


Research

Early childhood development in México before and after the Covid-19 pandemic: national results from 2018 to 2021

Francisco-Javier Prado-Galbarro¹  · Ana-Estela Gamiño-Arroyo²  · Jasmine-Rena Baldwin³ · Carlos Sanchez-Piedra⁴ 

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Abstract

Background Children were exposed to the social, psychological and academic effects of the COVID-19 pandemic. The objective of this analysis was to assess the prevalence of delayed early childhood development (ECD) among children aged 36 to 59 months in Mexico, both before (2018) and after the COVID-19 pandemic (2021).

Methods Observational study. ECD was assessed through the Early Childhood Development Index (ECDI) following the methodology of the Cluster Indicator Surveys (MICS), using data from the ENSANUT 2018–19 and 2021. Prevalences were estimated with population weights and Poisson regression models were applied to analyze association between ECD delay and covariates.

Results A total of 19.34% of children aged 36 to 59 months had ECD delay in 2018 and 18.52% in 2021. The factors associated with ECD delay in 2018 were socioeconomic status, access to at least three children's books, domestic violence, and severe functioning difficulties, and the associated factors in 2021 were sex, region, learning support, access to at least three children's books, early education attendance, being an adolescent mother, severe functioning difficulties, and the child's age.

Conclusion Factors associated with delayed ECD in Mexico changed after the pandemic: there was an increase in learning support within the family, and the impact of socioeconomic differences on ECD was reduced.

Keywords COVID-19 · Caregivers · Child development · Children · Health inequities

1 Introduction

Child development encompasses the biological, emotional, and cognitive processes that occur from pregnancy through adolescence, during which human beings progress towards increasing autonomy [1]. The first five years of a child's life are crucial to their health and well-being due to the speed of development of brain [2]. This period involves a complex interplay of neural connections, strongly influenced and shaped by experiences and the surrounding environment [3, 4]. Early childhood is crucial for governments' efforts to improve the quality of life for their populations. Governments, communities, and families have this critical window of opportunity to promote healthy child development during these early years [5, 6].

✉ Carlos Sanchez-Piedra, carlos.sanchez@isciii.es | ¹Departamento de Investigación, Hospital Infantil de México Federico Gómez, Ciudad de México, Mexico. ²Departamento de Epidemiología, Hospital Infantil de México Federico Gómez, Ciudad de México, Mexico. ³University of Illinois Chicago, Chicago, USA. ⁴Health Technology Assessment Agency, Instituto de Salud Carlos III (ISCIII), Av. Monforte de Lemos 5, 28029 Madrid, Spain.



The pandemic drastically impacted societies and economies worldwide, leading to significant disruptions in education, healthcare, and social support systems [7]. While some scientists may have predicted this catastrophe, many considered the pandemic as unforeseen [8]. The World Health Organization (WHO) released its first statement to the public in January 2020, announcing a suggestive outbreak in Wuhan, China (2020), and by the end of March 2020, the entire world began to enter into their tentative lockdowns [9]. The pandemic caused large numbers of adults to face pernicious circumstances such as isolation, feelings of loneliness, job loss, financial instability, illness and grief [10]. A KFF/CNN survey of US adults found that 90% believed that the pandemic had created a mental health crisis in the country [11].

The most negatively affected populations have been marginalized groups in society, including women and childhood [12]. Moreover, according to UNICEF, children were the hidden victims of the pandemic [13]. Regardless of experiencing lower to moderate symptoms and low mortality rates when infected by COVID-19, this population was still exposed to its social, psychological, and academic impacts. The major crises children confronted during the pandemic were an expansion in physical violence, worsened mental health, a rise in online violence, closed schools, and a surge in poverty [14, 15]. Several studies revealed that parents in the United States thought their children experienced changes to their health during the pandemic [11, 16]. While high-income countries faced significant challenges, the impact of the COVID-19 pandemic on low- and middle-income countries like Mexico was particularly severe. The World Bank Group declared that emerging nations were hit hardest by the pandemic [17]. UNICEF analyzed the impact of the COVID-19 pandemic on children and families in Latin America and the Caribbean, concluding that the pandemic had very detrimental consequences [13]. In 2020, only 47 per cent of adults in households with children were working, and 22% consumed less than 3 meals a day. Between 2021 and 2022, about 1 in 3 households were still living in survival mode, 31 per cent of households with children were not able to meet their basic needs for more than 2 weeks, 37 per cent had to rely on informal work as their main source of income, and 50% of adults in households with children and 10% of children still reduced their portion sizes of meals [13]. Furthermore, UNICEF reported more than 95 per cent of children enrolled in schools in Latin America and the Caribbean have temporarily stopped attending because of the pandemic [18].

Given the significant disruptions caused by the pandemic and the recognized vulnerability of young children, the aim of this study was to assess the prevalence of delayed ECD among children aged 36 to 59 months in Mexico, both before (2018) and after the COVID-19 pandemic (2021). We compared rates for child characteristics, maternal characteristics, household conditions, and well-being indicators, before and after the pandemic. Additionally, we aimed to understand the factors associated with ECD before and after COVID-19 pandemic.

2 Methods

This study was conducted on two nationally representative surveys called the National Health and Nutrition Survey (ENSANUT). Surveys are probabilistic, multi-stage, stratified, and clustered, representative of the national, regional, and rural/urban levels. The Ensanut 2018 survey was conducted between August 2018 and February 2019, visiting 50,654 households, with a response rate of 87%. [19]. The Ensanut 2021 survey was conducted between August and November 2021, visiting 12,619 households with a response rate of 75% [20]. Starting in 2020, the Ensanut became the Continuous Ensanut and is conducted annually with a smaller sample size compared to previous Ensanut surveys (which were conducted every five years). In this analysis, Ensanut surveys prior to 2018 and the Continuous Ensanut 2020 are not included, as they do not contain information on ECD.

The outcome variable is ECD, measured with the United Nations Children's Fund (UNICEF) Early Childhood Development Index (ECDI). For this study, a random subsample of children aged 36 to 59 months (1705 in 2018 and 1226 in 2020) was selected to measure ECDI. In 2018, ECDI measured the developmental status of children aged 36 to 59 months, which includes 10 items across four domains: language/cognitive (3 items), physical (2 items), social-emotional (3 items) and approaches to learning (2 items). Therefore, the ECDI represents the percentage of children aged 36 to 59 months who were developmentally on track in at least three of these four domains. However, the ECDI was reviewed in 2020 and is composed of 20 items covering 3 domains (learning, psychosocial well-being and health) and 12 subdomains. The 20 dichotomous questions were used to calculate a single score, with the minimum value of 1 and the maximum of 20. To determine if the development is adequate, the score obtained must be greater than or equal to the cutoff point, which by age is as follows: a child between the ages of 24 and 29 months would need to endorse at least 7 of the 20 items; 30 to 35 months—9 points; 36 to 41 months—11 points; 42 to 47 months—13 points; and 48 to 59 months—15 points. In 2022, children between 24 and 35 months were not selected, as they were not considered in the ECDI calculation in

2018. Finally, to identify girls and boys with developmental delays, the ECDI was recoded as "delayed" (code = 1) and "not delayed" (code = 0).

2.1 Covariates

Children's characteristics included as covariates were sex, age in months (36–47 months and 48–59 months), and whether he or she lived with the biological father. For the mother, mother's age at the child's birth (adolescent and adult; adolescent mother was defined as someone who was under 20 years old at the time of her child's birth) and education (primary school or less, middle school, and high school/college/university), and marital status (single, free union/married and separated/divorced/widow) and depressive symptoms (maternal indicator measured with the CESD-7 scale [21]).

Regarding household characteristics, the variables explored were: socioeconomic status (SES) was divided into low, medium, and high levels, using tertiles as cut-off points; indigenous ethnicity defined as speaking an indigenous language (Yes/No); residence area (in 2018, rural and urban; and in 2021, rural (areas < 2500 inhabitants), urban (areas \geq 2500 and areas < 100 000 inhabitants), or metropolitan (\geq 100 000 inhabitants)); and region (in 2018, four categories: North, Center, Mexico City, and South; and in 2021, nine categories).

Finally, the well-being indicators considered in the study were whether the child attended early education (percentage of children aged 36 to 59 months attending preschool education programs), had learning support, had three or more children's books at home, experienced violent discipline methods by their caregivers, whether the care was inadequate (percentage of children aged 0 to 59 months left alone and/or under the care of another child under 10 years old for at least one hour during the week prior to the survey), presence of severe functional difficulties in at least one domain (seeing, hearing, walking, fine motor coordination, understanding, being understood, learning things, playing, and, where applicable, controlling behavior).

2.2 Statistical analysis

Descriptive statistics of continuous variables (mean \pm standard deviation) and categorical variables (percentages and 95% confidence intervals) for child, maternal, and household characteristics, as well as well-being indicators, were examined in each survey. We also conducted bivariate analyses of these characteristics and indicators according to the EDC, using a chi-square test to evaluate differences between categories.

Finally (22) we adjusted modified Poisson models to estimate the factors associated with ECD delay, given that the prevalence of ECD delay exceeded 10% [22]. This method, also called the robust Poisson regression, produces more robust estimators with lower variance than the log-binomial method when sample size is moderate and prevalences are high, and results can be interpreted as risk or prevalence ratios. In addition, the robust Poisson method assumes a log-linear relationship between the prevalence of the outcome and the explanatory variables [23]. The prevalence ratio (PR) with 95% confidence intervals was presented in the table. Independent variables were included in the model if they had a p-value < 0.25 in the bivariate analysis. The models were adjusted by the same set of covariates: sex, age in months, the child lives with biological father, mother's age, maternal education, mother's marital status, SES, region, residence area, early education attendance, learning support, access to three or more children's books at home, exposed to domestic violence, Inadequate care, and severe functional difficulties.

All estimates were performed using Stata statistical software version 17.0 (Stata, Stata Corp, College Station). We used the "svy" command to account for the complex sampling design, and a p-value of < 0.05 was considered statistically significant.

3 Results

Table 1 presents the characteristics of the study population in children aged 36 to 59 months in Mexico in 2018 and in 2021. In 2018, 19.3% of children aged 36 to 59 months had ECD delay. In absolute numbers, this percentage translates into approximately 787,860 children. 49.38% of the study population were girls, 49.76% of the children were between 48 and 59 months, and 74.13% lived with biological father. 18.02% were children of mothers with primary education or less, 23.01% were adolescents, 81.99% were married or lived in free unión, and 65.14% presented depressive symptoms. Additionally, 69.78% of the children lived in urban areas, and 41.84% in households with low SES. Nationally, 67.55% attended early education, 47.47% of the children had support for learning at home, 40.44% had access to three or more

Table 1 Characteristics of the study population in Mexico

	2018 n = 1,705 (N = 4,073,006)	2021 n = 1,226 (N = 4,626,739)	p-value
Child Characteristics			
Sex			
<i>Male</i>	50.62 (46.21–55.01)	50.13 (46.32–53.94)	0.869
<i>Female</i>	49.38 (44.99–53.79)	49.87 (46.06–53.68)	
Age group (months)			
<i>36–47</i>	50.24 (46.21–54.27)	48.30 (45.10–51.51)	0.478
<i>48–59</i>	49.76 (45.73–53.79)	51.70 (48.49–54.90)	
Lived with biological father			
<i>No</i>	25.87 (22.71–29.31)	29.29 (25.88–32.95)	0.167
<i>Yes</i>	74.13 (70.69–77.29)	70.71 (67.05–74.12)	
Characteristics of the Mother			
Mother's age			
<i>Adult</i>	76.99 (72.53–80.92)	81.62 (78.48–84.39)	0.063
<i>Adolescent</i>	23.01 (19.08–27.47)	18.38 (15.61–21.52)	
Mother's education			
<i>Primary or less</i>	18.02 (15.45–20.92)	19.13 (16.23–22.40)	0.585
<i>Middle School</i>	38.2 (34.4–42.14)	35.41 (31.84–39.15)	
<i>High School/College/ University</i>	43.78 (39.76–47.88)	45.46 (41.31–49.68)	
Mother's marital status			
<i>Free union/married</i>	81.99 (78.81–84.78)	77.83 (74.4–80.93)	0.066
<i>Separated/divorced/widow</i>	11.16 (8.99–13.79)	11.85 (9.46–14.74)	
<i>Single</i>	6.85 (5.15–9.05)	10.31 (8.35–12.68)	
Depressive symptoms	65.14 (59.06–70.76)	67.13 (62.69–71.29)	0.594
Characteristics of the Home			
Socioeconomic status (SES)			
<i>Low</i>	41.84 (37.79–46.01)	41.26 (37.83–44.77)	0.046
<i>Middle</i>	36.24 (32.55–40.1)	31.12 (27.76–34.7)	
<i>High</i>	21.91 (19.02–25.11)	27.62 (23.96–31.61)	
Indigenous ethnicity			
	7.96 (6.19–10.18)	4.24 (2.86–6.25)	0.005
Region (2018)			
<i>North</i>	18.13 (16.32–20.09)		
<i>Center</i>	35.54 (31.9–39.35)		
<i>Mexico City</i>	11.68 (9.31–14.56)		
<i>South</i>	34.65 (31.49–37.96)		
Region (2021)			
<i>Pacific north</i>		7.45 (5.74–9.62)	
<i>Border</i>		12.19 (10.13–14.62)	
<i>Pacific center</i>		11.65 (9.38–14.38)	
<i>Center north</i>		13.59 (12.07–15.25)	
<i>Center</i>		10.36 (8.4–12.73)	
<i>Mexico City</i>		5 (4.22–5.9)	
<i>State of Mexico</i>		13.04 (11.05–15.33)	
<i>Pacific South</i>		15.79 (13.54–18.32)	
<i>Peninsula</i>		10.94 (9.16–13)	
Residence area			
<i>Urban</i>	69.78 (66.36–72.99)	26.19 (23.28–29.33)	
<i>Rural</i>	30.22 (27.01–33.64)	33.57 (30.7–36.57)	
<i>Metropolitan</i>		40.24 (37.13–43.43)	
Well-being Indicators			
Early education attendance	67.55 (63.65–71.23)	53.44 (49.46–57.38)	< 0.001
Learning support	47.47 (43.47–51.49)	84.01 (81–86.63)	< 0.001

Table 1 (continued)

	2018 n = 1,705 (N = 4,073,006)	2021 n = 1,226 (N = 4,626,739)	p-value
Access to three or more children's books at home	40.44 (36.81–44.18)	48.22 (44.79–51.67)	0,004
Domestic violence	69.57 (66.13–72.81)	59.11 (55.66–62.47)	< 0.001
Inadequate care	6.75 (5.08–8.93)	12.39 (10.04–15.19)	0.001
Severe functional difficulties	6.54 (4.87–8.75)	2.57 (1.76–3.75)	< 0.001
ECDI			
<i>With delay</i>	80.66 (76.54–84.20)	81.48 (78.53–84.12)	0.730
<i>Without delay</i>	19.34 (15.80–23.46)	18.52 (15.88–21.47)	

children's books at home, 69.57% were exposed to methods of violent discipline, 6.75% had inadequate care, and 6.54% presented severe functional difficulties.

However, in 2021, 18.52% of children aged 36 to 59 months had ECD delay. In absolute numbers, this percentage translates into approximately 856,724 children. 49.87% of the study population were girls, 51.70% of the children were between 48 and 59 months, and 70.71% lived with biological father. 19.13% were children of mothers with primary education or less, 18.38% were adolescents, 77.83% were married or lived in free union, and 67.13% presented depressive symptoms. Additionally, 66.43% of the children lived in urban or metropolitan areas, and 41.26% in households with low SES. Nationally, 53.44% attended early education, 84.01% of the children had support for learning at home, 48.22% had access to three or more children's books at home, 59.11% were exposed to methods of violent discipline, 12.39% had inadequate care, and 2.57% presented severe functional difficulties. There were differences in all well-being indicators between 2018 and 2021 (Table 1).

The percentage of ECD delay was 20.44% in females and 18.28% in males in 2018; in 2021, the percentage decreased in females (17.12%) and increased in males (23.77%) (Table 2). The percentage of ECD delay also increased among children who did not live with their biological father (21.69%), children in households with high SES (14.37%), children belonging to an indigenous household (27.67%), and children without support for learning at home (30.71%) in 2021 compared to 2018 (16.79%, 10.66%, 18.37%, and 21.49%, respectively). However, the percentage of ECD delay decreased in children who lived in households with low SES (22%), children who were exposed to violent disciplinary methods (18.56%), and in children of adolescent mothers (12.47%) compared to 2018 (25.75%, 22.50%, and 25.75%, respectively).

3.1 Factors associated with ECD: before and after pandemic results

Figure 1 shows the variables associated with ECD delay in 2018. Children who lived in households with high SES had lower odds of ECD delay than those in households with low SES (PR = 0.59, 95% CI: 0.35, 0.90). Children with support for learning at home had lower odds of ECD delay (PR = 0.63, 95% CI: 0.43, 0.90) than those without support. Children who were exposed to violent disciplinary methods and/or with functional difficulties had greater odds of presenting ECD delay (PR = 2.07, 95% CI: 1.36, 3.10, and PR = 2.51, 95% CI: 1.79, 3.50, respectively).

Prevalence Ratio (PR); 95% Confidence interval (CI). Values were obtained using modified poisson regression models adjusted for: sex, age in months, the child lives with biological father, mother's age, maternal education, mother's marital status, SES, region, residence area, early education attendance, learning support, access to three or more children's books at home, exposed to domestic violence, inadequate care, and severe functional difficulties.

Variables associated with ECD delay in 2021 were presented in Fig. 2. Girls had a lower risk of ECD delay than boys (PR = 0.60; 95% CI: 0.44, 0.83), and children aged 48 to 59 months had a greater risk than those aged 36 to 47 months (PR = 1.45; 95% CI: 1.06, 1.98). Children living in the Border, Center, Pacific South, and Peninsula regions had a higher risk of ECD delay compared to those in the Pacific North region. Children with functional difficulties had greater odds of experiencing ECD delay (PR = 2.26, 95% CI: 1.55, 3.30). Finally, it was observed that children who had support for learning at home (PR = 0.58, 95% CI: 0.38, 0.87), had access to three or more children's books at home (PR = 0.63, 95% CI: 0.44, 0.91), who attended early education (PR = 0.67, 95% CI: 0.49, 0.93), and children of adolescent mothers (PR = 0.58, 95% CI: 0.38, 0.87) were negatively associated with ECD delay.

Prevalence Ratio (PR); 95% Confidence interval (CI). Values were obtained using modified poisson regression models adjusted for: sex, age in months, the child lives with biological father, mother's age, maternal education, mother's marital

Table 2 Prevalence of ECD delay in children aged 36 and 59 months by survey

Child Characteristics	Without delay n = 1393 (N = 3,285,146) % (CI 95%)	ECD, 2018 With delay n = 312 (N = 787,860) % (CI 95%)	P-value	Without delay n = 1006 (N = 3,770,014) % (CI 95%)	ECD, 2021 With delay n = 220 (N = 856,724) % (CI 95%)	P-value
Sex						
Male	81.72 (77.17–85.54)	18.28 (14.46–22.83)	0.606	76.23 (71.58–80.34)	23.77 (19.66–28.42)	< 0.001
Female	79.56 (71.89–85.56)	20.44 (14.44–28.11)		86.76 (83.1–89.73)	13.24 (10.27–16.9)	
Age group (months)						
36–47	80.10 (75.77–83.83)	19.90 (16.17–24.23)	0.8	78.31 (71.44–83.9)	17.24 (13.87–21.23)	0.435
48–59	81.21 (73.14–87.28)	18.79 (12.72–26.86)		82.8 (79.64–85.55)	19.71 (15.56–24.65)	
Lived with biological father						
No	83.21 (78.35–87.15)	16.79 (12.85–21.65)	0.318	78.31 (71.44–83.9)	21.69 (16.1–28.56)	0.19
Yes	79.79 (74.4–84.28)	20.21 (15.72–25.6)		82.8 (79.64–85.55)	17.2 (14.45–20.36)	
Characteristics of the Mother						
Mother's age						
Adult	82.4 (79.09–85.28)	17.6 (14.72–20.91)	0.168	80.14 (76.45–83.38)	19.66 (16.45–23.32)	0.046
Adolescent	74.25 (59.77–84.84)	25.75 (15.16–40.23)		86.81 (80.69–91.21)	12.47 (8.30–18.33)	
Mother's education						
Primary or less	81.82 (75.51–86.79)	18.18 (13.21–24.49)	0.852	82.52 (75.30–87.97)	17.48 (12.03–24.70)	0.229
Middle School	79.51 (74.19–83.98)	20.49 (16.02–25.81)		78.58 (73.62–82.82)	21.42 (17.53–25.9)	
High School/College/ University	81.02 (71.66–87.81)	18.98 (12.19–28.34)		83.93 (78.33–88.30)	16.07 (11.70–21.67)	
Mother's marital status						
Free union/married	79.65 (74.64–83.88)	20.35 (16.12–25.36)	0.039	82.23 (79.13–84.95)	17.77 (15.05–20.87)	0.327
Separated/divorced/widow	80.44 (72.3–86.63)	19.56 (13.37–27.7)		75.5 (62.25–85.21)	24.5 (14.79–37.75)	
Single	93.03 (85.02–96.91)	6.97 (3.09–14.98)		83.65 (75.18–89.64)	16.35 (10.36–24.82)	
Depressive symptoms						
No	84.66 (78.17–89.48)	15.34 (10.52–21.83)	0.018	84.12 (77.85–88.88)	15.88 (11.12–22.15)	0.181
Yes	71.32 (59.93–80.53)	28.68 (19.47–40.07)		78.44 (72.14–83.64)	21.56 (16.36–27.86)	
Characteristics of the Home						
Socioeconomic status (SES)						
Low	74.43 (66.38–81.1)	25.57 (18.9–33.62)	0.005	78 (73.98–81.56)	22 (18.44–26.02)	0.129
Middle	82.68 (76.45–87.53)	17.32 (12.47–23.55)		82.42 (77.03–86.76)	17.58 (13.24–22.97)	
High	89.34 (84.5–92.79)	10.66 (7.21–15.5)		85.63 (78.21–90.82)	14.37 (9.18–21.79)	
Indigenous ethnicity						
No	81.63 (70.76–89.08)	19.5 (15.66–24.01)	0.827	81.99 (78.99–84.64)	18.01 (15.36–21.01)	0.083
Yes	80.5 (75.99–84.34)	18.37 (10.92–29.24)		72.33 (58.78–82.74)	27.67 (17.26–41.22)	

Table 2 (continued)

	Without delay n = 1393 (N = 3,285,146) % (CI 95%)	ECD, 2018 With delay n = 312 (N = 787,860) % (CI 95%)	P-value	Without delay n = 1006 (N = 3,770,014) % (CI 95%)	ECD, 2021 With delay n = 220 (N = 856,724) % (CI 95%)	P-value
Region (2018)						
North	85.28 (77.33–90.78)	14.72 (9.22–22.67)	0.024			
Center	86.8 (83.64–89.42)	13.2 (10.5816,36)				
Mexico City	76.18 (57.2–88.44)	23.82 (11.56–42.8)				
South	73.41 (64.7–80.62)	26.59 (19.38–35.3)				
Region (2021)						
Pacific North				89.38 (84.89–92.66)	10.62 (7.34–15.11)	0.162
Border				75.87 (64.61–84.42)	24.13 (15.58–35.39)	
Pacific Center				84.65 (73.2–91.76)	15.35 (8.24–26.8)	
Center North				85.52 (80.37–89.49)	14.48 (10.51–19.63)	
Center				77.16 (61.89–87.54)	22.84 (12.46–38.11)	
Mexico City				89.33 (79.95–94.61)	10.67 (5.39–20.05)	
State of Mexico				82.76 (74.31–88.85)	17.24 (11.15–25.69)	
Pacific South				79.74 (73.29–84.95)	20.26 (15.05–26.71)	
Peninsula				75.48 (67.89–81.76)	24.52 (18.24–32.11)	
Residence area						
Urban	80.03 (74.25–84.78)	19.97 (15.22–25.75)	0.513	78.43 (73.15–82.92)	21.57 (17.08–26.85)	0.404
Rural	82.11 (78.35–85.33)	17.89 (14.67–21.65)		82.58 (78.37–86.12)	17.42 (13.88–21.63)	
Metropolitan				82.55 (76.87–87.08)	17.45 (12.92–23.13)	
Well-being Indicators						
Early education attendance						
No	78.94 (73.07–83.81)	21.06 (16.19–26.93)	0.548	78.77 (74.55–82.46)	21.23 (17.54–25.45)	0.103
Yes	81.5 (75.32–86.42)	18.5 (13.58–24.68)		83.74 (79.23–87.42)	16.26 (12.58–20.77)	
Learning support						
No	78.51 (73.99–82.44)	21.49 (17.56–26.01)	0.317	69.29 (62.24–75.55)	30.71 (24.45–37.76)	< 0.001
Yes	83.05 (74.8–88.99)	16.95 (11.01–25.2)		83.8 (80.65–86.52)	16.2 (13.48–19.35)	
Access to three or more children's books at home						
No	76.45 (70.73–81.35)	23.55 (18.65–29.27)	0.005	76.06 (71.75–79.9)	23.94 (20.1–28.25)	< 0.001
Yes	86.91 (81.37–90.98)	13.09 (9.02–18.63)		87.3 (82.47–90.95)	12.7 (9.05–17.53)	
Domestic violence						
No	87.82 (83.07–91.37)	12.18 (8.63–16.93)	0.003	81.54 (75.88–86.12)	18.46 (14.08–23.82)	0.974
Yes	77.5 (71.93–82.24)	22.50 (17.76–28.07)		81.44 (77.86–84.56)	18.56 (15.51–22.05)	
Inadequate care						

Table 2 (continued)

	Without delay n = 1393 (N = 3,285,146) % (CI 95%)	ECD, 2018 With delay n = 312 (N = 787,860) % (CI 95%)	P-value	Without delay n = 1006 (N = 3,770,014) % (CI 95%)	ECD, 2021 With delay n = 220 (N = 856,724) % (CI 95%)	P-value
No	81.18 (76.9–84.83)	18.82 (15.17–23.1)	0.293	81.58 (78.28–84.48)	18.42 (15.52–21.72)	0.681
Yes	73.58 (56.06–85.88)	26.42 (14.12–43.94)		79.96 (72.19–85.98)	20.04 (14.02–27.81)	
Severe functional difficulties						
No	82.76 (78.50–86.32)	17.24 (13.68–21.50)	<0.001	82.15 (79.23–84.75)	17.85 (15.25–20.77)	<0.001
Yes	50.74 (36.30–65.06)	49.26 (34.94–63.70)		56.07 (38.72–72.06)	43.93 (27.94–61.28)	

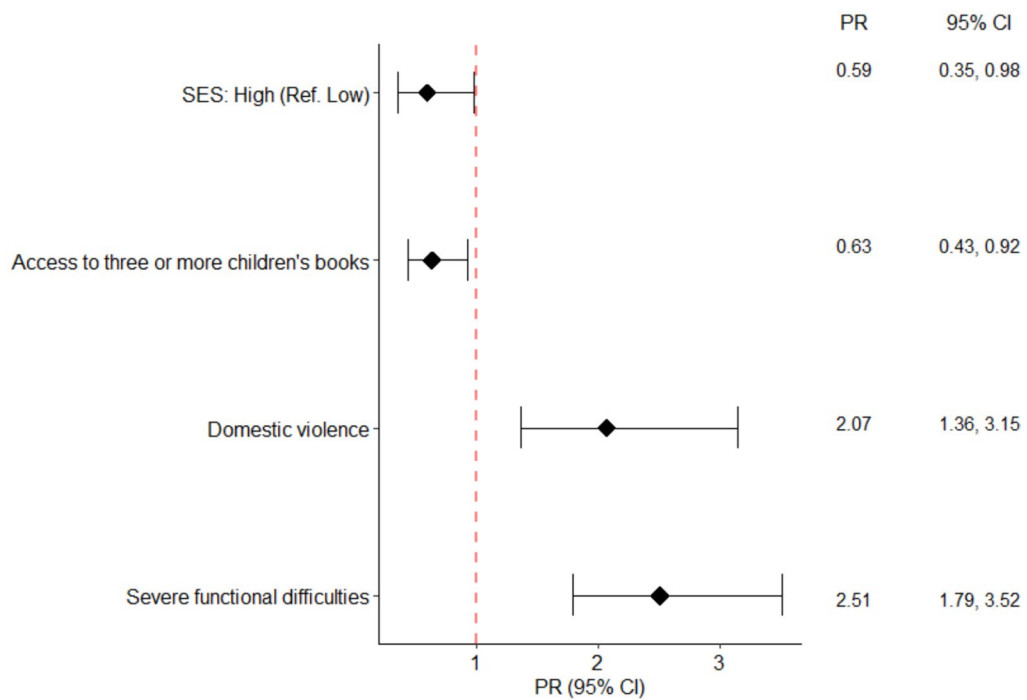


Fig. 1 Factors associated with ECD delay in Mexico (2018)

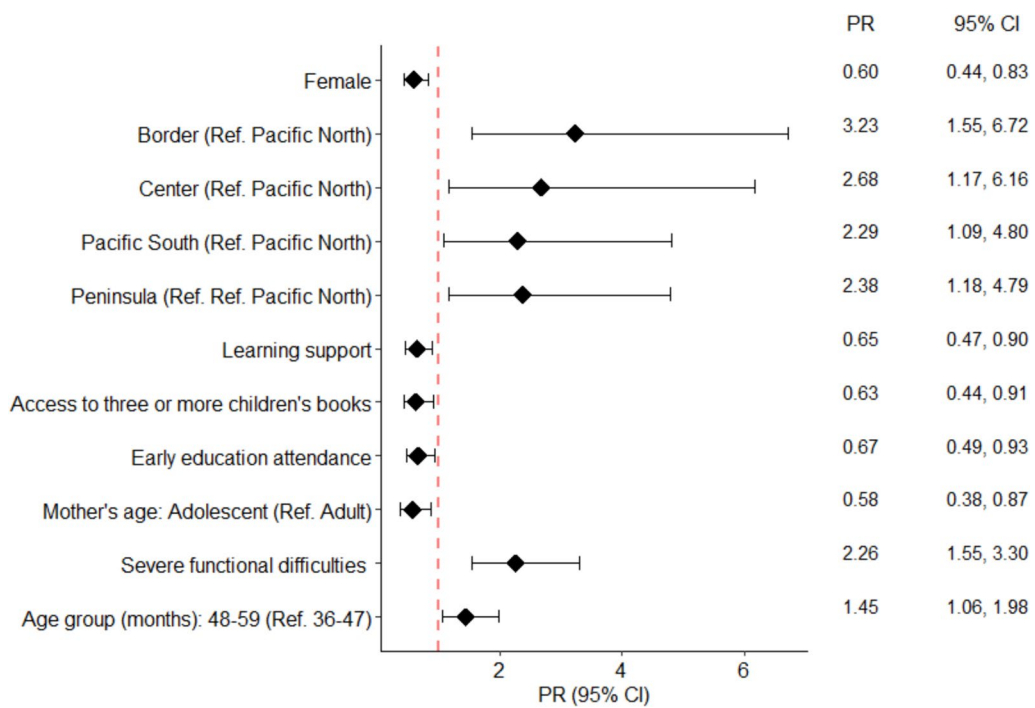


Fig. 2 Factors associated with ECD delay in Mexico (2021)

status, SES, region, residence area, early education attendance, learning support, access to three or more children’s books at home, exposed to domestic violence, inadequate care, and severe functional difficulties.

4 Discussion

In this study, we assessed factors associated to delayed ECD in Mexico before and after pandemic. The most important findings of this manuscript can be summarized as follows: (1) Overall, factors associated to delayed ECD in Mexico changed after COVID-19 pandemic, (2) an increase in support for learning within the family after pandemic, and (3) impact of socioeconomic differences on ECD seems to be reduced after pandemic.

Previous research showed the negative impact of extreme events on educational outcomes of young children [12]. Recent studies analyzed the impact of pandemic on ECD [24]. Pandemics lead to a heavy burden on the development of young children [25, 26]. We found a combination of changes in the factors associated with inadequate ECD in Mexico after pandemic. A study in Japan showed that children exposed to the pandemic were behind in ECD at age 5 years compared with those not exposed to the pandemic [27]. Responses to the COVID-19 pandemic varied widely across countries. These variations, as well as differences in socio-economic and educational contexts, could explain the different findings of the analyses carried out in different countries.

With regards to our findings, an important part of them can be explained as short-term consequences of lockdown-related measures due to COVID-19. Firstly, a decreased in early education attendance was detected. However, during the pandemic, it was a protective factor for the adequate development of girls and boys. In August 2021, the reopening of schools was announced in Mexico, starting with the regions with the lowest risk of spreading COVID-19 infection, coinciding on the date the survey was conducted. Previously, classes were held virtually, and children and parents had to use digital tools. Several studies have reported that parents had to provide support to their children, which had a positive effect on family–child relationships during the pandemic [28–30]. Thus, our findings are consistent with other studies showing the importance of parental support during the pandemic.

Secondly, studies of previous economic crises shown the impact on life-long negative effects of exposure to poverty early in life [31, 32]. However, our study showed a shift in the pattern of the socioeconomic factor after the pandemic. These findings can be explained partially due to the lockdown measures that affected all families independently of their economic status. Differences across different economic, social and political contexts could also explain this results. Finally, our analysis showed a short-term change, but it is necessary to evaluate the effect of the pandemic and the socioeconomic variable in the medium and long term.

Violence within the family has been a controversial topic. Our results show a decrease in domestic violence after pandemics. A previous analysis in Mexico found that domestic violence had decreased in children under 5 years of age and had increased in those over 5 years of age [33]. The causes that explain these changes after the pandemic are still under consideration.

Being an adolescent mother is among the main factors associated with a higher risk of ECD delay [34]. However, in our study we found that children of adolescent mothers had a lower risk of ECD delay in 2021. This finding warrants further exploration, as Mexico is a country where the family plays a crucial role in the lives of its members, and some studies have shown that the attachment of grandparents is particularly significant for both adolescent mothers and their children [35–38].

The changes detected between the different regions before and after the pandemic could also be explained by sociodemographic and economic factors, which may vary significantly across regions. Socioeconomic disparities between regions could have exacerbated or mitigated the effects of the pandemic on early childhood development. Recent studies focused on the impact of the pandemic on childhood development have demonstrated regional differences in Mexico, with some areas showing more severe effects due to pre-existing vulnerabilities, while others may have benefitted from more robust local policies or community support systems [39]. These regional differences highlight the importance of tailoring interventions to the specific needs and contexts of each region in order to effectively address the long-term consequences of the pandemic.

The impact of the pandemic on ECD is far from over, and its effects likely will be felt for several years to come. Our results provide relevant information for parents and policy makers to improve interventions to timely address severe and persistent negative impacts to the ECD. Our findings point out to an urgent need for further global research efforts on evaluating the impact of pandemic in ECD.

Our work is subject to a series of limitations. Firstly, this analysis is based on a cross-sectional design, so we cannot establish causal relationships. Moreover, this study may present reverse causality, as is probably the case of children of adolescent mothers. In any case, the analysis responds to a specific objective, it allows to assess possible changes before and after the pandemic and to generate further research hypotheses. Secondly, further disaggregation of the

data was not possible due to the sample size. Finally, the tool for calculating the ECD was modified. The ECD-2030 only allows population-level measurement of DIT for children aged 24–59 months. It has been assumed that this modification does not affect the findings obtained in this study and is methodologically suitable.

5 Conclusion

In conclusion, our findings provide valuable insights into the impact of the COVID-19 pandemic on ECD in Mexico. Notably, we observed an increase in the role of family learning support and a potential attenuation of the impact of socioeconomic disparities on ECD. These findings highlight the importance of ongoing monitoring and evaluation of children's developmental outcomes and the need for flexible and responsive interventions to support their well-being.

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Data availability Data supporting this study are openly available from ENSANUT at <https://ensanut.insp.mx/>

Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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