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Authors

Aranbarri, Aritz
Aizpitarte, Alazne
Arranz-Freijo, Enrique
et al.

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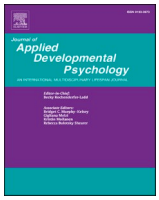

What influences early cognitive development? Family context as a key mediator.

Aritz Aranbarri [a,b,d,e,*], Alazne Aizpitarte [a,d,e], Enrique Arranz-Freijo [a,b], Eduardo Fano [a,b], Manuel Sánchez de Miguel [a,b], Aubyn C. Stahmer [c], Jesus Maria Ibarluzea [a,b,f,g]

[a] University of the Basque Country UPV/EHU, Faculty of Psychology, Tolosa Avenue 70, Donostia-San Sebastián 20018, Spain
[b] Biodonostia Health Research Institute, Epidemiology and Public Health Area, Environmental Epidemiology and Child Development Group, Doctor Begiristain St, Donostia-San Sebastián 20014, Spain
[c] The MIND Institute, University of California Davis, Collaborative START Lab, 2825 50th St, Sacramento, CA 95817, USA
[d] Hospital Sant Joan de Déu Barcelona, Child and Adolescent Mental Health Area, Psychiatry and Psychology, Sant Joan de Déu St 2, Esplugues de Llobregat 08950, Spain
[e] Institut de Recerca Sant Joan de Déu, Child and Adolescent Mental Health Research Group, Santa Rosa St 39-57, Esplugues de Llobregat 08950, Spain
[f] Health Department of Basque Government, Sub-directorate of Public Health of Gipuzkoa, Navarra Avenue 4, Donostia-San Sebastián 20013, Spain
[g] CIBER Epidemiology and Public Health (CIBERESP), Madrid, Spain

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ABSTRACT

Early cognitive development is sensitive to multiple biological, social, familial, and psychological factors. However, discerning the underlying mechanistic pathways has proved to be challenging. Using data from 506 mother-child dyads from the prospective longitudinal birth-cohort of the INMA—INfancia y Medio Ambiente—(Environment and Childhood) Project, this study aimed to test how maternal SES influences early cognitive development, examining potential mediating factors, including maternal mental health, family context, and first nursery school attendance. Results indicate that the association of maternal mental health and SES on early cognitive development is fully mediated by the quality of the family context. Nursery attendance early in life also had a full mediation effect on maternal SES. These findings suggest that epidemiological studies should consider more than SES variables when studying environmental influences on early cognitive development. Policy implications are discussed in the current context of a global likelihood of economic crises and mental health challenges.

Although considerable brain development happens prenatally, critical developmental changes in terms of brain and behavior continue to occur in the first two years of life (Andersen, 2003). Early childhood cognitive development is characterized by extensive plasticity in brain organization, during which time genetically driven brain development can be modified and influenced by the environment (Marshall & Kenney, 2009). In fact, children's cognitive development is affected by multiple biological, chemical, environmental, social, familial, and psychological factors (Walker et al., 2011).

Contemporary developmental science models, such as the bioecological model (Bronfenbrenner & Morris, 2006), provide a framework for examining the association of social-environmental factors on development. This model accounts for the bi-directional relationship between the individual child and multiple aspects of the environment, including both risk and protective factors (Woolfenden et al., 2015), such as innate biological vulnerability, as well as the quality of proximal and distal environmental factors (Walker et al., 2011). Biological determinants and environmental risk factors might include exposure to smoking and alcohol during pregnancy (e.g., Ekblad, Korkeila, & Lehtonen, 2015), low-birthweight (e.g., Scharf, Stroustrup, Conaway, & Deboer, 2016) and prematurity (e.g., Batalle et al., 2017), and lack of breastfeeding during the first year of life (e.g., Boucher et al., 2016), among others.

Proximal processes are those that directly involve the interaction between the child's own development and the environment. This might include the quality of the family context (e.g., caregiver scaffolding, availability of books and toys), the primary caregiver's mental health, and nursery school attendance. The quality and intensity of a child's

* Corresponding author at: Child and Adolescent Mental Health Research Group, Child and Adolescent Mental Health Area, Sant Joan de Déu Barcelona Children's Hospital, Passeig Sant Joan de Déu 2, Esplugues de Llobregat 08950, Spain.
E-mail address: aritz.aranbarri@sjd.es (A. Aranbarri).

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interaction with these external factors can influence learning opportunities and the acquisition of developmental skills early in life. Distal environmental factors are those that surround the family and limit its capacity to change or advance, often due to societal constraints, such as socioeconomic factors and parental education. According to the model, quality proximal processes could act as potential mediating factors in the relation between the more distal factors and early cognitive development (Woolfenden et al., 2015).

The influence of the primary caregiver's SES on early cognitive development

Socio-economic status (SES) is recognized as a multidimensional construct that has often been measured as a composite of primary caregivers' education, occupational prestige or income, or some combination of these variables. A strong body of research has associated growing up in a disadvantaged environment with poorer performance on a diverse range of cognitive skills in later childhood (e.g., Beauregard, Drews-Botsch, Sales, Flanders, & Kramer, 2018; Noble, McCandliss, & Farah, 2007). Growing up with a lower SES background, which may mean less access to fewer learning materials and enriched environments, has been associated with poorer academic achievement (Schoon, Jones, Cheng, & Maughan, 2012).

Contemporary research has included parental education as a key variable when developing a rubric of parental SES. A primary caregiver's higher level of education is often correlated with higher cognitive development in their children (Guryan, Hurst, & Kearney, 2008). Similarly, a literature review by Pace, Luo, Hirsh-Pasek, and Golinkoff (2017) reported maternal education as one of the strongest variables associated with child developmental outcomes. In the same review, SES status (including maternal education and occupation) was associated with available home learning materials and parent-child interaction style supporting early language development. Particularly, SES was associated with the quantity and quality of caregiver language input, the contingency and reciprocity of interactions, parental warmth and sensitivity, access to books, or prevalence of environmental hazards.

However, these associations may not be direct, and many other mediating factors (e.g., behavioral, psychosocial, and lifestyle factors) may influence a child's general health and development, including their cognitive development. Much is still unknown about how these pathways interact with each other.

Larrañaga et al. (2013) found that women with higher SES reported healthier habits during pregnancy, more prenatal appointments and showed lower sedentary and passive smoking behaviors. These healthy habits, potentially related to greater resources, could lead to healthier early prenatal brain development, which in turn affects early cognitive development.

Similarly, a lower SES leading to limited access to resources during pregnancy and early childhood development has been associated with lower birth-weight, dietary deficiencies, increased exposure to passive smoking and infection agents, and fewer educational opportunities (Ben-shlomo & Kuh, 2002). Thus, we consider SES as a way to represent individuals with similar levels of access to learning resources and risk associated with predictors of knowledge, exposure, and health habits (Valero, Villalbí, Borrell, & Nebot, 1996) that have the potential to affect both proximal environmental factors and early cognitive development starting with influences before birth.

SES potential mediating factors

Nursery school/childcare

Geoffroy et al. (2007) found that children living in lower resource environments, who experienced childcare early in life, tended to have receptive language skills that were indistinguishable from their counterparts living in higher resource environments. In an independent study Geoffroy et al. (2010), found a similar beneficial effect of early childcare experience on children's academic achievement at the age of 6–7 years in low-income families and mothers with lower education. In contrast, this finding was not found in children of mothers with higher education. This has been described as a potential *buffering effect* of early childhood education that may be most pronounced for children from more disadvantaged backgrounds.

Indeed, childcare attendance has been described as a critical leverage point for closing cognitive disparities caused by poorer learning environments (Berry et al., 2016). However, there are limited data examining the relationship between childcare and its beneficial effect on early cognitive development when studying general population-based families in well-resourced countries or regions.

Although research has been focused on the beneficial effect of childcare for children living in low-resourced communities, we theorize that medium-to-high SES families might also experience benefits from a structured early childcare experience. Examples of how children from higher SES families may achieve these benefits include: 1) higher maternal-SES implies a higher likelihood of both parents working, therefore may imply a higher need for external daycare and lack of time at home with caregivers, 2) families with higher maternal-SES, along with higher education levels, might be more likely seek early education for their child because they have the resources to pay for it and have an understanding of the beneficial effects of early learning environments, 3) in a general-population sample that includes high resource communities, we expect that due to the heterogeneity of the populations' parenting skills and knowledge of early development, children might benefit from attending a nursery school.

Maternal mental health

Maternal mental health, specifically maternal depression, has been associated with low SES. Similarly, different SES variables such as poverty, low maternal education, together with high stress, lack of empowerment, and poor social support, are risk factors for both poor child's cognitive development and maternal depression (Wachs, Black, & Engle, 2009; Walker et al., 2011).

Multilevel longitudinal analysis showed a stable relationship between poorer cognitive development in children of depressed mothers from infancy through toddlerhood (Liu et al., 2017). Maternal depression mediates family socioeconomic disadvantages and parenting practices affecting child development (Linver, Brooks-Gunn, & Kohen, 1999). In fact, children of depressed mothers living in low-income, high-risk urban environments are significantly more likely to exhibit behavioral, emotional, and functional problems than children living in similar settings with non-depressed mothers (Riley et al., 2009).

It is plausible to think that maternal mental health influences cognitive development via the quality of the family context (i.e., this alternative mediational path will be tested in addition to other paths in this study). To date, we do not understand the role of broader maternal mental health traits or symptoms in non-clinical populations and its potential effect on the early cognitive development of neurotypically developing children.

Quality of the family context

Developmental literature has a strong history of evidence supporting the beneficial effect of a high-quality family context on children's cognitive development regardless of family SES (Bronfenbrenner, 1979; Vygotsky, 1978). More recent data continue to support the role of family context on cognitive development (e.g., Rijlaarsdam et al., 2013; Tong, Baghurst, Vimpani, & McMichael, 2007).

In our study, "*the quality of the family context*" considers both the interaction between the family and home environment as well as the family investment model (FIM; stimulating materials, stimulating activities, emotional climate, as well as an external family, and physical

environmental organization). Because FIM requires resources to provide stimulating materials and developmentally beneficial physical space, it has been simultaneously associated with family SES (Conger & Donnellan, 2007) and can have a potential effect on stimulating children's cognitive development. This includes child cognitive-linguistic and socioemotional stimulation (i.e., through available learning materials and parent-child interaction strategies), and accounts for the protective factors that circle and organize the physical environment (e.g., Galende, de Miguel, & Arranz, 2011) and the support system of the family where the child is developing (i.e., multiple adults in the household).

Maternal caregiver behaviors (as the most frequent primary caregiver in the existing literature), such as sensitive responding and didactic interaction that stimulates cognitive and language development, are associated with children's cognitive development even after adjusting for maternal education and home adversity (Mermelshtine & Barnes, 2016). Other authors also found a consistent association between high-quality socioemotional parenting (e.g., sensitive responses, positive affect) during the first two years of life and higher child cognitive development (Cha, 2017; Mills-Koonce et al., 2015).

Recent findings reveal that developmentally stimulating parenting practices significantly mediated intervention effects on children's longer-term cognitive and socioemotional development (Jeong et al., 2019). Other intervention strategies, such as those focusing on parenting quality in low-income families, show detectable effects on cognitive development at the age of 3 (Obradovíc, Yousafzai, Finch, & Rasheed, 2016). These effects have proved to be stable over time, as well as showing an association between the family context and family SES through the first three years of life, likely due to the challenges of having limited resources (Arranz, Oliva, Sánchez De Miguel, Olabarrieta, & Richards, 2010; Lugo-Gil & Tamis-LeMonda, 2008).

It is difficult to discern the mechanistic pathways that underlie the complex effects of SES, home environment, other proximal environments (e.g., nursery schools), caregiver mental health, and parenting style on children's early cognitive development in the general population. Likely, these factors interact to facilitate or hinder early learning and development. Therefore, a comprehensive view of maternal SES and other more proximal and complex mediating pathways (e.g., family context) must be studied to understand how these factors interact to support or hinder development.

Thus far, it has been challenging to uncouple these factors in comprehensive models nested in prospective studies that integrate all these variables at once and adjust for relevant biological variables that could influence early development. It seems quite intuitive to assume that more advantaged SES will correlate with less maternal mental health challenges, higher quality of the family context (e.g., more resources to provide learning materials, less family stress), and a higher attendance to nursery school (e.g., economic resources to access non-parental daycare), generally understood as a direct effect of more resourced families. Despite the extensive literature in this matter, based on the comparison of high vs. low-resourced families, research is still limited about the interrelations between these early childhood environmental variables in medium-to-high SES population-based samples without clinical mental health challenges, and their potential effect on the cognitive development of the neurotypical children.

Present study and hypotheses

Through this study, we aimed to test the mediational pathways of how maternal SES directly or indirectly influences early cognitive development within a larger mediational model. For this, we hypothesized that SES would also be associated with a higher quality family context, fewer mental health challenges, and higher exposure to structured out-of-home childcare experiences. However, these associations could be different in high-resourced populations and could differentially influence early cognitive development in this population.

Thus, the present study extends previous research in several ways. First, we use a comprehensive measure of family context to test a theoretical explanatory model of early cognitive development, which accounts for both risk and protective factors, based on the bioecological approach (Walker et al., 2011). Second, this study is embedded in a general population birth-cohort with a prospective longitudinal design, which ensures the representativeness of the sample, high-quality data collection, and the generalizability of the results to the general population. Third, the analyses method used (i.e., Structural Equation Modeling) allows us to examine the complex interplay between biological, familial, and social factors which gives us a more comprehensive picture of how multiple factors may contribute to the children early cognitive development through different mediating pathways, and controlling for both maternal and child characteristics that affect child development. Fourth, we investigated the complex interplay of mediating pathways in a less studied medium-to-high SES European background sample, where a well-resourced general population challenges proximal environmental factors' significant role in the child's development. This may provide information for this population as well as help us understand the potential protective factors in populations with access to fewer resources. Fifth, we assessed the quality of the family context with a generationally updated scale based on a multidimensional (family and home environment interaction, together with the family investment model on child development) and multi-method approach (i.e., parent questionnaire, parent interview, direct observation parent-child interaction, and direct assessment of the available play materials and home physical environment), while prior research has relied on a single method (e.g., Observational or questionnaire-based) or instruments that had lost their ecological validity due to current standards for a high-quality family context in a medium-to-high resourced European families.

Based on the existing literature, we hypothesize a tentative explanatory model, which includes variables based on the different levels of the environmental hierarchy (i.e., proximal and distal factors). We expected that maternal mental health symptoms, the quality of the family context, and nursery attendance would mediate the associations between maternal SES and early cognitive development (see Fig. 1). We also expected maternal mental health to, directly and indirectly,influence early cognitive development. In sum, we raise the questionof how (i.e., through what mediators) maternal SES influences a child's early cognitive development. We expect that the association will be mediated by maternal mental health, the quality of the family context and nursery attendance. All these associations were controlled by several children and maternal characteristics, such as child's height at birth, child's sex, child risk factors (i.e., prematurity, low-weight birth, and non-sustained-breastfeeding), maternal age, maternal parity (number of times mother has been pregnant) and maternal prenatal consumption (i.e., smoking and alcohol).

Method

Sample and study design

The INMA project (INfancia y Medio Ambiente — Environment and Childhood project) is a multicenter prospective general-population mother-child birth-cohort study, established in several regions of Spain and following a standard protocol and study design (see more details here; Guxens et al., 2012). The project, as a whole, aims to evaluate the association of a broad spectrum of environmental exposures on fetal and infant growth, health, and development.

In this paper, we considered the INMA birth-cohort of Gipuzkoa (in the Basque Country, in northern Spain), where we added an additional follow-up, including cognitive testing at age two, together with nursery school attendance data collection and a new measurement of the quality of the family context. This birth-cohort was located in the Basque Country region, which held the third position in the Human Development Index (HDI; 0.964) world ranking (EUSTAT, 2007) during the

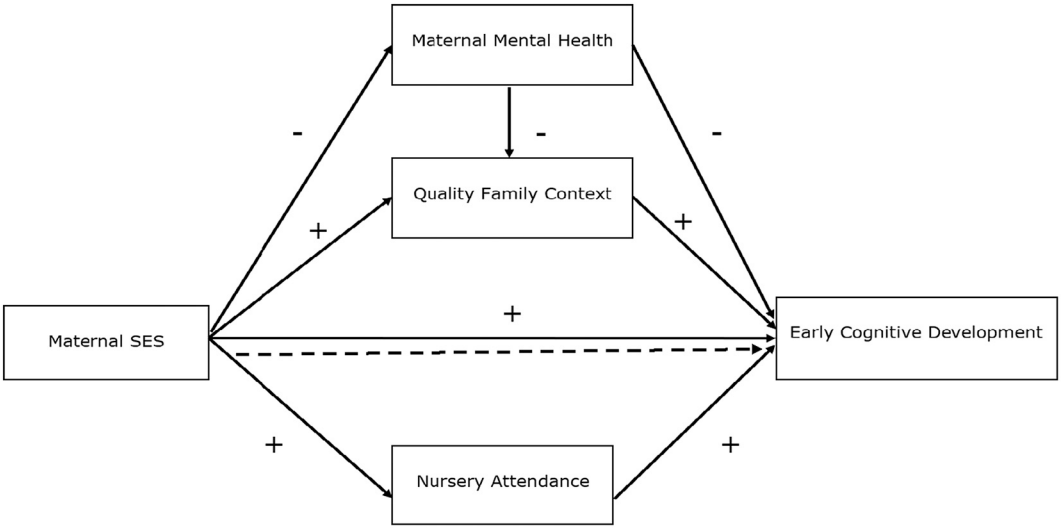

Fig. 1. The hypothesized mediation model.
Note. Model adjusted by *child's height at birth, child's sex, child risk factors, maternal age, maternal parity, maternal prenatal consumption.* The discontinuous arrow means the pathway is non-significant.

recruitment period. It is one of the wealthiest regions of Spain, representing a homogeneous and well-resourced EU population. The Gipuzkoa cohort was established between May 2006 and January 2008 in the Zumarraga Hospital, the public hospital for the study area.

Over 90% of the pregnant women in the study catchment area have their pregnancy care and give birth in the Basque Public-health system. The study was presented by the collaborating obstetrics team of the hospital to all women starting their pregnancy care at the cited hospital, and 71.4% ($N = 638$) agreed to participate and met inclusion criteria (i.e., ≥16 years of age, non-sever health challenges, intending to deliver at the referral hospital, singleton pregnancy, non-assisted conception and ability to communicate in Spanish or Basque). No sociodemographic differences were found between participating and non-participating women based on hospital records collected in the first trimester of pregnancy. We collected a signed informed consent after informing each participant of the nature, objectives, and study protocol of each follow-up. This protocol was approved by the Ethics Committee of the main hospital of the province (Donostia University Hospital), as well as by the BioDonostia Health Research Institute conducting the study. The retention rate at the time of the 2nd year follow-up was 79.3% (i.e., 506 mother-child dyads).

Measures and variables

Data included in this paper were collected during the first and third trimesters of pregnancy, at the child's birth, and when the child was 14 months and 26 months (see Table 1), where the main independent variable (maternal SES) was collected at pregnancy, and the primary outcome, at last follow up visit at age 26 months.

Maternal variables

Mothers completed three semi-structured interviews and questionnaires in the first and third trimesters of pregnancy and when the child turned 14 months. Data included sociodemographic variables, maternal age at pregnancy, and a parity and maternal health general questionnaire on the child's first birthday. We also created two composite variables representing maternal toxic consumption during pregnancy and the socioeconomic status (SES) of the mother at study entry:

Maternal socioeconomic status (SES). Maternal education and occupation were collected in the first trimester questionnaires as indicators of maternal socioeconomic status (maternal SES). The highest level of education completed by the pregnant women was grouped into three categories: 1 = *primary school* (≤11 years of education), 2 = *secondary school* (12–15 years), and 3 = *university or graduate school completed* (≥16 years).

Occupational class was defined according to the woman's occupation during the interview or just before pregnancy. The occupational class was divided into six categories: unemployed and the remaining five according to the Spanish adaptation of the British Register General's Social Class (RGSC) classification. This includes five levels from I (highest class) to V (lowest class): I = managers of companies with ten or more employees, senior technical staff, and higher level professionals; II = managers of companies with fewer than ten employees, and intermediate level professionals; III = financial management, administrative and other support staff, other self-employed professionals, supervisors of manual workers, and skilled non-manual workers; IV = skilled and partly skilled manual workers; and V = unskilled manual workers. The Spanish version of the RGSC classification was previously recommended

Table 1
Study timeline, monitoring phases and collected variables for this study in each follow-up.

Pregnancy		Birth	14 months	26 months
First trimester	Third trimester			
General study questionnaire ✓ Maternal Education ✓ Maternal occupation ✓ Maternal age ✓ Parity ✓ Smoking ✓ Alcohol	General study questionnaire ✓ Smoking ✓ Alcohol	Newborn birth records ✓ Child's sex ✓ Child's weight ✓ Child's height ✓ Weeks of gestation	Maternal health and child's food intake questionnaires ✓ Maternal mental health ✓ Breastfeeding duration	Family context and cognitive development assessments ✓ Home and family assessment ✓ Nursery attendance information ✓ Child's cognitive testing

by the Spanish Epidemiological Society (Domingo-Salvany, Regidor, Alonso, & Alvarez-Dardet, 2000) to measure social status.

For this study, a composite score of maternal education and occupation class was created as the maternal SES variable. Unemployed women scored a 1 in occupation, lowest occupational class (i.e., *V occupational class*) received a score of 2, and the highest occupational class received a score of 6 (i.e., *I occupational class*). The composite score was calculated by using the proportional weight for educational and occupational variables according to the number of categories of each variable, where higher scores indicate higher education level and more skilled occupation. For example, a woman with university level education (scored as 3) and *I occupational class* (scored as 6), would have a score of 2 [(3/3) + (6/6)], and a woman with a primary educational level (scored as 1) and unemployed (scored as 1), would obtain a score of 0.5 [(1/3) + (1/6)]. Scores range between 0.5 and 2, with higher scores indicating a higher SES.

Maternal mental health. We used the General Health Questionnaire (GHQ, Goldberg, 1972) to assess maternal psychiatric well-being at the child's birth follow-up. This is a widely used measure in research and clinical practice. For this study, we used the 12-item scale, which includes indicators of psychological stress, anxiety, lack of social skills, and psychosomatic symptoms. The response range was a 4-point Likert scale. The scores were summed up by adding all the items on the scale, with final scores having a potential range from 12 to 48. Higher scores are indicative of worse mental health.

Maternal covariates

Consumption during pregnancy. Prenatal toxic consumption included alcohol (i.e., "yes" = one drink or more per week before the assessment) and smoking (dichotomizing to yes or no), including information at both pregnancy visits. We then created a composite score summing both alcohol consumption and/or smoking (yes = 1, no = 0) during the first and third trimesters (for a possible range of scores from 0 to 4), with higher scores meaning more toxic (alcohol/smoking) regular consumption during pregnancy.

Other maternal covariates. Maternal age, parity (*primiparous* = 0, first time pregnant; *multiparous* = 1, pregnant more than one time) and maternal country of origin (Spaniards = 0; foreigners = 1) were also collected through questionnaires at the first trimester.

Child variables

Early cognitive development. The Spanish version of the Bayley Scales of Infant Development (Bayley, 1969; Bayley, 1977) was used to assess child's cognitive scores at 26 months. This instrument was selected following the INMA project general birth-cohort protocol (Guxens et al., 2012). For this study, we used the Mental Scale, which consists of 163 items that assess aspects of cognitive development and communication skills (hereafter, "Bayley Cognitive Score"). More specifically, it assesses sensory-perceptual acuity, discrimination and responsiveness to stimuli, memory capacity and "object constancy," learning and problem-solving ability, the ability to generalize and classify, and verbal communication. All assessments were performed by a highly trained developmental neuropsychologist.

Nursery school attendance/childcare. This information was reported at the 26-month follow-up, using a dichotomized variable option of attendance (1 = *attended at least one month before the cognitive testing*) or non-attendance (0 = *non-attendance or attending for less than one month before cognitive testing)* due to the lack of more precise available data on all our participants (e.g., exact start timing and school characteristics). In accordance with Basque Government 297/2002 Law of December 17, 2002 (before this study), nursery schools (private and public) for children from zero to three years of age are required to follow specific quality regulations in the Basque Country region. The primary objective of this law is to reduce inequalities among schools and reduce barriers to accessibility for all families as a fundamental right for all citizens across different SES backgrounds.

Child covariates

Children's birth information. Sex and height were directly collected from the child's hospital birth record.

Child risk. We created a child-risk composite variable that included the following dichotomous variables: Premature birth (<37 weeks gestation = risk) and low birth weight (< 2500 g = risk) according to birth hospital records, and lack of sustained breastfeeding (< 2-month duration = risk) according to child's first-year food intake questionnaire at the 14 months follow-up. All these variables were coded as dichotomous variables, 0 = *non-risk,* and 1 = *risk,* and summed into the composite variable, where higher scores indicate a higher risk.

Child's age at assessment. Child's age in months was collected on the cognitive assessment day as a control measurement for our outcome.

Family variable

Quality of the family context. Haezi-Etxadi Family Assessment Scale 2 years (HEFAS-2, current name, and abbreviation according to last publications by the authors) is a comprehensive assessment tool designed to assess the family context of two-year-old children, measuring several quality indicators (i.e., neighborhood and home characteristics and parent-child in-home interactions) with a multidimensional assessment of family context that have been associated with early development in past research. Scores are obtained through family psychologists' direct observation and caregivers' interviews and questionnaires, following a multi-method and multi-informant approach. According to the authors (see more details here; Arranz, Olabarrieta, Manzano, Martín Ayala, & Galende, 2014), this scale was developed to update the broadly used HOME Scale (Caldwell & Bradley, 2003) and the Developmental History (Pettit, Bates, & Dodge, 1997). HEFAS-2 also adds relevant items that could act as precursors of early development, such as the *potential for play*; *stimulation of cognitive development*; *emotional expressiveness*, *setting of limits and optimal frustration*, *enhancing self-esteem and autonomy*, *father's involvement*, and *relations with the school*, making the scale more sensitive and generation-specific for a wide range of socioeconomic status families.

The HEFAS-2 total score has been measured through three subscales: Stimulation of the Cognitive and Linguistic Development (33 items), Stimulation of the Social and Emotional Development (31 items), and Organization of the Social Context and Physical Environment (63 items), with the factor structure confirmed by Velasco et al. (2014). The total score used composed of a weighted scores summary (i.e., the weighting is calculated considering the number of items of each subscale) and considers the means from a different source of information (i.e., direct observation, interview, questionnaire), and informants (i.e., psychologist, mother, and father). Data for each subscale was obtained through three different methods during a 90-min home visit in every participant's household when the child was 26-month-old. For this study, we used the total score (scores ranged between 0 and 127), where higher scores represent a higher quality family context. Highly trained family psychologists performed all assessments and observations.

Recent research has shown HEFAS' reliability and factor structure that covers family context influencing child development at age 4 with HEFAS-4 (Barreto, Sánchez de Miguel, Ibarluzea, Andiarena, & Arranz, 2017; Sánchez de Miguel, Baigorri Zia, Barreto, Santa-Marina, & Arranz-

Freijo, 2020), at age 6 with HEFAS-6 (Agirregoikoa, Acha, Barreto-Zarza, & Arranz-Freijo, 2021) and at age 7 to 11 with HEFAS-7-11 (Barreto-Zarza et al., 2021).

Statistical analyses

Firstly, descriptive statistics, univariate analysis of variance (ANOVA), and bivariate correlations were computed (see Tables 2 and 3). Then, we used structural equation modeling (SEM) with Mplus 6 (Muthén & Muthén, 2010) to simultaneously test the overall set of associations among predictors, mediators, and outcomes of our hypothesized theoretical model (see Fig. 1).

Mediating variables were: 1) maternal mental health, 2) the quality of the family context, and 3) nursery school attendance. The model was adjusted by several sociodemographic, maternal, and child's biological and social characteristics collected in the first trimester of pregnancy to child's 14 months follow-up. These covariates were child's height at birth, child's sex, child risk factors (i.e., low-weight, prematurity, and no-sustained-breastfeeding), maternal age at pregnancy, maternal parity, and maternal consumption (alcohol and smoking during pregnancy).

We used the weighted least squares estimator (WLSMV) to account for the categorical mediator (i.e., nursery school attendance). We also apply the bootstrap method (500 iterations) to construct confidence intervals for the indirect effects. Missing data were handled by a full

Table 2
Descriptive statistics and mean differences on children early cognitive scores by characteristics of mothers and children (N = 506).

Variables		N (%)	Mean (SD)	Min	Max	Early cognitive development mean (SD)	*F*	*p*
Maternal								
SES composite			1.26 (0.42)	0.33	1.83			
	Education							
	Primary School	65 (12.9)				97.0 (16.5)	0.53	0.587
	Secondary School	181 (35.8)				97.0 (17.0)		
	Graduate School/Univ.	259 (51.3)				98.5 (16.8)		
	Occupation							
	I	85 (16.8)				98.0 (16.8)	2.93	0.013
	II	68 (13.5)				101.5 (15.8)		
	III	134 (26.5)				100.5 (16.7)		
	IV	146 (28.9)				95.5 (17.1)		
	V	28 (5.5)				94.5 (16.3)		
	Unemployed	44 (8.7)				93.1 (15.8)		
Mental Health			21.1 (3.3)	12	34			
Consumption pregnangy			0.21 (0.44)	0.00	2.00			
	Alcohol consumption							
	> 1 drink/week	43 (8.5)				97.4 (15.3)	0.03	0.859
	< 1 dring/week	463 (91.5)				97.9 (17.0)		
	Smoking							
	Yes	69 (13.6)				95.8 (16.0)	1.13	0.288
	No	437 (86.4)				98.1 (16.9)		
Age			31.4 (3.5)	19	43			
	≤25	20 (4.0)				93.0 (16.4)	0.92	0.431
	25–29	142 (28.1)				97.7 (16.4)		
	30–34	250 (49.4)				98.7 (16.9)		
	≥ 35	94 (18.6)				96.7 (17.4)		
Parity								
	Primiparous	278 (54.9)				99.5 (17.0)	5.86	0.016
	Multiparous	228 (45.1)				95.8 (16.4)		
	Country of Origin							
	Spanish	412 (96,5)				98.5 (16.7)	4.02	0.046
	Foreigners	15 (3.5)				89.7 (16.6)		
Child								
	Age in months at assessment		26.3 (0.6)	25	29			
Bayley Scores	Early Cognitive Development		97.82 (16.1)	52	148			
Nursery attendance								
	Yes	276 (54.5)				99.8 (16.2)	8.57	0.004
	No	230 (45.5)				95.4 (17.2)		
Sex								
	Male	243 (48.0)				94.6 (16.4)	17.71	0.000
	Female	263 (52.0)				100.8 (16.6)		
Height at birth (cm)			49.0 (1.9)	43	55			
Child Risk Composite			0.40 (0.60)	0.00	3.00			
	Prematurity							
	Yes	13 (2.6)				97.3 (17.9)	0.013	0.911
	No	493 (97.4)				97.8 (16.8)		
	Low weight at birth							
	<2500 kg	19 (3.8)				98.3 (12.4)	0.016	0.899
	Over 2500 kg	487 (96.2)				98.0 (17.0)		
	Breastfeeding							
	Yes	415 (82.0)				98.3 (16.6)	1.88	0.171
	No	91 (18.0)				95.6 (17.6)		
Family								
	Quality of Family Context		73.5 (10.4)	27	95.4			

Note. Early Cognitive Development = dependent variable; SES composite = Independent variable; Mental Health, Nursery attendance, and Family = mediators; Pregnancy consumption, Age, Parity, Height at birth, Prematurity, Low weight at birth, Breastfeeding = covariates.

Table 3
Inter-correlations between continuous variables (N = 506 mother-child dyads).

	1	2	3	4	5	6	7	8
1. Cognitive Scores	–							
2. Maternal SES	0.09*	–						
3. Maternal mental health	0.01	−0.05	–					
4. Quality family context	0.26**	0.10*	−0.14*	–				
5. Maternal age	0.01	−0.03	0.08	0.01	–			
6. Maternal consumption pregnancy	−0.02	−0.15**	−0.13	0.05	-0.03	–		
7. Height at birth	0.10*	0.03	−0.02	0.01	0.01	−0.12**	–	
8. Child risk Composite	−0.03	−0.16**	0.04	−0.07	−0.11*	0.15**	−0.23*	–

Note. Maternal SES: composite score which proportionally combines maternal occupation and education. Maternal consumption is composed of alcohol consumption and smoking during pregnancy. Child risk is a composite of prematurity, no breastfeeding, and low weight at birth. *$p < .05$, **$p < .01$, ***$p < .001$.

information maximum likelihood (FIML) estimator. This method does not replace or impute data; instead, it uses all available information to estimate the model. FIML has been shown to be a more efficient method than traditional approaches (e.g., case-wise deletion), producing unbiased parameter estimates and standard errors. To test whether the proposed hypothetical model fits data the, the following indices were considered: a) χ^2 statistic and its significance, with a non-significant value indicating good model fit; b) comparative fit index (TLI and CFI) greater than or equal to 0.95 indicating good model fit (Hu & Bentler, 1999); c) root mean square error approximation (RMSEA) with a value below 0.05 indicating good model fit (MacCallum, Widaman, Preacher, & Hong, 2001). We also reported the variance explained by the independent variables on the outcome (i.e., early cognitive development) through R^2 values. Finally, we examined the significance and magnitude of the direct and indirect effects of maternal SES on early cognitive development mediated by maternal mental health, quality of the family context, and nursery school attendance.

Results

Preliminary analyses: descriptive statistics and correlations

Analyses included data from 506 mother-child dyads from the INMA Gipuzkoa cohort. Table 2 describes the sample and the relationships between these characteristics and the dependent variable (i.e., early cognitive development). Cognitive development was assessed between 25 and 29 months of age ($M = 26.26$; $SD = 0.61$), and 52% of the sample was female. More than half (54.5%) attended nursery school before 25 months. Concerning maternal characteristics, almost the entire sample was of Spanish origin (96.5%), and almost half (49.4%) were between 30 and 34 years old and had a university level of education (51.3%). Most participating mothers (91.3%) were employed during pregnancy, with 56.8% in a skilled and non-manual occupation (class I, II, and III). Significant differences were found in several maternal and child group variables. Children whose mothers reported a skilled and non-manual occupation class, a primiparous birth, were of Spanish origin, and aged between 30 and 34 years old scored higher in early cognitive development. Concerning child variables, children who attended nursery school and were girls showed higher cognitive development. For a more detailed description, see Table 2.

Higher early cognitive development was also correlated with some maternal and child's characteristics, such as maternal SES ($r = 0.09$, $p = .036$), quality family context ($r = 0.26$, $p < .019$), and height at birth ($r = 0.10$, $p = .049$). Maternal SES also correlated with other study variables and covariates, such as quality family context ($r = 0.10$, $p = .019$), maternal alcohol and tabaco consumption at pregnancy ($r = -0.15$, $p = .001$), and child risk factors ($r = -0.16$, $p = .001$), which included prematurity, low birth weight and lack of sustained breastfeeding (see Table 3).

Structural equation modeling: mediation analysis

We conducted Structural Equation Modeling (SEM) to examine whether our explanatory model fits the empirical data. In this explanatory model, maternal SES predicted early cognitive development mediated by maternal mental health, quality of the family context, and nursery attendance (see Fig. 1). After adjusting the analyses to account for child's height at birth, child's sex, maternal age, maternal parity, maternal consumption (i.e., alcohol and smoking), and child risk (i.e., prematurity, low-weight at birth, and non-sustained-breastfeeding) all goodness-of-fit indices were good. Thus, we confirmed that the data fit well the estimated model ($\chi^2_{(2)} = 2.16$; $p = .34$; TLI = 0.98; CFI = 0.99; RMSEA = 0.01[0.00–0.09].

Results showed (see Fig. 2): a) significant direct effect of maternal SES on the quality of the family context ($\beta = 0.09$; $p = .037$), and nursery attendance ($\beta = 0.27$; $p = .000$), and no significant effects of maternal SES on maternal mental health ($\beta = -0.05$; $p = .448$) and did not have any direct effect on the early cognitive development ($\beta = 0.03$; $p = .841$); b) maternal mental health had a negative direct effect on the quality of the family context ($\beta = -0.13$; $p = .010$), but did not have a direct effect on early cognitive development ($\beta = -0.03$; *ns*); c) the direct effects of the quality of the family context ($\beta = 0.23$; $p = .000$) and nursery attendance ($\beta = 0.11$; $p = .020$) on the early cognitive development (i.e., outcome) were significant.

Also, we tested the significance and the magnitude of the direct and indirect pathways. Results showed that maternal SES did not directly affect early cognitive development ($\beta = 0.01$, $p = .839$), while the total indirect pathway between maternal SES on early cognitive development was significant ($\beta = 0.07$, $p = .010$), even after adjusting for covariates.

Thus, our results point to a full mediation model where, in this population, maternal SES is not exerting a direct influence on early cognitive development but influences through the additive effect of two out of three proposed mediating variables (i.e., quality of the family context and nursery attendance). To understand the specific mediating pathways, we analyzed the indirect effects. The quality of the family context and nursery attendance fully mediated the relationship between maternal SES and early cognitive development ($\beta = 0.02$ and 0.05, respectively). That is, the association between SES and cognitive development is solely found when we account for family context and nursery attendance.

Also, although maternal mental health did not directly affect early cognitive development ($\beta = 0.02$, $p = .51$), it exerts an influence on early cognitive development through the quality of the family context ($\beta = -0.03$, $p = .043$). Specifically, the quality of the family context fully mediates the association between maternal mental health and early cognitive development (see all in Table 4).

We also tested the model removing nursery attendance to see whether family context had a unique contribution to the model (not just in combination with nursery attendance). The results confirmed that family context significantly contributes to the total effect ($B = 0.02$; $p = .04$) without having nursery attendance as part of the total indirect effect. Using the same method, we also confirmed that nursery attendance

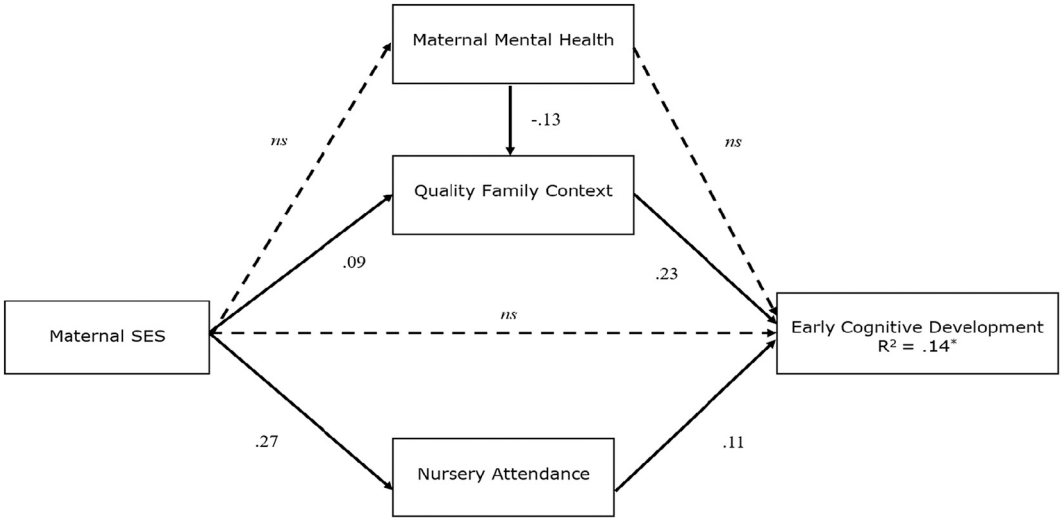

Fig. 2. Results of our explanatory model of early cognitive development ($N = 506$ mother-child dyads).
Note. Pathways with solid lines arrows are all statistically significant standardized coefficients ($p < .05$), and discontinuous arrows are not statistically significant ($p > .05$). Results adjusted by *child's height at birth, child's sex, child risk factors, maternal age, maternal parity, maternal prenatal consumption.*

Table 4
Summary of direct and indirect effects of maternal socioeconomic status on early cognitive development.

Effects	β (SE)	95% CI	*P* value
Total effect	0.08* (0.03)	[0.00 to 0.16]	0.012
Total indirect effect	0.07 (0.03)	[0.00 to 0.15]	0.010
Direct effect			
Maternal SES➔Early Cognitive Development	0.01 (0.04)	[−0.09 to 0.11]	0.839
Specific Indirect effects			
Maternal SES➔ Maternal Mental Health➔Early Cognitive Development	−0.00 (0.00)	[−0.01 to 0.01]	0.828
Maternal SES➔ Quality of the Family Context➔Early Cognitive Development	0.02* (0.01)	[−0.01 to 0.05]	0.045
Maternal SES➔ Nursery Attendance➔ Early Cognitive Development	0.05* (0.02)	[−0.01 to 0.11]	0.024
Maternal SES➔Maternal Mental Health➔ Quality of the Family Context➔Early Cognitive Development	0.00 (0.00)	[−0.00 to 0.01]	0.542
Maternal Mental Health➔ Quality of the Family Context➔Early Cognitive Development	−0.03* (0.02)	[−0.07 to 0.01]	0.043

Note. *$p < .05$, **$p < .01$, ***$p < .001$. The 95% confidence intervals for the effects are obtained using Boostrapping method.

has a unique contribution to the total effect when we remove family context from the model ($B = 0.06$; $p = .02$). As a further step, we tested the unique contribution of family and nursery separately controlled by each other, that is, we tested the family context mediating pathway adjusted by the nursery attendance and in the other way around. Both mediator variables continued to make unique contributions to the total effect ($B_{family} = 0.02$; $p = .05$; $B_{nursery} = 0.05$; $p = .04$). Overall, squared multiple correlation indices revealed that the proposed model explained 14% of the variance of early cognitive development.

Discussion

This study extends previous research examining the effect of SES on early cognitive development by accounting for the complex interplay between biological, familial, and social co-occurring risk and protective factors based on a bioecological approach. Overall, we found that maternal SES did not exert a direct influence on early cognitive development in this population-based sample, with mothers holding a medium to high education and occupation level. Instead, maternal SES indirectly influenced early cognitive development through the quality of the family context and nursery attendance. This result confirmed the presence of a full mediation between maternal SES and early cognitive development.

However, maternal SES did not influence maternal mental health, and maternal mental health did not directly affect early cognitive development but instead affected development through the quality of the family context. Below, we discuss the theoretical and applied implications of these findings.

Influence of maternal SES on early cognitive development

Although most of the recent literature supports the idea that associations between SES and early cognitive skills may imply interaction among different indirect pathways, literature in this area has primarily focused on language skills and academic achievement (e.g., Attig & Weinert, 2020; Pace et al., 2017), where much is still unknown regarding how these variables interact to influence general cognitive development. In previous studies (e.g., Beauregard et al., 2018; Noble et al., 2007), family SES background appeared as one of the strongest variables associated with early cognitive performance (specially with language skills), showing a partial mediational effect or moderator role of SES influence.

In addition, different research areas (e.g., environmental epidemiology), have traditionally used parental SES as the major covariate when adjusting for variables influencing early cognitive development, not accounting for other more proximal variables. In our findings, maternal SES (distal variable) was associated with cognitive development through family context and nursery attendance. One explanation might be due to the different types of populations traditionally studied when testing SES influences cognitive development.

The main rationale to study the SES effect on children's development in low-resourced families relies on the social influences of how family inequalities can disadvantage the next generation. However, our study focused on a well-resourced European general population with a medium-to-high SES, while referenced studies compare more extreme *low* vs. *high* SES populations. Therefore, even if our study did not test for

differences based on extreme SES groups, it did allow us to test whether a more homogeneous, and well-resourced western country-population could show enough differences on maternal mental health, family context, and nursery attendance, and still have a significant influence on cognitive development.

Our findings showed small-to-moderate effects on the outcome, even with a quite homogeneous sample. In a recent study of another European birth-cohort (Attig & Weinert, 2020), family SES did predict both mother's interaction behavior with their child (i.e., maternal sensitivity and stimulation behavior) and child's language development (i.e., vocabulary and grammar) at age two, which gets partially replicated by our findings considering language development part of the child's cognitive development. Additionally, epidemiological studies have traditionally relied on more distal environmental variables when adjusting for potential confounders, providing limited data on more proximal environmental factors.

Another alternative explanation could be based on the nature of our SES-composite variable. Maternal education and occupational class represent more than just the economic resources of the family household. We had no direct information about family income, which could lead to a misinterpretation of our results, as a low maternal SES could be supported by general family income or other economic resources.

In general, extended scientific literature considers occupational class a good approximation of family resources. However, our SES composite variable could instead be a proxy for a parent's ability to provide stimulating materials, a strong learning environment, and higher maternal self-efficacy in infant care, as a continuum effect of parental adult learning effect through education and followed by the occupational learning experiences.

A recent longitudinal study (Zheng, Morrell, & Watts, 2018) and a very recent cross-sectional study (Liu, Zhang, & Jiang, 2020) support this idea. In the longitudinal study, maternal education and occupational class were associated with maternal self-efficacy in infant care during early life. In the cross-sectional study, the strongest mediation pathway was shown for paternal education effects on child's cognitive development mediated by parental self-efficacy. Similarly, Larrañaga et al. (2013), found that women with higher education and occupational class showed healthier behaviors in all pregnancy-health related domains, which may predict a healthier pregnancy, better biological outcomes of child development, and followed by more skilled parental practices, based on access to education regarding child development, associated with higher cognitive development of their children.

One of the strengths of this study is that we adjust for the biological characteristics of the child (e.g., prematurity, low birthweight) or the mother (e.g., maternal age) when studying social-environmental factors that support cognitive development. This is relevant to discern the SES effect among related biological factors that might strongly affect development (Ekblad et al., 2015).

In our sample, both maternal consumption during pregnancy (i.e., smoking and alcohol) and child's risk factors (i.e., prematurity, low birthweight, and lack of sustained breastfeeding) correlated with maternal SES. In contrast, maternal education and occupational class were closely linked to maternal age, which in turn, has been associated with higher pregnancy risk and worse overall developmental outcomes for early childhood. Thus, these factors may need to be adequately adjusted to correct for the potential confounding effect and correctly understand the effect of complex mediating environmental variables. After adjusting for the cited confounders our study showed that the primary caregiver's educational and occupational social class represented by the maternal SES had a small-to-moderate effect on the outcome through two out of three mediating pathways.

Influence of maternal mental health on early cognitive development

Contrary to our expectations, we did not find a significant association between maternal SES and maternal mental health status, nor did maternal mental health mediate the relationship between maternal SES and early cognitive development. This may be due to the low variability in both variables (i.e., maternal SES and maternal mental health), as our general population-based cohort was not characterized by neither low educated families nor by mothers with clinically diagnosed mental health issues.

Maternal mental health did exert an influence on early cognitive development, fully mediated through the quality of the family context. That is, higher endorsement of maternal mental health concerns is related to a lower quality family context, which, in turn, is associated with a lower child's early cognitive development. This result is supported by a population-based study (Comaskey et al., 2017), where results indicated that language and cognitive development were influenced by maternal depression and anxiety disorder through the mediating role of the family context. Another recently published 16-year longitudinal study (Wu et al., 2018) found that familial emotional investment and availability of learning-materials mediated the association between maternal depression and early cognitive development in all ages.

Additionally, a study of 2-years old children exposed to poor maternal mental health has shown that family support in the form of a higher quality of the family context acts as protective factor to child's early development (McDonald, Kehler, & Tough, 2016). When we pull the evidence from depressive symptoms (considered the most prevalent maternal mental health issue), we find that depression can lead to withdrawal and lack of sensitivity of mothers' responsiveness to infants' developmental needs, decreasing early learning opportunities, as well as persistent loss of interest in daily activities that may also reduce mothers' motivation to play or interact with their child (Caughy, 2009).

Although our mental health measurement through the General Health Questionnaire is not a diagnostic tool, it does capture mental health general well-being. Over 90% of the pregnant women in the study received their pregnancy care and gave birth in the public health system, from which we deduced that a sample-based in the general population is mainly healthy. Thus, our study contributes to the limited knowledge regarding the influence of subclinical maternal mental health symptoms (i.e., not as a clinical diagnosis) on early child cognitive development, when both the mothers and the children are pulled from the general population.

The mediating role of child's proximal developmental contexts

In early life, the child's proximal developmental contexts are mainly composed of the home environment and childcare, which in our study, fully mediated the relation between maternal SES and child's early cognitive development. Besides, the quality of the family context also mediated the maternal mental health effect on early cognitive development. That means the quality of the family context is key to early cognitive development above and beyond SES and across the general-population mental health spectrum.

There is an assumption that a more advantaged SES-background is linked with an increased likelihood of having a more enriched home and community environment, but this does not explain the entire heterogeneity of family characteristics and the family's specific capability to support the child's cognitive development.

In our study, the quality of the family context included a comprehensive assessment of facilitative and protective factors in the organization of the social context and physical environment which had shown to be relevant in early development (Galende et al., 2011). This multidimensional measure captured critical ingredients for a child's cognitive development, such as sensitive responses to the child, didactic cognitive and language stimulation, parenting positive affect, caregiver scaffolding, and characteristics of the physical home environment that promote early stimulation opportunities. The comprehensive nature of the assessment may explain the strength of the relationship with cognitive development.

These results are consistent with studies comparing the positive effects of positive parenting and quality mother-child interaction across cultures, countries, and families (Pastorelli et al., 2016). Interventions that improve child development also conclude that children's cognitive development were greater when the intervention improved the environment and promoted parent-child interaction as compared to those based only on economic, nutrition, and health issues (Schady, 2011). Across SES and cultures, access to learning materials, caregiver responsiveness, and interaction have been shown to have active elements to facilitate toddlers' cognitive development (Pace et al., 2017).

When studying caregiver's SES and mental health influence on cognitive development, we should account for the child's learning opportunities via cognitive, linguistic, and socioemotional stimulation of their proximal familial context, as well as the protective and risk factors, even when studying more advantaged medium-to-high SES populations.

Nursery attendance also fully mediated the relationship between maternal SES and early cognitive development. That is, higher maternal SES was related to attending formal nursery school (e.g., linked to pedagogically stimulating context and early socialization processes), resulting in a higher early cognitive development of the infant. These findings suggest that nursery attendance could be associated not only with a *buffering effect* of low-SES home environments (Berry et al., 2016) but also could facilitate and stimulate the early cognitive development of children in moderate-to-high SES households. That is, the influence of attending nursery early in life goes beyond the buffering effect found in low-SES families, also shown to be beneficial in children from medium-to-high-SES families.

Moreover, when understanding this nursery attendance mediating pathway between SES and early cognitive development, it is reasonable to think that highly-educated and employed mothers holding a higher occupation class will be more likely to 1) have the resources to afford nursery school; 2) have the means to compliment the child's caregiving system with an additional public or private resources; 3) be better informed about how to select the best educational options for their children; 4) expose their children to other peers and positive early socialization and cognitive stimulation activities through pedagogically designed playtime that might promote their cognitive development.

Findings are consistent with other studies linking early school attendance to later cognitive development across countries and socioeconomic backgrounds (Burger, 2010; Patel, Corter, Pelletier, & Bertrand, 2016). Overall, our findings support the beneficial effect of early nursery attendance on cognitive development, even with a well-resourced population, and including maternal mental health and family context variables in the model.

Strengths and limitations

These findings add to the previous literature by providing an analysis of proximal meaningful mediating variables tested in a comprehensive bioecological model examining its' effects on early cognitive development. All this is embedded in a prospective longitudinal and general population birth-cohort study (medium-to-high SES and non-clinical population).

Our study highlights that the generationally updated multidimensional, multi-method and multi-informant comprehensive measurements used to assess family context are sensitive enough to detect mediational effects across SES strata and primary caregiver mental health spectrum even when studying more homogeneous, more resourced, and non-clinical families. Likewise, non-parental early childcare through nursery school attendance is also a significant mediational path between maternal SES and early cognitive development.

Although our study supports a bioecological modeling of early child development, we need to be cautious about making inferences of causality given the cross-sectional nature of our analyses. This cross-sectional nature means we are unable to assess the change over time. Therefore, longitudinal studies of these outcomes will be relevant to analyze the developmental trajectories of early cognitive development to examine how the factors included in our model influence over time.

Our data on nursery school attendance (e.g., specific timing and characteristics of attended schools) are limited, constraining our potential interpretation of this mediational pathway and related implications. In our study, although most of the mothers considered themselves to be the primary caregiver of the child (89%), we do not have specific reports of time spent with the child for each participating mother, which rendered us unable to weigh quantity vs. quality of maternal care in our analyses.

Also, we are limited by the lack of information on maternal IQ (both as a hereditable cognitive profile and as a self-efficacy validation variable), even though recent literature shows (Ye et al., 2019) that maternal education and occupation can be good proxies of intellectual performance when direct tools have not been applied.

Conclusion and recommendations for practice

Our results suggest several recommendations, both for future epidemiological studies and family intervention policies. Epidemiological studies tend to use the primary caregiver's SES as a proxy for unmeasured social variables that may affect the child's cognitive development. Still, according to our results, this may be insufficient to control for more proximal factors (e.g., quality of the family context) affecting cognitive development, especially when including more resourced populations and non-clinical samples.

Due to the current COVID-19 pandemic, having experienced highly restricted confinement periods across countries, now followed by a global economic crisis, social systems may face a historic increase in the number of families struggling with multiple socio-economic issues, as well as challenging mental health symptoms. To date, social policies designed to promote early development predominantly address basic economic, nutrition, and health needs. However, our results suggest that cognitive development could be improved by facilitating access to nursery school early in life, as well as supporting families in promoting the quality of the family and home environment (e.g., Arranz Freijo et al., 2019; Lugo-Gil & Tamis-LeMonda, 2008). Public policies that intervene by supporting the family context, such as teaching parenting strategies, may also protect early development from the negative effect of primary caregiver mental health challenges.

Author contributions statement

The authors above declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Competing Interest

None.

Data availability

Data will be made available on request.

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