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# Role of home nurturing environment on early childhood neurodevelopment: a community-based survey in Shanghai, China

Chunhua Jiang[1†], Xingying Li[2†], Bing-Cheng Du[3], Jun Huang[4], Yun Li[1], Ying Zhang[1], Muxin Wei[2,5], Xiaoxi Xu[6], Yulin Yang[7*] and Hong Jiang[2*]

## Abstract

**Background** Ages of 0–3 years are critical stages for children's neurodevelopment. However, the impact of the home nurturing environment on early childhood neurodevelopment remains unclear.

**Objective** To explore the role of the home nurturing environment on early childhood neurodevelopment and to provide evidence of an association between fostering quality home nurturing and achieving optimal neurodevelopment.

**Participants and setting** An online cross-sectional survey using the stratified sampling method was conducted from 16 June, 2021 to 18, February, 2022 in all 13 communities of Minhang District, Shanghai. A total of 2,402 children aged 0–3 years with balanced sex distribution were included.

**Methods** The quality of home nurturing environments was measured using validated Child Home Nurture Environment Scales. Neurodevelopment was measured using the Ages and Stages Questionnaire - Third edition (ASQ-3). Generalized Linear Mixed Modeling was used to analyze the association between the quality of home nurturing environments and neurodevelopment.

**Results** Among children aged 0–1, neglect or restriction was reported as the most prevalent problem (8.02%) among home nurturing environment dimensions, and was associated with an increased risk of suspected fine motor development delay (OR = 2.82, 95% CI: 1.18–6.69, $P = 0.019$). Among children aged 1–3, inadequate parental warmth, as the foremost (16.10%) problem, was associated with an increased risk of suspected gross motor development delay (OR = 4.12, 95% CI: 1.35–12.53, $P = 0.013$) and suspected personal-social development delay (OR = 12.50, 95%CI: 1.48-105.36, $P = 0.020$).

[†]Chunhua Jiang and Xingying Li are co-first authors.

*Correspondence:
Yulin Yang
yangyulin@shmchc.cn
Hong Jiang
h_jiang@fudan.edu.cn

Full list of author information is available at the end of the article

**Conclusions** Poor home nurturing environments were associated with an increased risk of suspected early childhood neurodevelopment delay. There exists a need for services to guide for establishing a quality home nurturing environment.

**Keywords** Home nurturing environment, Early childhood, Neurodevelopment

## Background

The ages of 0–3 years are characterized as the most active stages for the neurodevelopment of children, during which milestone developments in language, motor, cognition, and social-emotional dimensions are achieved [1]. Within this period, the parenting behaviors, which are fundamental to parent-child relationships, significantly influence early childhood neurodevelopment and overall mental well-being [2]. It is widely acknowledged that parenting practice is one of the most crucial components of the home nurturing environment. Home nurturing environment, considered as the primary environment for child survival, refers to the collection of physical and psychosocial factors provided by the family while the child interacts with the surrounding environment [3, 4]. In Jiangsu Province which is near Shanghai and shares a similar cultural environment with Shanghai, the rate of poor home nurturing environment in children aged 1–3 was around 4% [5]. For children aged 0–3, a supportive and positive home nurturing environment is believed to facilitate the maturation of the hippocampus, thus promoting neurodevelopment in children's sensory systems, language acquisition, and motor coordination [6–8]. Compared to distal factors like socioeconomic status, the home nurturing environment was considered a more effective factor in shaping young children's neurodevelopment [9]. Evidence from randomized controlled trials demonstrated the benefits of a good home nurturing environment, cultivated by parents' positive parenting skills and emotional support, on children's social adaptability and emotional functioning [10, 11]. Conversely, exposure to maltreatment and neglect can elevate stress levels, leading to a higher risk of neurodevelopmental disorders (NDDs) or suspected developmental delay (SDD) in children [12–14].

SDD is defined as developmental deficits like suboptimal performance in cognition, communication, or motor functions [6]. Findings from various countries such as China, the USA, and Korea, revealed that the prevalence of SDD in at least one domain of neurodevelopment reached around 10%, indicating a large number of children might suffer from SDD-related problems [15–17]. A study covered more than 20 provinces/autonomous regions/municipalities in China has also indicated that, the prevalence of SDD in Chinese urban children aged 0–3 was around 12% [18]. Studies also noted that children living in families with lower socio-economic status (SES) and living in rural areas were more likely to suffer from SDD, which was considered to be closely associated with malnutrition [19, 20]. However, few studies have analyzed the impact of home nurturing environment on children's neurodevelopment in urban areas where nowadays malnutrition is uncommon.

Since the home nurturing environment reflects an integration of caregivers' parenting practices, it always serves as a mediator bridging parenting practices and children's development [21, 22]. However, the majority of existing studies had been focused on a single specific parenting behavior, such as parent-child interaction, neglect, etc., or with a relatively small sample size [23]. By now, very few studies have been conducted to comprehensively assess the home nurturing environment and understand its role in shaping early childhood neurodevelopment. Therefore, to fill in the knowledge gap in this field, we carried out this study to explore the role of the home nurturing environment on young children's neurodevelopment, thereby contributing to cultivating effective interventions for quality home nurturing and achieving optimal neurodevelopment in early childhood.

## Methods

### Settings

Minhang District is one of the 16 administrative districts in Shanghai, China. This district lies in the southwest of Shanghai, and ranks second for population size and third for GDP among the 16 districts in 2022 [24].

A cross-sectional online survey was carried out from 16 June, 2021 to 18 February, 2022 in Minhang District, Shanghai, China. The main caregivers of children aged 0–3 years from all 13 communities in Minhang District, Shanghai, were invited. The inclusion criteria of caregivers included the ability to communicate both orally and in writing. Caregivers of children with severe congenital abnormalities and caregivers of twins were excluded. On the first page of the survey, a brief introduction, including the purpose and contents of the questionnaire as well as the estimated time to complete the whole survey, was provided. Participants could either choose to start to answer the questionnaire, which implied informed consent to this study according to the introduction, or close the page to exit the survey. In addition, they were informed the right to quit at any time during the survey. The characteristics of participating children and families were collected, such as parents' educational levels, employment status, household income, marital status, child's age and sex, number of children in the family,

family harmony, and challenges encountered in acquiring parenting relevant information.

This study had obtained ethical approval from Shanghai Minhang Maternal and Child Health Care Hospital ([2020]-KS-06).

### Sample size

According to existing studies, we estimated that the rate of SDD was around 25.0% in our study, and the rate of poor home nurturing environment was around 10%, with the odds ratio (OR) value as 1.3 [25–27]. PASS 15.0 was used to calculate the sample size. A number of 1,602 children were required at 0.95 confidence level and 0.95 confidence interval. Assuming a valid response rate of 85%, 1,885 participants were required for the recruitment.

A stratified sampling method was utilized in this study. Within each community of Minhang District, children were proportionally selected in accordance with the children's number at 6 months, 12 months, 24 months, and 36 months. Notably, within each age group, there was a balanced distribution between girls and boys.

### Measures

#### *Quality of home nurturing environment*

The quality of home nurturing environments of children aged 0–3 years was measured by the use of 0–1 years and the 1–3 years versions of "Child Home Nurturing Environment Scales" developed by Shousen He et al. [28, 29]. The scales have been validated among Chinese children, and the Cronbach's alpha coefficient of 0–1 years and 1–3 years was 0.930 and 0.918, respectively. Both construct and criterion-related validity were satisfied. Construct validity was demonstrated by moderate to high correlations among the scale's factors and between the factors and the overall scale. Criterion-related validity was shown as significantly correlated with the child development quotient (DQ) assessed using the 0–4 years child nerve and mental development scale [28, 29]. The scale for children aged 0–1 year includes a total of 32 items belonging to four dimensions, namely 'cognition' such as training on pronunciation, playing toys with children; 'emotion/parental warmth' such as eye contact or body contact with children; 'neglect/restriction' such as unwilling to stay with children, restricting children's activities; and 'interpersonal interaction/feeding' such as allowing children to play with others, adding complementary food appropriately [4, 29]. The scale for children aged 1–3 years consists of a total of 41 items allocated to four dimensions including 'parental warmth' such as taking children to outdoor activities, participating children in early education, and responding to children's needs timely; 'social adaptation/self-care' such as encouraging children to do easy housework, guiding children to do handcrafts; 'language/cognition' such as reading with children, training on children's language; and 'neglect/punishment' such as neglecting, punishing, or restricting children [4, 28]. Each item in the two scales was scored on a 5-point Likert scale ranging from 1 (never) to 5 (very often), while items in the neglect/restriction dimension (Items 3, 6, 13, 15, 26, 28, 30) in the scale for children aged 0–1 year and items in the neglect/punishment dimension (Items 2, 16, 25, 29, 35, 38, 40) in the scale for children aged 1–3 years were inversely keyed. The total scores and percentiles of scores for each dimension were calculated. Based on the norms for the Chinese Child Home Nurturing Environment Scales, a score above the 80th percentile of normative Chinese population scores was classified as indicative of a good home nurturing environment, while a dimension whose score at or below to 20th percentile suggested a poor environment. Scores falling between the 20th and 80th percentiles were considered to reflect a medium environment [30].

#### *Early childhood neurodevelopment*

Early childhood neurodevelopment was assessed by the Chinese version of the Ages and Stages Questionnaire - Third edition (ASQ-3) [31]. The ASQ-3 scales contained 21 different questionnaires for children of different ages ranging from 1 to 66 months [32]. The questionnaire of ASQ-3 at 1,2 and 3 years comprised 5 dimensions of communication, gross motor, fine motor, problem-solving, and personal-social skills with a total of 30 items [33]. Each item was scored in 10, 5, and 0 points according to the response options of "yes" (10 points), "sometimes" (5 points), and "not yet" (0 points) [34]. Children were defined as SDD if their scores in one or more dimensions were two standard deviations (SD) below the normative mean in Shanghai [35–37].

#### *Quality control*

One question was added in the middle of the questionnaire to control the online survey quality: "This question is to verify whether you have completed the survey carefully. Please select 'Always' in this question." If a participant failed to answer the question correctly, their responses would be seen as invalid. Among all 2,601 participants in this survey, 2,402 participants returned a valid response. The rate of valid questionnaires was 92.3% (2,402/2,601).

### Statistical analysis

Median and interquartile range (IQR) were used to describe continuous variables with non-normal contribution, and proportion was used to describe categorical variables. Independent samples t-test and Chi-square test were used to compare the distribution of demographic and family characteristics between different development groups. Besides, Generalized Linear Mixed Modeling

(GLMM) was used to analyze the association between the quality of home nurturing environments and early childhood neurodevelopment, while controlling for confounding factors including sex of the child, permanent residence registration of the child (Shanghai or non-Shanghai), household income per capita, educational level of parents, employment status of parents, only child or not, modes of conception and delivery, maternal age, preterm birth or low birth weight of the child, the main caregiver of the child, family harmony, and difficulties in obtaining parenting knowledge of the caregiver. Notably, family harmony was collected as a self-reported question with the choice of "Good", "Medium", and "Poor", and was introduced as a confounding factor in the analysis. Each community in Minhang was introduced into the model as a random effect, while evaluation results of the home nurturing environment scales and the above confounding factors were introduced as fixed effects, with the rate of SDD in each dimension in the ASQ-3 scales as the dependent variable respectively. The significance level is $P<0.05$, and data were analyzed by SPSS 28.0.

## Results

### Demographic characteristics

The median age of all 2,402 participating children was 2.50 years (IQR: 1.00-3.42), among whom 47.75% (1,147/2,402) were younger than 1 year old, and 52.25% (1,255/2,402) were aged between 1 and 3 years old. The sex distribution was almost equal, with boys accounting for 50.33% (1,209/2,402) and girls for 49.67% (1,193/2,402). Less than half of the children (42.09%, 1,011/2,402) had permanent residence registration in Shanghai. Among caregivers who participated in the survey, 63.91% (1,535/2,402) were parents, while 36.09% (867/2,402) were other caregivers, such as grandparents. Most parents investigated in our survey had a college and above educational level, 76.10% among mothers and 75.81% among fathers. And the majority of parents were employed, 79.14% of mothers and 98.13% of fathers (Supplementary Table 1). All children were Han Chinese in this study. The largest number of children came from the Zhuanqiao community (13.99%, 336/2,402), while the smallest number of children came from Xinhong community (2.79%, 67/2,402), which had the most and least numbers of children among all communities respectively (Table 1).

**Table 1** Number of children enrolled in different communities in Minhang District ($n=2,402$)

| Community | Number of children *n* (%) | Community | Number of children *n* (%) |
|---|---|---|---|
| Gumei | 142 (5.91%) | Pujin | 139 (5.79%) |
| Hongqiao | 122 (5.08%) | Qibao | 188 (7.83%) |
| Huacao | 159 (6.62%) | Xinzhuang | 273 (11.36%) |
| Jiangchuan | 164 (6.83%) | Wujing | 128 (5.33%) |
| Maqiao | 155 (6.45%) | Xinhong | 67 (2.79%) |
| Meilong | 247 (10.28%) | Zhuanqiao | 336 (13.99%) |
| Pujiang | 282 (11.74%) | | |

### Quality of home nurturing environment and early childhood neurodevelopment among children aged 0–3 years

Among all children aged 0–3 years in our study, 3.08% (74/2,402) children's home nurturing environments were assessed as poor, 38.26% (919/2,402) as medium, and 58.66% (1,409/2,402) as good. The quality of home nurturing environments significantly differed between children aged 0–1 and those aged 1–3 (Supplementary Table 1).

Among children aged 0–1 year, the overall poor home nurturing environment rate was 3.49% (40/1,147), while the rate of poor home nurturing environment in the dimension of cognition, emotion or parental warmth, neglect or restriction, and interpersonal interaction or feeding was 4.62% (53/1,147), 6.45% (74/1,147), 8.02% (92/1,147), and 7.24% (83/1,147), respectively (Supplementary Table 2). Among children aged 1–3 years, the overall rate of poor home nurturing environment was 2.71% (34/1,255), while the rate of poor home nurturing environment in the parental warmth dimension, social adaptation or self-care dimension, language or cognition dimension, and neglect or punishment dimension was 16.10% (202/1,255), 3.58% (45/1,255), 1.59% (20/1,255), and 0.32% (4/1,255), respectively (Supplementary Table 3).

Furthermore, the total rate of SDD in at least one dimension in children aged 0–1 and 1–3 was 16.22% (186/1,147) and 13.23% (166/1,255), respectively. The rates of SDD in at least one dimension differed between children aged 0–1 and those aged 1–3 (Supplementary Table 1). Supplementary Table 2 showed the details of early childhood neurodevelopment of different dimensions among boys and girls aged 0–3. The rate of SDD in the five dimensions was 5.16% (124/2,402), 5.54% (133/2,402), 4.29% (103/2,402), 3.83% (92/2,402), and 3.29% (79/2,402), respectively. Among both children aged 0–1 and 1–3, the Chi-square test showed that children experiencing poor overall home nurturing environments were more likely to suffer from SDD in at least one dimension of neurodevelopment (Supplementary Tables 2 & 3).

### The association between home nurturing environment and neurodevelopment in children aged 0–3

Generalized Linear Mixed Modeling (GLMM) showed, among children aged 0–1, comparing to good home nurturing environment, an overall poor home

nurturing environment was associated with a significantly higher risk of SDD in the communication (Odds Ratio (OR)=6.51, 95% Confidence Interval (CI): 2.12–19.94, $P$=0.01), gross motor (OR=8.63, 95% CI: 2.90-25.67, $P$<0.001), fine motor (OR=7.42, 95% CI: 2.44–22.56, $P$<0.001), problem-solving (OR=8.19, 95% CI: 2.41–27.82, $P$=0.001), and personal-social development (OR=4.49, 95% CI: 1.63–12.35, $P$=0.004), while the medium overall home nurturing environment was associated with a significantly higher risk of SDD in the fine motor (OR=2.88, 95% CI: 1.56–5.31, $P$=0.001) and problem-solving (OR=2.83, 95% CI: 1.36–5.89, $P$=0.005) development as well. Additionally, poor overall home nurturing environment (OR=4.61, 95% CI: 1.98–10.71, $P$<0.001), poor home nurturing in emotion or parental warmth (OR=2.45, 95% CI: 1.21–4.96, $P$=0.013) and interpersonal interaction or feeding (OR=3.28, 95% CI: 1.75–6.12, $P$<0.001) was associated with a significantly higher risk of SDD in at least one dimension. Similarly, medium home nurturing environment in overall (OR=1.62, 95% CI: 1.13–2.33, $P$=0.009) and emotion or parental warmth (OR=1.73, 95% CI: 1.18–2.55, $P$=0.005) were also associated with a significantly higher risk of SDD in at least one dimension. Furthermore, poor home nurturing in the dimension of cognition (OR=6.65, 95% CI: 2.30-19.22, $P$<0.001), emotion or parental warmth (OR=4.61, 95% CI: 1.70-12.52, $P$=0.003), and interpersonal interaction or feeding (OR=6.78, 95% CI: 2.99–15.35, $P$<0.001) was associated with a significantly higher risk of SDD in gross motor development. Moreover, poor home nurturing in the dimension of emotion or parental warmth (OR=5.70, 95% CI: 2.20-14.76, $P$<0.001), neglect or restriction (OR=2.82, 95% CI: 1.18–6.69, $P$=0.019), and interpersonal interaction or feeding (OR=5.37, 95% CI: 2.33–12.36, $P$<0.001), medium home nurturing in cognition (OR=1.99, 95% CI: 1.10–3.62, $P$=0.024), emotion or parental warmth (OR=2.49, 95% CI: 1.28–4.88, $P$=0.008), and interpersonal interaction or feeding (OR=1.81, 95% CI: 1.01–3.25, $P$=0.047), was associated with a significantly higher risk of SDD in early childhood fine motor development. Moreover, poor home nurturing in the dimension of emotion or parental warmth (OR=6.88, 95% CI: 2.11–22.43, $P$=0.001) and interpersonal interaction or feeding (OR=4.64, 95% CI: 1.72–12.52, $P$=0.002), medium home nurturing in cognition (OR=2.19, 95% CI: 1.08–4.45, $P$=0.030), emotion or parental warmth (OR=3.56, 95% CI: 1.45–8.76, $P$=0.006), and interpersonal interaction or feeding (OR=2.16, 95% CI: 1.07–4.34, $P$=0.031) was also associated with a significantly higher risk of SDD in the problem-solving development among children aged 0–1 year (Supplementary Table 4).

Among children aged 1–3, similarly, comparing to good home nurturing environment, an overall poor home nurturing environment was associated with a significantly higher risk of SDD in the communication (OR=9.56, 95% CI: 3.09–29.62, $P$<0.001), gross motor (OR=10.50, 95% CI: 3.57–30.86, $P$<0.001), fine motor (OR=4.13, 95% CI: 1.44–11.83, $P$=0.008), problem-solving (OR=5.48, 95% CI: 1.51–19.88, $P$=0.010), and personal-social development (OR=9.63, 95% CI: 2.23–41.58, $P$=0.002), while the medium home nurturing environment was also associated with a significantly higher risk of SDD in communication (OR=2.21, 95% CI: 1.17–24.17, $P$=0.015), gross motor (OR=3.27, 95% CI: 1.81–5.91, $P$<0.001), and personal-social development (OR=4.81, 95% CI: 2.13–10.85, $P$<0.001). Furthermore, poor home nurturing in overall (OR=10.11, 95% CI: 4.11–24.87, $P$<0.001), parental warmth (OR=2.83, 95% CI: 1.32–6.07, $P$=0.007), social adaptation or self-care (OR=5.41, 95% CI: 2.28–12.84, $P$<0.001), language or cognition (OR=13.40, 95% CI: 4.42–40.57, $P$<0.001), and neglect or punishment (OR=15.62, 95% CI: 2.49–98.17, $P$=0.003) was associated with a significantly higher risk of SDD in at least one dimension. Medium home nurturing in overall (OR=3.24, 95% CI: 2.03–5.15, $P$<0.001), social adaptation or self-care (OR=1.74, 95% CI: 1.17–2.58, $P$=0.006), and language or cognition (OR=2.04, 95% CI: 1.25–3.33, $P$=0.004) also showed this association. The results demonstrated that poor home nurturing in the dimension of social adaptation or self-care (OR=10.78, 95% CI: 3.64–31.94, $P$<0.001; OR=3.01, 95% CI: 1.04–8.66, $P$=0.041) and language or cognition (OR=12.16, 95% CI: 3.39–43.57, $P$<0.001; OR=5.34, 95% CI: 1.59-18.00, $P$=0.007) was associated with a significantly higher risk of SDD in both the communication and fine motor development, while medium home nurturing in the social adaptation or self-care dimension (OR=2.37, 95%CI: 1.31–4.28, $P$=0.004) also showed a significantly higher risk of SDD in the communication development comparing to good home nurturing. Additionally, poor home nurturing in the dimension of parental warmth (OR=4.12, 95% CI: 1.35–12.53, $P$=0.013), social adaptation or self-care (OR=4.50, 95% CI: 1.48–13.71, $P$=0.008), language or cognition (OR=7.55, 95% CI: 2.04–27.99, $P$=0.003), and neglect or punishment (OR=16.27, 95% CI: 1.22–217.50, $P$=0.035), medium home nurturing in the social adaptation or self-care (OR=1.81, 95% CI: 1.06–3.10, $P$=0.031) and language or cognition dimension (OR=2.73, 95% CI: 1.45–5.13, $P$=0.002), was associated with a significantly higher risk of SDD in the gross motor development. Only poor home nurturing in the neglect or punishment dimension (OR=32.38, 95% CI: 2.24–468.00, $P$=0.011) showed significant association with a higher risk of SDD in the problem-solving development, while the poor home nurturing in the parental warmth dimension (OR=12.50, 95%CI: 1.48-105.36, $P$=0.020) medium home nurturing

in the social-adaptation/self-care dimension (OR=2.40, 95%CI: 1.12–5.12, $P$=0.024), and both poor and medium home nurturing in the language or cognition dimension (OR=6.60, 95% CI: 1.24–35.16, $P$=0.027; OR=2.92, 95%CI: 1.24–6.92, $P$=0.015) all showed significant association with a higher risk of SDD in early childhood personal-social development (Supplementary Table 5).

## Discussion

Through the survey involving all communities of one district of Shanghai, it was demonstrated that around 3% of children were faced with a poor home nurturing environment, which indicated the service needs of parenting intervention. Furthermore, a significant association between the quality of home nurturing environments and early childhood neurodevelopment was identified in this study, suggesting the important role of the home environment in terms of optimal neurodevelopment in the first three years of life. Among all dimensions of home nurturing environments examined in this study, the rate of neglect or restriction was found to be the highest in children aged 0–1 year, while lack of parental warmth nurturing was the most prominent problem for children aged 1–3 years.

Among children aged 0–1, the total rate of SDD was 16.22%, which was similar to previous research conducted in urban China [18]. The rate of poor home nurturing environment in the dimension of neglect or restriction was around 8% measured by the Child Home Nurturing Environment Scales. Although there were other scales like the IT-HOME scales assessing home nurturing environment through observations during home visits, but this had high requirements for adequate human resources [38]. Considering the limited health staff in communities, we applied the Child Home Nurturing Environment Scales which had good reliability and validity and collected information via self-reported approach in this study. This finding was similar to a systematic review that reported approximately 10% of children being emotionally maltreated or neglected [39]. Adverse impacts of neglect or restriction on infants' neurodevelopment had been evidently shown in various studies [40–42]. Globally, around 80% of maltreatment victims under the age of 5 suffered from neglect, and infants exhibited an even higher vulnerability to neglect [43, 44]. The negative effects of neglect, particularly the lack of responsiveness to infants' needs, could cause impaired cerebellum function and, consequently, harm infants' fine motor development [45]. Effective intervention strategies such as home visits that equip parents with skills to foster stimulating and cooperative activities, could be adopted to enhance the overall home nurturing environment [46–48]. Longitudinal studies have proved the effects of the home visiting program in mitigating child neglect and promoting early childhood neurodevelopment [49]. Other interventions such as co-parenting, especially engaging fathers in parenting, could effectively prevent harsh parenting and child abuse like physical punishment, and play important roles in building a warm and cooperative home nurturing environment for children [50].

Among children aged 1–3 years, the rate of poor home nurturing environment in the dimension of parental warmth was around 16% and was the highest among all dimensions of the home nurturing environment. This was the same with the results of another Chinese research conducted in Jiangsu [51]. Moreover, our study identified an association between inadequate parental warmth and a significantly higher risk of delayed development in gross motor and personal-social skills. Previous studies have indicated that the absence of parental warmth could lead to an increased risk of abnormal gross motor development among preschool-aged children [52–54]. The absence of parental warmth was more commonly aligned with the overuse of smartphones, which was an emerging issue in both parents and children [55–57] and could lead to decreased face-to-face intimate communication and subsequently reduced emotional interactions [58, 59]. Interactive interventions such as eye contact and interactive playing to improve parental care and warmth, were encouraged [60, 61]. Studies also have shown parental involvement in children's early education is critical for cultivating a good environment for children to learn new skills and facilitate neurodevelopment in gross motor [62, 63]. Since parental warmth was always characterized by healthy parent-child interaction, it was suggested that the home environment with frequent and effective parent-child interaction could help child develop a good mindset during activities, which is significant for the development of motor skills among children under three years [64, 65]. Furthermore, responsive parenting practices could further stimulate children's early motor development and personal-social development by providing parental encouragement and the subsequent reinforcement of familial bonds [66–68], since a secure and positive attachment relationship could facilitate children's feelings of connection and empathy, therefore promoting their regulation of emotions, which could foster social friendliness and personal-social development in children aged around 3 [69, 70].

The strength of our study included the use of the Child Home Nurturing Environment Scales which were specifically designed to assess parental nurturing environment for children aged 0–3, and allowed the assessment of both the overall quality of the home nurturing environment and specific dimensions. We used stratified random sampling to obtain a representative sample for study population, and the use of GLMM for multifactorial analysis

reduced potential bias. However, our study only recruited children living in Shanghai, which might limit the generalizability of research findings. Moreover, the cross-sectional design could not allow for causal inferences. In addition, the measurements of the home nurturing environment, as well as children's neurodevelopment, were both reported by parents, which could introduce reporting bias or recall bias to this study. Furthermore, the sample size of children with abnormal ASQ performance in poor home nurturing environments was inadequate in some dimensions, which could lead to a lack of adequate statistical power to detect the differences between the groups.

## Conclusions

Poor home nurturing environments were associated with increased risks of delayed early childhood neurodevelopment. However, future studies using prospective study design, sufficient sample size for each child neurodevelopment outcome and more reliable information collection methods were needed to further confirm the role of home nurturing environment. It was essential for parents to establish a quality home nurturing environment to achieve children's optimal neurodevelopment, especially in the first three years of life.

### Abbreviations

| | |
|---|---|
| ASQ-3 | Ages and Stages Questionnaire - Third edition |
| NDDs | Neurodevelopmental Disorders |
| SD | Standard Deviation |
| GLMM | Generalized Linear Mixed Modeling |
| CI | Confidence Interval |
| OR | Odds Ratio |
| DQ | Development quotient |
| IQR | Interquartile range |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12887-024-05190-3.

Supplementary Material 1

Supplementary Material 2

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### Author contributions

CJ and HJ conceived and obtained funding of this study. CJ, JH, YL, YZ, MW, XX and HJ coordinated and supervised data collection. CJ and XL conducted the data analysis. XL drafted the manuscript. BD, YY and HJ provided critical comments and revised the manuscript. All authors approved the final version of the manuscript.

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### Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

The ethical approval was obtained from Shanghai Minhang Maternal and Child Health Care Hospital ([2020]-KS-06). All participants in the study had been informed and consented to participate in this study.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

### Author details

[1]Department of Child Health Care, Minhang Maternal and Child Health Care Hospital, Minhang District, Shanghai, China
[2]School of Public Health, Key Laboratory of Health Technology Assessment (National Health Commission of the People's Republic of China), Fudan University, Xuhui District, Shanghai, China
[3]Department of Statistics, University of Toronto, Toronto, Canada
[4]Department of Environmental and Occupational health, Minhang Municipal Center for Disease Control & Prevention, Minhang District, Shanghai, China
[5]Department of Public Health, Maqiao Community Health Service Center, Minhang District, Shanghai, China
[6]Department of Child Health Care, Gumei Community Health Service Center, Minhang District, Shanghai, China
[7]Shanghai Center for Women and Children's Health, Putuo District, Shanghai, China

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### References

1. Liu S, Wang Z, Zhao C, Huang X, Liang X, Wang X et al. Effects of early comprehensive interventions on child neurodevelopment in poor rural areas of China: a moderated mediation analysis. Public Health. 2018; 159: 116–122. https://doi.org/10.1016/j.puhe.2018.02.010
2. Horner MS, Editorial. Parenting in Mind: Neurodevelopment and the Influence of Children's Most Profound Relationship. Journal of the American Academy of Child & Adolescent Psychiatry. 2020; 59 (2): 227–228. https://doi.org/10.1016/j.jaac.2019.09.036
3. Meng W, Black CFD, Feng M. Associations among family socioeconomic status, parenting and sustained attention for socioeconomically disadvantaged children at age 5 years. Infant and Child Development. 2024; n/a (n/a): e2491. https://doi.org/10.1002/icd.2491
4. Ding L, He S, Zhou Q, Xu X, Tang J, Zhang Y. Prospective study of home nurture environment on early childhood developmental quotients and social emotional development. Chin J Child Health Care. 2016; 24 (9): 910–912 + 916. https://doi.org/10.11852/zgetbjzz2016-24-09-05
5. Song J, Zhang D, Li J, Zhao Y, Qin R, Hu Y. Study on correlation between family rearing environment, social and emotional development of 1 ~ 3 years old children of Jiangsu province. Chinese Journal of Child Health Care. 2016; 24 (03): 256–259. https://doi.org/10.11852/zgetbjzz2016-24-03-10
6. Britto PR, Lye SJ, Proulx K, Yousafzai AK, Matthews SG, Vaivada T et al. Nurturing care: promoting early childhood development. The Lancet. 2017; 389 (10064): 91–102. https://doi.org/10.1016/S0140-6736(16)31390-3
7. Förster K, Danzer L, Redlich R, Opel N, Grotegerd D, Leehr E et al. Social support and hippocampal volume are negatively associated in adults with previous experience of childhood maltreatment. Journal of psychiatry & neuroscience: JPN. 2021; 46: E328-E336. https://doi.org/10.1503/jpn.200162

8. Meaney MJ. Mother nurture and the social definition of neurodevelopment. Proceedings of the National Academy of Sciences. 2016; 113 (22): 6094–6096. https://doi.org/10.1073/pnas.1605859113
9. Chajes JR, Stern JA, Kelsey CM, Grossmann T. Examining the Role of Socioeconomic Status and Maternal Sensitivity in Predicting Functional Brain Network Connectivity in 5-Month-Old Infants. Frontiers in Neuroscience. 2022; 16: https://doi.org/10.3389/fnins.2022.892482
10. Law E, F E, Palermo CE. TM. Psychological interventions for parents of children and adolescents with chronic illness. Cochrane Database of Systematic Reviews. 2019; 2019 (3): CD009660. https://doi.org/10.1002/14651858.CD009660.pub4
11. Strobel NA, Chamberlain C, Campbell SK, Shields L, Bainbridge RG, Adams C et al. Family-centred interventions for Indigenous early childhood well-being by primary healthcare services. Cochrane Database of Systematic Reviews. 2022; (12): https://doi.org/10.1002/14651858.CD012463.pub2
12. Aita M, De Clifford Faugère G, Lavallée A, Feeley N, Stremler R, Rioux É et al. Effectiveness of interventions on early neurodevelopment of preterm infants: a systematic review and meta-analysis. BMC Pediatrics. 2021; 21 (1): 210. https://doi.org/10.1186/s12887-021-02559-6
13. Theoharides TC, Kavalioti M, Martinotti R. Factors adversely influencing neurodevelopment. journal of Biological Regulators & Homeostatic Agents. 2019; 33 (6): 1663–1667. https://doi.org/10.23812/19-33n6Edit_Theoharides
14. Turner F, Venturini E, Kainth G, Crawford K, O'Connor R, Balestrieri M et al. The expected and the unexpected in recovery and development after abuse and neglect: The role of early foster carer commitment on young children's symptoms of attachment disorders and mental health problems over time. Child Abuse & Neglect. 2022; 127: 105585. https://doi.org/10.1016/j.chiabu.2022.105585
15. Kim SW, Han Z-A, Jeon HR, Choi JY, Chung HJ, Kim YK et al. Neurodevelopmental Disorders of Children Screened by The Infantile Health Promotion System. Ann Rehabil Med. 2011; 35 (6): 867–872. https://doi.org/10.5535/arm.2011.35.6.867
16. Sharma P, Kularatna S, Abell B, Eagleson K, Vo L, Halahakone U et al. Preferences in the Design and Delivery of Neurodevelopmental Follow-Up Care for Children: A Systematic Review of Discrete Choice Experiments. Patient Preference and Adherence. 2023; Volume 17: 2325–2341. https://doi.org/10.2147/PPA.S425578
17. Zhu H, Yuan C, Liu Z. Recent research on neurodevelopmental disorders in children. Chin J Contemp Pediatr. 2023;25(01):91–7. Available from:.
18. Yang Y, Shi L, Jin X, Tong S. Association of perinatal factors with suspected developmental delay in urban children aged 1–36 months - a large-scale cross-sectional study in China. BMC Pediatrics. 2023; 23 (1): 11. https://doi.org/10.1186/s12887-022-03819-9
19. Komanchuk J, Cameron JL, Kurbatfinski S, Duffett-Leger L, Letourneau N. A realist review of digitally delivered child development assessment and screening tools: Psychometrics and considerations for future use. Early Human Development. 2023; 183: 105818. https://doi.org/10.1016/j.earlhumdev.2023.105818
20. Bhutta Zulfiqar A, Black Robert E. Global Maternal, Newborn, and Child Health — So Near and Yet So Far. New England Journal of Medicine. 369 (23): 2226–2235. https://doi.org/10.1056/NEJMra1111853
21. Veldhuis L, van Grieken A, Renders CM, HiraSing RA, Raat H. Parenting Style, the Home Environment, and Screen Time of 5-Year-Old Children; The 'Be Active, Eat Right' Study. PLOS ONE. 2014; 9 (2): e88486. https://doi.org/10.1371/journal.pone.0088486
22. Conlon BA, McGinn AP, Lounsbury DW, Diamantis PM, Groisman-Perelstein AE, Wylie-Rosett J et al. The Role of Parenting Practices in the Home Environment among Underserved Youth. Childhood Obesity. 2015; 11 (4): 394–405. https://doi.org/10.1089/chi.2014.0093
23. Ding L, He S, Zhou Q, Xu X, Tang J, Zhang Y. Prospective study of home nurture environment on early childhood developmental quotients and social emotional development. Chinese Journal of Child Health Care. 2016; 24 (09): 910–912 + 916. https://doi.org/10.11852/zgetbjzz2016-24-09-05
24. Shanghai Government of Minhang District. Overview of Minhang district. http://www.shmh.gov.cn/shmh/mhgl/index.html (2022). Accessed 20 October 2023.
25. Gil JDC, Ewerling F, Ferreira LZ, Barros AJD. Early childhood suspected developmental delay in 63 low-and middle-income countries: Large within-and between-country inequalities documented using national health surveys. Journal of Global Health. 2020; 10 (1): https://doi.org/10.7189/JOGH.10.010427
26. Zhang Y, Jin X, Chen J, Li Y, Wang S, Bian X et al. Study on correlation between family nurture environment and toddlers' social-emotional development in urban areas of Shanghai. J Bio-education. 2020; 8 (1): 36–42. https://doi.org/10.3969/j.issn.2095-4301.2020.01.007
27. Hua M. Effect of child neglect on neuropsychological development in toddle hood. Suzhou University; 2017.
28. He S, Wang Y, Guan C, Zhou Y, Tang J, Ni C et al. 1 ~ 3 years Child Home Nurture Environment Scales: development, reliability and validity. Chin J Child Health Care. 2008; 16 (06): 650–652. https://doi.org/10.3969/j.issn.1008-6579.2008.06.012
29. He S, Wang Y, Sun Z, Ni C, Zhou Y, Li Y. Development, reliability and validity of 0 ~ 1 year Child Home Nurture Environment Scales. Chin J Child Health Care. 2008; 16 (5): 503–506. https://doi.org/10.3969/j.issn.1008-6579.2008.05.004
30. Jiang C, Wei M, Huang J, Li Y, Zhang Y, Jiang H et al. Status quo and risk factors of infant home nurture environment for children aged 5–6 and 11–12 months in Minhang district, Shanghai. Chinese Journal of Child Health Care. 2023; 31 (10): 1151–1155. Available from.
31. Wang P, Xie J, Jiao X-C, Ma S-S, Liu Y, Yin W-J et al. Maternal Glycemia During Pregnancy and Early Offspring Development: A Prospective Birth Cohort Study. The Journal of Clinical Endocrinology & Metabolism. 2021; 106 (8): 2279–2290. https://doi.org/10.1210/clinem/dgab331
32. Vásquez-Echeverría A, Alvarez-Nuñez L, Gonzalez M, Loose T, Rudnitzky F. Role of parenting practices, mother's personality and depressive symptoms in early child development. Infant Behavior and Development. 2022; 67: 101701. https://doi.org/10.1016/j.infbeh.2022.101701
33. Hessami K, Norooznezhad AH, Monteiro S, Barrozo ER, Abdolmaleki AS, Arian SE et al. COVID-19 Pandemic and Infant Neurodevelopmental Impairment: A Systematic Review and Meta-analysis. JAMA Network Open. 2022; 5 (10): e2238941-e2238941. https://doi.org/10.1001/jamanetworkopen.2022.38941
34. Wang K, Qi Y, Wei Q, Shi Y, Zhang Y, Shi H. Responsive Caregiving and Opportunities for Early Learning Associated With Infant Development: Results From a Prospective Birth Cohort in China. Front Pediatr. 2022; 10: https://doi.org/10.3389/fped.2022.857107
35. Bian X, Yao G, Squires J, Wei M, Chen C-I, Fang B. Studies of the norm and psychometric properties of Ages and Stages Questionnaires in Shanghai children. Chinese Journal of Pediatrics. 2010; 48 (07): 492–496. https://doi.org/10.3760/cma.j.issn.0578-1310.2010.07.003
36. Wei M, Bian X, Squires J, Yao G, Wang X, Xie H et al. Studies of the norm and psychometrical properties of the ages and stages questionnaires, third edition, with a Chinese national sample. Chinese Journal of Pediatrics. 2015; 53 (12): 913–918. https://doi.org/10.3760/cma.j.issn.0578-1310.2015.12.009
37. Wang P, Zhao Y, Li J, Zhou Y, Luo R, Meng X et al. Prenatal exposure to ambient fine particulate matter and early childhood neurodevelopment: A population-based birth cohort study. Science of The Total Environment. 2021; 785: 147334. https://doi.org/10.1016/j.scitotenv.2021.147334
38. Dou Y, Li M, Shi H, Duan X, Tan C, Zhao C et al. The relationship between home environment and early childhood development of left-behind children under 3 years in rural China. Infant Behavior and Development. 2023; 71: 101829. https://doi.org/10.1016/j.infbeh.2023.101829
39. Zeanah CH, Humphreys KL. Child Abuse and Neglect. Journal of the American Academy of Child & Adolescent Psychiatry. 2018; 57 (9): 637–644. https://doi.org/10.1016/j.jaac.2018.06.007
40. Matsuki T, Ebara T, Tamada H, Kato S, Kaneko K, Kano H et al. Repeated maternal non-responsiveness to baby's crying during postpartum and infant neuropsychological development: The Japan Environment and Children's Study. Child Abuse & Neglect. 2022; 127: 105581. https://doi.org/10.1016/j.chiabu.2022.105581
41. Eismann EA, Theuerling J, Cassedy A, Curry PA, Colliers T, Makoroff KL. Early developmental, behavioral, and quality of life outcomes following abusive head trauma in infants. Child Abuse & Neglect. 2020; 108: 104643. https://doi.org/10.1016/j.chiabu.2020.104643
42. Cox A, Frederico M, Mosse H, Radford L, Ambry D, Ryan C. Australian Maltreated Infants and Young Children Can Achieve Positive Relational Health With Neurodevelopmentally- and Trauma-Informed Interventions Provided Within Relationally-Positive and Stable Environments. Frontiers in Psychiatry. 2021; 12: https://doi.org/10.3389/fpsyt.2021.680343
43. Jonson-Reid M, Drake B, Constantino JN, Tandon M, Pons L, Kohl P et al. A Randomized Trial of Home Visitation for CPS-Involved Families: The Moderating Impact of Maternal Depression and CPS History. Child Maltreatment. 2018; 23 (3): 281–293. https://doi.org/10.1177/1077559517751671

44. DeVooght K, McCoy-Roth M, Freundlich M. Young and vulnerable: children five and under experience high maltreatment rates. Child Trends: Early Child Highlights. 2011;2(2):1–20. Available from:.
45. Sartori RF, Ribeiro Bandeira PF, Nobre GC, da Silva Ramalho MH, Valentini NC. Associations between motor proficiency in children with history of maltreatment and living in social economically vulnerability. Child Abuse & Neglect. 2017; 70: 75–81. https://doi.org/10.1016/j.chiabu.2017.05.014
46. Lee E, Kirkland K, Miranda-Julian C, Greene R. Reducing maltreatment recurrence through home visitation: A promising intervention for child welfare involved families. Child Abuse & Neglect. 2018; 86: 55–66. https://doi.org/10.1016/j.chiabu.2018.09.004
47. Sadoo S, Nalugya R, Lassman R, Kohli-Lynch M, Chariot G, Davies HG et al. Early detection and intervention for young children with early developmental disabilities in Western Uganda: a mixed-methods evaluation. BMC Pediatrics. 2022; 22 (1): 158. https://doi.org/10.1186/s12887-022-03184-7
48. Wallander JL, McClure E, Biasini F, Goudar SS, Pasha O, Chomba E et al. Brain Research to Ameliorate Impaired Neurodevelopment - Home-based Intervention Trial (BRAIN-HIT). BMC Pediatrics. 2010; 10 (1): 27. https://doi.org/10.1186/1471-2431-10-27
49. Sharon G, Anna P, Hannah B, Tracey B, Fiona M, Francesca O et al. 'right@ home': a randomised controlled trial of sustained nurse home visiting from pregnancy to child age 2 years, versus usual care, to improve parent care, parent responsivity and the home learning environment at 2 years. BMJ Open. 2017; 7 (3): e013307. https://doi.org/10.1136/bmjopen-2016-013307
50. Branco MSS, Altafim ERP, Linhares MBM. Universal Intervention to Strengthen Parenting and Prevent Child Maltreatment: Updated Systematic Review., Trauma. Violence, & Abuse. 2021; 23 (5): 1658–1676. https://doi.org/10.1177/15248380211013131
51. Tian T, Song J, Qin Y, Zhang D, Li J, Hu Y. Study on the relationship between home nurture environment and behavior problems of preschool children in Jiangsu province. Chinese Journal of Child Health Care. 2017; 25 (12): 1215–1217. https://doi.org/10.11852/zgetbjzz2017-25-12-08
52. Wang Y, Chen L, Wu T, Shi H, Li Q, Jiang H et al. Impact of Covid-19 in pregnancy on mother's psychological status and infant's neurobehavioral development: a longitudinal cohort study in China. BMC Med. 2020; 18 (1): 347. https://doi.org/10.1186/s12916-020-01825-1
53. Miller MI, Williams BM, McCabe JE, Williamson JA, King S, Laplante DP et al. Perinatal anxiety and depressive symptoms and perception of child behavior and temperament in early motherhood. J Dev Orig Health Dis. 2021; 12 (3): 513–522. https://doi.org/10.1017/S2040174420000781
54. Gilbert AL, BN S, Carroll AE, Downs SM. Child exposure to parental violence and psychological distress associated with delayed milestones. Pediatrics. 2013; 132 (6): e1577-83. https://doi.org/10.1542/peds.2013-1020
55. Zhang Z, Predy M, Hesketh KD, Pritchard L, Carson V. Characteristics of tummy time and dose-response relationships with development in infants. European Journal of Pediatrics. 2023; 182 (1): 113–121. https://doi.org/10.1007/s00431-022-04647-w
56. Carson V, Zhang Z, Predy M, Pritchard L, Hesketh KD. Longitudinal associations between infant movement behaviours and development. International Journal of Behavioral Nutrition and Physical Activity. 2022; 19 (1): 10. https://doi.org/10.1186/s12966-022-01248-6
57. Pisoni C, Provenzi L, Moncecchi M, Caporali C, Naboni C, Stronati M et al. Early parenting intervention promotes 24-month psychomotor development in preterm children. Acta Paediatrica. 2021; 110 (1): 101–108. https://doi.org/10.1111/apa.15345
58. Canadian Paediatric Society DHTFOO. Screen time and young children: Promoting health and development in a digital world. Paediatrics & Child Health. 2017; 22 (8): 461–468. https://doi.org/10.1093/pch/pxx123
59. Chaibal S, Chaiyakul S. The association between smartphone and tablet usage and children development. Acta Psychologica. 2022; 228: 103646. https://doi.org/10.1016/j.actpsy.2022.103646
60. Ku B, Stinson JD, MacDonald M, McIntyre LL. Parental Behavior Influences on Motor Skill Development in Young Children with Developmental Disabilities: A Two-Year Longitudinal Study. Child Psychiatry & Human Development. 2021: https://doi.org/10.1007/s10578-021-01263-x
61. Natrasony C, Teitelbaum D. Watch Me Move: A Program For Parents of Young Children With Gross-Motor Delays. Phys Occup Ther Pediatr. 2016; 36 (4): 388–400. https://doi.org/10.1080/01942638.2016.1205163
62. Liu X, Wang X-M, Ge J-J, Dong X-Q. Effects of the portage early education program on Chinese children with global developmental delay. Medicine. 2018; 97 (41): Available from.
63. Barnett LM, Hnatiuk JA, Salmon J, Hesketh KD. Modifiable factors which predict children's gross motor competence: a prospective cohort study. International Journal of Behavioral Nutrition and Physical Activity. 2019; 16 (1): 129. https://doi.org/10.1186/s12966-019-0888-0
64. Gibson BE, Mistry B, Wright FV. Development of Child and Family-Centered Engagement Guidelines for Clinical Administration of the Challenge to Measure Advanced Gross Motor Skills: A Qualitative Study. Physical & Occupational Therapy In Pediatrics. 2018; 38 (4): 417–426. https://doi.org/10.1080/01942638.2017.1341967
65. Natrasony C, Teitelbaum D. Watch Me Move: A Program For Parents of Young Children With Gross-Motor Delays. Physical & Occupational Therapy In Pediatrics. 2016; 36 (4): 388–400. https://doi.org/10.1080/01942638.2016.1205163
66. Treat AE, Sheffield Morris A, Hays-Grudo J, Williamson AC. The impact of positive parenting behaviors and maternal depression on the features of young children's home language environments. Journal of Child Language. 2020; 47 (2): 382–400. https://doi.org/10.1017/S030500091900062X
67. Glascoe FP, Leew S. Parenting Behaviors, Perceptions, and Psychosocial Risk: Impacts on Young Children's Development. Pediatrics. 2010; 125 (2): 313–319. https://doi.org/10.1542/peds.2008-3129
68. Sarah KGJ, Matias P-C, Shauna MM, Robert TB, Simo G, Jordan F et al. Effect of a home-visiting parenting program to promote early childhood development and prevent violence: a cluster-randomized trial in Rwanda. BMJ Global Health. 2021; 6 (1): e003508. https://doi.org/10.1136/bmjgh-2020-003508
69. Yavuz HM, Colasante T, Malti T. Parental warmth predicts more child prosocial behaviour in children with better emotion regulation. British Journal of Developmental Psychology. 2022; 40 (4): 539–556. https://doi.org/10.1111/bjdp.12425
70. Kao K, Tuladhar CT, Tarullo AR. Parental and Family-Level Sociocontextual Correlates of Emergent Emotion Regulation: Implications for Early Social Competence. Journal of Child and Family Studies. 2020; 29 (6): 1630–1641. https://doi.org/10.1007/s10826-020-01706-4


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