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Prevalence, Co-Occurring Difficulties, and Risk Factors of Developmental Language Disorder: First Evidence for Mandarin-Speaking Children in a Population-Based Study

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Summary

Background Developmental language disorder (DLD) is a condition that significantly affects children's achievement but has been understudied. We aim to estimate the prevalence of DLD in Shanghai, compare the co-occurrence of difficulties between children with DLD and those with typical development (TD), and investigate the early risk factors for DLD.

Methods We estimated DLD prevalence using data from a population-based survey with a cluster random sampling design in Shanghai, China. A subsample of children (aged 5–6 years) received an onsite evaluation, and each child was categorized as TD or DLD. The proportions of children with socio-emotional behavior (SEB) difficulties, low non-verbal IQ (NVIQ), and poor school readiness were calculated among children with TD and DLD. We used multiple imputation to address the missing values of risk factors. Univariate and multivariate regression models adjusted with sampling weights were used to estimate the correlation of each risk factor with DLD.

Findings Of 1082 children who were approached for the onsite evaluation, 974 (90.0%) completed the language ability assessments, of whom 74 met the criteria for DLD, resulting in a prevalence of 8.5% (95% CI 6.3–11.5) when adjusted with sampling weights. Compared with TD children, children with DLD had higher rates of concurrent difficulties, including SEB (total difficulties score at-risk: 156 [17.3%] of 900 TD vs. 28 [37.8%] of 74 DLD, $p < 0.0001$), low NVIQ (3 [0.3%] of 900 TD vs. 8 [10.8%] of 74 DLD, $p < 0.0001$), and poor school readiness (71 [7.9%] of 900 TD vs. 13 [17.6%] of 74 DLD, $p = 0.0040$). After accounting for all other risk factors, a higher risk of DLD was associated with a lack of parent-child interaction diversity (adjusted odds ratio [aOR] = 3.08, 95% CI = 1.29–7.37; $p = 0.012$) and lower kindergarten levels (compared to demonstration and first level: third level (aOR = 6.15, 95% CI = 1.92–19.63; $p = 0.0020$)).

Interpretation The prevalence of DLD and its co-occurrence with other difficulties suggest the need for further attention. Family and kindergarten factors were found to contribute to DLD, suggesting that multi-sector coordinated efforts are needed to better identify and serve DLD populations at home, in schools, and in clinical settings.

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Keywords: Developmental language disorder; Mandarin; Prevalence; Co-occurring difficulties; Risk factors

Research in context

Evidence before this study

Research on and public health awareness of developmental language disorder (DLD) is lacking. The most recent population-based DLD study, conducted in the United Kingdom in 2016, estimated a prevalence of 7.6% among young children (aged 4–5 years). A review of 31 cohort studies found that male gender, larger family size and later birth order, family history, lower socioeconomic status (SES) and parental education levels, and perinatal factors have received the most attention as potential risk factors for language development. China accounts for approximately one-eighth of the world's population of young children who speak Mandarin. Using the keywords of "developmental language disorder," "Mandarin or Chinese," and "population-based," we searched PubMed (English) and China National Knowledge Infrastructure (Chinese) for studies on DLD in China from January 1, 2010, to November 1, 2022, and found no publications.

Added value of this study

Using data from a population-based representative survey in Shanghai, the current study adds to the body of knowledge by providing the first evidence of the prevalence of DLD in Mandarin-speaking young children (aged 5–6 years). The study found higher co-occurring rates of socio-emotional behavior difficulties, low non-verbal IQ, and poor school readiness among children with DLD compared to children with typical development. Further, in addition to demographics and SES, other early risk factors, based on the nurturing care framework (health and nutrition, security and safety, caregiving pattern, and opportunity of early learning), for DLD were investigated.

Implications of all the available evidence

DLD is a prevalent neurodevelopmental disorder among Mandarin-speaking children and is associated with a higher occurrence of several other difficulties, which may have a potentially negative impact on children's daily life and learning abilities. Factors associated with the home and school environments were found to contribute to DLD. The study findings point to the need for further research coordinated across multiple sectors to include doctors, teachers, and speech and language therapists to better establish evidence-based identification, management, and intervention pathways for children with DLD.

Introduction

Developmental language disorder (DLD) is one of the most prevalent neurodevelopmental disorders that has profound and lasting effects on individual development.[1,2] A study from the United Kingdom found a total population prevalence estimate of 7.6% for DLD among 4- to 5-year-olds,[3] which was higher than the prevalence of autism spectrum disorder (ASD, 1.86%)[4] and attention-deficit/hyperactivity disorder (ADHD, 5%).[5] More importantly, compared to these frequently studied disorders, DLD presents comparable, if not higher, risks for children's school and daily life. For instance, children with ADHD were reported to be two to three times more likely to have dyslexia, significant spelling problems, and difficulties in learning math.[6] In contrast, children with language problems are four to six times more likely to have such problems.[7] Nevertheless, research attention to and public health awareness of DLD is lacking.[8–10] As culture and language can influence language development, representative studies from different cultural backgrounds are urgently needed to further explore the prevalence, impact on daily life, and risk factors of DLD.[11,12]

A review of 31 cohort studies on risk factors for language development found that male gender, larger family size and later birth order, family history, lower socioeconomic status (SES) and parental education levels, and perinatal factors such as premature or low birth weight have received the most attention as potential risk factors for language development.[13] This recent exploration of potential risk factors, however, may not be comprehensive.[14] Notably, the nurturing care framework indicates that children's early development requires health, nutrition, security and safety, responsive caregiving, and early learning.[15] Regarding language development, a recent study found that distal risk factors during infancy, including children's biological characteristics, SES, and family history of language difficulties, were found to account for less than 13% of children's language development.[16] Yet, few studies have focused on more proximal factors, that is, factors that more directly affect children's development, such as

parenting style, education quality, and language environment.[14,17] Evidence based on a comprehensive exploration of the relationship between these proximal risk factors and DLD should be of great significance in guiding clinical practice.

Of note, most of the above-reviewed findings appear to be based on populations with specific language impairment (SLI) or language disorder (LD) rather than DLD. Historically, these terms have been used interchangeably, which has caused debates (See Appendix 1 for details),[18–20] leading to the more recent establishment of differential diagnosis criteria.[21] For instance, the term *LD* referred to language disorders with or without known biomedical etiologies[22]; when children with language disorders without known biomedical etiologies combined have a non-verbal IQ (NVIQ) of 85 or higher, the term *SLI* is used instead.[23] Nevertheless, controversy arose around the use of NVIQ as a differential diagnosis criterion, owing to the lack of a predictive value of NVIQ for language functioning.[19,24] As a result, the term *DLD* was adopted in the current study and excludes language problems with biomedical etiologies, enabling practitioners to focus on the component of language impairment. In short, this definition of DLD indicates the necessity of research specifically on children with DLD.

To address research gaps, the current study used a Shanghai population representative sample of children aged 5–6 years, which is the youngest age range at which an accurate DLD diagnosis is considered possible.[25] Our aims were (1) establish the prevalence of DLD among Mandarin-speaking children; (2) document the co-occurrence of socio-emotional behavior (SEB), low NVIQ, and poor school readiness with DLD; and (3) investigate the risk factors of DLD, based on the nurturing care framework.

Methods

Study design and participants

This study used data from a large-scale population-based survey, the Shanghai Children's Health, Education and Lifestyle Evaluation-Preschool (SCHEDULE-P), a large cohort study that examines how nurturing care affects early childhood development among 3- to 6-year-olds. The survey design and methods have been described in detail elsewhere.[26] Briefly, the SCHEDULE-P uses a multi-stage, stratified, cluster random sampling design to select a Shanghai representative sample of kindergarten children. The first stage of sampling was conducted at the time of kindergarten enrollment, resulting in an initial sample of 20,899 children aged 3–4 years from 191 kindergartens. Primary caregivers of these children were invited to participate in online surveys through questionnaires at kindergarten entrance (November 10–24, 2016, aged 3–4 years), mid-kindergarten (April 12–26, 2018, aged 4–5 years), and graduation from kindergarten (April 22–May 5, 2019, aged 5–6 years).

For those primary caregivers who had problems in digital access or illiteracy, we asked teachers to interview parents, using paper questionnaires (n = 18). Based on the results of the first stage, we designed the second stage to involve an onsite evaluation (April 29–June 6, 2019) at graduation from kindergarten. We set districts as primary sampling units (PSUs) and defined secondary sampling units (SSUs) based on the kindergarten's ownership and level. In Shanghai, kindergartens are divided into two categories (public or private) and are rated in terms of levels, depending on the teaching quality, health care, facility and equipment, kindergarten management, and other factors, with the demonstration level as the highest and the third level as the lowest. In each SSU, one or two kindergartens were randomly selected, and all children in the selected kindergartens were invited to the onsite evaluation, resulting in a subsample of 1082 children aged 5–6 years from 20 kindergartens. We excluded schools for children with special needs during the sampling procedure, which means that children with severe ASD, moderate to severe intellectual disability, and permanent hearing loss were not included.

The study was approved by the Institutional Review Board of the Shanghai Children's Medical Center, Shanghai Jiao Tong University (SCMCIRB-K2016022-01). All parents of children who participated in the study gave electronic informed consent at the beginning of each online or onsite evaluation.

Procedures

During the onsite evaluation, the language outcomes were assessed with a standardized, tablet-based instrument, the Diagnostic Receptive and Expressive Assessment of Mandarin (DREAM; Appendix 2).[27] After the assessment, a total language score index and four other indices (receptive, expressive, semantic, and syntax) were generated. When a child received a score of <80 on any one of the five DREAM test scales, the child was characterized as having low language abilities. Based on parent-report information, children diagnosed with other disabilities and special needs were excluded. The Raven Standard Progressive Matrices (Raven's SPM; Appendix 2)[28] was administered to measure children's NVIQ. Children with both low language status and intellectual disabilities (standard IQ < 70) were excluded.

To ensure that all children who participated in the onsite evaluation had Mandarin as their first language, we excluded international kindergartens from the sampling process, and parents were asked to report the most commonly used language of the child at the beginning of the language assessment. Children who were native Mandarin speakers, met the criteria of low language abilities, and were confirmed to have no other existing biomedical conditions were classified as DLD (Table S1,

Appendix 3). Other children were classified as having typical development (TD).

Children's SEB difficulties and school readiness were evaluated through online surveys. The Strengths and Difficulties Questionnaire (SDQ; Appendix 2) was used to identify children with SEB difficulties, based on the recommended cut-off values in China.[29] The early Human Capability Index (eHCI; Appendix 2) was used to assess children's school readiness.[30] Following the previous study, we defined a child as having poor school readiness if the eHCI score was lower than the 20th percentile of the Chinese norm data in his or her age group.[31]

Age, sex, and kindergarten level of all participants were retrieved from the Shanghai Kindergarten Registry Database of the Shanghai Education Committee and further confirmed by parents at the beginning of each online survey. All other putative risk factors (Appendix 2) were collected through an online survey and divided into six categories based on the nurturing care framework, including demographics (birth order), SES (mother's education and annual household income), health and nutrition status (birth weight, neonatal intensive care unit [NICU] history, maternal disease during pregnancy, and stunting), security and safety (parents divorced or separated, maltreatment, and neglect), caregiving pattern (primary caregiver, primary caregiver's mental health, parent-child interaction, and screen exposure time), and opportunity for early learning (attendance of early education or daycare programs before entering kindergarten). Among these risk factors, birth-related risk factors, including birth weight, NICU history, and maternal disease during pregnancy, were collected in November 2016 (when the children were aged 3–4 years) to minimize recall bias. Stunting also was calculated, using data collected at the same time, as it is largely determined by a child's first 1000 days.[32] Parent-child interaction and screen exposure time were also assessed at the age of 3–4 years to capture the caregiving patterns at home before the children entered kindergarten. Finally, taking into consideration the potential impact of using dialect on language performance, we also collected information on whether the child used mainly dialects other than Mandarin at the beginning of the language assessment.

Statistical analysis

Mother's education of those whose consent was declined or withdrawn during the survey versus those included in the final analytical sample were described (Table S2, Appendix 3). Multiple imputation (MI) was performed to address the missing data (Appendix 2). The dataset used for this study contained 974 observations and 19 variables with 903 complete case observations (92.7%). Differences in the demographic characteristics were compared between participants with complete and incomplete data (Table S3, Appendix 3). Children with incomplete data were found to have lower SES and were more likely to be diagnosed with DLD. A sensitivity analysis that included only complete cases produced comparable conclusions (Table S4, Appendix 3).

Sampling weights were computed using inverse probability weighting and adjusted with the rate of completing a language outcome assessment during the onsite assessment, which represented the inverse of the combined selection probability in each sampling stage. Demographic characteristics and standard language scores measured by DREAM were estimated using datasets after MI and the use of sampling weights to describe the Shanghai population-representative characteristics. The prevalence of DLD was estimated using sampling weights. The proportions of children who experienced co-occurrence with SEB difficulties, low NVIQ, and poor school readiness in those with TD and DLD were calculated. Chi-square tests were used to test statistical differences in the co-occurring difficulties between the two groups.

To explore the correlation between the putative risk factors and DLD, we first used a multilevel model to account for the random effect of the kindergarten level. The random effect, however, was not significant. Therefore, univariate and multivariate logistic regression models were conducted to estimate the odds ratio (OR) of each risk factor to DLD when unadjusted and adjusted to all other risk factors, respectively. The multivariate logistic regression model was used as the primary analysis. Linear regression models were fitted to the DREAM total scores as sensitivity analyses of the above logistic regression models. To obtain robust regression estimation, we employed the *svy* command in Stata to account for the survey design (clustering/stratification) and sampling weights across all estimates.

All tests were two-sided, with a *p*-value lower than 0.05 as denoting statistical significance. All data analyses were conducted using Stata version 16.0.

Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report.

Results

A total of 1082 children were approached for the onsite evaluation, of whom 993 (91.8%) consented to participate. Of the children who participated in the onsite evaluation, 19 cases were excluded for not completing the language assessments, resulting in an analytical sample of 974 children (mean age = 6.18 years, SD = 0.29, range = 5.58–6.71), consisting of 507 (52.0%) boys and 467 (48.0%) girls (Fig. 1).

Participants were classified as children with TD (n = 900) or children with DLD (n = 74). After adjusting

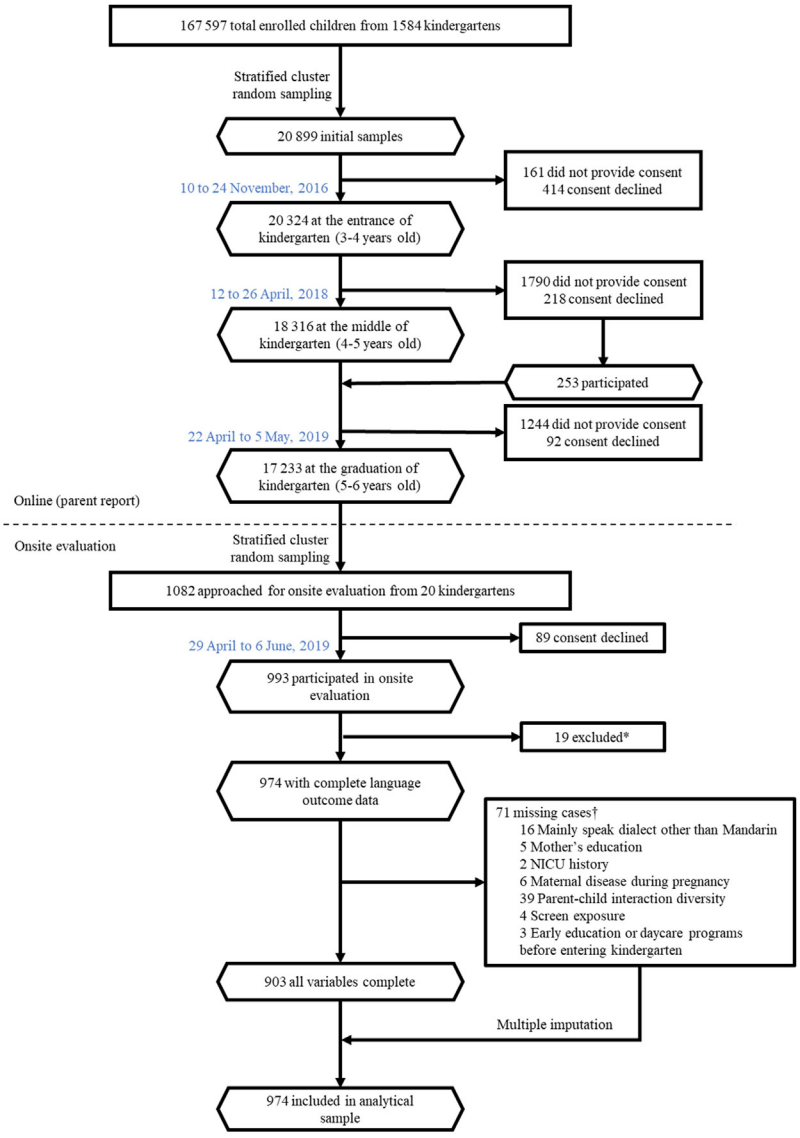

Fig. 1: **Flow chart of included analytical sample**. NICU=Neonatal Intensive Care Unit. *Excluded for not completing the language assessment. †Not mutually exclusive.

for sample weights, the Shanghai population representative prevalence of DLD among kindergarten children was estimated at 8.5% (95 CI% = 6.3%, 11.5%). Characteristics of the whole population and the two groups using datasets after MI and adjusting with sampling weights are displayed in Table 1. Children with DLD were found to have a lower mother's education level ($p < 0.0001$) and annual household income ($p < 0.0001$) than were TD children.

The rates of co-occurring difficulties in children with DLD versus those with TD are shown in Fig. 2. Compared with TD children, children with DLD had higher rates of concurrent difficulties. For SEB difficulties, compared with TD children, children with DLD had higher co-occurring rates of total difficulties related to being at-risk (37.8% vs.17.3%, $p < 0.0001$) and other subscales related to being at-risk: emotional symptoms (32.4% vs. 16.8%, $p = 0.0010$), conduct problems (33.8% vs. 23.8%, $p = 0.055$), hyperactivity or inattention (27.0% vs.12.8%, $p = 0.0010$), peer problems (20.3% vs. 8.6%, $p = 0.0010$), and poor prosocial behavior (36.5% vs. 16.4%, $p < 0.0001$). Children with DLD were also more likely to have low NVIQ (10.8% vs. 0.3%, $p < 0.0001$) and poor school readiness (17.6% vs. 7.9%, $p = 0.0040$).

	Whole population	TD (n = 900)	DLD (n = 74)	p value
Age, years	6.19 (6.17, 6.21)	6.20 (6.17, 6.22)	6.10 (6.01, 6.20)	0.061
Sex				
Female	47.0 (42.9, 51.2)	47.4 (43.1, 51.7)	42.7 (26.6, 58.8)	0.57
Male	53.0 (48.8, 57.1)	52.6 (48.3, 56.9)	57.3 (41.2, 73.4)	
Mother's education				
Junior high school or below	7.8 (5.4, 10.2)	6.5 (4.2, 8.8)	21.9 (8.4, 35.5)	<0.0001
High school and junior college	39.3 (35.1, 43.4)	37.4 (33.1, 41.6)	59.8 (44.2, 75.4)	
Undergraduate or above	52.9 (48.7, 57.1)	56.2 (51.8, 60.5)	18.3 (7.4, 29.2)	
Annual household income, RMB				
≤100 k	13.7 (10.5, 16.8)	11.7 (8.7, 14.7)	34.9 (18.6, 51.3)	<0.0001
>100 k to ≤300 k	42.3 (38.1, 46.4)	42.3 (38.0, 46.6)	41.6 (25.7, 57.5)	
>300 k	32.1 (28.3, 35.9)	34.3 (30.3, 38.3)	8.4 (0.3, 16.5)	
Refused to answer	12.0 (9.4, 14.5)	11.7 (9.0, 14.4)	15.1 (5.7, 24.4)	
Language outcomes, points				
Total score	103.57 (102.89, 104.25)	104.89 (104.31, 105.47)	89.40 (87.55, 91.24)	<0.0001
Receptive	104.77 (104.12, 105.42)	105.91 (105.33, 106.49)	92.53 (90.47, 94.58)	<0.0001
Expressive	97.56 (96.56, 98.55)	99.74 (98.93, 100.55)	74.12 (72.91, 75.33)	<0.0001
Semantic	110.86 (110.07, 111.66)	112.15 (111.45, 112.86)	96.99 (93.86, 100.12)	<0.0001
Syntax	96.27 (95.59, 96.95)	97.62 (97.05, 98.19)	81.73 (80.21, 83.25)	<0.0001

Data are mean (95% CI) or % (95% CI). Estimates were acquired by using datasets after multiple imputation and using sampling weights, which could represent the Shanghai population. T-tests or Pearson's chi-squared tests were used to test the difference between TD and DLD groups. TD = typical development. DLD = developmental language disorder. RMB = Ren Min Bi.

Table 1: **Description of demographic characteristics and language outcomes.**

In univariate analysis (Table 2), lower mother's education (compared with undergraduate or above, for high school and junior college, OR = 4.92 [2.28–10.65]; for junior high school or below, OR = 10.40 [3.84–28.17]) and lower annual household income (compared with >300 K RMB, for >100 K to ≤300KRMB, OR = 4.00 [1.32–12.11]; for ≤100 K RMB, OR = 12.18 [3.72–39.84]) were found to be related to higher risk for DLD. Lack of parent-child interaction diversity (OR = 6.88 [3.22–14.70]), longer screen exposure time (compared to ≤ 1 h/day, for >4 h/day, OR = 4.79 [1.42–16.18]), lack of early education or daycare programs before entering kindergarten (OR = 2.55 [1.03–6.32]), and lower kindergarten level (compared to

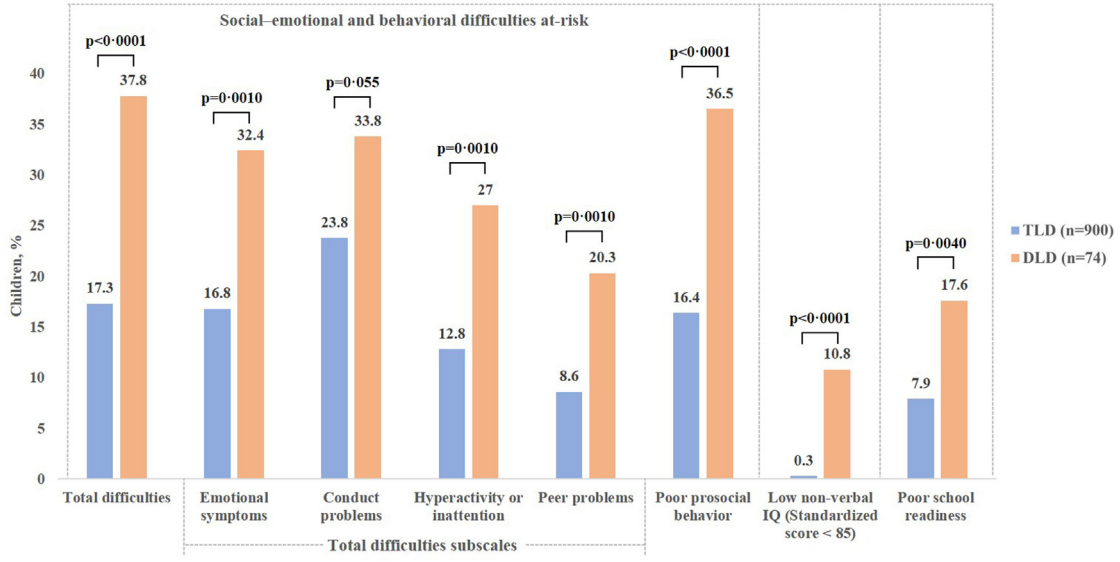

Fig. 2: **Rates of co-occurring difficulties in children with typical development (TD) versus those with developmental language disorder (DLD).**

	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Mainly speak dialects other than Mandarin				
No	1 (ref)		1 (ref)	
Yes	1.42 (0.49, 4.13)	0.52	1.89 (0.51, 6.95)	0.34
(1) Demographics				
Age	0.33 (0.10, 1.05)	0.061	0.30 (0.09, 1.02)	0.054
Sex				
Female	1 (ref)		1 (ref)	
Male	1.21 (0.62, 2.36)	0.58	1.35 (0.67, 2.74)	0.40
Birth order				
Only child	1 (ref)		1 (ref)	
First	1.63 (0.71, 3.74)	0.25	1.88 (0.78, 4.53)	0.16
Second and later	0.78 (0.32, 1.91)	0.59	0.41 (0.11, 1.53)	0.18
Twin	1.02 (0.32, 3.27)	0.97	1.14 (0.25, 5.22)	0.86
(2) Socioeconomic status				
Mother's education				
Undergraduate or above	1 (ref)		1 (ref)	
High school and junior college	4.92 (2.28, 10.65)	<0.0001	1.87 (0.86, 4.05)	0.11
Junior high school or below	10.40 (3.84, 28.17)	<0.0001	1.42 (0.32, 6.26)	0.64
Annual household income, RMB				
>300 k	1 (ref)		1 (ref)	
>100 k to ≤300 k	4.00 (1.32, 12.11)	0.014	2.19 (0.74, 6.45)	0.16
≤100 k	12.18 (3.72, 39.84)	<0.0001	3.31 (0.96, 11.43)	0.058
Refused to answer	5.25 (1.60, 17.26)	0.0060	2.88 (0.78, 10.63)	0.11
(3) Health and nutrition status[a]				
Low birth weight (<2.5 kg)				
No	1 (ref)		1 (ref)	
Yes	0.37 (0.05, 3.01)	0.36	0.43 (0.05, 3.60)	0.43
NICU history				
No	1 (ref)		1 (ref)	
Yes	1.16 (0.42, 3.18)	0.78	1.92 (0.66, 5.58)	0.23
Maternal disease during pregnancy				
No	1 (ref)		1 (ref)	
Yes	0.47 (0.14, 1.59)	0.22	0.63 (0.16, 2.44)	0.50
Stunting				
No	1 (ref)		1 (ref)	
Yes	2.38 (0.28, 20.01)	0.42	1.72 (0.06, 52.51)	0.76
(4) Security and safety				
Parents divorced or separated				
No	1 (ref)		1 (ref)	
Yes	1.76 (0.70, 4.45)	0.23	1.69 (0.72, 3.94)	0.23
Maltreatment				
No	1 (ref)		1 (ref)	
Yes	0.86 (0.44, 1.69)	0.67	0.72 (0.35, 1.48)	0.37
Neglect				
No	1 (ref)		1 (ref)	
Yes	1.17 (0.42, 3.29)	0.76	1.12 (0.37, 3.39)	0.84
(5) Caregiving pattern				
Primary caregiver				
Mother	1 (ref)		1 (ref)	
Father	0.32 (0.09, 1.11)	0.072	0.34 (0.07, 1.62)	0.18
Grandparents or others	0.52 (0.25, 1.12)	0.094	0.62 (0.28, 1.36)	0.23
Primary caregiver mental health at-risk				
No	1 (ref)		1 (ref)	
Yes	0.76 (0.34, 1.72)	0.52	0.81 (0.32, 2.09)	0.67

(Table 2 continues on next page)

	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)	p value
(Continued from previous page)				
Lack of parent-child interaction diversity[a]				
No	1 (ref)		1 (ref)	
Yes	6.88 (3.22, 14.70)	<0.0001	3.08 (1.29, 7.37)	0.012
Screen exposure, hours/day[a]				
≤1	1 (ref)		1 (ref)	
>1 to ≤2	1.85 (0.50, 6.85)	0.36	1.28 (0.33, 4.91)	0.72
>2 to ≤3	2.98 (0.80, 11.10)	0.10	2.00 (0.54, 7.48)	0.30
>3 to ≤4	1.75 (0.44, 7.07)	0.43	1.27 (0.30, 5.38)	0.75
>4	4.79 (1.42, 16.18)	0.012	1.74 (0.52, 5.88)	0.37
(6) Opportunity of early learning				
Lack of early education or daycare programs before entering kindergarten				
No	1 (ref)		1 (ref)	
Yes	2.55 (1.03, 6.32)	0.043	1.44 (0.53, 3.92)	0.47
Kindergarten level				
Demonstration and first level	1 (ref)		1 (ref)	
Second level	2.64 (1.22, 5.69)	0.013	1.80 (0.82, 3.95)	0.14
Third level	19.14 (7.81, 46.89)	<0.0001	6.15 (1.92, 19.63)	0.002
Undetermined	2.19 (0.59, 8.14)	0.24	2.18 (0.57, 8.28)	0.25

Estimates were acquired by using datasets after multiple imputation and using sampling weights. Maternal disease during pregnancy was defined as "Yes" when the mother was reported having any disease including gestational diabetes, gestational hypertension, smoking, alcohol abuse, drug use, mental stress or emotional problems, malnutrition, and exposure to toxic or harmful substances during the pregnancy. Primary caregiver mental health at-risk was defined as "Yes" when the primary score of 5-item World Health Organization Well-Being Index (WHO-5) was lower than 13. Less than once a week in any of the four interaction types including learning-related, reading, recreation, and interaction with environment was defined as lack of parent-child interaction diversity. RMB = Ren Min Bi. NICU=Neonatal Intensive Care Unit. [a]Collected at the entrance of kindergarten (3–4 years old).

Table 2: **Univariate and multivariate regression analysis of nurturing care framework risk factors for developmental language disorder (DLD) Status.**

demonstration and first level, for second level OR = 2.64 [1.22–5.69]; for third level OR = 19.14 [7.81–46.89]) also were found to be risk factors of DLD. Speaking mainly a dialect other than Mandarin, age, male, higher birth order or twin, low birth weight, NICU history, maternal disease during pregnancy, stunting, parents divorced or separated, maltreatment, neglect, primary caregiver, and primary caregiver mental health at-risk were found to have no statistically significant association with DLD.

In multivariate analysis (Table 2), lack of parent-child interaction diversity (aOR = 3.08 [1.29–7.37]) and lower kindergarten level (compared to demonstration and first level, third level aOR = 6.15 [1.92–19.63]) conferred additive risk for DLD. Other factors include speaking mainly a dialect other than Mandarin, age, male, higher birth order or twin, lower mother's education, lower annual household income, low birth weight, NICU history, maternal disease during pregnancy, stunting, parents divorced or separated, maltreatment, neglect, primary caregiver, primary caregiver mental health at-risk, excessive screen exposure time, and lack of early education or daycare programs before entering kindergarten were found to have no statistically significant association with DLD.

The results of linear regression analyses of risk factors of language total score assessed by DREAM (Table S5, Appendix 3) showed that male, second or later birth order, lower SES, parents divorced or separated, lack of parent-child interaction diversity, longer screen exposure time, lack of early education or daycare programs before entering kindergarten, and lower kindergarten were negatively related to children's language ability.

Discussion

The current study is among the first to report the prevalence of DLD in Mandarin-speaking children with population-based representative data. Higher risks of co-occurring SEB difficulties, low NVIQ, and poor school readiness were found among children with DLD compared to children with TD. Further, guided by the nurturing care framework, the current study examined risk factors in the early years of DLD. Results revealed that a lack of parent-child interaction diversity and lower kindergarten level were correlated with higher risks of DLD.

Our estimate of the prevalence of DLD was close to those reported in Western countries. For instance, compared to the 2016 study in the United Kingdom (7.6%),[3] we achieved a similar prevalence of DLD (8.5%). The language assessment instrument, DREAM, was developed by a team comprised of linguistic experts in Mandarin from Mainland China, Western-trained bilingual speech-language pathologists, and experts in assessment development with a standardized method.[27]

In addition, the methodology of defining DLD is comparable to that of other studies. Therefore, we believe that the prevalence data can be compared with studies from other cultures and languages. In studies that adopt other definitions, it should be noted that the definition varied from that of LD (not excluding language disorders associated with other existing biomedical conditions) or SLI (excluding language disorder with NVIQ <85). Thus, the prevalence of DLD should be between LD and SLI. Further, it is worth noting that children who did not enroll in kindergarten (around 3% in Shanghai) and children in special education kindergarten were not included in our sample. These children are more likely to seek medical services for their language problems compared to the children in our sample. Therefore, the prevalence estimate in our study should be considered as the minimum estimate of need.

Because the definition of DLD adopted in this study excluded language problems associated with other existing biomedical conditions, we focused on the co-occurrence of neuropsychological symptoms and academic ability. The current study found that children with DLD were at higher risk for co-occurring difficulties than were children with TD at a population level. Children with DLD were about two times more likely to have SEB difficulties than were TD children. Up to 37.8% of children with DLD were found to be at-risk in terms of total difficulties. Similar results were found among 7-year-old Australian children, for whom those with low language abilities were two to three times more likely to have co-occurring SEB difficulties than were TD children.[16] The risk of concurrent low NVIQ (standard score <85) for children with DLD was even higher compared with that for TD children, which is consistent with previous findings that reported strong correlations between language ability and NVIQ.[19] Behavioral studies find that children with language impairment perform less well than do peers on procedural learning tasks that depend on corticostriatal learning circuits,[33] indicating a possible overlap of the neural circuits between verbal and nonverbal learning that could partially explain the high co-occurrence that we found. In addition, children with DLD were found to have a higher rate of poor school readiness. This also suggests the need for additional attention to the academic difficulties of children with DLD.[2] The high co-occurring rates of SEB difficulties, low NVIQ, and poor school readiness suggested that language issues are related to certain adverse social and educational outcomes. For children who are struggling in school, language assessment should be incorporated as part of the package of assessment. Under the current education system in China, however, there is no identification of or intervention path for DLD in either primary schools or kindergartens, and teachers' awareness of and sensitivity to this problem are far from sufficient.[34]

As for risk factors, different from other studies that show a nearly universal pattern of risk factors from the nurturing care framework as associated with developmental outcomes such as mental health,[35] we found that the home and education environment are more prominently correlated with DLD. Parent-child interaction has long been regarded as an important intervention target to promote children's language ability.[36] In the current study, we focused on the diversity rather than the frequency of parent-child interactions, measuring the variety of activities to which the child was exposed. It was not surprising to find that a lack of diverse parent-child interaction activities was associated with lower language ability, indicating that the diversity, rather than the quantity of parent input, matters more for children's language development.[37] In addition, a lower kindergarten level, which was measured as a comprehensive set of indicators of teaching quality, health care, facility and equipment, and kindergarten management, was identified as a strong risk factor for DLD. Studies in education also have found that emotional support, classroom management, and instructional support are positive predictors of children's vocabulary competency at preschools.[38] Additional research is necessary to confirm the findings of previous studies and to create a comprehensive list of risk factors in educational practice that can affect children's language abilities.The results indicated that stimulations from parents at home and teachers and peers in school are significantly associated with early language development. Future intervention studies should take these identified home and school environmental factors into consideration to better establish evidence-based intervention pathways coordinated across multiple sectors, including parents, pediatricians, teachers, and speech and language therapists for children with DLD.[39]

Our study is the first to report the DLD prevalence at a regional level in Asia and uniquely measure the co-occurrence of SEB problems, low NVIQ, and poor school readiness in a population-representative sample, reducing the potential influence of referral bias that is evident in clinically referred samples. It is also the first study to examine risk factors for children with strictly diagnosed DLD based on the nurturing care framework. Nevertheless, our study had several limitations. First, the family history of speech or language disorder, which has been identified as a risk factor for language development,[40] was not collected. The risk of lack of parent-child interaction diversity we found for DLD could be the result of poor language skills of parents. Nevertheless, whether the association between family history and DLD is caused by heredity or indirectly through proximal family environment factors (such as decreased parent-child positive interaction) due to poor parental language ability has not been well demonstrated.[18] Further studies are strongly encouraged to determine the pathways. Second, we did not measure whether the

poor language ability caused significant limitations in the individual's ability to communicate, which is a diagnostic criterion of DLD according to the International Classification of Diseases 11th Revision (ICD11)[22] and may lead to an overestimation of DLD prevalence. However, the criterion of defining "low-language ability" as any one of the five DREAM indices scores <80 had high sensitivity and specificity compared to a prior pediatrician judgment and a standardized narrative test, both of which reflect the child's communicative use of language.[27] Therefore, we believe it is unlikely that our prevalence is meaningfully over-estimated. Third, for the diagnostic criteria of DLD, due to a lack of physician assessment for biomedical conditions and diagnostic tools for intellectual disability, there might be a small number of children with undetected conditions, such as mild ASD, brain injury, and certain neurodegenerative conditions, which could cause a slight overestimate of DLD prevalence. Nevertheless, considering the universal newborn and kindergarten admission hearing screening policy in Shanghai,[41] the Raven's SPM screening test, and parent-reported biomedical conditions, undetected cases were largely minimized. Fourth, the assessment of whether children have other disabilities and special needs, co-occurring SEB difficulties, poor school readiness, and almost all risk factors were collected by an online parent-report questionnaire, which may cause recall bias. By choosing standardized and widely used instruments during the online survey, however, the validity and reliability of the information collected were ensured. Finally, although we used a representative sample of Shanghai children, caution is advised for the generalization of our findings. Estimates of prevalence could be higher in other areas in China.

The current study attempted to address three gaps in the field of DLD research. First, we revealed a high prevalence of DLD among Mandarin-speaking children. Second, we found higher co-occurring difficulties of DLD, which broadly influence children's life and learning. Finally, the investigation of risk factors suggested that high-quality, diverse interactions with parents, teachers, and peers may be important environmental protective factors for DLD. As children face a neurodevelopmental disorder with such a high prevalence and significant impact on their life, our results highlight the need to raise awareness among educators and health services about DLD and advocate for further empirical research to better establish evidence-based identification, management, and intervention pathways for children with DLD.

Contributors

SW contributed to conceptualization, formal analysis, visualization, methodology, writing – original draft, and writing – review & editing; JZ contributed to the investigation, data curation, and project administration, JV and XLL contributed to conceptualization and writing – review & editing; XS contributed to writing – review & editing; ER, XL, and HP contributed to methodology and software; HW contributed to data validation; QZ and YD contributed to the investigation; YZ contributed to conceptualisation, the survey design, data curation, project administration, supervision, and writing – review & editing; FJ contributed to conceptualization, the survey design, funding acquisition, supervision, and writing – review & editing.

Data sharing statement

Survey data were examined after importing from the online survey system and are held and managed by the research group at Shanghai Children's Medical Center with the format of a STATA file (.dta). There is an application process for using the data. After the application is approved by the Publication Committee, de-identified data can be shared with collaborators for research purposes.

Declaration of interests

We declare no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2023.100713.

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