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Comparison of Concordance and Predictive Validity of Head Injuries from Parental Reports and Medical Records

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Abstract

Objective:
To examine agreement between parental reports of head injury and evidence of head injury in medical records and to compare these two measures in predicting early conduct disorder (CD).

Design and Setting:
Parent survey data was compared with records of child head injury from the National Health Services Register (*Régie de l'assurance maladie du Québec,* RAMQ) administrative database.

Participants:
Children ($N = 685$) ages 6–9 with and without CD. There were 147 children with RAMQ recorded head injury and 39 children with parent-reported head injury.

Main Measures:
Indication of one or more head injury before 6 years of age as reported by parents and/or as noted in medical data. Early CD (present by age 9) according to parents and/or teachers.

Results:
Results indicated poor agreement between the two forms of reporting $\kappa = .161$ (95% CI, .083 to .239), $p < .001$. Medical data significantly predicted the presence of CD in children, with a RAMQ coded head injury suggesting a child was 1.88 times more likely to have CD. Parent reports of head injury did not significantly predict CD.

Conclusion:
Medical data should be prioritized in research addressing pediatric head injury, given that parent reports may fail to capture incidence of injury and therefore may be less predictive of other known correlates of head injury.

Key words: head injury, parent-report, conduct disorder, pediatric, measurement

Comparison of Concordance and Predictive Validity of Head Injuries from Parental Reports and Medical Records

Pediatric head injuries are a leading cause of death and disability among children,[1] with medical record estimates yielding median annual rates of 973 moderate to severe injuries per 100 000 youth.[2] The public health burden of childhood head injury is notably high because adverse developmental outcomes can manifest over a long period and require long-term support.[3-5] Research indicates that youth who experience a head injury are more likely to show adverse psychosocial outcomes, such as externalizing problems,[6-17] internalizing problems,[7-9, 11, 12] lower academic performance,[12,18,19] and poorer adaptive functioning,[20,21] both concurrently and longitudinally. In order to better predict the risk and to mitigate associated difficulties, it is critical to have reliable reports of pediatric head injuries. While much of the current research employs retrospective parent reports of child head injuries, [10,11,17, 22, 23] there is a lack of knowledge about the psychometric qualities of such measures.

To address this gap in the literature, the present study utilized a sample featuring a large portion of children with conduct disorder (CD). Agreement was examined between retrospective parental reports and medical records of child head injuries from birth to the age of 6. Given strong past evidence indicating a link between head injuries and CD,[6-17] the study also sought to use the high proportion of CD, present in this sample among both boys and girls, to compare parent reports and medical records of head injuries in the prediction of early CD. This allowed the study to explore the comparative incidence of head injury captured by each measure, while also determining how both measures compare in capturing the potential correlate CD.

Parent-Report & Self-Report versus Medical Records

One previous study has examined concordance in evaluations of children's head injuries. Kostylova and colleagues[24] examined concordance between a Canadian hospitals injury surveillance system and a physician billing claims database (Régie de l'assurance maladie du Québec, RAMQ), exclusively among children presenting to the emergency department for head injury. The surveillance system included a patient or accompanying adult completed questionnaire indicating the injury context (at time of admission) and physician added diagnostic codes, injury location, and treatment provided. RAMQ, Quebec's provincial government health insurance plan, records type of consultation, ICD-9-CM diagnostic codes, and procedure codes for services provided. Although concordance between the data sources was ''substantial'' (Kappa 0.66), the two measures were compared on the basis of injury diagnosis and there was no examination of the extent to which parents in particular completed the questionnaire or whether their reports aligned with RAMQ data.

In the absence of research directly examining the psychometric qualities of parent-reported measures of pediatric head injury, other studies on the utility of parent-report data for child health care usage can offer some insights. In one study, retrospective parent-report data was linked with administrative health records for mental health-related service contacts among youth.[25] Disorder prevalence and service contact estimates were significantly higher in the parent-reported data in all cases, except for mood disorders. These findings were largely attributed to non-physician community and school-based services being excluded from the administrative data, while these services were recalled as much more commonly used according to parents. Medical attention is not always sought for children's head injuries,[26] but when it is, it may be in several different types of medical settings. However, studies often use data from only one point of medical service use,[7,9,12] which can overlook cases that are assessed in other clinical settings. For example, in one study, it was found that among children and adolescents, 81.9% had their first concussion visit in primary care, 5.2% in specialty care, 11.7% in the emergency department, and 1.2% were directly admitted to the hospital.[27] However, in the same study 51.9% of children below the age of 5 sought emergency department care. This highlights the variation in service point entry and the importance of data that covers a broader range of services.

The use of parent-reported service use data has also been supported by research assessing agreement between the results of a child respiratory health survey and RAMQ data.[28] This study found moderate agreement between both types of data and validated the use of parent-report data when examining pediatric asthma and related health service use.

When examining self-report data in comparison to medical records, a population-based study using self-report data from Canadian adult participants discovered that approximately 75% of those recorded to have accessed mental health services according to medical records did not self-report using mental health services.[29] The odds of disagreement were higher among mothers of young children but decreased with education level. Odds also decreased as the number of recorded mental health services increased and with a shorter length of time between the survey and receiving mental health support.

In an examination of agreement between self-reported and medically recorded self-harm data from adolescent participants, only a small percentage of participants (3%) who reported a history of self-harm had a medical record of self-harm.[30] However, one-fifth of hospital attendance for self-harm was not reported on the questionnaire. Also, self-harm was reported inconsistently over time; one third of those who reported life-time self-harm at age 16, did not report it at 18.

Another study looking at rates and types of chronic conditions (e.g., heart disease, anxiety/depression), found that only 26.9% of participants showed perfect agreement on both number and type of chronic conditions between administrative and self-report data.[31] Moreover, for the 62.5% of those who exhibited complete disagreement, the number of chronic conditions was higher in administrative data compared to self-reports. Results from a systematic review showed variable accuracy of self-reported health care use.[32] An increased length of time between receiving care and reporting was linked with higher under-reporting. Stigmatized care, like mental health care, was also associated with under-reporting. The reporting of health services also tended to be more accurate for salient services (e.g., hospitalization vs. outpatient services).

While stigma around service use and recall bias might help to explain discrepancies seen between self-reported measures and medical data, the same may be true for differences between parent-reported head injuries versus medical data. Especially for parents of young children, reporting of a head injury could induce fear of perceived abuse and if another injury was involved alongside the head injury, the memory of the other injury may override that of the head injury. Taken together, both parent-report and administrative data have the potential to offer reliable estimates of head injury among children. Given the possibility of factors like recall bias and social desirability influencing responses,[11, 23] however, these two sources of data should be directly compared to better understand their accuracy and predictive abilities.

Head Injuries and Conduct Disorder (CD)

A robust body of literature has demonstrated a strong connection between childhood head injury and the development of CD. Ewing-Cobbs and colleagues[9] conducted a longitudinal study of children and adolescents receiving care for a head injury. Compared to an orthopedic injury group, CD was significantly higher among children with head injuries and this behaviour did not resolve to pre-injury levels even three years post-injury. Numerous other studies have also lent support to this pattern of findings.[7, 8, 10, 12-17]

According to Moffitt's[33] developmental taxonomy of antisocial behaviour, CD that takes place in childhood can be rooted in neurodevelopmental processes. These neurodevelopmental underpinnings of early CD are particularly relevant when considering head injury among children. Head injury has been associated with executive dysfunction and verbal deficits,[34, 35] which have in turn been associated with CD.[33, 36, 37] Neurocognitive impairments, such as those that may be acquired through head injury, can represent a pathway enabling genetic and psychosocial influences to manifest in early CD.[37] Examining CD before the age of 10 is specifically critical given that evidence suggests children with early onset CD have significantly worse outcomes on an array of measures including depression, cannabis use, alcohol use, official records of antisocial behaviour, general health, education, and employment, when compared to those with adolescent-onset CD.[38]

Given the link between head injuries and childhood CD, the oversampling of children with CD distinguishes this sample as one that is uniquely poised to use CD as a comparison point between parent-reported head injuries and medical data. Past studies have linked head injuries to CD both solely through parent reports of head injury[10, 11, 17, 23] and through administrative data.[6, 7, 9, 13-16] The present study will be able to distinguish the predictive abilities of these two measures more thoroughly when directly compared within the same sample. We will examine this relationship while controlling for sex[39], family income and parental education level.[40]

Objectives

Although several authors have suggested that the use of parent-reported head injuries in children is a limitation in study design,[9, 11, 17, 23] no study has directly compared parent-reported head injuries to administrative data and parental reports of child head injuries continue to be frequently used in the literature.[10, 11, 22, 23] The overarching goal of this study is to compare parent-reported head injury in children with evidence of head injury in medical records. Our first aim is to examine the agreement between parental reports and evidence of head injuries in medical records. We expect moderate agreement between parental reports and administrative records. Our second aim is to compare parent-reported head injuries to medical records of head injuries in the prediction of child CD. Based on the extant literature,[6-17] we would expect that both parent-reported head injuries and medical records of head injuries would significantly predict CD. However, insofar as the evidence suggesting medical records might more closely resemble actual incidents (at least in a country with universal health care coverage, such as Canada), we would expect medical records to be stronger predictors of head injuries than parent reports.

Method

Participants

Participants (N = 744; 47% girls, M*age* = 8.4; *SD* = .93) were drawn from an ongoing longitudinal study of boys and girls with and without childhood CD. Children were recruited between 2008 and 2010 across 155 public schools from four regions in Québec, Canada when they were 6-9 years old. Our selection methodology was aimed at increasing the probability of recruiting children with clinical levels of CD before the age of ten. The tenth birthday was selected as an appropriate cut-off as the *Diagnostic and Statistical Manual of Mental Disorders*[41] recognizes childhood-onset CD when at least one criterion characteristic is evident before this age. Clinical levels of CD were operationalized as reaching the clinical cut-off (T-score ≥ 70) on the DSM-oriented scale for Conduct Problems in the *Achenbach System of Empirically Based Assessment* (ASEBA).[42]

Approximately half of the sample (n = 370) was selected from the school boards' lists of children younger than 10 who had been referred to psychosocial services for CD. Of these, 277 children (43% girls) were classified as having CD before the age of 10 years, including 238 children with CD at the time of recruitment, and 39 others who developed clinical levels of CD over the subsequent years (still prior to age 10). (See Supplemental material for a graphic presentation of the sample selection).

The other half of the sample (n = 374) was recruited from among 881 students not receiving services who were screened for CD with the same DSM-oriented scale completed by parents and teachers.[42] This multi-gated screening procedure was carried out in schools located in low socio-economic neighborhoods[43] to reduce socio-economic disparities between children with and without CD and to increase the probability of identifying children with CD. This method identified 95 children with elevated scores on the DSM-oriented scales for CD including 45 children (62% girls) with CD before age 10 at the time of recruitment and six others (50% girls) who developed clinical levels of CD over the subsequent years, but still before age 10. We also selected from this pool of 881 students 279 children who were not at risk (T < 65) for CD at Time 1 according to parent and teacher ratings. Among these children, however, 5 (20% girls) developed clinical levels of CD before age 10 over the subsequent years.

Seven years later, in the eighth annual wave of assessment, 685 participants (92%, 321 girls; 46.8%; 304 children with CD) gave their consent for the research team to gain access to their provincial medical records.

Measures

Medical Service Utilization for Head Injury. The RAMQ holds administrative data on the persons registered and eligible for the Québec Health Insurance Plan, which is the singlepayer public health plan. Data from the RAMQ provided information on physician services billed on a fee-for-service basis (e.g., type of service, diagnosis). To evaluate the services received by participants, the presence of at least one visit for head injuries between participants' birth and 6th birthday was used. Visits for head injuries were identified using codes referring to medical visits with diagnoses for injuries (i.e., superficial injury of head, fracture of skull and facial bones, intracranial injury, etc.). The presence of any of these codes was given a value of 1. All others with no indications of head injury were coded as 0.

Parent-Reported Early Head Injuries. At study inception parents were asked, "Has the child suffered from a concussion, head injury or traumatic brain injury in their lifetime?" Parents indicated the age at which the first injury occurred. Children who had not sustained a head injury or who did for the first time after the age of six were coded as 0 for the variable early head injury. All children whose parents reported a head injury prior to the sixth birthday were coded as 1.

Early CD. Early CD was evaluated by parents and teachers with the DSM-oriented scale for conduct problems on the parent-report Child Behavior Checklist (CBCL) and Teacher's Report Form (TRF) of the ASEBA.[42] The CBCL contains 17 items and the TRF contains 13 items. All items are arranged on a 3-point Likert scale, ranging from 0 (*not true*) to 2 (*very true* or *very often*). The items assess behaviors that are consistent with symptoms of CD as described in the fourth and fifth editions of the DSM.[41,44]

Covariates. Child sex was reported by parents at study inception. Family income was reported by parents at study inception using a 14-point scale that was subsequently weighted to normalize the distribution. Parental education level was reported at study inception.

Procedure

Following approval for this study from McGill University's ethics review board, parental consent was obtained yearly prior to the collection of CD data. Data collection took place in the homes of the participants by trained graduate-level research assistants studying in psychology or psychoeducation. In addition, parental consent was sought yearly so that information regarding child CD could be collected from the child's teacher. Families and teachers were financially compensated. Seven years after study inception, permission was requested from participants and their parents for the research team to obtain data on their medical service utilization. Approval to obtain provincial medical records of participants was then asked of the *Commission d'accès à l'information du Québec*, the regulatory body in Québec which oversees research access to public health records. Once this formal authorization was granted, the research team requested the data from the RAMQ.

Statistical Analysis

Our first aim was addressed using chi-square analyses to examine the percentages of agreement and disagreement between the parent-reported incidence of head injury and the RAMQ data. A kappa interrater coefficient between the two sources of data was computed. For our second aim, logistic regressions were performed to compare parent reports and RAMQ data in their ability to predict the presence of CD in children before age 10. Three models were assessed, one containing parent-reported head injuries and covariates, another with RAMQ data and covariates, and a third with both predictors and covariates. Confidence intervals were estimated at the 95% confidence level.

Results

Demographic information is shown in Table 1. The sample included 364 (53.1%) boys and 321 (46.9%) girls (N = 685). There was one missing case among the parent-reported head injury data. In the regression analyses, there were six cases with no reported annual income and one parent education level unreported (n = 678). Thirty-nine children had parent-reported incidents of a head injury prior to the age of six and of those, 48.7% of children had CD. Within the RAMQ data there were 147 children (57.1% with CD) coded as having received medical care for at least one head injury prior to age six.

Table 1 about here

Agreement between Parental Reports and Medical Records of Head Injuries

Of the 685 children considered in the analysis, it was agreed upon by both parent reports and RAMQ data that 521 (76.1%) children did not experience a head injury and that 22 (3.2%) children did experience a head injury. Notably, there was disagreement between the two indices with 125 (18.2%) records of head injury but without parental reports of head injury and 17 (2.5%) with parental reports of head injuries but no accompanying RAMQ records (see Table 2).

A chi-square (χ^2) test was performed to determine the degree of association between RAMQ and parent-report data across binary categories (head injury vs. no head injury). The analysis was statistically significant $\chi^2(1) = 29.97$, $p < .001$, indicating that RAMQ-reported head injuries are associated with parent reports of head injury. Cohen's kappa (κ) was also computed, and this indicated poor agreement[46] between the two types of head injury reports, κ = .161 (95% CI, .083 to .239), $p < .001$).

Table 2 about here

Prediction of CD from Parent Reports and Medical Records of Head Injuries

A binary logistic regression was performed to compare RAMQ-indicated and parent-reported head injuries in predicting the presence of early CD. Three models were tested (Table 3) with the inclusion of parent-reported head injuries in Model 1, RAMQ-reported head injuries in

Model 2, and both reports in Model 3. Parent-reported head injuries did not significantly predict early CD in Models 1 and 3. RAMQ-coded head injuries were found to significantly predict early CD in Models 2 and 3. Children with a RAMQ-coded incidence of head injury were 1.88 times more likely to have CD. Model 2 explained the same amount of variance (17.1% Nagelkerke R^2) as Model 3. Therefore, Model 2 was retained as the most parsimonious model $\chi^2(4) = 92.68$, $p < .001$. Parental education level, income, and sex were included in each model as covariates. Parent-reported education and income significantly predicted child CD.

Table 3 about here

Discussion

Given the long-term and multifaceted impacts of pediatric head injury, it is critical to understand how the most accurate reports can be captured. While some studies have examined administrative health records compared to parent or self-report measures of other types of health problems[25, 27-31] no previous study has directly compared parent-reported data for child head injuries to administrative medical data.

Agreement Between Parent Reports and Medical Records

Our results demonstrated low agreement[45] between parental reports of child head injury and medical records. Over 3.5 times more head injuries were reported in RAMQ medical records when compared to parent reports. Although similar research is scarce, these results align with past studies comparing self-report data to administrative data in other contexts, where social desirability or recall bias could be at play.[28, 30] Parents may associate their child's head injury with the appearance of abuse and thus may be less likely to disclose this information. Moreover, conceptual variations of what constitutes a head injury could play a role in how parents interpreted the question. Studies examining concussions in athletes have found that when a definition with a list of symptoms is provided, significantly higher rates of concussions are reported.[46,47] A child could experience a head injury and yet the parent may not deem it severe enough to warrant reporting it via survey or through seeking medical attention. Recall bias may have presented issues for parents if the injury had occurred long before the survey, if it occurred with another salient injury, or if it was of lesser severity.[26]

While these findings offer compelling evidence for the comparative accuracy of medical records over parent-report, the accuracy of administrative data relies on individuals seeking services for injuries. One study found that 42% of people who indicated they had sustained a traumatic brain injury did not seek medical attention,[26] while another found that only approximately 1 in 10 Canadians who reported a traumatic brain injury said they visited a doctor's office for treatment.[48] In the present study, 17 of the 39 parent-reported cases of head injury had no head injury reported in the RAMQ medical records. These cases may not represent an issue with underreporting, but rather, they could be instances where parents were aware of an injury and yet medical care was not sought. In these cases, further research on the factors that guide parents in deciding whether or not their child receives care could offer meaningful insight.

Prospective links with Child CD

Our results indicated that RAMQ head injury data was significantly linked to the presence of CD in children prior to the age of 10, while parental reports were not. Even with a distinct sample that presented a high proportion of children with CD, this association was still not found for parent reports. Parents may under-report incidence rates and as a result, their reports may also lack the power to predict related outcomes, like CD. Despite not aligning with past research demonstrating a link between parent-reported head injury in early childhood and CD,[10, 11, 17, 23] this study suggests that past studies may have found stronger associations if they had additionally examined administrative head injury data. Conversely, given that there is strong evidence linking head injury with CD and yet parent reports still do not reliably detect this association, then it is possible that studies relying solely on parental reports may be failing to detect other significant associations beyond that of CD. The present findings offer important insight for future research seeking to examine other potential correlates with head injury.

Limitations and Recommendations for Future Research

It is important to contextualize these findings in light of the limitations of this study. The present study only contained 39 cases of head injury indicated by parents and 147 cases identified by medical records. In seeking to examine links with mental health, past studies have employed samples with over 200 000 incidents of concussion and have linked concussion to an array of mental health concerns including behavioural disorders.[49] Relatedly, the present study was unable to examine severity of head injury. A larger sample size, including more cases of head injuries could have offered a broader severity range and thus could also capture potential variation in CD based on severity. Past work has specified injury severity as a key predictor of post-injury psychopathology, including CD.[4, 8, 11, 13-16, 21]

Research has also suggested that individuals are more likely to recall severe head injuries.[30] Although we were unable to assess severity, the medical administrative data represents injuries which parents deemed required medical attention. Nevertheless, it is possible that our sample contained a disproportionate amount of mild to moderate injuries that may have been more difficult for parents to recall (but that did result in medical attention). Given that the present study was unable to include age at injury or number of injuries, these potential covariates would also be important for future work to examine. Past research has indicated that multiple injuries may be associated with increased behavioural problems[17] and age has also been linked to variation in behavioural outcomes, though with inconsistent findings.[4, 13-16]

While this study warrants replication, these findings underscore the importance of using administrative medical data where possible to capture child head injury. However, this may not always be possible. In studies where administrative records are not available or appropriate, researchers should seek to adopt strategies that may optimize the accuracy of parent reports. For instance, decreasing the length of the reference period by obtaining parent-report measures more frequently and using a calendar to highlight key events that have occurred during the period could improve reporting.[27] As previously noted, the type of healthcare service accessed may also vary with time and child age,[32] illustrating the importance of using wide-ranging measures capturing several different types of medical service delivery.

This study was also conducted in the Canadian context, where universal health care is offered to all Canadians. These results may not be generalizable to jurisdictions where many children, especially those whose parents have lower incomes, do not have health insurance. Given these considerations, pooling both parent and medical records could offer a more comprehensive measure of actual incidence. In seeking to better predict and address the public health burden of pediatric head injury, a valid measure is critical. Future research can use the information from these findings to design studies with a focus on obtaining administrative medical data or on combining parent reports with additional indices. Such measures would optimize the ability for a study to accurately investigate correlates of head injury.

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Table 1

Demographics

	Boys	Girls	Total
Sex	364(53.1%)	321(46.9%)	685(100%)
At least 1 HI prior to 6: Parent Report	21(3.1%)	18(2.6%)	39(5.7%)
CD & HI: Parent Report	11(1.6%)	8(1.2%)	19(2.8%)
No CD with HI: Parent Report	10(1.5%)	10(1.5%)	20(2.9%)
At least 1 HI prior to 6: RAMQ	95(13.9%)	52(7.6%)	147(21.5%)
CD & HI: RAMQ	57(8.3%)	27(3.9%)	84(12.3%)
No CD with HI: RAMQ	38(5.5%)	25(3.6%)	63(9.2%)
Total CD Status	**CD**	**No CD**	
	304(44.4%)	381(55.6%)	685(100%)
Parental Annual Income	**< $25,000**	**> $25,000**	
	139(20.3%)	540(78.7%)	679(99.1%)

Parent Education Level (80% mothers)	**High school diploma or less**	**Professional certificate**	**Two-year college certificate**	**University certificate**	**Bachelor's degree**	**Master's or doctoral degree**	**Total**
	273(39.8%)	140(20.4%)	127(18.5%)	17(2.5%)	89(13.0%)	38(5.5%)	684(99.9%)

Note. HI: Head Injury.

Table 2

Head Injury by Parent Report Versus RAMQ Data - n (% of total)

		Parent Report HI		
		Yes	No	Total
RAMQ HI	Yes	22 (3.2%)	125 (18.2%)	147 (21.5%)
	No	17 (2.5%)	521 (76.1%)	538 (78.5%)
	Total	39 (5.7%)	646 (94.3%)	685 (100%)

Note. HI: Head Injury. $\chi^2(1) = 29.97$, $p < .001$

Table 3

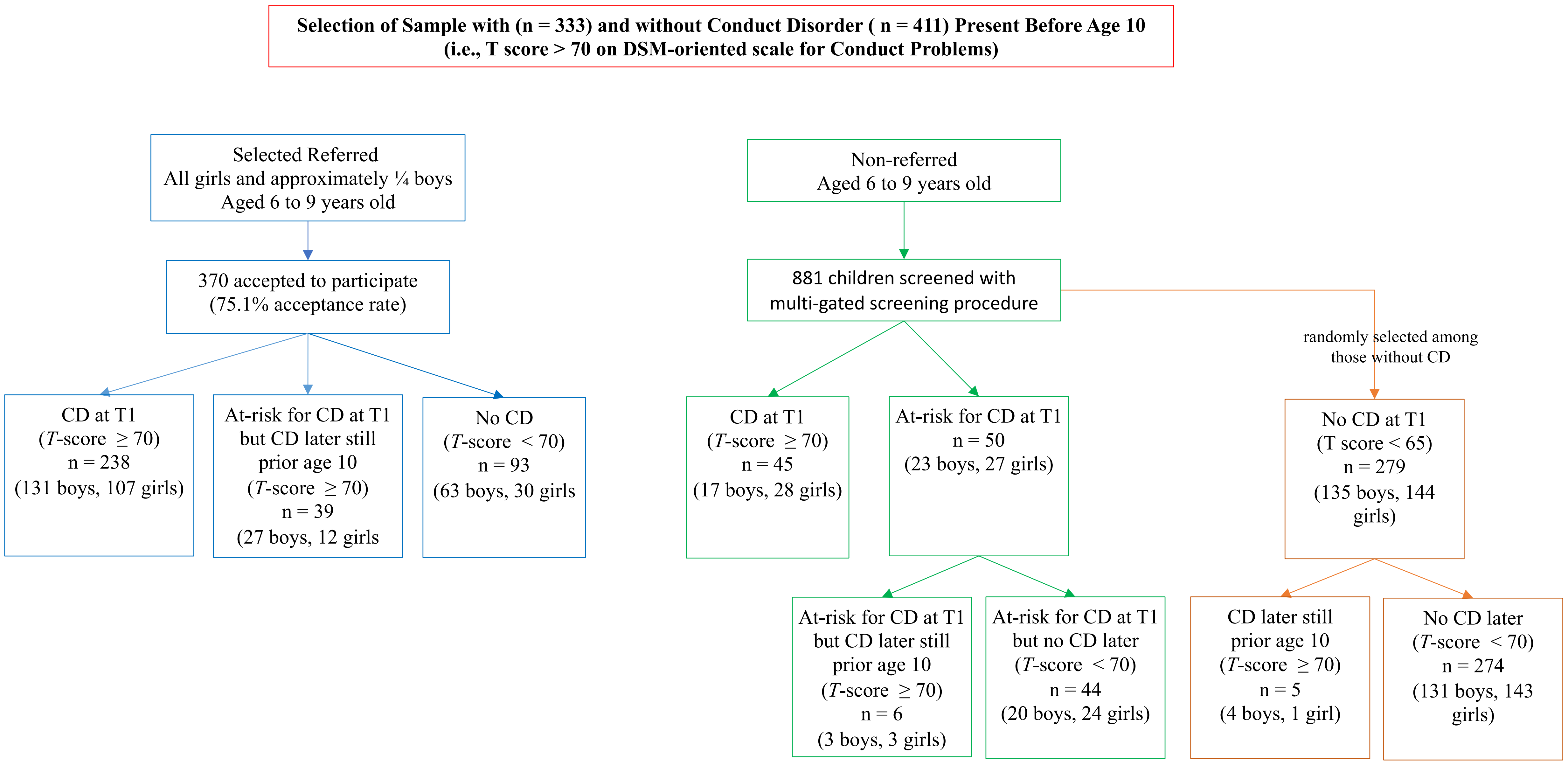
Logistic Regression Models Predicting CD (n= 678)

	Model 1 R^2=.155			Model 2 R^2=.171			Model 3 R^2=.171		
	b(SE)	*OR*	[$CI_{95\%}$]	*b(SE)*	*OR*	[$CI_{95\%}$]	*b(SE)*	*OR*	[$CI_{95\%}$]
RAMQ HI	-	-	-	**.62(.20)***	**1.88**	**[1.25, 2.79]**	**.63(.21)***	**1.87**	**[1.24, 2.81]**
Parent Report HI	.22(.35)	1.25	[.63, 2.48]	-	-	-	-.01(.36)	1.00	[.50, 2.00]
Sex	-.26(.17)	.77	[.56, 1.07]	-.19(.17)	.83	[.60, 1.16]	-.19(.17)	.83	[.60, 1.16]
Income	**-.13(.03)****	**.88**	**[.83, .93]**	**.13(.03)****	**.88**	**[.83, .93]**	**-.13(.03)****	**.88**	**[.83, .93]**
Parent Education Level	**-.21(.04)****	**.81**	**[.75, .89]**	**-.21(.04)****	**.81**	**[.74, .88]**	**-.21(.04)****	**.81**	**[.74, .88]**

Note. Text in bold represents statistically significant results. b(SE)= coefficient and (Standard Error); OR = Odds Ratio; * *p <.05.* ** *p <.001; HI: Head Injury.*

List of Supplemental Digital Content

- Supplemental Digital Content 1. pdf


Selection of Sample with (n = 333) and without Conduct Disorder (n = 411) Present Before Age 10
(i.e., T score > 70 on DSM-oriented scale for Conduct Problems)
Selected Referred
All girls and approximately ¼ boys
Aged 6 to 9 years old
370 accepted to participate
(75.1% acceptance rate)
CD at T1
(T-score ≥ 70)
n = 238
(131 boys, 107 girls)
At-risk for CD at T1
but CD later still
prior age 10
(T-score ≥ 70)
n = 39
(27 boys, 12 girls
No CD
(T-score < 70)
n = 93
(63 boys, 30 girls
Non-referred
Aged 6 to 9 years old
881 children screened with
multi-gated screening procedure
randomly selected among
those without CD
CD at T1
(T-score ≥ 70)
n = 45
(17 boys, 28 girls)
At-risk for CD at T1
n = 50
(23 boys, 27 girls)
No CD at T1
(T score < 65)
n = 279
(135 boys, 144
girls)
At-risk for CD at T1
but CD later still
prior age 10
(T-score ≥ 70)
n = 6
(3 boys, 3 girls)
At-risk for CD at T1
but no CD later
(T-score < 70)
n = 44
(20 boys, 24 girls)
CD later still
prior age 10
(T-score ≥ 70)
n = 5
(4 boys, 1 girl)
No CD later
(T-score < 70)
n = 274
(131 boys, 143
girls)