



Head injury secondary to suspected child maltreatment: Results of a prospective Canadian national surveillance program[☆]

Susan Bennett^{a,b,*}, Michelle Ward^b, Katherine Moreau^c, Gilles Fortin^d, Jim King^b, Morag MacKay^e, Amy Plint^b

^a Department of Psychiatry, Children's Hospital of Eastern Ontario, University of Ottawa, ON, Canada K1H 8L1

^b Department of Pediatrics, Children's Hospital of Eastern Ontario, University of Ottawa, Ottawa, ON, Canada K1H 8L1

^c Clinical Research Unit, Children's Hospital of Eastern Ontario Research Institute, Ottawa, ON, Canada K1H 8L1

^d Department of Pediatric Neurology, Université de Montréal, Montreal, QC, Canada H3C 3J7

^e European Child Safety Alliance, Birmingham B15 1RP, UK

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ABSTRACT

Objective: We sought to determine the incidence, clinical features, and demographic profile of head injury secondary to suspected child maltreatment (abuse or neglect) in Canada to help inform the development and evaluation of prevention programs for abusive head injuries.

Methods: From March 1, 2005 to February 28, 2008, an average of 2,545 paediatricians and paediatric subspecialists were surveyed monthly through the established network of the Canadian Paediatric Surveillance Program. We calculated incidence rates using the number of confirmed cases over the product of the duration of the study (3 years) and population estimates by age group.

Results: There were 220 confirmed cases of head injury from suspected child maltreatment. The annual incidence rate was 14.1 per 100,000 for children less than 1 year of age and 1.4 per 100,000 for those less than 15 years. Seventy three percent (141) of cases involved infants less than 12 months of age and 52% (100) of cases involved infants less than 6 months of age. Seventy-five percent (165) of cases presented to the emergency room. With regard to outcome, 12% (27) of cases resulted in death and 45% (75) of survivors had neurological sequelae at discharge. Thirty percent (67) of all cases, as well as 30% (8) of deaths were previously known to child welfare authorities.

Conclusion: This study provides an estimate of the rate of head injury secondary to suspected child maltreatment in Canada. The young age and poor medical outcomes of those involved highlights the need for prevention efforts that are implemented early in life. Given that a significant percentage of injured infants and children were already known to child welfare authorities, the study also highlights the need to establish and evaluate additional preventive efforts for parents and caregivers already in the child welfare system.

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Introduction

Although head injury is the most common cause of death from physical abuse among children less than 1 year of age (Reece & Sege, 2000), the measurement of head injury from child maltreatment is challenging (Barr & Runyan, 2008). Many

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* Corresponding author address: Children's Hospital of Eastern Ontario, 401 Smyth Rd., Ottawa, ON, Canada K1H 8L1.

of these difficulties are attributable to: (a) missed diagnoses as symptoms may be non-specific (Jenny, Hymel, Ritzen, Reinert, & Hay, 1999), (b) the underreporting of cases by professionals (Flaherty et al., 2008), (c) infrequent confessions because of the social and legal implications, (d) victims who are too young to disclose what occurred, and (e) a lack of witnesses to the abuse. Additionally, research efforts are complicated by variations in definitions and terminology for the clinical entity of abusive head injury (e.g., inflicted head injury, non-accidental head injury, intentional childhood neurotrauma, inflicted traumatic brain injury, shaken baby syndrome, shaken impact syndrome) (Reece & Nicholson, 2003).

Although information on the nature and scope of abusive head injuries is crucial for the development and evaluation of prevention programs (Barr, Rivara, et al., 2009; Dias et al., 2005; Goulet et al., 2009; Tolliday et al., 2010) there have only been two attempts to quantify the extent of abusive head injury in Canada. One study was hospital based, retrospective and examined only shaken baby syndrome (SBS) (King, MacKay, & Sirnick, 2003) and the other was limited to cases where the determination of physical harm was made by child welfare workers in a study that was not focused primarily on medical injuries (Public Health Agency of Canada, 2010). The purpose of the current study was to determine the incidence, clinical features, and demographic profile of head injury secondary to suspected child maltreatment (abuse or neglect) through the Canadian Paediatric Surveillance Program (CPSP; www.cps.ca/cpsp) which is part of the International Network of Paediatric Surveillance Units (INoPSU; www.inopsu.com).

Methods

Study design

From March 1, 2005 to February 28, 2008, a monthly average of 2,545 paediatricians and paediatric subspecialists were surveyed through the CPSP. The CPSP is a national prospective surveillance network established in 1996 and is a joint project between the Canadian Paediatric Society (CPS) and the Public Health Agency of Canada. Approximately 90% of Canadian active practicing paediatricians and paediatric sub specialists (e.g., emergentologists, intensivists, neurologists, coroners) who may or may not be CPS members participate monthly on a voluntary basis in the network. For this study, all participating physicians received a summary of the study protocol and the case definition for a head injury secondary to suspected child maltreatment. The CPSP data collection process involved two-tiered reporting. Participating physicians were first mailed a monthly check-off form asking if they had seen any new cases of head injuries secondary to suspected child maltreatment in the previous month. If a participating physician sent a positive response, they were then mailed a detailed questionnaire to confirm that case criteria were met and to obtain demographic and clinical details of the case. To maximize response rates, the CPSP sent quarterly reminders to non-responders. The detailed reporting form included both open and closed-ended questions about the infant or child's age, household, initial presentation, past medical history, clinical investigations, injuries, and type of suspected abuse or neglect. Confidentiality was maintained by using non-nominal information. The Research Ethics Board at the Children's Hospital of Eastern Ontario approved the study.

Eligibility criteria

Children were eligible for the study if they were 14 years of age or younger, sustained a head or brain injury consistent with suspected child maltreatment and the injury was reported to a provincial or territorial child welfare agency. There are mandatory reporting laws for suspected child maltreatment in all of the 13 Canadian provinces and territories. A head or brain injury required either objective diagnostic evidence (i.e., radiologic, ophthalmologic, or forensic findings such as skull fracture, cerebral contusion, subdural or epidural or subarachnoid hemorrhage, cerebral edema, or retinal hemorrhages) or clinical evidence of a significant head or brain injury (i.e., severe head soft tissue injury, depressed level of consciousness, seizures, or focal neurological findings). Case ascertainment was monitored and verified by personnel from the CPSP who investigated potential duplicate reports (i.e., cases with identical dates of birth and gender) and ensured that cases met eligibility criteria. If participating physicians had any questions about eligibility criteria or the completion of the detailed questionnaire they were able to contact the CPSP office who then, if necessary, forwarded their questions to the study investigator for clarification. Lastly, if a participating physician sent a positive response on the monthly check-off form but did not return the detailed questionnaire, the case was excluded for the study and assumed to be ineligible. If physicians completed the detailed questionnaire and the case criteria were met, the case was considered a confirmed case of head injury secondary to suspected child maltreatment ("confirmed case").

Statistical analysis

Descriptive results are presented as frequencies and percentages or medians and minimum to maximum values. The annual Canadian incidence rate overall and for each age group (<1, 1–2 years, >2–4 years, >4) is computed as the number of confirmed cases divided by the product of the duration of the study (3 years) and the estimated population in that age group obtained from Statistics Canada's socio-economic database (Canadian Socio-economic Information Management System, 2003). Poisson-based 95% confidence intervals for the incidence rates are also computed.

Table 1

Number and status of reported cases by year.

Year	Status			
	Reported	Duplicate	Excluded	Confirmed
2005 ^a	111	30	18	63
2006	112	39	15	58
2007	149	19	38	92
2008 ^b	22	4	11	7
Total	394	92	82	220

^a From March 1 to December 31, 2005.^b From January 1 to February 28, 2008.**Table 2**Incidence of head injury in Canada from March 1, 2005 to February 28, 2008 by age group ($n = 193$).

	Age group, yr			
	<1	1–2	>2–4	>4
Total number of confirmed cases	141	33	17	2
Estimates of population 2006 (thousands) ^a	332.2	339.5	684.5	3927.2
Annual incidence rate per 100,000	14.1	3.2	0.82	0.02
95% confidence intervals	11.8–16.5	2.2–4.6	0.5–1.3	0–0.06

^a The 2006 population estimates from Statistics Canada (CANSIM) were used, with 2006 representing the midpoint of the study.

Results

Identification of eligible children

From March 2005 to February 2008, CPSP received 394 initial case reports of head injury secondary to suspected child maltreatment (see Table 1). Of these initial reports, 220 met the criteria for inclusion. Fifty-one cases were excluded because they did not meet the study eligibility criteria. Thirty-one cases were reported by participating physicians on the monthly check-off form but a detailed questionnaire was not completed and thus, these cases were also excluded. The overall response rate to the monthly case identification form was 80% whereas the response rate for the detailed study questionnaire was 92%.

Incidence of head injury from suspected child maltreatment

Age at initial presentation was available for 193 of the 220 confirmed cases. Of these, 52% ($n = 100$) involved infants less than 6 months of age, 73% ($n = 141$) involved infants less than 12 months of age, and only 1% ($n = 2$) involved children over 4 years of age. The median age at initial presentation was 5 months (min-max 1 week–10.5 years). Fifty-nine percentage ($n = 128$) of the cases were male. The overall annual incidence for head injury from suspected child maltreatment for infants and children 14 years of age and younger was 1.4 per 100,000 (95% CI 1.2–1.6) with a higher incidence observed in the youngest age group (see Table 2).

Demographic and clinical characteristics of confirmed cases

Of the 220 confirmed cases, 33% (72) were reported from Western provinces (BC, AB, SK, and MB), 60% (132) from Central Canada (ON and QC), and 7% (16) from Eastern and Northern Canada (NS, NB, NL and NT). Table 3 provides the demographic and clinical characteristics of the confirmed cases with available data, by specific age group.

In terms of initial presentation, 75% presented to the Emergency Department, 11% to their family doctor, and 6% to their paediatrician. Ninety-one percent of cases were admitted to hospital and 52% required ICU care. The median length of hospital stay was 10 days (min-max 1–392 days) and the median length of ICU stay was 3 days (min-max 1–35 days). Infants and children requiring intensive care treatment had a longer hospitalization, with an overall median length of admission of 21 days (min-max 1–392 days) as compared to infants and children not requiring intensive care treatment who had a median length of stay of 6 days (min-max 1–63 days; $p < 0.001$).

Clinical presentations, injuries, and outcomes

At presentation, the reported signs and symptoms varied from non specific to more serious presentations (see Table 4). Of the confirmed cases, there was one with soft tissue injuries at initial presentation however, the specific identifiable soft tissue injuries were not provided on the detailed questionnaire. As such, reported identifiable injuries were only available for 219 confirmed cases (see Table 5). More than 70% of cases had subdural hemorrhage(s) and 50% had retinal hemorrhage(s).

Table 3Demographic and clinical characteristics of the confirmed cases ($n = 220$), by age ($n = 193$) and by specific age group.^a

Characteristic ^b	Total no. (%) of confirmed cases $n = 217$	Total no. (%) of cases with known age $n = 190$	Age group, yr; no. (%) of cases			
			<1 $n = 140$	1–2 $n = 31$	>2–4 $n = 17$	>4 $n = 2$
Gender						
Male	128(59)	116(61)	89(64)	19(61)	7(41)	1(50)
	$n = 82$	$n = 72$	$n = 52$	$n = 9$	$n = 11$	$n = 0$
Past medical problems						
Prematurity	18(22)	15(21)	13(25)	2(22)	0	0
Excessive crying	18(22)	16(22)	13(25)	3(33)	0	0
Developmental delay	13(16)	11(15)	3(6)	2(22)	6(55)	0
Previous maltreatment	12(15)	11(15)	8(15)	2(22)	1(9)	0
Feeding difficulties	11(13)	9(13)	8(15)	0	1(9)	0
	$n = 220$	$n = 193$	$n = 141$	$n = 33$	$n = 17$	$n = 2$
Location of initial presentation						
Emergency department	165(75)	143(74)	98(70)	27(82)	16(94)	2(100)
Family physician	23(11)	21(11)	20(14)	1(3)	0	0
Paediatrician	14(6)	13(7)	12(9)	1(3)	0	0
Unidentified location	18(8)	16(8)	11(8)	4(12)	1(6)	0
Admitted to hospital						
Yes	200(91)	176(91)	129(91)	31(94)	15(88)	1(50)
No	16(7)	14(7)	11(8)	1(3)	1(6)	1(50)
Unknown	4(2)	3(2)	1(1)	1(3)	1(6)	0
Admitted to ICU						
Yes	115(52)	100(52)	64(45)	23(70)	12(71)	1(50)
No	98(45)	87(45)	72(51)	9(27)	5(29)	1(50)
Unknown	7(3)	6(3)	5(4)	1(3)	0	0
Previous child welfare investigation						
Yes	67(30)	59(30)	47(33)	8(24)	3(18)	1(50)
No	103(47)	92(48)	64(45)	19(58)	9(53)	0
Unknown	50(23)	42(22)	30(21)	6(18)	5(29)	1(50)

^a In 27 confirmed cases, age was not reported.^b Not all confirmed cases reported on all characteristics.**Table 4**Presenting signs and/or symptoms of confirmed cases at initial presentation ($n = 220$), by age ($n = 193$) and by specific age group.^a

Presenting signs or symptoms ^b	Total no. (%) of confirmed cases $n = 220$	Total no. (%) of cases with known age $n = 193$	Age group, yr; no. (%) of cases				p -Value ^c
			<1 $n = 141$	1–2 $n = 33$	>2–4 $n = 17$	>4 $n = 2$	
Decreased level of consciousness	78(36)	66(34)	38(27)	16(49)	11(65)	1(50)	0.002
Soft tissue injury	66(30)	57(30)	44(31)	6(18)	6(35)	1(50)	0.339
Seizure	63(29)	59(31)	41(29)	15(46)	3(18)	0	0.140
Lethargy	62(28)	57(30)	40(28)	11(33)	6(35)	0	0.803
Irritability	55(25)	51(26)	40(28)	9(27)	2(12)	0	0.478
Vomiting	53(24)	50(26)	35(25)	11(33)	3(18)	1(50)	0.432
Apnea	33(15)	29(15)	21(15)	5(15)	3(18)	0	0.956
Respiratory difficulty	30(14)	26(13)	16(11)	6(18)	4(24)	0	0.348

^a In 27 confirmed cases, age was not reported.^b Some confirmed cases reported more than one finding.^c p -Values not corrected for multiple testing. p -Values less than 0.05/8 = 0.006 may be considered statistically significant.

Of the 220 confirmed cases, 12% (27) resulted in death and data was not reported for 12% (27). For the remaining 166 infants and children, the medical status at time of discharge was reported by physicians as normal in 55% (91) and with neurological sequelae in 45% (75). Of the cases with neurological sequelae, 32% (24) were considered mild, 27% (20) were moderate, 27% (20) were severe, and the severity was unknown for 15% (11). Thirty percent (67) of all cases had been previously investigated by child welfare authorities, as well as 30% (8) of the deaths.

The social status at the time of discharge was provided for 81% (179). Of these, 46% (83) were placed in foster care, 40% (71) were in the care of family, and other arrangements were made in 14% (25). There was no significant relationship between social status at discharge and any specific injury, classification of abuse, or medical outcome.

Table 5Identifiable injuries of confirmed cases ($n = 219$), by age ($n = 193$) and by specific age group.^a

Injuries ^b	Total no. (%) of confirmed cases	Total no. (%) of cases with known age	Age group, yr; no. (%) of cases				<i>p</i> -Value ^c
			<1 <i>n</i> = 141	1–2 <i>n</i> = 33	>2–4 <i>n</i> = 17	>4 <i>n</i> = 1	
Intracranial injuries	<i>n</i> = 219	<i>n</i> = 192					
Subdural hematoma	156(71)	137(71)	98(70)	26(79)	12(71)	1 (100)	0.596
Cerebral edema	58(26)	52(27)	29(20)	13(39)	9(53)	1 (100)	0.004
Cerebral contusion	43(20)	40(21)	26(18)	9(27)	5(29)	0	0.462
Subarachnoid hematoma	37(17)	32(17)	23(16)	8(24)	1(6)	0	0.404
Epidural hematoma	16(7)	12(6)	10(7)	1(3)	1(6)	0	0.893
Other head and neck injuries							
Retinal hemorrhage	111(51)	96(50)	69(49)	18(55)	9(53)	0	0.627
Skull fracture(s)	80(37)	73(38)	59(42)	11(33)	3(18)	0	0.148
Cervical spine injury	1(0.5)	1(0.5)	0	1(3)	0	0	0.269
Fractures							
Long bone(s)	35(16)	30(16)	24(17)	2(6)	4(24)	0	0.264
Rib(s)	31(14)	27(14)	24(17)	3(9)	0	0	0.200
Other	22(10)	21(11)	15(11)	1(3)	5(29)	0	0.050
Skin injuries							
Abrasion(s)	24(11)	23(12)	7(5)	8(24)	7(41)	1 (100)	<0.001
Bruising	86(39)	71(37)	47(33)	16(48)	7(41)	1 (100)	0.331
Burn(s)	9(4)	8(4)	1(0.7)	1(3)	5(29)	1 (100)	<0.001

^a In 27 confirmed cases, age was not reported.^b Some confirmed cases reported more than one injury.^c *p*-Values not corrected for multiple testing. *p*-Values less than 0.05/14 = 0.004 may be considered statistically significant.

Classification of head injury from suspected child maltreatment

Reporting physicians classified confirmed cases of head injury secondary to suspected child maltreatment as SBS, other physical abuse, or neglect and many chose more than 1 category. Shaken baby syndrome was suspected for 64% (140) of infants and children and was the sole diagnosis for 46 (102). Other physical abuse was suspected for 49% (108) and was the sole diagnosis for 31% (69). Neglect was suspected in 7% (16) of cases and was the sole diagnosis in 9 (5%).

Interpretation

This study reports prospective national estimates on the incidence of cases defined as head injury secondary to child maltreatment in Canada over a 3 year period. While previous prospective population-based studies have been conducted to describe the incidence of abusive head injury (e.g., through the International Network of Paediatric Surveillance Units), case ascertainment processes as well as case definitions used have differed and included: subdural hemorrhages, haematomas or effusion (Hobbs, Childs, Wynne, & Livingston, 2005), subdural hematoma (Kelly & Farrant, 2008), shaken baby syndrome (Fanconi & Lips, 2010), abusive brain injury and subdural hematoma (Sibert et al., 2002), severe inflicted traumatic brain injury (Keenan et al., 2003), and shaken impact syndrome (Barlow & Minns, 2000). As a consequence, these studies are not directly comparable to ours.

Our results however, are consistent with the previously published Canadian (King et al., 2003) and international (Barlow & Minns, 2000; Fanconi & Lips, 2010; Hobbs et al., 2005; Keenan et al., 2003; Kelly & Farrant, 2008; Sibert et al., 2002) findings on abusive head injury in terms of the victims' ages, gender and substantial injuries with poor medical outcomes. Similar to these reports, our study suggests that very young children, particularly those in the first 6 months of life, are vulnerable to abusive head injury, that there is a slight preponderance of male victims, and that most cases present with substantial injuries including subdural hematomas, retinal hemorrhages, fractures, and bruises.

Given the non-specific presentation of cases found in our study as well as others (Hobbs et al., 2005; King et al., 2003), more education of health and child welfare professionals is needed to ensure the early identification of head injuries. Also, since many of the victims, in both our study and King et al. (2003), had previous involvement with child welfare authorities there is growing evidence to support the further establishment and evaluation of prevention programs for children already involved with the child welfare system.

Finally, given the annual incidence of 14.1 per 100,000 for children less than 1 year, it is clear that prevention efforts must be targeted at parents and caregivers during pregnancy or early in infants' lives. A study by Barr, Trent, and Cross (2006) indicates that crying is an important stimulus for a caregiver to shake a baby out of frustration and as such, programs that help parents cope with infant crying are an important part of abusive head injury prevention efforts. To date, several of these prevention initiatives have been established throughout the world. For instance, Dias et al. (2005) implemented a program in western New York nurseries that included a brief video and written materials to teach new parents about violent infant-shaking and alternatives to use when their infants cried. During the first 5 years of their program, Dias and

colleagues found that the incidence of abusive head injuries decreased by 47%. Furthermore, a program developed by Barr, Barr, et al. (2009) entitled, the *Period of PURPLE Crying Program* (www.dontshake.org), that also uses a brief video and written material to educate new parents about normal crying and how to cope with an infant's crying, has shown to improve mothers' knowledge about crying and their attitudes and responses to it. Similarly, Goulet et al. (2009) demonstrated that the Perinatal Shaken Baby Syndrome Prevention Program in Quebec, Canada has increased parents' knowledge about infant crying and provided parents with anger management skills and personal coping strategies for infant crying. Finally, a shaken baby prevention project in Western Sydney, Australia (Tolliday et al., 2010), has shown to increase parent as well as professionals' knowledge of the negative impact of shaking a baby. Given the early successes of these initiatives, it is hoped that the creation of additional prevention programs and strategies will help to reduce the incidence of abusive head injury.

Our study has several limitations. In particular, our method of sampling relied on voluntary reporting by paediatricians and paediatric subspecialists participating in the CPSP and as such, the cases reported may underestimate the actual incidence. For example, some cases of abusive head injury may have been reported to local child welfare and child protection authorities but not to CPSP, whereas others may have been missed because the victims died before reaching the healthcare system. Moreover, although 27 children died in our study and 75 had neurological sequelae at time of discharge, it is important to note that neurological findings at discharge may not reflect the long term consequences of abusive head injury since delayed morbidity and long term disabilities are common (Barlow, Thomson, Johnson, & Minns, 2005).

Furthermore, physicians made their own assessments as to whether a case was suspected to be secondary to maltreatment and because no guidelines on what constitutes or differentiates SBS, other physical abuse, or neglect exist or were given for the purposes of this study, there were many cases where participating physicians selected multiple classifications. This variability in classification of SBS, other physical abuse, or neglect even with the same constellation of injuries suggests that there is still uncertainty with diagnosis and perhaps with recognition of injury. This may have also contributed to the variability in participants' response for the diagnostic categories. Increasingly, the term "Shaken Baby Syndrome" is being avoided as it can be considered to have emotive connotations, and more importantly, does not adequately describe the range of mechanisms for head injuries. Finally, although cases of suspected maltreatment needed to be reported to a provincial or territorial child welfare agency, the accuracy of data reported was not standardized or verifiable by child welfare authorities or chart reviews.

Conclusion

In conclusion, this study estimates the incidence of abusive head injury secondary to suspected child maltreatment using national prospective surveillance in Canada. It also highlights the nonspecific presentation with substantial injuries and the associated poor medical outcomes. Given that the majority of cases presented at less than 1 year of age to emergency departments and that a significant percentage were reportedly already known to child welfare authorities, our study suggests the need for multi pronged prevention efforts. These initiatives should include targeted prevention efforts for parents and caregivers of very young children as well as education for health and child welfare professionals to facilitate early identification of child abuse in general, and abusive head injury in particular. It is also important to establish and evaluate additional preventive efforts for children already in the child welfare system.

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