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# ENVIRONMENTAL RISK FACTORS IN A CHILDREN WITH DYSLEXIA

# OKOLINSKI FAKTORI RIZIKA KOD DJECE S DISLEKSIJOM

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## ABSTRACT

The aim of this study was to analyze various environmental factors influencing dyslexia to enhance our understanding of its risk factors, including the exposure of mothers of dyslexic children to potential negative developmental influences, perinatal and postnatal developmental characteristics of dyslexic children, genetic predisposition, socioeconomic status, and reading exposure in dyslexic children. Mothers of both dyslexic and non-dyslexic children took part in the study. The home literacy environment and the development of motor skills emerge as significant risk indicators for dyslexia. These findings hold profound implications for public health, emphasizing the critical importance of early childhood in providing children with the best possible educational opportunities.

**Key words:** risk factors, dyslexia, child development, developmental influences, home literacy environment

## SAŽETAK

Cilj ovog istraživanja bio je analizirati različite okolinske faktore koji utječu na disleksiju kako bismo poboljšali razumijevanje faktora rizika, uključujući izloženost majki djece s disleksijom potencijalno negativnim razvojnim utjecajima, perinatalne i postnatalne karakteristike razvoja djece s disleksijom, genetsku predispoziciju, socioekonomski status i izloženost čitanju kod djece s disleksijom. U istraživanju su sudjelovale majke djece s disleksijom i djece bez disleksije. Okruženje kućne pismenosti i razvoj motoričkih vještina

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iskazuju se kao značajni indikatori rizika za disleksiju. Ovi rezultati imaju duboke implikacije za javno zdravstvo, ističući ključnu važnost ranog djetinjstva u pružanju najboljih mogućih obrazovnih prilika djeci.

**Ključne riječi:** faktori rizika, disleksija, razvoj djeteta, razvojni utjecaji, okruženje kućne pismenosti

## INTRODUCTION

Dyslexia, a condition characterized by poor reading ability despite age-appropriate intelligence, education, and instruction, presents challenges in accurate and fluent word recognition, spelling, and decoding abilities (Lyon, Shaywitz & Shaywitz, 2003). This neurodevelopmental disorder of biological origin (American Psychiatric Association, 2013) is among the most frequently diagnosed disorders in childhood (Fisher et al., 2002). According to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V) (American Psychiatric Association, 2013), the prevalence of all learning disorders, including reading, writing, and mathematics impairments, is estimated to be around 5–15% globally. Given that difficulties in reading persist into adolescence and adulthood, dyslexia has lifelong consequences (Shaywitz et al., 1999).

The etiology of dyslexia involves multiple risk factors, which may stem from both genetic and environmental influences (Mascheretti et al., 2013a). Family history of dyslexia is a robust predictor of literacy outcomes (Thompson et al., 2015), suggesting a strong genetic component that can be heterogeneous in nature (Mascheretti et al., 2017). Numerous studies have demonstrated the significantly heritable nature of dyslexia (Fisher et al., 2002; Schumacher et al., 2007). Various loci and candidate genes, including DYX1C1, DCDC2, KIAA0319, and ROBO1, have been identified as primary candidates (Carrion-Castillo , Franke & Fisher, 2013; Kere, 2014; Paracchini, Diaz & Stein, 2016).

Regarding environmental risk and protective factors, there exists a strong correlation between poor reading abilities and low socioeconomic status (SES) (Duncan & Magnuson, 2012; Hair et al., 2015). SES and parental education level are predictive of literacy outcomes (Phillips & Lonigan, 2005). The home literacy environment is linked to early reading skills and may partly mediate the impact of SES (Senechal & LeFevre, 2002).

In a systematic review (Becker et al., 2017), environmental risk factors for developmental dyslexia in children were examined. Another study identified several environmental factors significantly associated with developmental dyslexia, including maternal smoking during pregnancy, child birth weight, socioeconomic status (Mascheretti et al., 2013a), risk of hospitalization due to miscarriage, parental age at childbirth, and parental educational level during the child's first three years (Mascheretti et al., 2013b). Chinese studies also identified the child's level of active learning as a significant risk factor for dyslexia (Sun et al., 2013).

The period of incidence of potential risk factors extends beyond infancy and childhood; the pre- and perinatal periods are also crucial for reading ability (Becker et al., 2017). For example, two independent studies demonstrated a correlation between the number of cigarettes smoked by the mother during pregnancy and her child's language, reading, spelling, and mathematics skills Batstra, Hadders-Algra & Neeleman, 2003; Fried, Watkinson

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& Siegel, 1997). In one study, even after adjusting for confounders such as low SES and pre- and perinatal complications, low scores on reading tests remained associated with maternal smoking (Batstra et al., 2003). Additionally, a study on school-aged children from the Avon Longitudinal Study of Parents and Children (ALSPAC) found that prenatal nicotine exposure was linked to poor performance in specific reading skill outcomes, particularly in decoding single words (Cho et al., 2013).

Nevertheless, some of the results obtained support earlier research findings. Previous studies have shown higher rates of dyslexia among children born to parents younger than 30 years old, as well as lower education levels among mothers of children with dyslexia (Melekian, 1990).

Other research has indicated a higher risk of cognitive disadvantage and educational underachievement for children of younger mothers (Fergusson & Lynskey, 1993; Fergusson & Woodward, 1999). Additionally, evidence supports the impact of familial structure on the development of cognitive and learning abilities (O'Connor et al., 2000). For example, parental separation predicts worse outcomes and more difficulties in learning and preliteracy in children beginning kindergarten, as well as worse academic achievement in adolescents (De Fries, Plomin & Fulker, 1994; Jee et al., 2008).

In a recent study, family history of neuropsychiatric diseases, maternal infectious diseases, difficult vaginal delivery, preterm birth, and neonatal asphyxia were identified as environmental risk factors for developmental dyslexia (Hokkanen, Launes & Michelsson, 2014). Children affected by neonatal hyperbilirubinemia had persisting problems with reading, writing, and mathematics in a prospective birth cohort (Duncan, Brooks-Gunn & Klebanov, 1994).

Studies investigating environmental factors related to dyslexia have received less attention compared to other factors, with fewer publications in the last decade. In a systematic review of environmental factor studies (Becker et al., 2017), it was noted that one Chinese group (Sun et al., 2013) focused on variables associated with educational practices, while another, the Italian group (Mascheretti et al., 2013a), studied variables associated with parental conditions and health history. The aim of the present study is to build upon previous research and examine the association of both educational and health risk factors with dyslexia.

It has been observed that certain sociodemographic characteristics of the family, such as low income and lower maternal education, increase the likelihood of poor outcomes for children (Tough et al., 2008; Kenner & D'Apolito, 1997). Exposure to substances in utero can affect birth outcomes and child development (Kenner & D'Apolito, 1997). Postpartum depression has been linked to adverse cognitive and emotional development in infants (Murray & Cooper, 1997), while the home literacy environment and child health have been identified as predictors of reading readiness (Dilnot et al., 2017).

Various environmental risk factors have been analyzed separately, yielding inconsistent results. The study aimed to consolidate and analyze different environmental factors influencing dyslexia to enhance our understanding of its risk factors. Its objectives were to assess:

- The exposure of mothers of dyslexic children to potential negative developmental influences.

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- Perinatal and postnatal developmental characteristics of dyslexic children.
- Genetic predisposition, socioeconomic status, and reading exposure in dyslexic children.

## METHODS

### Participants

The sample comprised 70 participants, including 35 mothers of children with dyslexia and 35 mothers of typically achieving children. Initially, children were assessed and classified as dyslexic based on the International Classification of Diseases (ICD-11) (World Health Organization, 2018) criteria: scoring at or below the 10th percentile in reading tasks, with nonverbal intelligence test results indicating an average or above-average intelligence (IQ). All children underwent nonverbal IQ assessment using Raven's Progressive Matrices (Raven, 1956), with the Dyslexia Assessment Test subtests (Duranovic, 2013) employed for further evaluation of reading accuracy and speed, both in word and nonword reading.

Children were classified as dyslexic if they exhibited at least two attainment scores in reading tasks (errors and/or speed) at or below the 10th percentile. Five children displayed lower non-verbal intelligence scores compared to their chronological age peers and were excluded from the dyslexic group. Participants scoring below 2 standard deviations of the typically achieving children group on the nonverbal intelligence task were also excluded from the study. Ultimately, 35 children with dyslexia and 35 typically achieving children constituted the final sample. Means and standard deviations for all tests are shown in Table 1.

**Table 1.** Test scores for participants with dyslexia and chronological age control children

| Variable | Dyslexic group | | Non-dyslexic group | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| One minute reading[a] | 34.00** | 16.86 | 72.31 | 16.83 |
| Real word reading | | | 39.80 | .47 |
| Accurately[a] | 34.29** | 4.88 | | |
| Reading time (s)[a] | 89.94** | 64.87 | 29.89 | 12.48 |
| Nonword reading | | | | |
| Accurately[a] | 28.89** | 6.44 | 39.09 | .95 |
| Reading time (s)[a] | 133.66 | 83.18 | 51.03 | 20.56 |
| Spelling [a] | 37.54** | 8.86 | 48.40 | 2.23 |
| IQ[b] | 34.29 | 1.73 | 34.14 | 1.40 |

Note. [a]Sub tests of the Dyslexia Screening Test (Duranovic, 2013) [b] IQ, average of individual intelligence quotients according to the Standard Progressive Matrices Test.

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After identifying children with dyslexia and typically developing children, their mothers were invited to participate in the research. The mothers' ages ranged from 26 to 40 years (M = 32.89, SD = 4.08). Information on education and income was gathered through questionnaires (see Table 2).

Regarding education, the mothers of children with dyslexia had the following educational statuses: 17.1% had only primary education, 62.9% had secondary education, and 20.0% had higher education. The educational statuses of the mothers of typically developing children were as follows: 74.3% had secondary education, 20.0% had higher education, and 5.7% had a master's degree. The educational statuses of fathers were also analyzed, though this information is not provided.

Income information, defined as net household income, was collected in two intervals: less than 500 euros and more than 500 euros per month. The income distribution among families of children with dyslexia was as follows: 57.14% had an income below 500 euros, and 42.86% had an income above 500 euros. Among families of typically developing children, 42.9% had an income below 500 euros, while 57.14% had an income above 500 euros.

**Table 2.** Characteristics of mothers and fathers who participated in the study

| Variable | Dyslexic group | | Non-dyslexic | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| Age of mothers | 32.80 | 4.12 | 34.40 | 4.05 |
| | n (%) | | n (%) | |
| Education of mothers | | | | |
| Primary education | 6 (17.1) | | | |
| Secondary education | 22 (62.9) | | 26 (74.3) | |
| Higher education | 7 (20) | | 7 (20) | |
| Master's degree | | | 2 (5.7) | |
| Education of fathers* | | | | |
| Primary education | 5 (14.3) | | | |
| Secondary education | 27 (77.1) | | 27 (77.1) | |
| Higher education | 3 (8.6) | | 8 (22.9) | |
| Income | | | | |
| below 500 eur | 20 (57.14) | | 15 (42.86) | |
| above 500 eur | 15 (42.86) | | 20 (57.14) | |

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## Measuring instruments and method of conducting research

The research was conducted in regular primary schools in Srebrenik and Brčko, Bosnia and Herzegovina. The research was conducted in accordance with the Declaration of Helsinki and all procedures were carried out with the adequate understanding and written consent of the subjects. The protocol was approved by the Scientific Committee of the Faculty of Education and Rehabilitation, University of Tuzla.

Children were individually tested in quiet rooms of the primary schools to identify students with dyslexia. Following the identification of students with dyslexia, questionnaires were sent to mothers of children diagnosed with dyslexia and children without reading and writing difficulties. The questionnaire consisted of 36 questions and was anonymous.

Several studies have indicated that a family history of dyslexia or speech and language disorders adversely affects students' performance on reading tests. Much of the research on the influence of genetic factors on reading ability focuses on the prevalence of dyslexia among family members. Hence, one of the questions in the questionnaire enquired whether anyone in the family had difficulty in speaking, reading, or writing. Parents responded by circling either yes or no. If the answer was yes, further details were requested, including which relative had dyslexia or a speech-language disorder. Research found that more than half of students with at least one family member with dyslexia experienced reading difficulties at the age of 8 (Snowling, Gallagher & Frith, 2003). A family history of reading difficulties predicts reading failure (Lewis, Freebairn & Taylor, 2000). Furthermore, the family history of reading problems significantly predicted spelling difficulties. The role of family history of speech-language disorders as a risk factor for reading has been less researched.

Speech and language skills are considered potential risk factors for reading difficulties. Thus, one of the questions in the questionnaire asked whether the child had experienced speech or language difficulties and whether they had received speech therapy. To gather information about speech and language characteristics is to investigate the child's history of speech therapy (Gijsel, Bosman & Verhoeven, 2006).

The parent questionnaire included information on the amount of reading practice the child engaged in at home during the year prior to starting school, categorized from 1 (little exercise) to 5 (lots of exercise). Additionally, the child's exposure to reading was assessed through variables such as how often the parents read to the child, how often the parents read themselves, how often the child read independently, and at what age the parents started reading to the child. The questionnaire also incorporated inquiries regarding parental educational and socioeconomic status.

Furthermore, the questionnaire encompassed questions about prenatal, perinatal, and postnatal developmental characteristics of the child, as well as the mother's exposure to various factors. These included inquiries about the mother's history of serious illness or trauma during pregnancy, use of drugs, alcohol, or cigarettes, utilization of therapy during pregnancy, occurrence of bleeding during pregnancy, consumption of coffee, use of cosmetics, experience of excessive mental problems during pregnancy, premature rupture of amniotic fluid at birth, mode of delivery, infant crying at birth, birth weight, Apgar score, use of an incubator at birth, breastfeeding, speech and motor development delays in the child,

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allergies, viruses, or infections during early development, frequency of ear infections, age of diaper cessation, crawling, exposure to excessive noise or light, and exposure to extreme temperatures.

## RESULTS

### Association between Prenatal Risk Factors and Dyslexia.

Table 3 presents the association between potential prenatal risk factors, including the mother's health condition, and dyslexia. No risk factors, such as the presence of serious illness or trauma, use of drugs, alcohol, cigarettes, medications, bleeding during pregnancy, or consumption of coffee, were significantly associated with dyslexia.

Table 4 presents the association between potential prenatal risk factors, encompassing child health conditions, and dyslexia. Dyslexic children exhibited a significantly higher proportion of delayed motor skills development (40.0% vs. 8.6%). This was the sole prenatal risk factor demonstrating a significant main effect ($P < 0.05$). Other risk factors pertaining to child health conditions, such as immediate crying after birth, birth weight, Apgar score, incubator duration, crawling, speech development, ear infections, speech disorders, and participation in speech therapy, did not exhibit significant associations with dyslexia.

Linear regression analyses were performed to examine the effect of development of motor skills on reading and writing for the dyslexic and the control group. The dependent variable was development of motor skills, and predictors were variables of reading and writing skills. The results are presented in Table 5. Development of motor skills was found to explain 24.1% variance in reading and writing. The multiple linear regression model did not indicate a significant association between development of motor skills and nonword reading ($p > .05$) and spelling ($p > .05$).

Table 6 presents the association between a child's exposure to reading and dyslexia. Mothers of children with dyslexia read to them less often than mothers of children without problems, the mothers of children with dyslexia themselves read less, and children with dyslexia generally read less than normally achieving children. Significant main effects were found for these three risk factors ($P < 0.05$).

Linear regression analyses were conducted to investigate the impact of mother's reading on reading and writing abilities for both the dyslexic and control groups. The dependent variable was the development of reading and writing skills, with predictors being variables related to reading and writing abilities. The results are summarized in Table 7. Mother's reading was found to account for 20.6% of the variance in reading and writing abilities. The multiple linear regression model revealed a significant association between mother's reading and nonword reading ($p < .01$). However, no significant associations were found between mother's reading to the child and the child's reading and spelling abilities.

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**Table 3.** Analytical statistics for the association between prenatal risk factors including mother's health condition and dyslexia

| During pregnancy: | Dyslexic n (%) | Non-dyslexic n (%) | Chi-square | *P* value | adjusted *OR* (95% CI) | *P* value |
|---|---|---|---|---|---|---|
| mother suffered from a serious illness or trauma | 2 (2.57) | 0 (0) | 2.06 | .15 | 1.00 | 1.00 |
| Using of: | | | | | | |
| drugs | 0 | 0 | | | | |
| alcohol | 0 | 0 | | | | |
| cigarettes | 8 (22.9) | 6 (17.1) | 2.01 | .57 | .00 | 1.00 |
| medicines | 6 (17.1) | 6 (17.1) | .00 | 1.00 | .00 | 1.00 |
| Aldomet | 2 (5.7) | | 12.00 | .15 | .00 | 1.00 |
| Paracetamol | 2 (5.7) | | | | | |
| Ultrogestan | 1 (2.9) | | | | | |
| Ferum | 1 (2.9) | | | | | |
| Vitamins | | 1 (2.9) | | | | |
| Gynipral | | 3 (8.6) | | | | |
| Dabrostan | | 1 (2.9) | | | | |
| Canesten | | 1 (2.9) | | | | |
| Bleeding | 7 (20) | 3 (8.6) | 1.87 | .17 | 6.38 | .67 |
| Coffee | 17 (80) | 30 (85.7) | 5.44 | .36 | .71 | .43 |
| 1 cup | 3 (8.6) | 9 (25.7) | | | | |
| 2 cups | 16 (45.7) | 16 (45.7) | | | | |
| 3 cups | 5 (14.3) | 4 (11.4) | | | | |
| 4 cups | 3 (8.6) | 1 (2.9) | | | | |
| 10 cups | 1 (2.9) | | | | | |

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**Table 4.** Analytical statistics for the association between prenatal risk factors including child health condition and dyslexia

| | Dyslexic n (%) | Non-dyslexic n (%) | Chi-square | *P* value | adjusted *OR* (95% CI) | *P* value |
|---|---|---|---|---|---|---|
| did not cry immediately after birth | 2 (5.7) | 1 (2.9) | .35 | .56 | 1.56 | .79 |
| Childbirth weight at birth | | | 1.76 | .78 | .67 | .30 |
| unknown | 1 (2.9) | 5 (14.3) | | | | |
| 2000-2500 | 3 (8.6) | 4 (11.4) | | | | |
| 2500-3000 | 3 (8.6) | 21 (60) | | | | |
| 3000-4000 | 22 (62.9) | 5 (14.3) | | | | |
| 4000-4500 | 6 (17.1) | | | | | |
| Apgar score | | | 4.79 | .44 | .37 | .94 |
| unknown | 20 (57.2) | 15 (42.9) | | | | |
| 3 | 1 (2.9) | | | | | |
| 8 | 1 (2.9) | 1 (2.9) | | | | |
| 9 | 10 (29.6) | 11 (31.4) | | | | |
| 10 | 3 (8.6) | 8 (22.9) | | | | |
| Was in the incubator | 6 (17.1) | 3 (8.6) | 1.15 | .28 | 1.35 | .77 |
| Crawled | 33 (94.3) | 28 (80) | 3.19 | .07 | .11 | 6.89 |
| The development of motor skills was delayed | 14 (40.0) | 3 (8.6) | 9.40 | **.002** | 9.97 | **.01** |
| Speech development was delayed | 4 (11.49) | 3 (8.6) | .16 | .69 | .05 | **.17** |
| Had frequent ear infections | 3 (8.6) | 4 (11.4) | .16 | .69 | .00 | **1.00** |
| Had speech disorders | 3 (8.6) | 1 (2.9) | 1.06 | .30 | .71 | .00 |
| Speech therapy | 8 (22.9) | 3 (8.6) | 2.70 | .10 | 1.00 | 4.06 |

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**Table 5.** Regression analysis for dependent variable development of motor skills

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .554 | .307 | .241 | .376 |

**Table 6.** Analytical statistics for the association between child's exposure to reading and dyslexia

| | Dyslexic n (%) | Non-dyslexic (%) | Chi-square | *P* value | adjusted *OR* (95% CI) | *P* value |
|---|---|---|---|---|---|---|
| reading at home a year before going to school | | | .83 | .94 | .14 | .48 |
| little | 11 (31.4) | 13 (37.1) | | | | |
| rare | 14 (40.0) | 9 (25.7) | | | | |
| sometimes | 7 (20.0) | 6 (17.1) | | | | |
| often | 3 (8.6) | 5 (14.3) | | | | |
| a lot | | 2 (5.7) | | | | |
| The mother read to the child | | | 2.15 | .71 | .81 | .02 |
| little | 3 (8.6) | 4 (11.4) | | | | |
| rare | 9 (25.7) | | | | | |
| sometimes | 5 (14.3) | 18 (51.4) | | | | |
| often | 13 (37.1) | 2 (5.7) | | | | |
| a lot | 5 (14.3) | 11 (31.4) | | | | |
| Mother reads | | | 5.15 | .27 | 1.28 | .04 |
| little | 5 (14.3) | 2 (5.7) | | | | |
| rare | 16 (45.7) | 9 (25.7) | | | | |
| sometimes | 5 (14.3) | 3 (8.6) | | | | |
| often | 8 (22.9) | 13 (37.1) | | | | |
| a lot | 1 (2.9) | 8 (22.9) | | | | |
| Child reads | | | 7.37 | .12 | 1.82 | .02 |
| little | 2 (5.7) | 6 (17.1) | | | | |
| rare | 7 (20.0) | | | | | |
| sometimes | 7 (20.0) | 10 (28.6) | | | | |
| often | 15 (42.9) | 8 (22.9) | | | | |
| a lot | 4 (11.4) | 11 (31.4) | | | | |

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**Table 7.** Regression analysis for dependent variable mother's reading

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .524 | .275 | .206 | 1.088 |

## DISCUSSION

The aim of this research was to identify envoronmental factors for dyslexia. To determine this, mothers of children with dyslexia were examined regarding various factors that could impair the process of brain cell growth in the fetus during pregnancy, perinatal and postnatal developmental characteristics of children with dyslexia, as well as genetic predispositions, socio-economic characteristics, and the exposure to reading of dyslexic children.

Developmental dyslexia is a neurodevelopmental disorder, however, the results of this research have shown that no risk factors, such as the presence of serious illness or trauma, use of drugs, alcohol, cigarettes, medications, bleeding during pregnancy, or consumption of coffee, were found to be significantly associated with dyslexia. In other study (Liu et al., 2016) an association between maternal infectious diseases and dyslexia. However, contrary to their findings, this study did not find support for such an association.

A longitudinal study of mothers and children has shown that prenatal exposure to nicotine is associated with poor reading performance, particularly in word decoding skills (Cho et al., 2013). A link between smoking during pregnancy and dyslexia was found (Mascheretti et al., 2013a) However, this research did not confirm it, as both mothers of children with dyslexia and mothers of children without difficulties were exposed to nicotine, so it cannot be determined as an indicator for dyslexia.

A connection between maternal infections during pregnancy and dyslexia was found (Liu et al., 2016). However, this study did not confirm it, as there were no differences in illnesses, medication usage, or presence of any infections among mothers of dyslexic children compared to mothers of children without reading and writing difficulties. Both groups of mothers used medication during pregnancy in equal proportions. Mothers of both groups of children drank coffee during pregnancy and used cosmetics.

Children with dyslexia experienced birth-related issues such as having the umbilical cord wrapped around their neck, exceeding the due date for delivery and necessitating induced labor due to being past the due date, ventricular septal defect (a characteristic of prematurely born children), jaundice, whereas a child without reading and writing difficulties encountered issues such as aspirating meconium and not breathing immediately after birth.

Children with neonatal jaundice have difficulties in reading, writing, and mathematics (Hokkanen, Launes & Michelsson, 2014). In this study, children with dyslexia did not have neonatal encephalopathy with perinatal asphyxia or neonatal jaundice, so this research cannot confirm the previous claims.

Various other factors related to child health status, including immediate post-birth crying, birth weight, Apgar score, duration in the incubator, crawling ability, speech development, history of ear infections, speech disorders, and engagement in speech therapy, did not show

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significant associations with dyslexia. Although a meta-analysis has shown that school-aged children born prematurely have poorer decoding and reading comprehension abilities than their peers (Kovachy et al., 2015), this research did not find differences between children with and without dyslexia regarding preterm birth and other health conditions at birth.

Although some studies (Bishop 6 Snowling, 2004) noted preschool language impairment as a risk factor for dyslexia, and many children at familial risk of dyslexia experience delays and difficulties with speech and language development (Scarborough, 1990), this study did not find this data. Children with dyslexia during the developmental period, according to mothers' reports, did not have more frequent delays in speech-language development and were not more involved in speech therapy than typically developing children.

Results showed that dyslexic children exhibited a markedly higher incidence of delayed motor skill development, which emerged as the sole prenatal risk factor with a notable primary effect. Various research findings have indicated that children with dyslexia exhibit deficits in motor skills compared to their typically developing peers, including deficits in both gross (Getchell et al., 2007; Iversen et al., 2005; Nicolson & Fawcett, 1994; Ramus, Pidgeon & Frith, 2003) and fine motor skills (Iversen et al., 2005; Nicolson & Fawcett, 1994; Ramus, Pidgeon & Frith, 2003). The Cerebellar Deficit Theory of Dyslexia suggests that these motor skill impairments can be linked to cerebellar dysfunction (Nicolson, Fawcett & Dean, 2001).

Although there was a difference in the development of motor skills between children with and without dyslexia, motor skills were not found to be significant predictors of reading and writing skills, as indicated by the results of the multiple linear regression analysis. The association between motor skills and nonword reading as well as spelling did not reach statistical significance.

It is known that dyslexia is familial and moderately hereditary (Liu et al., 2016). The results indicate that in 14.3% of cases, someone in the family of children with dyslexia, such as a cousin, father, or brother, experienced difficulties in speech, reading, and writing. This characteristic significantly distinguished children with dyslexia from those without reading and writing difficulties. This is consistent with the study of Liu et al. (2016) which also found a family history of dyslexia.

Results illustrated the relationship between a child's exposure to reading and dyslexia. It revealed that mothers of children with dyslexia read to them less frequently compared to mothers of children without dyslexia. Additionally, mothers of children with dyslexia themselves engaged in less reading, and children with dyslexia tended to read less than their typically achieving counterparts.

Engaging in shared storybook reading is a crucial avenue for language acquisition, often marking young children's initial exposure to written language. The caliber of these early shared reading experiences has been recognized as a key indicator of language and reading proficiency. However, there is limited research investigating these interactions among children who are at familial risk of dyslexia (Hamilton, Hayiou-Thomas & Snowling, 2021). Parents and the home literacy environment they cultivate at home are widely acknowledged to play a pivotal role in shaping children's language and literacy abilities (Frijters, Barron & Brunello, 2000; Grolig et al., 2019). There are a small number of reports that have highlighted subtle distinctions in the home literacy environments of children at familial risk of dyslexia compared to those not at risk. For instance, some studies (van Bergen et al.,

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2014) observed less frequent shared reading between fathers with dyslexia and their children compared to controls. Similarly, another study (Torppa et al., 2007) noted reduced engagement in book, newspaper, and magazine reading among parents in at-risk families, with more variability in shared reading activities when children were 2 years old.

Furthermore, results of study (Scarborough, Dobrich & Hager, 1991) showed that parents of children who later developed dyslexia often attributed limited shared storybook reading to their children's apparent lack of interest in books. While certain studies indicate differences in the home literacy environment between children at familial risk of dyslexia and those not at risk (Dilnot et al., 2017), others show no discernible difference (van Bergen et al., 2014; Torppa et al., 2007). Results in this study showed difference in the home literacy environment between children with and without dyslexia. Mothers of children with dyslexia tend to read to them less frequently than mothers of children without difficulties. Additionally, mothers of children with dyslexia themselves engage in less reading, and children with dyslexia typically read less than their typically achieving peers. However, no significant correlations were found between the frequency of mothers reading to their children and the children's reading and spelling abilities.

The educational level of the mother (Sun et al., 2013), and in this case, the educational status of the father, were found to be associated with the occurrence of dyslexia. Additionally, in these studies, activities undertaken before the onset of reading instruction were linked to dyslexia. This study confirmed the above, as predictors that could be identified as associated with the occurrence of dyslexia were obtained, such as how often the mother reads, how often she read to the child, and how often the child read.

The results of this study have shown different outcomes compared to previous research. This indicates the need for further investigation to determine which environmental factors are truly associated with dyslexia. Additionally, socio-cultural circumstances and the education level of mothers regarding proper prenatal care vary across countries and influence maternal behaviors during pregnancy. This study has demonstrated that mothers in Bosnia and Herzegovina did not consume unwanted substances and medications, indicating their good knowledge of proper prenatal care.

However, what has been shown as a significant risk indicator for dyslexia is the home literacy environment and the development of motor skills. These discoveries carry profound implications for public health, underscoring the criticality of early childhood in affording youngsters optimal educational opportunities. Furthermore, they hint at the prospect of interventions aimed at aiding parents in fostering a home environment conducive to nurturing their children's burgeoning reading abilities (Dilnot et al., 2017).

Parents should prioritize the motor development of their children because it plays a vital role in their overall growth and well-being. Futhermore, pediatricians should consider motor development during routine check-ups and assessments, as delays or abnormalities may indicate underlying health conditions or developmental issues. Pediatricians can offer advice on promoting healthy motor development through age-appropriate activities, recommend interventions for children with delays, and refer families to specialists if needed. By working collaboratively with parents, pediatricians can ensure that children receive the support and resources necessary to optimize their motor development and prevent reading difficulties.

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