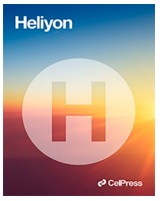
Heliyon 9 (2023) e22100

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Home reading environment, sociometric and demographic factors associated with dyslexia in primary school students in China: A case-control study

Lijing Zou [a], Anyan Huang [a,b], Kusheng Wu [c], Xuanzhi Zhang [a,d], Kaiguo Zhang [e], Wanyi Wen [f], Liwen Guan [f], Yanhong Huang [a,d,*]

[a] Mental Health Center of Shantou University, Shantou, Guangdong, China
[b] Department of Health Care, Shantou Maternal and Child Health Hospital, Shantou, Guangdong, China
[c] Department of Preventive Medicine, Shantou University Medical College, Shantou, Guangdong, China
[d] Shantou University Medical College—Faculty of Medicine of University of Manitoba Joint Laboratory of Biological Psychiatry, China
[e] Somatotherapy Department, Shenzhen Mental Health Center, Shenzhen, Guangdong, China
[f] School of Public Health, Shantou University, Shantou, Guangdong, China

ARTICLE INFO

Keywords:
Developmental dyslexia
LASSO regression
Home reading environment
Sociometric and demographic factors
Reading activity
Risk factor analysis

ABSTRACT

Background: Developmental dyslexia (DD) has been generally recognized as a multifactorial psychological disorder in recent decades. However, studies on reading and learning environment, social and demographic factors affecting Chinese developmental dyslexia (DD) are still scarce in China. This study aims to explore multidimensional home influencing factors associated with DD before and after birth.

Methods: A total of 60 dyslexic and 252 normal elementary school students graded 2–5 were recruited in Shantou, China. The Least Absolute Shrinkage and Selection Operator (LASSO) regression model was used for the social and demographic variables screening. Odds ratios (ORs) with 95 % confidence intervals (CIs) for associations between DD and related factors were estimated by multivariate logistic regression models.

Results: Through LASSO regression, we ultimately identified 13 key variables, including maternal education level and family monthly income, among others. The logistic regression analyses showed that the risk of DD was higher in children with lower maternal education levels. Divergent parenting styles may be a risk factor for developing DD as opposed to consistent parenting styles (OR = 4.93, 95%CI: 1.11–21.91). Children whose mothers suffered from malnutrition during pregnancy were more likely to develop DD (OR = 10.31, 95%CI: 1.84–37.86), as well as exposure to second-hand smoking at home every day (OR = 5.33, 95%CI: 1.52–18.66). Interestingly, children's active reading (OR = 0.26, 95%CI: 0.08–0.84; OR = 0.17, 95%CI: 0.04–0.76 for "sometimes" and "often" compared to none, respectively), children having extracurricular reading fairy tale books (OR = 0.37, 95%CI: 0.15–0.90), and children having extracurricular reading composition books (OR = 0.25, 95%CI: 0.09–0.69) were significant protective factors for DD.

Conclusions: Home reading environment, several educational, sociometric and demographic factors may influence the development of dyslexia. We should pay attention to these factors on the

* Corresponding author. Mental Health Center of Shantou University, North Taishan Road, Shantou 515065, Guangdong Province, China.
E-mail address: 12yhhuang@stu.edu.cn (Y. Huang).

https://doi.org/10.1016/j.heliyon.2023.e22100
Received 24 August 2023; Received in revised form 13 October 2023; Accepted 3 November 2023
Available online 4 November 2023

development of dyslexia, so as to provide the well social and familial environment to ensure the healthy development of children.

1. Introduction

Dyslexia is a neurodevelopmental disorder characterized by inaccurate, non-fluent word recognition and poor writing skills [1]. Despite having adequate learning experiences, normal intelligence, and intact perceptual abilities, children with dyslexia have difficulty with word recognition, reading, and spelling. Studies have shown that the prevalence of dyslexia in school-age children ranged from 5 % to 17.5 % in Western countries [2]. While in China, the prevalence of DD is between 3.9 % and 13.5 % among school-age children [3]. Although the prevalence of dyslexia in Chinese appears to be lower than that in other languages, the impact of Chinese dyslexia on children's development in China should not be underestimated. DD is now widely recognized to be influenced by a variety of factors that alter the development of multiple nervous systems and cognitive functions required for normal growth. So far, many studies have focused on identifying candidate genes and risk loci for DD [4,5]. However, in addition to the genetic factors, it is also critical to identify environmental factors such as socioeconomic status, home literacy environment and maternal perinatal factors in the development of dyslexia [6].

Many previous studies have concentrated on the associations between the specific factor and DD. An Italian study investigated the socioeconomic status of dyslexic children and reported that low educational levels of parents were the risk factors [7]. Another study which focused on the home literacy environment found that, parent-child reading and teaching may be the protective factors for DD [8]. In addition, Liu et al. conducted an in-depth study of a wide range of perinatal factors in children with dyslexia in China, revealing that a family history of neuropsychiatric disorders, maternal infectious diseases, difficult vaginal delivery, preterm birth, and neonatal asphyxia may increase the risk of DD [9]. However, a comprehensive analysis of the multifaceted influences on dyslexia has rarely been conducted, presumably due to the limitations of traditional statistical methods. Epidemiological studies often present high-dimensional and complex data, making traditional regression models less robust when dealing with such high-dimensional variables due to collinearity issues. The least absolute shrinkage and selection operator (LASSO) is a variable shrinkage method which is robust to address multicollinearity [10]. Compared to traditional variable shrinkage selection methods, LASSO regression can be effective in screening independent variables when analyzing the association of multiple variables with outcomes, thus improving the accuracy of variable prediction.

In this study, we aimed to use LASSO regression to identify the significant multidimensional influencing factors associated with dyslexia, and to explore potential influence factors for DD by interacting with other typical multivariate methods such as Logistic regression.

2. Materials and methods

2.1. Participants

This was a case control study. In order to minimize the impact of confounding factors [11], we set the sample ratio between the case group and the control group as 1:4. The case group in the present study were recruited from children in grades 2 through 5 who had been diagnosed with dyslexia during our previous school screening. The control group were typically developing children who were recruited at the same schools.

The inclusion criteria for the cases were: (1) IQ $>$ 80 on the Raven's Standard Progressive Matrices (SPM) test [12]; (2) the Chinese language test scores in the last 20 % of the class; (3) the scores on the Dyslexia Checklist for Chinese Children (DCCC) more than two standard deviations of the average in the same grade [13]; (4) scores $<$65 on the Pupil Rating Scale-Revised for Learning Disabilities (PRS) [14]; (5) Children diagnosed with dyslexia by a child psychiatrist based on the results of the Chinese Reading Ability Test (CRAT) [15] and the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [16]. The inclusion criteria for the control group were: typically developing children who were not dyslexic. Both groups excluded children with neurodevelopmental delays, previous traumatic brain injury or other organic brain disorders, color blindness, visual-auditory impairment, and attention deficit hyperactivity disorder.

The informed consent was received and signed by the parents or guardians prior to the investigation. The current study was approved by the Ethics Committee of the Mental Health Center of Shantou University (MSUMC-2021-09).

2.2. Instruments

A self-designed questionnaire on dyslexia influencing factors was applied. The questionnaires were filled out by parents or guardians, and covered basic family information, prenatal and perinatal factors, the family literacy environment, and the children's lifestyle and learning habits. Prenatal and perinatal factors included maternal smoking during pregnancy, exposure to second-hand smoke during pregnancy, drug use during pregnancy, gestational age, etc. Overall, the questionnaire covered five main categories of relevant factors, with a total of 57 items.

2.3. Investigation process and quality control

Envelopes containing the questionnaire and written informed consent were distributed to participants by the faculty. Students bring them home for parents or guardians to fill out and turn them in to their teachers, who then collect them for the professional investigators.

To ensure a good implementation of the survey, strict quality control was carried out at every stage of the survey. Prior to the survey, we invited the principals and teachers to a workshop to explain the purpose and content of the survey for their assistance. In addition, a pre-survey was conducted to examine the plausibility of the items in the questionnaire, and the contents of the questionnaire were improved based on the feedback results. During the data collection phase, investigators checked the questionnaires for accuracy and completeness in a timely manner. Invalid questionnaires were eliminated according to the following principles: questionnaires were not answered as required; questionnaires with more than 20 % of the total entries missed and questionnaires with illogical answers. Finally, the data input was performed by two trained investigators.

2.4. Variable definition

In this study, the family structure was classified as core family, reconstituted family, single-parent family, and large family. A core family is a family consisting of a couple and unmarried children and a big family is a family consisting of three or more generations. The American psychologist Diana Baumrind proposed two dimensions of family parenting styles: demandingness and responsiveness. Demandingness refers to whether or not a parent establishes appropriate standards for the child's behavior and insists that the child meet those standards. Responsiveness refers to the degree of amicable acceptance of the child and sensitivity to the child's needs. Based on the two dimensions of family parenting styles, parenting styles can be divided as authoritative, authoritarian, indulgent and neglectful [17]. Authoritative parenting: High in responsiveness and high in demandingness. Authoritative parents are warm, nurturing, and supportive, while also setting clear boundaries and expectations. Authoritarian parenting: Low in responsiveness and high in demandingness. Authoritarian parents tend to enforce strict rules and expect absolute obedience without much warmth or open communication. Indulgent parenting: High in responsiveness and low in demandingness. Permissive parents are warm and indulgent but set few rules or expectations. Neglectful parenting: Low in responsiveness and low in demandingness. Neglectful parents do not meet their children's needs and are generally disengaged from their lives.

Pregnant reactions are physiological phenomena in early pregnancy that include dizziness and weakness, loss of appetite, a preference for acidic foods or an aversion to greasy foods, nausea, morning sickness, and vomiting. EPA and DHA-rich supplementation after birth refers to the additional intake of EPA and DHA-rich substances in addition to a child's daily diet between the ages of 0 and 3 years. Maternal smoking during pregnancy was defined as cigarette smoking (at least 1 time/per day, including e-cigarettes) more than 6 months during pregnancy. Maternal drinking during pregnancy was defined as the mother's consumption of alcohol (including all alcoholic beverages) during pregnancy for a cumulative period of more than 6 months. Second-hand smoking during pregnancy refers to exposure to family members smoking in the home.

The sample size required for the study was calculated according to the sample size formula for a cohort case-control study, which is as follows:

$$n = \frac{\left[Z_{1-\alpha/2}\sqrt{2\overline{P}(1-P_1)} + Z_{\beta}\sqrt{P_1(1-P_1)+P_0(1-P_0)}\right]^2}{(P_1-P_0)^2}\mathrm{n}$$

In the present study, $\alpha = 0.05$, $\beta = 0.10$; $r = 4$. The exposure rate of mothers' literacy junior high school and below in the population was obtained by reviewing the literature as 0.27, with an OR of 3.7. Considering that there were close to 20 independent variables eventually included in the multifactorial analysis and based on the fact that the sample size should be at least 10 times great than the number of variables included in the equation, at least 200 cases were required. The total sample size for this study was determined to be 312, meeting all requirements.

Table 1
The general demographic characteristics between children with dyslexia and normal development children (*n*, %).

Variables	Dyslexic ($n = 60$)	Control ($n = 252$)	χ^2/t	*P*
Age (Mean ± SD)	9.78 ± 1.24	9.72 ± 1.18	0.351	0.726
Gender			1.353	0.245
Male	44(73.3)	165(65.5)		
Female	16(26.7)	87(34.5)		
Grade			2.067	0.599
Grade2	13(21.7)	56(22.2)		
Grade3	12(20.0)	62(24.6)		
Grade4	20(33.3)	62(24.6)		
Grade5	15(25.0)	72(28.6)		

2.5. Statistical analysis

SPSS 26.0 (IBM Corp., Armonk, NY, USA) and R 4.1.4 (R Core Team, Vienna, Austria) were used for statistical analyses. The continuous variables were expressed using mean ± standard deviation (mean ± SD), and the categorical variables were expressed using frequencies and percentages. The *t*-test, chi-square test, and Kruskal-Wallis *H* test were used for group comparisons. Based on the LASSO regression model, the 10-fold cross-validation was used to calculate the model λ value, and the variables were screened according to the lambda1se. The associations between dyslexia risk and the related factors were analyzed using logistic regression models. The significant level was set to 0.05 of two-side.

3. Results

3.1. General demographic characteristics

The general demographic characteristics of the participants were shown in Table 1. A total of 60 children with dyslexia and 252 normally developing children were included. There was no statistically significant difference between the two groups in terms of gender, age, or grade (all $p > 0.05$).

3.2. Comparison of basic family information

The general family information of the participants is shown in Tables S1 and S2. The results showed that the parental education

Table 2
Comparison of maternal prenatal and perinatal influencing factors between children with dyslexia and normal development children (*n*, %).

Variables	Dyslexic ($n = 60$)	Control ($n = 252$)	χ^2/Z	*P*
Risk of pre-eclampsia			2.214	0.137
Yes	10(16.7)	25(9.9)		
No	50(83.3)	277(90.1)		
Pregnancy reactions			−2.494	**0.013**
No	15(25.0)	108(42.9)		
Mild	32(53.3)	94(37.3)		
Medium	8(13.3)	42(16.7)		
Heavy	5(8.3)	8(3.2)		
Miscarriage history			2.780	0.095
Yes	15(25.0)	40(15.9)		
No	45(75.0)	212(84.1)		
EPA and DHA supplement			7.864	**0.005**
Yes	12(20.0)	99(39.9)		
No	48(80.0)	153(60.7)		
Pregnancy smoke				0.751[a]
Yes	4(6.7)	13(5.2)		
No	56(93.3)	239(94.8)		
Second-hand smoke			−3.347	**0.001**
Never	28(46.7)	168(66.7)		
1~3 days per week	12(20.0)	49(19.4)		
4~6 days per week	8(13.3)	16(6.3)		
Every day	12(20.0)	19(7.5)		
Alcohol consumption				0.285[a]
Yes	4(6.7)	9(3.6)		
No	56(93.3)	243(96.4)		
Electronic device use			−1.839	0.066
<1 h	18(30.0)	125(49.6)		
1~4 h	32(53.3)	77(30.6)		
>4 h	10(16.7)	50(19.8)		
Main mood			9.450	**0.009**
Pleasant	13(21.7)	107(42.5)		
Calm	40(66.7)	129(51.2)		
Anxiety/Depression	7(11.7)	16(6.3)		
Gestational Week				**0.047**[a]
Full-term	51(85.0)	235(93.3)		
Preterm	7(11.7)	10(4.0)		
Overdue	2(3.3)	7(2.8)		
Delivery mode				0.147[a]
Normal delivery	35(58.3)	146(57.9)		
Cesarean delivery	22(36.7)	103(40.9)		
Difficult delivery	3(5.0)	3(1.2)		

The ordinal variables were analyzed by Kruskal-Wallis *H* test, otherwise by chi-square test.
[a] Calculated by Fisher's precision probability test.

levels were relatively low in the dyslexic group ($p < 0.001$). In addition, the proportions of paternal personalities between dyslexic group and control groups were also statistically different ($p < 0.01$).

The monthly household income and family categories of the study participants are shown in Figs. S1 and S2. The proportion of family income above 10,000 CNY was lower in the dyslexic group (41.7 % *vs.* 46.8 %), while the proportion of below 5000 CNY in the dyslexic group was significantly higher than that in the control group (33.3 % *vs.* 8.7 %) ($p < 0.001$).

The parenting styles of the children in both groups are shown in Table S3. There were statistical differences in the proportion of primary educator, primary parenting style, and the consistency of family parenting style (all $p < 0.001$). In addition, a significant larger proportion of parents in the dyslexia group chose an authoritarian parenting style than parents in the control group (20.0 % *vs.* 7.1 %). In terms of the consistency in family parenting styles, 31.7 % of the dyslexia group had different parenting styles compared to 7.9 % of the control group.

A comparison of family histories is presented in Table S4. No statistical differences were found in the composition ratios of the two groups in terms of family history of depression, family history of autoimmune diseases, and family history of dyslexia ($p > 0.05$).

3.3. Comparison of prenatal and perinatal influencing factors

The comparison of prenatal and perinatal influencing factors between the two groups is shown in Table 2. Mothers of the dyslexia group children had significantly lower rates of additional EPA and DHA supplementation during their pregnancies than the control group (20.0 % *vs.* 39.9 %, $p < 0.01$), but had a higher proportion of second-hand smoking during pregnancy (20.0 % *vs.* 7.5 %, $p = 0.001$).

Maternal disease history and medical history during pregnancy are shown in Table S5. A greater proportion of cases with maternal histories of gestational diabetes and malnutrition during pregnancy was found than in the control group (10.0 % *vs.* 2.0 % and 10.0 % *vs.* 1.6 %, both $p < 0.05$).

3.4. Comparison of factors in the growth and development of children

The comparison of developmental factors between the two groups of children is shown in Table S6. There was a significantly higher proportion of children with a birth weight below 2500 g in the dyslexic group than in the control group (25.0 % *vs.* 9.9 %, $p < 0.01$), as well as having atopic eczema after birth (8.3 % *vs.* 2.4 %). In the dyslexic group, the proportion of requiring incubator warming at birth was 11.7 %, whereas 3.6 % in the control group ($p < 0.05$). The feeding pattern was also different between the two groups, with a greater proportion of being breastfed at birth in the control group (63.1 % *vs.* 48.3 %, $p < 0.05$). In addition, there was also a statistically significant difference in the frequency of second-hand smoke exposure between the two groups (25.0 % *vs.* 6.3 %; $p < 0.01$). The proportion of children with additional EPA and DHA supplementation after birth was lower in the dyslexia group compared to the

Table 3
Comparison of home reading environment between children with dyslexia and normal development children (*n*, %).

Variables	Dyslexic ($n = 60$)	Control ($n = 252$)	χ^2/Z	*P*
Storytelling by parents			13.930	<**0.001**
None/Sometimes	54(90.0)	165(65.5)		
Often	6(10.0)	87(34.5)		
Teaching children to read			1.979	0.159
None/Sometimes	37(61.7)	130(51.6)		
Often	23(38.3)	122(48.4)		
Encourage reading outside of school			12.394	<**0.001**
None/Sometimes	35(58.3)	85(33.7)		
Often	25(41.7)	167(66.3)		
Buying books of interest			14.877	<**0.001**
None/Sometimes	44(73.3)	115(45.6)		
Often	16(26.7)	137(54.4)		
Frequency of buying books				**0.012**[a]
Weekly	2(3.3)	8(3.2)		
Monthly	3(5.0)	36(14.3)		
Every semester	22(36.7)	46(18.3)		
Annually	1(1.7)	2(0.8)		
Buy as needed	32(53.3)	160(63.5)		
Parental reading frequency			0.640	0.424
None/Sometimes	35(58.3)	161(63.9)		
Often	25(41.7)	91(36.1)		
Annual spending on books			−3.122	**0.002**
< 150yuan	11(18.3)	23(9.1)		
150~300yuan	28(46.7)	84(33.3)		
300~500yuan	12(20.0)	80(31.7)		
> 500yuan	9(15.0)	65(25.8)		

The ordinal variables were analyzed by Kruskal-Wallis *H* test, otherwise by chi-square test.
[a] Calculated by Fisher's precision probability test.

control (26.7 % *vs*. 46.7 %, $p < 0.01$).

3.5. Comparison of home literacy environments

The comparison of the home reading environments between the two groups is shown in Table 3. The results showed that the parents in the control group were more inclined to tell stories to their children, encourage reading outside of school, and buy books of interest for their children during the preschool years (34.5 % *vs*. 10.0 %, 66.3 % *vs*. 41.7 %, and 54.4 % *vs*. 26.7 %, $p < 0.001$, respectively). In addition, there were statistically significant differences between the dyslexic group and the control group in the frequency of buying books by parents and the annual spending on books (both $p < 0.05$). The proportion of children in the control group whose parents spent >500 CNY per year on books for their children was greater than that in the case group (25.8 % *vs*. 15.0 %, $p < 0.05$).

3.6. Comparison of children's reading and habits of life

The comparison of children's reading habits between the two groups is shown in Table S7. The ratio of children who read regularly and actively was lower in the dyslexic group (11.7 % *vs*. 43.3 %, $p < 0.001$), as well as the number of children who had extracurricular reading on a weekly frequency ($p < 0.001$). Regarding extracurricular reading of fairy tales, science books, and composition books, similar results were found (all $p < 0.001$).

As shown in Tables S8 and 84.9 % of the children in the control group primarily used electronic devices for learning, which was significantly greater than the children in the dyslexic group (56.7 %) ($p < 0.001$). However, a greater percentage of children used electronic devices to watch videos in the dyslexic group than in the control group (58.3 % *vs*. 34.9 %, $p < 0.001$). In addition, there was also significant difference in the distribution of tea-drinking habits, and physical exercise habits between the two groups (both $p < 0.05$).

3.7. Association between possible influencing factors and Chinese dyslexia

Variables that were statistically different in the univariate analysis were included in the LASSO regression for variable screening. The parameter λ was calculated using the 10-fold cross-validation method. According to lamda1se, 13 important variables were finally filtered out (Fig. 1). The values of the above variables were shown in Table S9.

Fig. 2 presents the results of a multivariate logistic regression analysis exploring the potential relationships between various influencing factors and the risk of dyslexia among Chinese children. The 13 independent variables were selected utilizing the LASSO regression. The risk of DD was 4.30 times higher and 5.65 times higher for children whose mothers had a junior high and elementary education level than a Bachelor's/junior college or above. The risk of DD was significantly lower in the group with monthly family income >10,000 CNY compared to <5000 CNY (OR = 0.26, 95%CI: 0.07–0.95). Additionally, divergent parenting styles may be a risk factor for develop DD as opposed to consistent parenting styles (OR = 4.93, 95%CI: 1.11–21.91). Children whose mothers were malnourished during pregnancy were more likely to develop DD (OR = 10.31, 95 % CI: 1.84–37.86). Our study also found that children exposed to daily second-hand smoke at home were 5.33 times more likely to develop DD than not (OR = 5.33, 95 % CI: 1.52–18.66). The risk of DD was lower among children who read occasionally or frequently compared to those who did not have an active reading habit (ORs of 0.26 and 0.17, respectively). In addition, reading fairy tale books and composition books may be a protective factor for DD (ORs of 0.37 and 0.25, respectively).

4. Discussion

Dyslexia undoubtedly poses a serious risk to a child's physical and mental health. As a multifactorial disorder, it is essential to focus

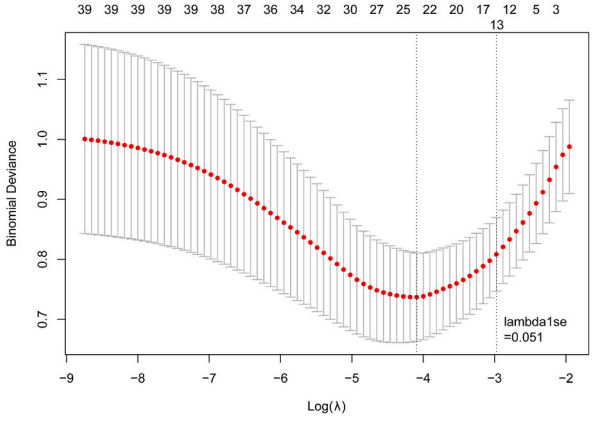


Fig. 1. Parameter λ selection process based on 10-fold cross validation.

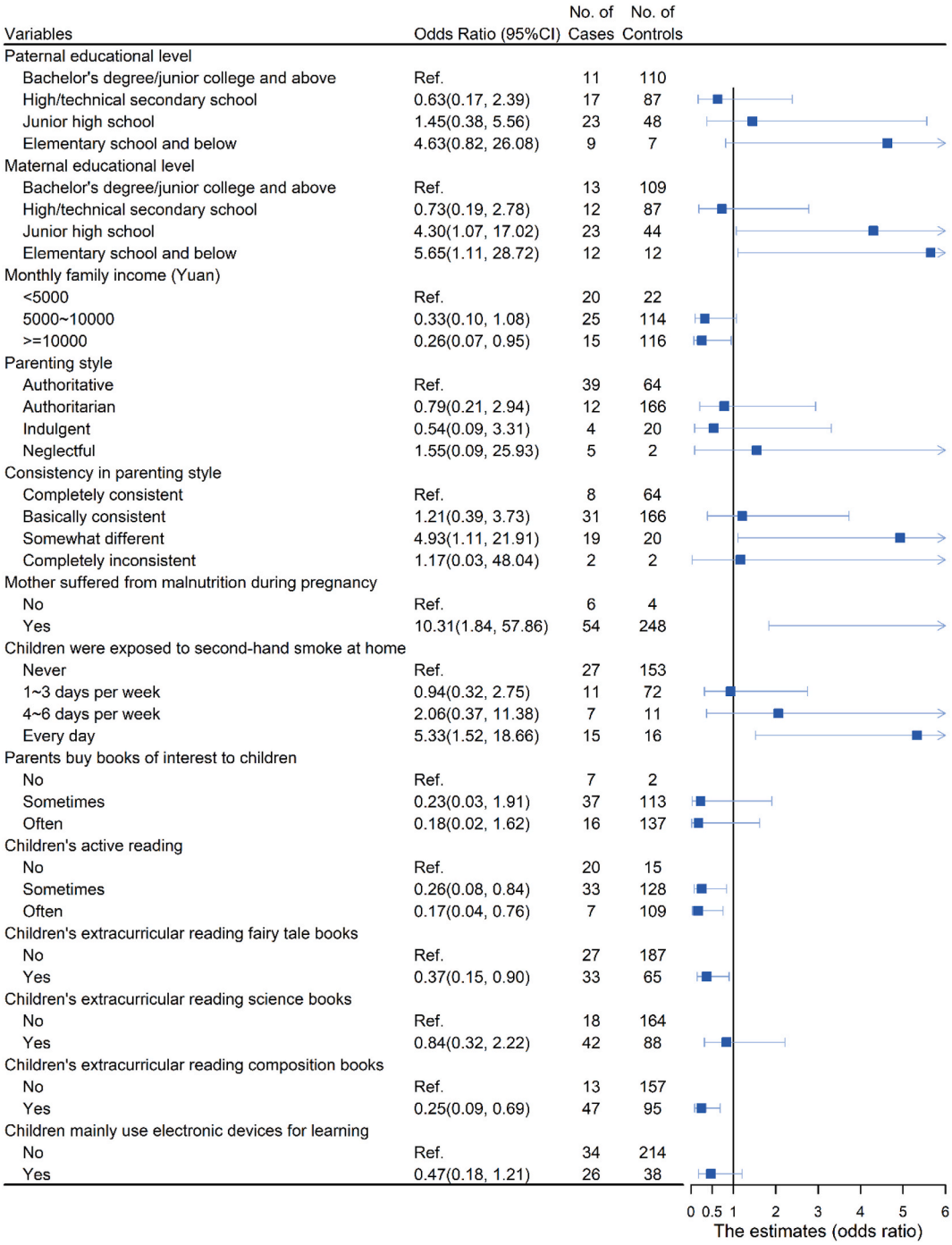


Fig. 2. The association between influencing factors and the risk of Chinese dyslexia.

on environmental influences in dyslexia in addition to genetics. Therefore, this study is based on a case-control study design that combines traditional multivariate logistic regression with LASSO regression analysis to explore multiple environmental effects on dyslexia in China. The findings suggest that maternal malnutrition during pregnancy, divergent family parenting practices, and children's daily exposure to second-hand smoke in the home may increase the risk of dyslexia. While high maternal education, high monthly household income, active child reading, reading fairy tale books, and reading composition books were protective factors for dyslexia. The findings of this study may shed some light on the prevention of dyslexia in future research.

4.1. Dyslexia and socioeconomic status in China

An association has been observed between family socioeconomic status, defined as the education level, occupation, and income of a family, and children's reading abilities [18]. In the current study, results show that a higher level of monthly family income reduces the risk of children developing dyslexia, which is consistent with other population-based studies in China [19]. Poor family economic status may affect the occurrence of dyslexia by reducing the frequency with which parents buy books for reading outside of school and by reducing the opportunities for children to read outside of school. Some studies suggest that poorer family socioeconomic status may indirectly affect children's reading development by amplifying the role of other factors, such as genetics, that contribute to dyslexia [20]. Studies analyzing the brain structure of children with dyslexia found that higher family socioeconomic levels were associated with thicker cortices in the peri lateral fissure and supramarginal gyrus regions on both sides of the brain, which play an important role in the body's language and reading abilities [21]. On the other hand, parental education level is also an important factor in the socioeconomic status of the family [22]. In the univariate analysis, paternal education levels were statistically different between the dyslexic and control groups; however, in the multifactorial analysis, a significant correlation was found between maternal education level and Chinese dyslexia. A study from the Netherlands found that higher parental education level was significantly associated with higher child reading ability [23]. However, some studies also found that the association between maternal education level and children's reading ability became less significant when correcting for influences related to the home reading environment [24]. We believe that this inconsistent result may be related to the Chinese family structure and the fact that fathers go out to work. In China, fathers often start working after their children reach one month, while mothers often stay at home to accompany and educate their children. Therefore, our study found that compared to fathers, mothers' educational level has a significant impact on their children's dyslexia. Overall, there is still much debate about the impact of family socioeconomic status on a child's reading disability, whether this effect is direct or indirect. However, it is undeniable that better family socioeconomic status will allow children to be better educated, and that parents will pay more attention to the development of their children's learning abilities, which in turn will reduce the chances of a child having dyslexia.

4.2. Association of dyslexia with maternal perinatal factors

To present, there has been a wealth of research on the relationship between various factors influencing maternal pregnancy and offspring neurodevelopment [25,26], but there has been little research on the association between childhood dyslexia as a neurodevelopmental disorder and factors during maternal pregnancy and delivery, especially in China [6]. Most previous studies have focused solely on the relationship between these factors and the reading ability of the offspring. Among these factors, pregnancy smoking was one of the most important influencing factors. Our study found that children's daily exposure to second-hand smoke at home significantly increased the risk of dyslexia. In a UK cohort study, maternal prenatal daily nicotine intake was shown to be moderately or significantly associated with poor performance in several reading-related outcomes (e.g., reading speed, word recognition, reading comprehension, etc.) [27]. However, the mechanisms underlying the association between postnatal second-hand smoke exposure and offspring neurodevelopment remain unclear, particularly for Chinese dyslexia and need further clarification through high-quality studies. In addition, two ethnically diverse studies from China and the United Kingdom found that a family history of mental illness, maternal infectious disease during pregnancy, maternal use of anti-infective drugs during pregnancy, maternal use of psychotherapeutic drugs during pregnancy, and difficult births can increase the risk of dyslexia [9,24]. In an Italian case-control study, Mascheretti et al. found a significant association between maternal risk of miscarriage during pregnancy and an increased risk of dyslexia in offspring. They concluded that the risk of miscarriage reflects a poor intrauterine environment for the mother, which can interfere with early fetal brain development and ultimately affect the reading ability of the offspring [7]. At the same time, the study also investigated the potential role of breastfeeding, but found that this factor did not increase the likelihood of dyslexia in offspring, in agreement with our findings. Notably, the results of this study found that maternal malnutrition during pregnancy may be a risk factor for dyslexia. To the best of our knowledge, this is the first time that an association between this factor and dyslexia has been reported. Malnutrition in the mother during pregnancy can affect the intrauterine energy supply during foetal development and thus the neurological development of the offspring. In addition to factors during pregnancy, several factors during the perinatal period have been reported to be associated with the development of dyslexia in offspring [28]. However, studies in this area also have inconsistent findings, and a previous study did not observe an association between obstructed labor and neurodevelopmental disorders-like disorders [29]. While there is growing evidence that multiple maternal factors during pregnancy and delivery influence the occurrence of dyslexia in offspring, replications between different studies are poor and more detailed studies are needed to perform this.

4.3. Association of Chinese dyslexia with childhood growth and development factors

In addition to factors affecting the mother during pregnancy and delivery, a range of factors related to growth and development of children after birth can also affect normal neurological development [30,31]. Among these factors, birth weight and whether or not to breastfeed were the focus of the current study. A recent meta-analysis showed that children with low versus very low birth weight have a significantly increased risk of ADHD (a neurodevelopmental disorder) [32]. Similarly, low birth weight has been found to be associated with dyslexia, which is also a neurodevelopmental disorder. The results of a study on very low birth weight infants showed that the prevalence of dyslexia in this population was much greater than that in the general population [33]. Lower birth weight may cause neurodevelopmental disorders through dysregulation of the hypothalamic-pituitary-adrenal axis or perinatal systemic

inflammation [34,35]. However, the growth and developmental problems associated with low birth weight may be only an indirect contributor to dyslexia, and the associated results are still highly controversial and their impact on the mechanisms of dyslexia development needs further research. Breastfeeding, on the other hand, is also a key influence on the neurodevelopment of offspring. Studies have reported that children who have been breastfed have larger areas of gray matter volume and better gray matter function than those who have not been breastfed, and a reduction in gray matter volume has been found in Chinese dyslexic children, suggesting a possible link between breastfeeding and dyslexia [36,37]. To the best of our knowledge, no previous study on this topic has been conducted in Chinese dyslexic children, and we investigated the breastfeeding status of our study participants, but found no statistically significant association between them. In addition to the above, the study found that children's daily exposure to second-hand smoke at home significantly increased the risk of dyslexia. However, the mechanisms underlying the association between postnatal second-hand smoke exposure and offspring neurodevelopment remain unclear, particularly for Chinese dyslexia, and remain to be clarified in more high-quality studies.

4.4. Association between Chinese dyslexia and the home reading environment

Of the various environmental factors that affect reading problems, the home reading environment is more closely associated with dyslexia. Studies in different populations have shown that a well home reading environment can reduce the risk of dyslexia [38–40]. And children's reading ability, achievement or risk of dyslexia can be predicted by their home reading environment. Hamilton et al. demonstrated that the home reading environment of preschool children was predictive of oral language, phonological awareness, and reading skills in grade 2 [41]. Although it has been suggested that the association between dyslexia and family reading environment is likely to be regulated by genetic factors, similar developmental trajectories can still be observed in non-at-risk populations [41,42]. In the present study, we found differences in the home reading environment between the two groups. The frequency of parental purchases of books of interest to the child, as screened by the LASSO regression analysis, also had a high significance in predicting dyslexia outcomes. However, after adjusting for other possible factors, no statistical association was found between it and dyslexia. This may be because the informal home reading environment doesn't directly influence children's language and reading development [43]. Informal home reading environments include multiple interactions such as parents reading aloud to their children or directing their attention to words in the environment. Research has concluded that informal home reading environments appear to be more closely associated with the development of a wide range of oral language skills, thus indirectly influencing reading comprehension and reading ability [44,45]. In contrast, formal home reading environments, such as adults teaching children to read and write directly in the home, are usually associated with better literacy skills [46]. It is worth noting that, regardless of whether the effect of the home reading environment on dyslexia is direct or indirect, a good home reading environment is necessary for parents' reading behaviors to serve as role models and for children to get more reading practice, which can be beneficial later in life.

4.5. The association of children's lifelong learning habits and Chinese dyslexia

Studies have concluded that by developing reading habits during the course of their studies, children can increase their reading experience and increase their own orthographic awareness, thus reducing the risk of dyslexia [47]. Some studies have also investigated children's electronic device use, and the results show that the risk of dyslexia increased significantly with the increase of children's electronic device use time [48]. With the development of technology, the use of related electronic devices has gradually become younger, especially nowadays with the rise of short video software, many children consume more time on recreational activities during such an important learning phase as school age, which not only tends to cause organic damage such as myopia, but also leads to some emotional and behavioral problems [49]. Using the results of multifactorial Logistic regression, we found that higher frequency of active reading, reading fairy tale books, and reading composition-based extracurricular books may be protective factors for children with Chinese dyslexia, which is consistent with the results of most studies [50]. Among these, reading composition books can exercise good reading comprehension skills, which are more logical and helpful than comic books. Because dyslexic children face special difficulties in reading, they often need to spend more time and energy in their daily learning to complete their schoolwork, which may easily cause frustration to develop eventually leading to negative self-awareness [51]. Negative self-awareness, in turn, may reduce children's motivation to read their opportunities to do so, trapping them in a vicious cycle that is difficult to resolve. Therefore, teachers and parents need to pay more attention to dyslexic children, give them more patience, and encourage them to engage in more reading-related activities.

4.6. Strengths and limitations

This study has several strengths. Firstly, based on previous research, this investigation comprehensively reviewed environmental factors impacting children with Chinese dyslexia. Secondly, we combined traditional multi-factor logistic regression with LASSO regression to identify environmental factors that contribute significantly to Chinese dyslexia for comprehensive analysis and to address the issue of high correlation and covariance among variables. Additionally, our rigorous diagnostic screening process, which had been implemented multiple times in previous surveys, effectively diagnosed representative Chinese dyslexic children. It is important to cautiously apply our findings to other contexts, considering potential variations in linguistic, educational, and cultural factors. Cross-cultural studies involving collaborative research across different countries and linguistic environments would help validate the universality or specificity of these factors.

However, this study also has some limitations. Firstly, it is a retrospective case-control study, which may be subject to recall bias,

and the data were all collected through questionnaires, which could be influenced by subjective factors. Additionally, the relatively small sample size of the study cautions against generalizing the results too widely. This study is a case-control study and cannot draw causal conclusions on regarding reading disorders in primary school students.

5. Conclusions

This study was based on a case-control study design that combined LASSO regression with multi-factor Logistic regression to analyze multiple environmental influences on children with Chinese dyslexia. Significant associations were found between Chinese dyslexia and socioeconomic status, appropriate extracurricular reading, reading composition books, maternal malnutrition during pregnancy, and children's daily exposure to second-hand smoking at home, which provide a theoretical basis and reference value for subsequent interventions for children with dyslexia and for the prevention of the occurrence of dyslexia.

Funding

The research was funded by Special Fund for Science and Technology of Guangdong Province (grant no.: STKJ2021043; STKJ202209070). The authors wish to thank all the students and teachers who participated in this project.

Ethics declarations

Ethics approval and consent to participate: The study procedures were carried out in accordance with the Declaration of Helsinki. Written informed consents were received and signed by the parents or guardians prior to the investigations. All participants/patients (or their proxies/legal guardians) provided informed consent to participate in the study. This study was reviewed and approved by the Ethics Committee of the Mental Health Center of Shantou University, with the approval number: (MSUMC-2021-09).

Availability of data and materials

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

CRediT authorship contribution statement

Lijing Zou: Conceptualization, Investigation, Methodology, Software, Validation, Writing – original draft. **Anyan Huang:** Conceptualization, Formal analysis, Methodology, Software. **Kusheng Wu:** Methodology, Project administration, Validation, Writing – review & editing. **Xuanzhi Zhang:** Data curation, Investigation. **Kaiguo Zhang:** Investigation. **Wanyi Wen:** Data curation. **Liwen Guan:** Data curation. **Yanhong Huang:** Funding acquisition, Project administration, Resources, Validation.

Declaration of competing interest

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

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e22100.

References

[1] R.L. Peterson, B.F. Pennington, Developmental dyslexia, Annu. Rev. Clin. Psychol. 11 (2015) 283–307, https://doi.org/10.1146/annurev-clinpsy-032814-112842.
[2] S.E. Shaywitz, Dyslexia, N. Engl. J. Med. 338 (1998) 307–312, https://doi.org/10.1056/nejm199801293380507.
[3] Y. Lin, X. Zhang, Q. Huang, L. Lv, A. Huang, A. Li, K. Wu, Y. Huang, The prevalence of dyslexia in primary school children and their Chinese literacy assessment in Shantou, China, Int. J. Environ. Res. Publ. Health 17 (2020), https://doi.org/10.3390/ijerph17197140.
[4] A. Carrion-Castillo, B. Maassen, B. Franke, A. Heister, M. Naber, A. van der Leij, C. Francks, S.E. Fisher, Association analysis of dyslexia candidate genes in a Dutch longitudinal sample, Eur. J. Hum. Genet. 25 (2017) 452–460, https://doi.org/10.1038/ejhg.2016.194.
[5] I.R. Konig, J. Schumacher, P. Hoffmann, A. Kleensang, K.U. Ludwig, T. Grimm, N. Neuhoff, M. Preis, D. Roeske, A. Warnke, P. Propping, H. Remschmidt, M. M. Nothen, A. Ziegler, B. Muller-Myhsok, G. Schulte-Korne, Mapping for dyslexia and related cognitive trait loci provides strong evidence for further risk genes on chromosome 6p21, Am J Med Genet B Neuropsychiatr Genet 156B (2011) 36–43, https://doi.org/10.1002/ajmg.b.31135.
[6] N. Becker, M. Vasconcelos, V. Oliveira, F.C.D. Santos, L. Bizarro, R.M.M. Almeida, J.F. Salles, M.R.S. Carvalho, Genetic and environmental risk factors for developmental dyslexia in children: systematic review of the last decade, Dev. Neuropsychol. 42 (2017) 423–445, https://doi.org/10.1080/87565641.2017.1374960.
[7] S. Mascheretti, C. Marino, D. Simone, E. Quadrelli, V. Riva, M.R. Cellino, M. Maziade, C. Brombin, M. Battaglia, Putative risk factors in developmental dyslexia: a case-control study of Italian children, J. Learn. Disabil. 48 (2015) 120–129, https://doi.org/10.1177/0022219413492853.

[8] L.G. Hamilton, M.E. Hayiou-Thomas, M.J. Snowling, Shared storybook reading with children at family risk of dyslexia, J. Res. Read. 44 (2021) 859–881, https://doi.org/10.1111/1467-9817.12375.

[9] L. Liu, J. Wang, S. Shao, X. Luo, R. Kong, X. Zhang, R. Song, Descriptive epidemiology of prenatal and perinatal risk factors in a Chinese population with reading disorder, Sci. Rep. 6 (2016), 36697, https://doi.org/10.1038/srep36697.

[10] B. Rajaratnam, S. Roberts, D. Sparks, O. Dalal, Lasso regression: estimation and shrinkage via the limit of Gibbs sampling, J. Roy. Stat. Soc. B 78 (2016) 153–174, https://doi.org/10.1111/rssb.12106.

[11] M.A. Mansournia, N.P. Jewell, S. Greenland, Case–control matching: effects, misconceptions, and recommendations, Eur. J. Epidemiol. 33 (2018) 5–14, https://doi.org/10.1007/s10654-017-0325-0.

[12] John, J. Raven, Raven progressive Matrices, in: R.S. McCallum (Ed.), Handbook of Nonverbal Assessment, Springer US, Boston, MA, 2003, pp. 223–237.

[13] F. Hou, L. Qi, L. Liu, X. Luo, H. Gu, X. Xie, X. Li, J. Zhang, R. Song, Validity and reliability of the dyslexia checklist for Chinese children, Front. Psychol. 9 (2018) 1915, https://doi.org/10.3389/fpsyg.2018.01915.

[14] M. Shiota, T. Koeda, K. Takeshita, [Clinical studies of learning disability. Part I: two-axial diagnosis of learning disability using the Pupil Rating Scale Revised (PRS) and WISC-R], No Hattatsu 27 (1995) 455–460.

[15] A. Huang, K. Wu, A. Li, X. Zhang, Y. Lin, Y. Huang, The reliability and validity of an assessment tool for developmental dyslexia in Chinese children, Int. J. Environ. Res. Publ. Health 17 (2020), https://doi.org/10.3390/ijerph17103660.

[16] M.A. Marty, D.L. Segal, DSM-5: Diagnostic and Statistical Manual of Mental Disorders, American Psychiatric Association, Washington, DC, USA, 2015.

[17] D. Baumrind, The influence of parenting style on adolescent competence and substance use, J. Early Adolesc. 11 (1991) 56–95, https://doi.org/10.1177/0272431691111004.

[18] S. Mascheretti, C. Andreola, S. Scaini, S. Sulpizio, Beyond genes: a systematic review of environmental risk factors in specific reading disorder, Res. Dev. Disabil. 82 (2018) 147–152, https://doi.org/10.1016/j.ridd.2018.03.005.

[19] H. Zhao, B. Zhang, Y. Chen, X. Zhou, P. Zuo, Environmental risk factors in han and Uyghur children with dyslexia: a comparative study, PLoS One 11 (2016), e0159042, https://doi.org/10.1371/journal.pone.0159042.

[20] T.K. Turesky, J. Sanfilippo, J. Zuk, B. Ahtam, B. Gagoski, A. Lee, K. Garrisi, J. Dunstan, C. Carruthers, J. Vanderauwera, X. Yu, N. Gaab, Home language and literacy environment and its relationship to socioeconomic status and white matter structure in infancy, Brain Struct. Funct. 227 (2022) 2633–2645, https://doi.org/10.1007/s00429-022-02560-4.

[21] R.R. Romeo, J.A. Christodoulou, K.K. Halverson, J. Murtagh, A.B. Cyr, C. Schimmel, P. Chang, P.E. Hook, J.D.E. Gabrieli, Socioeconomic status and reading disability: neuroanatomy and plasticity in response to intervention, Cerebr. Cortex 28 (2018) 2297–2312, https://doi.org/10.1093/cercor/bhx131. New York, N.Y. : 1991.

[22] J. Vanderauwera, E.R.H. van Setten, N.M. Maurits, B.A.M. Maassen, The interplay of socio-economic status represented by paternal educational level, white matter structure and reading, PLoS One 14 (2019), e0215560, https://doi.org/10.1371/journal.pone.0215560.

[23] E. van Bergen, P.F. de Jong, A. Regtvoort, F. Oort, S. van Otterloo, A. van der Leij, Dutch children at family risk of dyslexia: precursors, reading development, and parental effects, Dyslexia 17 (2011) 2–18, https://doi.org/10.1002/dys.423.

[24] J. Dilnot, L. Hamilton, B. Maughan, M.J. Snowling, Child and environmental risk factors predicting readiness for learning in children at high risk of dyslexia, Dev. Psychopathol. 29 (2017) 235–244, https://doi.org/10.1017/s0954579416000134.

[25] M. Herrmann, K. King, M. Weitzman, Prenatal tobacco smoke and postnatal secondhand smoke exposure and child neurodevelopment, Curr. Opin. Pediatr. 20 (2008) 184–190, https://doi.org/10.1097/MOP.0b013e3282f56165.

[26] Y. Jung, A.M. Lee, S.A. McKee, M.R. Picciotto, Maternal smoking and autism spectrum disorder: meta-analysis with population smoking metrics as moderators, Sci. Rep. 7 (2017) 4315, https://doi.org/10.1038/s41598-017-04413-1.

[27] K. Cho, J.C. Frijters, H. Zhang, L.L. Miller, J.R. Gruen, Prenatal exposure to nicotine and impaired reading performance, J. Pediatr. 162 (2013) 713–718.e712, https://doi.org/10.1016/j.jpeds.2012.09.041.

[28] N.N. Zavadenko, N.Y. Suvorinova, A.N. Zavadenko, V.V. Fateeva, [Neurodevelopmental disorders in children and the possibilities of their pharmacotherapy], Zhurnal nevrologii i psikhiatrii imeni S.S. Korsakova 121 (2021) 38–45, https://doi.org/10.17116/jnevro202112111238.

[29] M.G. Rosen, S.M. Debanne, K. Thompson, J.C. Dickinson, Abnormal labor and infant brain damage, Obstet. Gynecol. 80 (1992) 961–965.

[30] K.K. Ferguson, S. Sammallahti, E. Rosen, M. van den Dries, A. Pronk, S. Spaan, M. Guxens, H. Tiemeier, R. Gaillard, V.W.V. Jaddoe, Fetal growth trajectories among small for gestational age babies and child neurodevelopment, Epidemiology 32 (2021) 664–671, https://doi.org/10.1097/ede.0000000000001387.

[31] R.P. Upadhyay, S. Taneja, T.A. Strand, H. Sommerfelt, M. Hysing, S. Mazumder, N. Bhandari, J. Martines, T. Dua, P. Kariger, R. Bahl, Early child stimulation, linear growth and neurodevelopment in low birth weight infants, BMC Pediatr. 22 (2022) 586, https://doi.org/10.1186/s12887-022-03579-6.

[32] A.P. Franz, G.U. Bolat, H. Bolat, A. Matijasevich, I.S. Santos, R.C. Silveira, R.S. Procianoy, L.A. Rohde, C.R. Moreira-Maia, Attention-deficit/hyperactivity disorder and very preterm/very low birth weight: a meta-analysis, Pediatrics 141 (2018), https://doi.org/10.1542/peds.2017-1645.

[33] A. Takeuchi, T. Koeda, T. Takayanagi, K. Sato, N. Sugino, M. Bonno, A. Kada, M. Nakamura, M. Kageyama, Reading difficulty in school-aged very low birth weight infants in Japan, Brain Dev. 38 (2016) 800–806, https://doi.org/10.1016/j.braindev.2016.04.013.

[34] D. Coghill, J. Nigg, A. Rothenberger, E. Sonuga-Barke, R. Tannock, Whither causal models in the neuroscience of ADHD? Dev. Sci. 8 (2005) 105–114, https://doi.org/10.1111/j.1467-7687.2005.00397.x.

[35] O. Dammann, T.M. O'Shea, Cytokines and perinatal brain damage, Clin. Perinatol. 35 (2008) 643–663, https://doi.org/10.1016/j.clp.2008.07.011.

[36] X. Ou, A. Andres, R.T. Pivik, M.A. Cleves, J.H. Snow, Z. Ding, T.M. Badger, Voxel-based morphometry and fMRI revealed differences in brain gray matter in breastfed and milk formula-fed children, AJNR. American journal of neuroradiology 37 (2016) 713–719, https://doi.org/10.3174/ajnr.A4593.

[37] W.T. Siok, Z. Niu, Z. Jin, C.A. Perfetti, L.H. Tan, A structural-functional basis for dyslexia in the cortex of Chinese readers, Proc. Natl. Acad. Sci. U.S.A. 105 (2008) 5561–5566, https://doi.org/10.1073/pnas.0801750105.

[38] Z. Sun, L. Zou, J. Zhang, S. Mo, S. Shao, R. Zhong, J. Ke, X. Lu, X. Miao, R. Song, Prevalence and associated risk factors of dyslexic children in a middle-sized city of China: a cross-sectional study, PLoS One 8 (2013), e56688, https://doi.org/10.1371/journal.pone.0056688.

[39] M. Torppa, K. Eklund, E. van Bergen, H. Lyytinen, Late-emerging and resolving dyslexia: a follow-up study from age 3 to 14, J. Abnorm. Child Psychol. 43 (2015) 1389–1401, https://doi.org/10.1007/s10802-015-0003-1.

[40] E. van Bergen, P.F. de Jong, B. Maassen, A. van der Leij, The effect of parents' literacy skills and children's preliteracy skills on the risk of dyslexia, J. Abnorm. Child Psychol. 42 (2014) 1187–1200, https://doi.org/10.1007/s10802-014-9858-9.

[41] L.G. Hamilton, M.E. Hayiou-Thomas, C. Hulme, M.J. Snowling, The home literacy environment as a predictor of the early literacy development of children at family-risk of dyslexia, Sci. Stud. Read. : the official journal of the Society for the Scientific Study of Reading 20 (2016) 401–419, https://doi.org/10.1080/10888438.2016.1213266.

[42] M. Torppa, A.M. Poikkeus, M.L. Laakso, K. Eklund, H. Lyytinen, Predicting delayed letter knowledge development and its relation to grade 1 reading achievement among children with and without familial risk for dyslexia, Dev. Psychol. 42 (2006) 1128–1142, https://doi.org/10.1037/0012-1649.42.6.1128.

[43] M.L. Puglisi, C. Hulme, L.G. Hamilton, M.J. Snowling, The home literacy environment is a correlate, but perhaps not a cause, of variations in children's language and literacy development, Sci. Stud. Read. : the official journal of the Society for the Scientific Study of Reading 21 (2017) 498–514, https://doi.org/10.1080/10888438.2017.1346660.

[44] M. Pfost, N. Heyne, Joint book reading, library visits and letter teaching in families: relations to parent education and children's reading behavior, Read. Writ. (2023) 1–21, https://doi.org/10.1007/s11145-022-10389-w.

[45] M. Senechal, Testing the home literacy model: parent involvement in kindergarten is differentially related to grade 4 reading comprehension, fluency, spelling, and reading for pleasure, Sci. Stud. Read. 10 (2006) 59–87, https://doi.org/10.1207/s1532799xssr1001_4.

[46] C. Girard, T. Bastelica, J. Léone, J. Epinat-Duclos, L. Longo, J. Prado, Nurturing the reading brain: home literacy practices are associated with children's neural response to printed words through vocabulary skills, NPJ science of learning 6 (2021) 34, https://doi.org/10.1038/s41539-021-00112-9.

[47] S.H. Deacon, C. Mimeau, S.C. Chung, X. Chen, Young readers' skill in learning spellings and meanings of words during independent reading, J. Exp. Child Psychol. 181 (2019) 56–74, https://doi.org/10.1016/j.jecp.2018.12.007.
[48] L.H. Tan, M. Xu, C.Q. Chang, W.T. Siok, China's language input system in the digital age affects children's reading development, Proc. Natl. Acad. Sci. U.S.A. 110 (2013) 1119–1123, https://doi.org/10.1073/pnas.1213586110.
[49] A. Parkes, H. Sweeting, D. Wight, M. Henderson, Do television and electronic games predict children's psychosocial adjustment? Longitudinal research using the UK Millennium Cohort Study, Arch. Dis. Child. 98 (2013) 341–348, https://doi.org/10.1136/archdischild-2011-301508.
[50] P.L. Morgan, D. Fuchs, D.L. Compton, D.S. Cordray, L.S. Fuchs, Does early reading failure decrease children's reading motivation? J. Learn. Disabil. 41 (2008) 387–404, https://doi.org/10.1177/0022219408321112.
[51] L. Bazen, E.H. de Bree, M. van den Boer, P.F. de Jong, Perceived negative consequences of dyslexia: the influence of person and environmental factors, Ann. Dyslexia (2022), https://doi.org/10.1007/s11881-022-00274-0.