during the COVID-19 pandemic is scarce. A literature search yielded 3 studies that analysed neurodevelopmental disorders in children born during the pandemic, comparing them to prepandemic cohorts,<sup>5-7</sup> and a meta-analysis that assessed the risk of

neurodevelopmental disorder based on having been born before or during the pandemic.<sup>8</sup> We also found 2 studies that compared the risk of developmental disorder based on whether the mother had a history of diagnosis of COVID-19 during pregnancy or not; the study conducted by Wu *et al.* did not find differences between the two groups,<sup>9</sup> while the study conducted by Cheng *et al.* did find differences, although only the differences in fine motor skills were statistically significant.<sup>10</sup> All authors concluded that more studies with a longer followup are required to obtain adequate data and be able to draw valid conclusions, although the 3 studies identified in the search found an increased risk of neurodevelopmental disorders in children born during the COVID-19 pandemic, chiefly involving the areas of language and social interaction and communication.

At present, there is a dearth of published research analysing the impact of the change in social interactions stemming from the COVID-10 pandemic on child neurodevelopment. Further research is required to draw conclusions and develop prevention and early intervention plans.

## OBJECTIVES

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- To analyse whether social isolation resulting from the COVID-19 pandemic had an impact on psychomotor and neurologic development in children, focusing on infancy and early childhood (0-3 years).
- To determine which area of neurodevelopment was most affected in children born in 2020.

## METHODS

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We conducted a retrospective cohort study by retrieving the diagnostic codes related to neurodevelopmental, language and psychomotor delay. We collected data for children born in 2017 and in 2020, including the diagnoses coded through December 2019 and December 2022, respectively.

Thus, we obtained data on neurodevelopmental outcomes before the pandemic and after the beginning of the pandemic.

The data were collected from the Big Data Sanitario de Aragón (BIGAN) regional health database. Prior to initiation, we obtained the approval of the Research Ethics Committee of the Autonomous Community of Aragón (CEICA).

We included the diagnostic codes corresponding to:

- Language delay
- Motor skill delay.
- Behavioural disturbances in child.
- Behavioural disorder in child.
- Language impairment in child.
- Language disorder.
- Learning disorder.

After entering the data, we used the SPSS software to carry out a statistical analysis, starting with a descriptive analysis of each cohort, grouping children by birth year. Later on, we conducted a comparative analysis of the cohorts. With this approach, we assessed whether there were significant differences in psychomotor and neurodevelopmental outcomes in children born before the pandemic compared to children born during the period that encompassed the lockdown and reduced social interaction.

## INCLUSION AND EXCLUSION CRITERIA

**Inclusion criteria:** child born in 2017 or 2020 in the Autonomous Community of Aragón and registered user of the regional public health system.

**Exclusion criteria:** children who were not registered users of the regional public health system.

## RESULTS

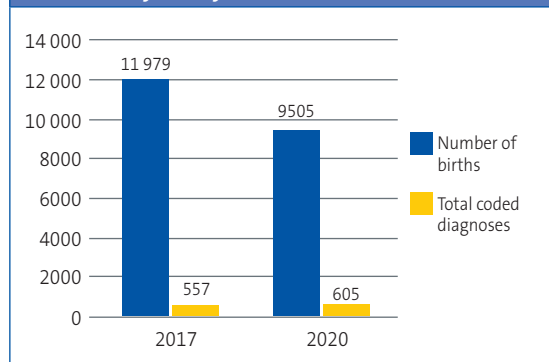
### Prevalence of neurodevelopmental disorders

The sample included 11 979 children born in 2017 and 9505 born in 2020, for a total of 21 484 births

in these two years in the Autonomous Community of Aragón, who were subsequently registered in the public health system of the region. For the cohort of children born in 2017, we included all the coded diagnoses recorded through December 2019; and for the cohort of children born in 2020, the codes recorded through December 2022. During these periods, a total of 1162 instances of neurodevelopmental delay or disorder were documented in the primary care health record database. **Figure 1** presents the distribution of births and the number of diagnoses recorded each year.

We classified the coded diagnoses into 4 areas: language, motor skills, behaviour and learning (**Table 1**). In the prepandemic cohort, the overall prevalence of neurodevelopmental disorders in any area of development coded in the health records was 4.6%, compared to 6.3% in the pandemic cohort. We also found an increased prevalence in children born in 2020 when we classified the diagnostic codes by area of development: the prevalence of language disorders increased from 2.2% in children born in 2017 to 3.4% in children born in 2020; the prevalence of motor skill disorders was very similar, of 1.7% and 2%, respectively, and the prevalence of behavioural disorders also increased, from 0.5% to 0.9%. There were no differences in learning disorders, for which we only found one diagnosis in each cohort documented in the health records during the established follow-up periods. These data are presented in **Table 1**.

**Figure 1. Chart of the births and diagnoses distributed by birth year**



**Table 1. Diagnoses classified by birth year and affected area of development**

Birth year	Number of births	Total diagnoses	Language disorder diagnosis	Motor skill disorder diagnosis	Behavioural disorder diagnosis	Learning disorder diagnosis
2017	11 979	557 (4.6%)	286 (2.2%)	209 (1.7%)	61 (0.5%)	1
2020	9505	605 (6.3%)	326 (3.4%)	191 (2%)	87 (0.9%)	1

### Relative risk of neurodevelopmental disorder by birth year

We analysed the data to calculate the relative risk of a future neurodevelopmental disorder based on the time of birth (prepandemic vs pandemic). The results showed a relative risk of neurodevelopmental disorders in children born in year 2020 compared to those born in 2017 of 1.369 (95% CI: 1.224-1.531;  $p < 0.001$ ). When we analysed each of the four areas of neurodevelopment separately, we found an increased relative risk in all except learning disorders. When it came to language disorders, the relative risk in the pandemic cohort was 1.437 (95% CI: 1.228-1.680;  $p < 0.001$ ); and the relative risk was even greater when it came to behavioural disorders, 1.797 (95% CI: 1.297-2.489;  $p < 0.001$ ). The relative risk of a motor skill disorder in the pandemic cohort compared to the prepandemic cohort in our sample was not statistically significant, 1.152 (95% CI: 0.948-1.399;  $p 0.155$ ). These data can be found in [Table 2](#).

### DISCUSSION

In agreement with the reviewed literature, the data in our population shows an increased risk of developmental disorder in children born in 2020,

during the COVID-19 pandemic, compared to children born in 2017. This increase in risk is more pronounced and statistically significant in the areas of language and behaviour, once again in agreement with the previous literature. The incidence of learning disorders was all but negligible in children in our sample, which can be explained by the early age at which we analysed the documented diagnostic codes in the sample, an age at which, usually, learning disorders are not yet diagnosed. The incidence of psychomotor disorders was similar, without a significant increase between patients in the two cohorts.

The prevalence of neurodevelopmental disorders observed in our sample is lesser compared to previous reports. The literature describes a prevalence of neurodevelopmental disorders of up to 16% and greater than 15% for language disorders. In our sample, the overall prevalence of neurodevelopmental in any area was 4.6% in the cohort born in 2017 and 6.3% in the cohort born in 2020. Language disorders were diagnosed in 2.2% of the children born in Aragón in 2017 compared to 3.4% of those born in 2020. These differences may be due to under-recording of these diagnoses, as a diagnosis of neurodevelopmental disorder may not be formally recorded in mild cases that do not require followup in the office or referral to speciality

**Table 2. Relative risks. Comparison with year 2016**

Compared years	RR developmental disorders overall	RR language disorder diagnosis	RR motor skill disorder diagnosis	RR behavioural disorder diagnosis
2017-2020	1.369 (1.369-1.224) [ $p < 0.001$ ]	1.437 (1.228-1.680) [ $p < 0.001$ ]	1.152 (0.948-1.399) [ $p 0.155$ ]	1.797 (1.297-2.489) [ $p < 0.001$ ]

RR: relative risk.

care. This could be one of the main limitations of our study, the under-recording and, in consequence, the underestimation of the frequency of neurodevelopmental disorders in our sample; on the other hand, this would not have a significant impact on the comparison of the two cohorts, as the bias would be present in both children born in 2017 and children born in 2020.

The COVID-19 pandemic motivated changes in social mores. There was a sudden and unexpected shift to social isolation accompanied by uncertainty and fear of contagion, disease and death. This situation led to an increase in mental health disorders, such as anxiety or depression, as evinced by multiple studies. In addition to home confinement, the COVID-19 pandemic brought employment instability, a decrease in social interaction and social and family isolation, among many other issues. All these changes in lifestyle and social life affected vulnerable groups, especially children and the elderly, more strongly. The decrease in social interaction, be it in at home, in school or in recreational settings, entailed a decrease in the stimuli that promote healthy neurologic development in children. Interactions in a restricted setting, without extended social circles, can lead to behavioural disorders, which were observed in our study. In addition, the use of face masks and decreased social contacts can delay language development in toddlers and preschool-aged children, which was also reflected in our sample. On the other hand, there is evidence of the deleterious impact of screen use on neurologic development, especially language and attention, in early childhood.<sup>11,12</sup> During the lockdown and in the later period of reduced social interaction, children were more exposed to screens, which may be one of the contributors to the increased incidence of neurodevelopmental disorders in children born during the pandemic observed in different studies.

## CONCLUSION

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The COVID-19 pandemic brought on a change in social interactions and lifestyles that may have contributed to an increase in neurodevelopmental disorders, especially in the areas of language and behaviour, as observed in the sample under study. More studies are required to gather data allowing the establishment of prevention, diagnosis, stimulation and treatment strategies in early childhood. There is evidence that delay in the detection of language disorders in early childhood may affect language acquisition and give rise to future learning difficulties in reading and writing.<sup>13</sup>

In the paediatric primary care setting, the entry point of families to the health system, we can implement the 3 levels of prevention: primary, through the management of children with risk factors; secondary, through the management of children with developmental delay to improve functioning; and tertiary, through the management of children with diagnosed impairments to improve their quality of life and that of their families.<sup>14</sup> Providers in primary care must remain vigilant to ensure early detection and intervention in order to improve outcomes in these children.<sup>15</sup>

## STUDY LIMITATIONS

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The study had a retrospective design, with the limitations that this entails.

The diagnosis of neurodevelopmental disorders may be under-recorded, especially in mild cases without close monitoring or referral to speciality care. The substantial sample size (all children born in the Autonomous Community of Aragón in 2017 and 2020), may mitigate the potential information bias caused by such under-recording. On the other hand, comparisons of the two years could be considered valid, as the bias would be present in both.

## CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare in relation to the preparation and publication of this article. The study was conducted as a master's thesis in primary care paediatrics in the programme organised by the AEPap at the Universidad Complutense de Madrid.

## AUTHORSHIP

All authors contributed equally to the development of the published manuscript.

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