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The Forgotten Learning Disability – Epidemiology of Written Language Disorder in a Population-Based Birth Cohort (1976-1982), Rochester, Minnesota

Slavica K. Katusic, MD^a, Robert C. Colligan, PhD^b, Amy L. Weaver, MS^c, and William J. Barbaresi, MD^d

^aDepartment of Health Sciences Research, Division of Epidemiology, Mayo Clinic, Rochester, Minnesota.

^bDepartment of Psychiatry & Psychology, Mayo Clinic, Rochester, Minnesota.

^cDepartment of Health Sciences Research, Division of Biostatistics, Mayo Clinic, Rochester, Minnesota.

^dDepartment of Pediatric and Adolescent Medicine, Division of Developmental and Behavioral Pediatrics, Mayo Clinic, Rochester, Minnesota.

Abstract

OBJECTIVE—The aim of this study was to report the incidence rates and other epidemiologic characterizations of Written Language Disorder (WLD). There have been no epidemiologic studies on the incidence of WLD in the United States and the use of a population-based birth cohort, longitudinally followed, is the most powerful method to reach this objective.

METHODS—In this population-based, retrospective birth cohort study, subjects included 5718 children born 1976-1982 in Rochester, Minnesota who remained in the community after age 5 years. Records from all public and nonpublic schools, medical facilities, and private tutorial services were reviewed and results of all individually administered IQ and achievement tests, and extensive medical, educational, and socioeconomic information were collected. The essential features of writing problems from the DSM-IV-TR were included in our operationalized definition of WLD. WLD incident cases were established using research criteria based on 3 formulas (regression-based discrepancy, non-regression-based discrepancy, low achievement).

RESULTS—Cumulative incidence rates of WLD varied from 6.9% to 14.7% depending on the formula. Boys were 2-3 times more likely to be affected than girls, regardless of the formula. Among all WLD cases (N=806), 25% (N=203) had WLD without Reading Disability (RD). Specifics of the writing problems were identified for 87% (N=702) of WLD cases.

CONCLUSION—In this population-based birth cohort of school aged children, WLD was at least as frequent as RD, and significantly more frequent among boys than girls.

Keywords

Written Language Disorder; Writing Disorder; writing problems; Disorder of Written Expression; writing difficulties; writing disabilities

Contact information: Slavica K. Katusic, MD, Department of Health Sciences Research, Mayo Clinic, 200 First Street SW, Rochester, MN 55905; Telephone: 507-284-0257; Fax: 507-284-1516; Email: katusic.slavica @mayo.edu.

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Writing is one of the most complex human functions; a critical skill for academic success, social and behavioral wellbeing. The developmental trajectory of written language has been demonstrated to be an important predictor of a child's overall development.¹ Children with Written Language Disorder (WLD) are at risk for long-term adverse personal and economic consequences, thus an enormous cost for society,^{1, 2} Hooper et al. stated that writing difficulties among middle school students “should be of major national concern.”³ Many different terms: Developmental output failure,⁴ Dysgraphia,⁵ Writing Disorder,⁶ Writing Problems,⁷ Disorder of Written Expression,⁸ Problems in Written Expression,⁹ Writing Difficulties,¹⁰ and Writing Disabilities¹¹ are used to describe problems of written language. The essential feature of WLD, according to DSM-IV-TR is “writing skills that fall substantially below those expected given the individual's chronological age, measured intelligence, and age-appropriate education.”⁸ Increased interest in WLD research emerged only in the past two decades,² in sharp contrast to research in reading disability (RD).^{2, 7} There have been no epidemiologic studies on the incidence of WLD in the United States and very few studies directly related to prevalence or other epidemiologic characterizations of WLD in general populations.^{6, 7, 9}

Incidence, a very important concept in epidemiology, is the measure primarily used for studying relationships between etiologic factors and the development of specific conditions.¹² A population-based birth cohort allows natural selection of subjects into different categories of possible risk for the condition being studied, and minimizes many biases that are encountered in studies based on prevalent cases.¹³

Our study has two primary purposes: 1) provide a detailed description of the methods and procedures used to identify all incident cases of WLD in this well-defined, population-based birth cohort; and 2) report incidence rates for WLD overall, and boys and girls separately.

METHODS

Study Setting

Rochester, Minnesota is 90 miles southeast of Minneapolis-St. Paul, the closest major urban center. Using 1990 census data, years the children from this birth cohort were in school, there were 70,745 residents: 96% white, 75% ≤ 45 years old, and primarily middle class.¹⁴

Birth Cohort

Our birth cohort consists of all children born between 1/1/76-12/31/82 to mothers residing in the townships comprising Minnesota ISD #535 (N=8548). The target population consists of 5,718 children (2,956 boys; 2,762 girls) who, at or after the age of 5, still lived in Rochester.^{15, 16} They were followed retrospectively from birth until death, emigration, or graduation. The steps and resources used for identification and follow-up of this birth cohort, and analyses of potential influence of migration bias, have been reported.^{15, 16}

Study Resources

Medical and school records were used to identify cases with childhood learning problems. Our IRB and ISD #535 School Board approved a contractual research agreement to access the cumulative, richly documented school records of all birth cohort members registered at any of the 41 public, parochial or private schools, including those who moved from the school district, were home schooled, deceased or graduated. The cumulative school record includes all school assessments, educational intervention reports (e.g., IEPs) and notes related to any type of difficulty in learning, performance or behavior, as observed by teacher, parent, school psychologist, physician, social worker, school nurse, or counselor.

Medical records of all birth cohort members were also reviewed. Mayo Clinic and Olmsted Medical Center provide virtually all primary and specialty care to the residents of Olmsted County; over 98% of known hospitalizations of Olmsted County residents occur in the three Rochester hospitals.¹⁴ Through the Rochester Epidemiology Project (REP), all diagnoses and surgical procedures recorded at Rochester medical facilities are indexed for automated retrieval.¹⁷ The medical record includes detailed history of all medical encounters in the community including social services, hospitalizations, emergency department and home visits as well as laboratory, psychiatry and psychology reports and test results, from birth until the patient no longer resides in the community, or is deceased.

Under a separate research agreement, permission was also obtained to review the records of birth cohort members seen and treated at the privately owned Reading Center/Dyslexia Institute of Minnesota (RCDIM). Their records included evaluations and outcomes of tutorial instruction spanning nearly 50 years.

Identification of Children with Learning Problems—Among all children from the birth cohort who at or after age 5 years still lived in Rochester (N=5,718) we intended to identify all who were believed to have any indication of problems with learning. Our overall strategy consisted of four steps (see Figure 1), employed multiple sources of information (school, medical, RCDIM records) and relied on a documented history of any learning/behavior concern, information on educational intervention (Individualized Education Program—IEP), and individually administered test results. The starting point (Step I) was a page by page review of each cumulative school record (public and private) for all 5,718 subjects, excluding 19 severely mentally retarded children. Children with any notes or reports related to any type of difficulty in learning/behavior, observed by teacher, parent, school psychologist, physician, social worker, school nurse, or counselor were designated as “learning/behavior concern-yes” (n=1,961). During Step II, the medical and RCDIM records of these 1,961 subjects were also reviewed. The following data were abstracted: individually administered academic achievement and cognitive ability test results, group achievement test results, detailed information related to behavioral problems (symptoms, clinical diagnoses, results from teacher/parent questionnaires, treatment), diagnoses of major psychiatric disorders, visual/hearing and motor impairment, frequency of school moves, absenteeism, family alcohol and other drug abuse, family abuse and neglect and family SES. Among the 1,961, there were 1,366 children (see Figure 1) with an IEP for reading, and/or math, and/or writing, and/or individual achievement test scores for reading and/or math and/or writing. This group (n=1,366) was designated as “learning problems-yes.”

To be certain that in Step I we did not miss any children with learning/behavior concerns, we completed an additional record-review (Step III) on the remaining 3,757 “learning/behavioral concern--no” (see Figure 1). This consisted of reviewing/abstracting medical records of all who had a medical diagnosis of LD, RD, Math LD, WLD, or any similar diagnoses related to problems with learning used by physicians at that time, including records of the RCDIM. All available data (see prior list) were abstracted and entered into a data base. Subjects who had individually administered tests for reading, math and writing (n=143; see Figure 1) were designated as “learning problem-yes.”

The procedures of Steps II and III (Figure 1) identified 1,509 children with learning problems (26% of all 5,718 birth cohort children).

Identification of WLD Incident Cases – Psychometric Criteria—All scores from individually administered IQ and achievement tests for all 1,509 subjects with learning problems were recorded. For each child, all writing achievement and IQ test scores were used to form pairs of cognitive ability and writing performance measures, within each

calendar year. In Step IV (Figure 1) three research formulas (Regression Minnesota-RM; Discrepancy Rochester-DS; Low Achievement-LA; see (Table 1) were then applied and subjects who met criteria for any of these formulas were designated as childhood research identified subjects with written language disorder (WLD) (Figure 1). The details of these three formulas were previously published (see Table 1).¹⁶ In each of the formulas, X represents the study subject's IQ score, and Y represents the predicted standard score from the writing achievement test: 1) Regression formula-Minnesota (RM), $Y < 17.40 + 0.62X$, issued by the Minnesota Department of Education;¹⁸ Children classified as having WLD by this formula had standard scores in written achievement that were >1.75 SD below their predicted standard score from an individually administered measure of cognitive ability (IQ). The value 0.62 represents the correlation between IQ and achievement used in the Minnesota formula. 2) Discrepancy-nonregression formula: This method was used in ISD #535 before 1989, when members of our birth cohort attended school. In this approach, differences between age-based standard scores on measures of individually administered intelligence and writing achievement varied by grade placement as follows: (i) kindergarten-3rd grade, 15 or more standard score points difference, with achievement lower; (ii) 4th-6th, ≥ 19 , achievement lower; and (iii) 7th-12th, ≥ 23 points difference; and 3) the Low Achievement (LA) formula: $X \geq 80$ (cognitive ability) and $Y \leq 90$ (achievement) represents an alternative method to identify LD.¹⁹⁻²¹ In this report, we present incidence rates for WLD regardless of information from medical and school records indicating the presence or absence of any comorbid conditions. We took this approach in order to represent the identification, diagnostic and instructional issues faced daily by professional staff.

Identification of Specific Difficulties in Children with Written Language Disorder (WLD) – Research Criteria—DSM-IV-TR describes four specific writing difficulties: grammatical or punctuation errors within sentences, poor paragraph organization, multiple spelling errors, excessively poor handwriting.”⁸ In order to operationalize these four specific writing difficulties, we employed retrospectively collected information from Individualized Education Program (IEP) *goals* for written language and/or specific writing subtest *scores* of ≤ 90 available for a majority of our subjects with research identified WLD. These specific writing *goals* and/or writing *scores* were then aligned with the four DSM-IV-TR defined specific writing difficulties.

Statistical Analyses

Cumulative incidence rates, the likelihood that subjects from our cohort who remained in Rochester throughout their school years, would be diagnosed as WLD, were calculated according to the Kaplan and Meier method. Children who did not meet research criteria for WLD were censored on the initial occurrence of migration from the community, death, last follow-up date or age 19 years. Cumulative incidence rates were calculated separately for boys and girls for each of the three WLD formulas. Risk ratios (boys vs. girls) and corresponding 95% CIs were determined using the regression coefficient and standard error for gender obtained by fitting Cox proportional hazards models.

RESULTS

Incidence Rates of Written Language Disorder (WLD) By Three Formulas and Gender

Table 2 provides cumulative incidence rates of WLD to age 19, overall and separately for boys and girls, by each of the three formulas. WLD was common, with cumulative incidence rates varying from 6.9% (95% CI, 6.2-7.7) by the RM formula to 14.7% (95% CI, 13.6-15.7) for LA. Gender-specific cumulative incidence rates for WLD varied from 10.0% for boys and 3.6% for girls (RM), to 18.9% for boys and 10.1% for girls (LA formula). Male:female relative risk ranged from 2-2.9, regardless of the formula. Cumulative incidence rates of

WLD, by age, gender and by formula is depicted in Figure 2. Table 3 presents age when incident cases met WLD research criteria (median age = 8.6 years) and was not significantly different between boys and girls ($p=0.43$ RM; 0.08 DS; 0.09 LA).

The mean number of individually administered cognitive ability measures was 2.7 and 2.8 for written achievement (not statistically different between boys and girls). Approximately 94.3% of the WLD children had been administered an age appropriate Wechsler scale; 85.1% were administered a Woodcock-Johnson achievement test.

Overlap among Children with WLD Identified By Different Formulas

Among the 5,718 birth cohort children, 806 WLD incident cases (unique children) were identified by at least one of the three formulas; some were identified by more than one formula. The details of frequency and overlap are presented in Table 4.

DSM-IV-TR Defined Specific Writing Difficulties among Research Identified WLD Incident Cases

Table 5 provides frequencies of specific writing difficulties as described in DSM-IV-TR among all WLD incident cases, identified by each, or any combination of the three formulas. Among 806 WLD incident cases so identified, we characterized specific written difficulties among 87% ($N=702$).

DISCUSSION

This report on incidence rates of WLD in a population-based birth cohort clearly indicates that WLD is common among school aged children, longitudinally followed from 5-19 years. Our research is unique since there are no incidence studies of WLD, the most important measure in epidemiology. In the absence of published WLD incidence studies, our cumulative incidence rates can only be compared with available reports of prevalence, assuming that subjects from these studies have the same chance to be identified as WLD cases as those in our birth cohort.²² Epidemiologic studies on prevalence rates of WLD are sparse and usually presented descriptively. Lerner²³ emphasized that the written language problem “is probably the most prevalent disability of the communication skills.” Reid Lyon stated that “...written language disorders affect at least 10% of the school-age population...”.²⁴ In 1999 the National Center for Educational Statistics reported 61% of 4th graders wrote at a “basic level” and 16% wrote below “basic level.”²⁵ The only paper providing prevalence estimates of written language problems was a population-based study of unreferred students from three middle schools located in different regions of the United States;⁷ significant writing problems were exhibited by 6-22%. These prevalence rates, comparable to our incidence rates, underscore the magnitude of written language problems.

Our study shows that boys are 2-3 times more likely than girls to be affected with WLD. These findings are comparable to the Hooper et al.,⁷ boy/girl ratios of 1.3:1, 1.6:1 and 2.6:1, depending on the region of the U.S. These findings of gender disparity are consistent with Berninger and Fuller.²⁶ The National Assessment of Educational Progress results showed that girls outperformed boys in writing and this discrepancy increased at the secondary level.²⁷ Berninger et al.¹¹ showed that boys were more impaired in handwriting and composing than girls. Further studies using incident WLD cases are essential to examine the potential genetic and environmental factors that may explain this apparent gender disparity.

Currently, there are no universally accepted tests, assessment batteries nor standards for identifying children with WLD.²⁸ The problems of operationalizing LD for research and clinical purposes have existed for over 30 years.²⁹ Recently, there has been a shift from discrepancy-based criteria toward that based on response to educational intervention (RTI).

While there may be potential benefits for RTI in early identification³⁰ and despite the limitations and conceptual issues in defining LD using discrepancy criteria,^{31, 32} still, 94% of state departments of education incorporate a discrepancy model in their identification criteria.^{29, 33, 34} Finally, Cellucci et al.³⁵ have stated that use of DSM-IV and case identification “based on documented limitations in achievement and cognitive testing remains a reasonable practice.”³⁵

To identify all children with writing problems, we applied three widely used formulas and determined the number of children with WLD who would not be identified if one were to rely on a single formula. Applying various definitions (cognitive-achievement discrepancy, low achievement) must be “vigorously pursued” in order to establish reliable prevalence rates.² We agree, and believe that our use of three different formulas allowed a more precise estimate of the number of children affected by WLD.

Research on the *specifics* of writing difficulties among children with WLD is almost non-existent.² We found 69% of all WLD incident cases had a combination of four *specific* problems in written expression described in DSM-IV-TR. Graham and Weintraub³⁶ stated that the prevalence of *handwriting only* difficulties has not been adequately established and that *handwriting* problems are “common among school-age children.” We found 5% of all children with WLD had *only handwriting*, and 13% *only spelling* problems, comparable to Berninger and Hart,⁶ who reported that up to 2.7% had isolated problems with *handwriting* and up to 4% had isolated problems with *spelling*. Since children with WLD are clearly a heterogeneous group, additional research is needed to identify specific interventions that target the *specifics* of writing problems.

It is remarkable that the relationship between WLD and RD has not been well investigated. Among our WLD incidence cases, preliminary findings suggest there may be two broad categories of WLD: WLD *without* RD, and WLD *with* RD. We identified 203 children (25%) who only had WLD. Further investigation of this important group—WLD *only*—is currently underway. This potential relationship has been underscored in the DSM-IV-TR which states that relatively little is known about WLD “...particularly...in the absence of reading disorders.”⁸

The limited studies of WLD demonstrate that WLD is at least as prevalent as reading disability (RD); that boys are more affected with WLD than girls (similar boy/girl ratio as RD); and that the age of diagnosis of WLD and RD are also comparable. Nevertheless, WLD is substantially less studied than RD.^{16, 37} Reid Lyon stated that epidemiological studies on WLD are lacking, particularly in comparison to studies of RD.^{24, 28} Hooper et al. also pointed out that WLD studies, especially epidemiological studies, have lagged well behind the research done on other academic-domains, specifically reading.^{2, 3, 9} Nancy Heath et al. in their analyses of the “core topics” of LD research during the last ten years, in the leading LD journals, reported that RD was the most published category (20%) compared to less than 1% related to WLD.³⁸

While our study has addressed the preceding shortcomings, three potential limitations remain. First, this is a retrospective study and there is a possibility for under-ascertainment of WLD incident cases. However, 34% of the entire birth cohort had a “learning/behavior concern” documented in one or more of the three sources of data (school, medical, private tutoring center). Further, the cumulative incidence of WLD by age 19, ranging from 6.9% to 14.7%, also suggests it is unlikely that incident cases of WLD were missed. A second potential limitation is related to emigration from the entire birth cohort of 8,548 children. Detailed comparison of children who left the community before age 5 and those who stayed strongly indicate that the 5,718 children included in the study are representative of the entire

birth cohort.¹⁵ Finally, Rochester is primarily a white, middle class community which may limit the generalization of these incidence rates for WLD to other populations.¹⁴ Nevertheless, these data provide much needed baseline information for comparison with similar studies.³⁹⁻⁴⁰

CONCLUSION

In summary, the incidence data from this population-based birth cohort, longitudinal, epidemiologic study, demonstrate that WLD occurs more frequently than RD, and is significantly more common in boys than in girls. Identification of these incident cases provides a powerful opportunity for further studies of WLD, including risk-factor analyses, comorbidities, subgroups of WLD, response to intervention, and important life outcomes. The results from our study provide research-based information to ambulatory and school settings, and should promote increased efforts to identify, and provide timely intervention for, children with Written Language Disorder.

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Abbreviations

WLD	Written Language Disorder
MLD	Math Learning Disorder
LD	Learning disability
RD	Reading disability
REP	Rochester Epidemiology Project
RCDIM	Reading Center/ Dyslexia Institute of Minnesota
IEP	Individualized Education Program
RM	Regression formula, Minnesota
DS	Discrepancy formula, Rochester
LA	Low Achievement
RTI	Response to Intervention.

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^aLearning/behavior concerns – yes: Children who had one or combination of following evidence: Individual Education Program (IEP) reports, individual assessment/reassessment report, referral forms, medical or medication reports, private evaluation and/or private tutoring reports, individually administered ability and achievement tests or any notation from teacher, parent or other person related to any type of difficulties in learning/behavior.

^bLearning/behavior concern – no: Children who were not identified through school system (see * above) as having learning/behavior problems.

^cRCDIM: Reading Center/Dyslexia Institute of Minnesota.

^dLearning problems – yes: All children who had an Individualized Education Program (IEP) assigned and/or individually administered standardized ability and/or achievement tests given (data collected through Step II).

^eLearning problems – yes: All children who had an individually administered standardized ability and/or achievement test given outside of school system (data collected through Step III).

^fRM: Regression Formula Minnesota.

^gDS: Discrepancy non-regression formula Rochester.

^hLA: Low achievement formula.

FIGURE 1.

Flow Diagram Describing Steps in Identifying Children with Written Language Disorder (WLD) among 1976-1982 Birth Cohort, Rochester, Minnesota

FIGURE 2.

Cumulative Incidence Rates of Written Language Disorder (WLD), Identified by Each Formula among 1976-1982 Birth Cohort, Rochester, MN, by Age and Sex; Lines Represent Cumulative Incidence with 95% CI

TABLE 1
Psychometric Formulas for WLD Case Identification

A. Regression Minnesota (RM)		$Y \leq 17.40 - 0.62X$
B. Discrepancy Rochester (DS) (non- regression based)		$X - Y = 15, 19 \text{ or } 23 \text{ points}$
C. Low Achievement (LA)		$X \geq 80; Y \geq 90$

Note: X = Full Scale intelligence Quotient; Y = Reading Achievement Test Standard Score

TABLE 2
Incidence of Written Language Disorder (WLD), Identified by Three Formulas, among 1976-1982 Birth Cohort, Rochester, Minnesota (N=5718)

Variables	WLD Formulas							
	RM ^a				DS ^b			
	All	Male	Female	All	Male	Female	All	LA ^c
Number of WLD	333	250	83	511	368	143	704	471
Cumulative incidence by age 19 (%)	6.9	10.0	3.6	10.4	14.5	6.0	14.7	18.9
95% CI ^d	6.2-7.7	8.8-11.2	2.8-4.4	9.6-11.3	13.1-15.9	5.1-7.0	13.6-15.7	17.3-20.4
RR (Male:Female) ^e		2.9			2.5			2.0
95% CI [§]		2.3-3.7			2.1-3.0			1.7-2.3

Directly adjusted to age distribution of the entire birth cohort

^aRM – Regression Formula Minnesota-psychometric method used to identify incident cases with WLD

^bDS - Discrepancy non-regression formula Rochester – psychometric method used to identify incident cases with WLD

^cLA – Low Achievement Formula – psychometric method used to identify incident cases of WLD

^dCI – Confidence interval

^eRR – Relative risk

Age when WLD^a Incident Cases met Research Criteria

TABLE 3

Research Identified WLD Cases ^b												
RM ^c			DS ^d			LA ^e			By Any of the 3 Formulas			
Male	Female	All	Male	Female	All	Male	Female	All	Male	Female	All	All
<hr/>												
Number with WLD	250	83	333	368	143	511	471	233	704	543	263	806
Age Mean (SD)	9.7 (2.9)	10.1 (3.2)	9.8 (3.0)	8.9 (2.4)	8.6 (2.5)	8.9 (2.4)	9.7 (2.9)	10.2 (3.3)	9.8 (3.0)	9.4 (2.8)	9.8 (3.2)	9.5 (2.9)
Median	8.6	9.0	8.7	8.4	8.0	8.2	8.7	9.3	8.9	8.5	8.9	8.6
Range	5.4-17.3	5.4-18.6	5.4-18.6	5.4-17.1	5.4-18.6	5.4-18.6	5.1-18.7	5.6-20.5	5.1-20.5	5.1-18.7	5.4-20.5	5.1-20.5

^aWLD – Written Language Disorder

^bResearch Identified WLD case: Among all children with learning problems (N=1509 – see Figure 1), one formula (RM or DS or LA) or any combination of the three formulas (RM, DS, LA) were used to identify WLD incidence cases

^cRM – Regression Formula Minnesota

^dDS – Discrepancy Non-Regression Formula – Rochester

^eLA – Low Achievement Formula

TABLE 4

Frequency and Overlap of Children with Written Language Disorder (WLD) Identified by 3 Formulas among 1976-1982 Birth Cohort (N=5,718), Rochester, MN

RM ^a	DS ^b	LA ^c	Frequency	Frequency
		•	275	275 (34%)
	•		81	198 (25%)
	•	•	117	
•			4	333 (41%)
•		•	16	
•	•		17	
•	•	•	296	
333	511	704	806	806

^aRM – Regression Formula Minnesota-psychometric method used to identify WLD incident cases

^bDS - Discrepancy non-regression formula Rochester – psychometric method used to identify WLD incident cases

^cLA – Low Achievement Formula – psychometric method used to identify WLD incident cases

TABLE 5

Distribution of DSM-IV-TR^a Described Specific WLD^b Difficulties among Research Identified WLD^c Incidence Cases

Specific Writing Difficulties Described in DSM-IV-TR		Research Identified WLD – Any of 3 Formulas (RM, DS, LA) ^d		
		Male	Female	All
DSM-IV-TR	Any combination of 4 specific writing difficulties ^e	380	178	558
	Handwriting only	23	13	36
	Spelling only	61	47	108
None ^f		79	25	104
Total		543	263	806

^aDSM-IV-TR – Diagnostic and Statistical Manual of Mental Disorders

^bWLD – Written Language Disorder

^cResearch Identified WLD – among all children with learning problems (N=1509) any combination of the 3 formulas (RM, DS, LA) were used to identify WLD incidence cases

^dRM – Regression Formula Minnesota; DS – Discrepancy Non-Regression Formula Rochester; LA – Low Achievement Formula

^eDSM-IV-TR – WLD cases who had any combination of four DSM-IV-TR described difficulties in: “grammatical errors, poor paragraph organization, multiple spelling errors, excessively poor handwriting” – but not spelling errors only and not excessively poor handwriting only

^fNone – WLD cases who were suspected to have learning problems and were individually tested for reading, math and writing difficulties but IEP goals for specific writing difficulties were not assigned and/or specific writing problem *subscore* were not available.