

Original Article

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Lethal abusive head trauma in infancy in Denmark from 2000 to 2011

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ABSTRACT

INTRODUCTION: We aimed to estimate the incidence of lethal abusive head trauma (AHT) in infancy in Denmark from 2000 through 2011 and to describe autopsy findings and information from police reports on lethal AHT cases.

METHODS: This was a nationwide retrospective study. We identified AHT cases in the National Cause of Death Register (CODR) and in forensic archives and compared data from the two sources. Moreover, we collected data on medical history, witness statements and conviction reports from police files and the Director of Public Prosecutions.

RESULTS: We identified eight cases of lethal infant AHT (incidence: 1.04 per 100,000 person years). Three AHT cases from autopsy reports were not registered correctly in the CODR. The median age of the victims was 46.5 days. They all had recent subdural and/or subarachnoid haemorrhage. We also found a high prevalence of retinal haemorrhage and fractures. Seven perpetrators were identified, all male relatives, and all were convicted. We moreover identified a surprisingly large number of infants with unspecific cause of death and missing information on whether an autopsy had been performed in the CODR (n = 56).

CONCLUSIONS: The incidence of lethal infant AHT found in this study is lower than findings from most other countries. Data from the CODR are inadequate for identifying all lethal AHTs. Further studies including non-fatal cases of AHT are needed to determine the real incidence of AHT in Denmark.

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Abusive head trauma (AHT) is among the causes of traumatic death in infancy. The mechanism of the trauma is by blunt impact, shaking (shaken baby syndrome (SBS)) or both (shaken impact syndrome (SIS)) [1]. SBS was previously considered a well-defined form of child abuse. However, since 2009, AHT is the preferred term to describe deliberately inflicted head traumas in children, as SBS suggests an interpretation of certain findings [2-4].

Approximately 80% of AHT cases occur in infancy [5-7], with a median age at diagnosis of two to six months [6, 8-11]. Among infants, the incidence ranges from 13 to 56 cases per 100,000 person years [6, 8, 10-13]. The mortality rate of AHT among hospitalised cases varies between 15% and 38% [6, 11, 14, 15]. A Swedish study reported a surprisingly low incidence of 0.4 per 100,000 persons years for fatal AHT [16]; data for Denmark are lacking.

We aimed to estimate the incidence of lethal AHT in infancy in Denmark from 2000 through 2011 and to describe autopsy findings and information from police files for lethal AHT cases.

METHODS

This was a nationwide retrospective study using data from the following sources:

The National Cause of Death Register

The National Cause of Death Register (CODR) includes data from all death certificates in Denmark as from 1970. A physician submits the death certificate to the Danish Health Authority.

The death certificate includes personal information, a personal identification number, time and place of death, the presumed manner of death (natural, suicide, assault, homicide, accident, unknown) and the cause of death (COD) and contributing COD according to the International Classification of Diseases, tenth revision (ICD-10).

We obtained data on all children who died 1-365 days old during the period from 01 January 2000 to 31 December 2011 and were registered with:

1. COD and/or contributing COD unknown/missing or one of the ICD-10 codes listed in **Table 1**.
2. Manner of death unknown/missing, assault, homicide or accident.

TABLE 1 List of International Classification of Diseases, tenth edition, diagnoses registered as cause of death (COD) or contributing COD in the National Cause of Death Register used to identify abusive head trauma cases.

Description	Codes
Intracranial haemorrhage, non-traumatic	I60-I62
Stroke, not specified as haemorrhage or infarction	I64
Sequelae of cerebrovascular disease	I69
Symptoms and abnormal findings, not elsewhere classified	R00-R99
Injuries to the head	S01, S02, S06, S07, S09
Injuries involving multiple body regions	T00-T07
Maltreatment syndromes	T74
Accidental injury	V01-X59
Assault	X85-Y09
Event of undetermined intent, complication of medical/surgical care and sequelae of external causes of morbidity and mortality	Y10-Y89

Medico-legal autopsy reports

The Police and a Medical Officer of Health conduct a medico-legal examination in case of suspected criminal acts, accidents, suicides, persons found dead, or sudden and unexpected deaths. The procedure includes an examination of the body, investigation of the death scene, review of hospital records and interviews with relatives and witnesses.

If the medico-legal examination raises suspicion of a criminal act or fails to establish the manner or the COD, and the police finds it warranted, a forensic autopsy is performed by one of the three Danish Departments of Forensic Medicine. After the autopsy, the Medical Officer of Health revises the death certificate accordingly. Forensic autopsies of infants include a whole-body X-ray, a CT, a total examination of the body, the organs,

histological examination of the organs and the brain, and, depending on the case, forensic chemistry.

AF and LF assessed the archives of the three Departments of Forensic Medicine, read all reports on infants, and identified infant deaths meeting the following criteria:

1. Head trauma
2. Age: 0-365 days
3. Died between 1 January 2000 and 31 December 2011.

We identified AHT cases based on the conclusion of the autopsy of inflicted head trauma. We excluded cases if the report raised suspicion of inflicted head trauma but was inconclusive. Using the personal identification number that is given to all persons born or living in Denmark, we linked cases to the CODR.

Police reports

The Director of Public Prosecutions was contacted by AF with a request for:

All homicide convictions for child abuse

Age of the child 0-365 days

Committed between 1 January 2000 and 31 December 2011.

AF moreover contacted the local police departments in the districts where the infants had died (information retrieved from the CODR), reviewed material from the police files and collected information on medical history, witness statements and conviction reports.

Trial registration: not relevant.

RESULTS

The National Cause of Death Register

A summary of the data retrieved from the CODR is presented in **Table 2**. We identified five infants who had died by AHT. The number of live births in Denmark during the same period was 768,468 [17]. Thus, the prevalence of lethal AHT was 0.6 per 100,000 live births and the approximated incidence was 0.6 per 100,000 person years.

TABLE 2 Data from the National Cause of Death Register on infant deaths in Denmark in 2000-2011 meeting our search criteria.

	Manner of death	Infants, n	Autopsy, n				
			forensic	hospital ^a	no	prohibited	no data
<i>Unspecified cause of death</i>							
Sudden infant death syndrome	Natural death	113	91	4	12	4	2
Found dead	Natural death	1	1	0	0	0	0
Instantaneous death	Natural death	1	1	0	0	0	0
Other ill-defined and unspecified causes of mortality:							
Age ≤ 24 h	Natural death	258	0	0	0	0	258
	Unknown	5	0	0	0	0	5
Age > 24 h	Natural death	52	1	0	0	0	51 ^b
	Unknown	5	0	0	0	0	5
Accidental suffocation and strangulation in bed	Accident	8	7	0	1	0	0
Subtotal	-	443	101	4	13	4	321
<i>Specific cause of death</i>							
Assault or maltreatment	Assault/homicide	5	5 ^b	0	0	0	0
Strangulation, suffocation, hanging	Assault/homicide	3	2	0	0	0	1
Rifle, shotgun and larger firearm discharge	Assault/homicide	1	1	0	0	0	0
Drowning or submersion	Assault/homicide	1	1	0	0	0	0
	Accident	2	2	0	0	0	0
	Unknown	1	1	0	0	0	0
Traffic accidents	Accident	16	1	0	14	1	0
Suffocation of food or other objects	Accident	10	10	0	0	0	0
Fall while being carried or supported by other persons	Accident	1	1 ^b	0	0	0	0
Other non-traffic accidents	Accident	8	4	1	3	0	0
Perinatal, neonatal, congenital, and acquired medical conditions and malformations	Natural death	52	9	17	14	11	1
Exposure to fire at home	Unknown	1	1	0	0	0	0
Subtotal	-	101	38	18	31	12	2

AHT = abusive head trauma.

a) An autopsy performed by a hospital pathologist after consent from the relatives, usually includes less thorough external examination than a forensic autopsy.

b) The 7 AHT cases who could be traced in the National Cause Of Death Register: 6 with registered forensic autopsy and 1 out of 51 without data on autopsy status.

Medico-legal autopsy reports

We reviewed forensic reports and identified eight AHT cases. This produced an estimated incidence of 1.04 per 100,000 person years. The median age was 46.5 days and five of the cases were boys. Six died in a hospital, one died at home and one was a newborn who was found dead. The autopsy findings in the AHT cases are presented in **Table 3**.

TABLE 3 Reported lesions and autopsy findings among eight cases of infant abusive head trauma deaths in Denmark in 2000-2011.

Reported lesions and autopsy findings	Case no.								Total, N
	1	2	3	4	5	6	7	8	
<i>Data from the police files</i>									
Older lesions reported (age of lesion) ^a	Bruises on posterior trunk (5 wks)	-	-	-	-	-	Bruise on cheek (1 wk)	-	2
Pre- and perinatal conditions	Small cerebral haemorrhage Low-grade asphyxia	-	-	-	-	-	-	-	1
Malformations	-	-	-	-	-	-	-	-	0
Disease reported	-	Acute bronchitis	-	-	Diarrhoea	Otitis media	-	-	3
<i>Data from the autopsy reports</i>									
Signs of disease	Chronic meningitis Cerebral atrophy ^b	Acute bronchitis	-	Aspiration pneumonia during resuscitation process	-	Pneumonia	-	-	4
Signs of older lesions > 1 wk (age of lesion)	-	Rib fractures (1-2 wks) Brain lesions (2-3 wks)	-	Diffuse microgliosis Traumatic cataract	-	-	Subarachnoid haemorrhage (10 days)	-	5
Cerebral oedema	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	7
Incarceration	Yes	Yes	-	-	Yes	-	Yes	-	4
Subdural haemorrhage	Yes	Yes	Yes	Yes	Yes	-	Yes	-	6
Subarachnoid haemorrhage (age of lesion)	Yes	Yes	Yes	Yes	Yes (> 3 days)	Yes	Yes (fresh and 10 days)	Yes	8
Cerebral contusion	Yes	Yes	-	-	-	Yes	Yes	Yes	5
Other cerebral lesions	-	-	Diffuse axonal damage	-	-	-	-	-	1
Retinal haemorrhage	Yes	Yes	Yes	Yes	-	Yes	Yes	-	6
Optical nerve haemorrhage	Yes	Yes	-	Yes	Yes	Yes	Yes	-	6
Skin or/and muscle lesions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Skull fracture	Yes	-	Yes	-	-	Yes	-	Yes	4
Rib fracture (age of lesion)	Yes	Yes (fresh and 1-2 wks)	-	-	-	Yes	-	-	3
Long-bone fracture	-	-	-	-	Yes	-	-	-	1

a) Reported by the caregiver or described in the medical file.

b) Concluded not contributing cause of death.

Police files

Our correspondence with the Director of Public Prosecutions and the local police departments revealed no further cases meeting our search criteria.

The local police departments supplied information on previous medical history (Table 3) and the perpetrator's relation to the AHT victims in seven cases (father in six cases and stepfather in one). The identity of the newborn and the perpetrator remains unknown. Seven victims had findings, records or other report of previous lesions. According to the police files, the sum of evidence led to conviction in the seven cases in which the perpetrator was identified.

Comparison of data from the National Cause of Death Register with data from autopsy reports

We provide an overview of the eight AHT cases in Table 4.

TABLE 4 Cases of abusive head trauma in Denmark in 2000-2011 identified in the National Cause of Death Register and/or in autopsy records.

Case no.	Manner of death	Cause of death ^a	Contributing causes of death ^a	Registration of autopsy in the CODR	Autopsy findings	Autopsy conclusion	Conviction
<i>Cases identified in the CODR</i>							
1	Assault/ violence	Y090 Assault by unspecified means home	S062 Diffuse traumatic brain injury	Yes, forensic	SDH SAH Cranial fracture Retinal haemorrhage	Shaken baby impact syndrome	Yes
2	Assault/ violence	Y08 Assault by other specified means	S065 Traumatic subdural haemorrhage	Yes, forensic	SDH Retinal haemorrhage	SBS	Yes
3	Assault/ violence	Y04 Assault by bodily force	S071 Crushing injury of skull	Yes, forensic	SDH SAH Cranial fracture Retinal haemorrhage	Inflicted head trauma: blunt force	Yes
4	Assault/ violence	Y071 Other maltreatment by parent	S065 Traumatic subdural haemorrhage	Yes, forensic	SDH SAH Retinal haemorrhage	SBS/impact syndrome	Yes
5	Assault/ violence	Y071 Other maltreatment by parent	G936 Cerebral oedema Yes S065 Traumatic subdural haemorrhage	Yes, forensic	SDH SAH	Battered child/shaken baby impact syndrome	Yes
<i>Cases identified in the autopsy reports</i>							
6	Accident	W04 Fall while being carried or supported by other persons	S062 Diffuse traumatic brain injury	Yes, forensic	SAH Cranial fracture Retinal haemorrhage	Battered child syndrome	Yes
7	Unknown	R990 Other ill-defined and unspecified causes of mortality		Unknown status	SDH Retinal haemorrhage	Inflicted head trauma Suspected SBS or impact	Yes
8	Not registered in the CODR ^b	-	-	-	SAH Cranial fracture	Head trauma: blunt force	-

CODR = National Cause of Death Register; SAH = subarachnoid haemorrhage; SBS = shaken baby syndrome; SDH = subdural haemorrhage.

a) According to the International Classification of Diseases, 10th edition.

b) Birth not registered and no personal identification number assigned.

The newborn AHT case could not be identified in the CODR because its birth was unreported and thus no personal identification number had been assigned. The remaining seven AHT cases are all included in our data from the CODR (Table 2). Five cases were registered correctly with assault/violence as manner of death, assault or maltreatment as COD, and head lesions as contributing COD. Two cases (no. 6 and 7) were coded incorrectly in the CODR, and both occurred before 2007 when online registration of the death certificates was implemented. Case 6 was registered with accident as manner of death, with *Fall while being carried or supported by other persons (W04)* as COD, and *Diffuse traumatic brain injury (S062)* as contributing COD. Correct information that a forensic autopsy had been performed was recorded in the CODR. The autopsy conclusion was AHT/battered child, but the COD was not revised in the CODR. Case 7 was registered with unknown manner of death and *Other ill-defined and unspecified causes of mortality (R990)* as COD. Information on whether an autopsy had been performed was missing in the CODR. A forensic autopsy was performed, revealing older and recent lesions in the head, skin, muscles and eyes (Table 3). The autopsy conclusion was SBS/SIS, but COD was not revised in the CODR for this case either.

DISCUSSION

By combining data from the two data sources, we identified eight cases of lethal AHT in Denmark from 1 January 2000 to 31 December 2011 (incidence: 1.04 per 100,000 person years). This is comparable to findings from Sweden, a country with a similar population and healthcare organisation [16] and significantly lower than estimates from other Western countries (6-7 per 100,000 persons years in the US).

The lower than expected incidence of fatal AHT may reflect the generally low violence and homicide rates in Scandinavia compared with most other Western countries: the annual homicide rate during the study period was 0.8-1:100,000 inhabitants in Denmark and 4.8 -5.7:100,000 in the USA [18]. Alternative explanations are highly hypothetical and may include exposure to milder forms of violence, earlier suspicion and reference of the

infants, easier and cost-free access to healthcare and support for the families of infants who are at risk of maltreatment.

Another possible explanation for the low incidence of lethal AHT in infancy found in Denmark may be missed cases (false negatives) despite the high standards of the healthcare system and the registers. A surprisingly large number of deaths in infancy beyond the first day of life were registered with an unspecific COD in the CODR (n = 59). For many of these cases, information on whether an autopsy had been performed was also missing (n = 56). One of the AHT cases identified in the autopsy reports was incorrectly registered in the CODR as a natural death with *Other ill-defined and unspecified causes of mortality (R990)* as COD. We cannot exclude that more AHT cases may exist among infants with unspecific causes of death where no forensic autopsy was performed. We have no data to confirm if a medico-legal examination was performed or if the police was contacted, but we expect that all infants who died outside the hospital setting were examined by a Medical Officer of Health as established by law. The decision to do a forensic autopsy is made in conjunction with the police and may thus be influenced by the police perspective. Infants admitted to hospital prior to death are not routinely examined by a Medical Officer of Health. AHT may present with unspecific symptoms mimicking severe infections, congenital diseases or inborn errors of metabolism. Misdiagnosed AHT cases may consequently not be investigated further unless the parents consent to a hospital autopsy. In a series of 546 infants who died suddenly and unexpectedly, post-mortem investigations identified 20 deaths by non-accidental trauma, predominantly head trauma [19]. In Sweden, a significantly larger proportion of infant deaths by *Sudden infant death syndrome* or undetermined COD was investigated by post-mortem examination during the same period [16], raising concerns about the procedures followed in Denmark.

We feel reassured that the risk of false positives among our eight cases is low, as the investigation was thorough and produced a conviction. We included cases in which the forensic investigation concluded that head trauma had been inflicted irrespective of the term used (AHT, SBS, SIS), as terms and criteria have changed significantly during the study period. We provide the precise forensic conclusion and detailed descriptions of the autopsy findings for transparency reasons and for easier comparison across time and countries. Optimally, the diagnosis of AHT should be established when findings are unequivocally consistent with abuse. The application of less strict criteria for diagnosing AHT, by e.g. the combination of subdural haemorrhage (SDH) and RH alone, may lead to misdiagnosis of accidental traumas as inflicted traumas, and might have led to an overestimation of the AHT incidence in some studies.

The median age of the lethal AHT cases in our study was 46.5 days. Most foreign studies have included both lethal and non-lethal cases and report older ages of the victims [5, 6, 8-11]. The predominance of boys among AHT victims is in accordance with most studies [6, 8, 10, 12]. All AHT victims had SDH and/or subarachnoid haemorrhage, whereas the prevalence of fractures and retinal haemorrhage was higher than reported in previous studies [2-4, 20]. The high prevalence of severe injuries may reflect that we only included fatal AHT cases. Six out of eight AHT cases had findings or reports of previous lesions. In a study from the US, 31.2% of AHT cases had been seen by physicians after the maltreatment, and the AHT diagnosis was missed [15].

In all AHT cases in which a perpetrator could be identified, it was a male relative of the child. A study of hospitalised AHT cases found a perpetrator male/female ratio of 50%. Victims of the male perpetrators had more serious acute presentations and all fatalities were committed by male perpetrators [11], as in our study.

Our comparison of data from the CODR with data from autopsy reports revealed that 38% of AHT cases identified from autopsy reports were not registered correctly in the CODR. Thus, the incidence of lethal infant AHT based exclusively on data from the CODR is underestimated.

The main strength of our study is the comparison of data from the CODR with autopsy reports. All forensic

autopsy reports concerning infants with head trauma during the study period were reviewed, assuring data completeness regarding infants who were autopsied. We can thus present a better estimate of the incidence than a data extraction from the CODR alone would have yielded. We further compared our findings with data from the police departments and the Director of Public Prosecutions and did not identify any additional AHT cases.

There are several limitations to our study. We limited the study group to lethal infant cases of AHT exclusively, resulting in a small number of identified cases. The total incidence of AHT, including fatal and non-fatal cases, may be more interesting for the clinician. To elucidate this, studies on non-fatal cases of AHT identified through the Danish National Patient Register, which includes all hospital admissions and discharge diagnoses, are warranted. Ideally, data from this register should be validated by using the medical files. The specific circumstances surrounding death may be under investigation at the time the death certificate is filed, but amendment of this information is expected once the autopsy results are known. In two of our cases, the information does not seem to have been revised. All cases from 2007 to 2011 are registered correctly in the CODR, which may suggest that online registration reduced errors.

Our results revealed an unexpectedly high number of infants with unexplained or unspecific COD. We assessed all autopsies that concluded head trauma as the COD; thus, we do not expect more AHT cases among the infants who have been autopsied. However, forensic autopsy is warranted for all unexplained infant deaths to avoid missing any AHT cases.

CONCLUSIONS

The incidence of lethal infant AHT found in this study is low compared with most other countries. Data were derived from the CODR and forensic autopsy reports and showed that the CODR was not sufficient for identifying all fatal AHT cases.

We recommend a forensic autopsy in the relatively large number of infants with unspecific COD found in the CODR to avoid missing any cases of AHT.

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