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**Editorial:**

**Turning point for death scene investigation in sudden unexpected child death**

Torleiv OLe Rognum

In the Scandinavian countries legal protection of human life has been recognized as the superior legal value. A nother important legal value is professional secrecy. During the last six years these values have been intensively debated in Norway. Subjects of controversy have been: Should medical doctors contact the police in cases where child maltreatment is suspected? Should the police investigate all cases of sudden, unexpected deaths in infants and small children? There is now a clear cut trend that more suspicious cases of child maltreatment are reported to the police, and on April 29, 2011, a law proposition instructing the police to investigate all sudden unexpected deaths in children up to 18 years, regardless whether the death is suspicious or not, passed the cabinet meeting.

On November 1, 2010, the voluntarily death scene investigation programme was launched. All families, in which an infant or small child dies suddenly and unexpectedly, are offered a death scene visit performed by a forensic pathologist and a police expert. This death scene investigation is voluntary and the parents have to sign an informed consent. The death scene visit is defined as a health service, but the visitors are not bound by professional secrecy. On the contrary suspicious findings are to be reported to the police. This mixture of health service and expert examination has been criticized. However, the new law proposal, in which the police is instructed to investigate all sudden deaths in children, may constitute a solution to the dilemma for the personell that perform the death scene investigations. The expert group that has been operative since November 1, may be re-defined from health servants to experts for the police. Such re-organisation would reduce the risk of sailing under false colours. Furthermore, the death scene visit may be made mandatory and not based on informed consent.

The research project performed in southeast Norway 2001-2004 (Rognum et al. Death scene investigation in sudden death in newborn, infants and small children. Scand J Forens Sci 2010; 16: 20-23) showed that 18 % of the sudden deaths in infants and toddlers were due to neglect, abuse and homicide/infanticide. have nothing to hide.

After 16 years with Norwegian headquarters it is due time to move the main editorial office to Denmark. From the next issue Professor Niels Lynnerup, The Panum Institute, Department of Forensic Medicine, is editor in chief. On behalf of editorial secretary Anne Gunn Wang, publisher Frank Holstad and myself, I want to thank all authors and reviewers who have contributed to Scand J Forens Sci throughout the years. We also thank the Danish editor Jørgen Lange Thomsen and the Swedish editor Håkan Sandler for constructive co-operation. The next Nordic conference on forensic medicine takes place in Århus in 2012. We are looking forward to increased Nordic co-operation, and hope that Scand J Forens Sci will play a role also in the future. From the next issue Professor Ingemar Thiblin, Department of Forensic Medicine, Uppsala, is new Swedish editor (see his editorial), and associate professor Arne Stray-Pedersen, Institute of Forensic Medicine, Oslo, is new Norwegian editor. The editorial board is aging and a new generation is about to take over. From Norway Arne Stray-Pedersen (37) represents a new generation of outstanding experts of forensic medicine. He has been active in forensic medicine since 2003, hemade his PhD on sudden infant death syndrome in 2008, and in 2011 he became associate professor at the institute in Oslo.
Forensic anthropology has been recognized as a specialty for a long time in many countries. Except the Nordic countries, where forensic anthropological expertise has resided only with a few people with a special interest, often people with a medical background, in the subject matter. This reflects the relatively small case load as the main topic of forensic anthropology is identification, and in the case of human remains such identification may nearly always be made by forensic odontologists. This is in turn due to the close personal registration which exists in the Nordic countries, so forensic anthropological analyses are really only necessary when the corpse is so degraded, e.g., after intense fire or explosions, that forensic anthropological analysis was used in conjunction with the investigations of the murder of the Swedish foreign secretary, Anna Lindh. If the specialty (and hence the police) in the other Nordic countries, is not to rely solely on the presence of a few especially interested persons, a wider Nordic cooperation should perhaps be established. The forensic anthropological unit in Copenhagen already has a centralized function for Denmark as pertains to identification of the living, and the unit participates in the education of medical candidates seeking specialization in forensic medical pathology. Our unit has had visiting researchers, including M Ds at other forensic institutions, from the Nordic countries. It would be conducive for securing the forensic anthropological specialty on a Nordic level in the short term, especially as concerns identification of the living, to refer such cases to our unit (as was the case with the Anna Lindh murder). In the long term, our unit can be used to sustain and develop continued education, including actual case-based teaching, and promote research and genuine transfer of knowledge in order to institute such capabilities in the other Nordic countries. Nordic cooperation is always beneficial, and in terms of anthropology this has already resulted in the publication of the first Nordic textbook on the specialty [1].

The Universal Age Distribution of the Sudden Infant Death Syndrome

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**SUMMARY**

The Sudden Infant Death Syndrome (SIDS) is a diagnosis of exclusion in the absence of finding any sufficient cause of death at autopsy and death scene investigation. The ages of SIDS have a 4-parameter lognormal (Johnson SB) distribution that is SIDS most unique and characteristic property, so any theory for the cause of SIDS must explain its apparent universality. The four parameters of this distribution appear to apply to all countries and have remained virtually constant during the period of redefinition of SIDS and change of preferred sleeping position from prone to supine in which the SIDS rate decreased dramatically. These data are shown to obey Cramér’s Theorem in that age distributions of male SIDS, female SIDS, and Sudden Unexpected Death in Infancy (SUDI) (defined here as ‘SIDS mentioned on death certificate as a possibility but other possible cause assigned’) have similar age distributions to SIDS where it is the only cause of death given on the certificate. The proposed universal SIDS age Normal Transform is \( y = \log\left(\frac{m - a}{b - m}\right) \), where \( y = \mu + \sigma z \), \( m \) is age in months, \( z \) is a standard normal deviate, and \( \mu = -1.05 \) and \( \sigma = 0.291 \) are median and standard deviation of \( y \). \( a = -0.31 \) month and \( b = 41.2 \) months are the 3rd and 4th parameters, respectively. For these fixed 3rd and 4th parameters the relative constancy of the mean and standard deviation of the SIDS and SUDI age distributions over many years implies that its parameters are both universal and independent of sleep position.

**Keywords:** SIDS, SUDI, 4-parameter lognormal, age distribution, sleep position, Johnson SB

**INTRODUCTION**

The sudden unexpected death of an infant or small child which remains unexplained after a thorough autopsy and death scene investigation has been known as Sudden Infant Death Syndrome (SIDS) since 1969 [1]. By convention, SIDS as an International Classification of Diseases (ICD) diagnosis (ICD9 798.0, ICD10 R95) has been arbitrarily restricted to ages less than one year. SIDS has a characteristic average male fraction of \(-0.61\) [2] and unique age distribution [3, 4]. "Any viable hypothesis for the cause of SIDS must account for its characteristic age distribution" [3]. This lognormal age distribution of SIDS that relatively spares infants during their first week of life is its most unique characteristic as virtually all other causes of infant death have maximal rates during that neonatal period [4]. The SIDS age distribution was originally shown by Raring [5] to appear to approximate a 2-parameter lognormal distribution which predicts that SIDS could occur at any age. Mage [6] showed that the age distribution of SIDS was best approximated by a bounded 4-parameter lognormal distribution, also known as the Johnson SB distribution [7]. However, with the recent research on SIDS risk factors and its possible causation, there has been a trend to report some SIDS-like deaths that had previously been called SIDS as Sudden Unexpected Death in Infancy (SUDI), with causes of death assigned to ICD classes that do not have a lognormal age distribution, shown as Equations 1 and 2 [6, 7], where:

\[
y = \log\left(\frac{m - a}{b - m}\right) \quad (1)
\]

\[
y = \mu + \sigma z \quad (2)
\]

and age \( m \) in months is bounded between ages \( a \) and \( b \), with \( \mu \) the median and \( \sigma \) the standard deviation of \( y \).

\[
dp(m)/dm = \sqrt{2\pi \sigma^2}^{-1}\left[\frac{1}{m - a} + \frac{1}{b - m}\right] \exp\left(-0.5\left(\frac{y - \mu}{\sigma}\right)^2\right); \quad a < m
\]

\[
y = \mu + \sigma z \quad (2)
\]

Equation 1 is the probability density function (pdf) of SIDS occurring in the interval between ages \( m \) and \( m + dm \), and Equation 2 is its integral cumulative distribution function (CDF) from birth to age \( m > 0 \). These four parameters (\( \mu, \sigma, a = -0.31 \) month, \( b = 41.2 \) months) may also have physical significance as to the SIDS risk factors that determine the age distribution [10]. It should be noted that in the limit as a goes to zero and b goes to infinity, the SB distribution becomes the 2-parameter lognormal distribution proposed for SIDS ages by Raring and others [5, 11, 12]. We also show that SIDS age data obey Cramér’s Theorem as predicted by their normal transformation (NT). Cramér’s Theorem states that if a NT variable \( A \) is the sum of other independent variables \( (B, C) \) so that \( A = B + C \), then \( B \) and \( C \) must have the same NT distribution as \( A \) [13, 14]. Therefore, if SIDS at age in months \( m \) are NT and a summation of various unrecognized causes of death at the same age then those unrecognized causes of death must all have an SB distribution, the same NT as SIDS. But no known other cause of infant death has a lognormal age distribution [4]. As will be shown, both SIDS and SUDI (SIDS like deaths with a possible cause cited instead of SIDS) appear to be the same phenomenon as they have the same age and gender distributions, and in many cases the same congenital anomalies [15].
MATERIALS AND METHODS

This study is based upon the statistical tabulations of the monthly ages of SIDS cases shown in Tables 1 and 2. Table 1 lists the numbers of SIDS by age from 15 combined global datasets (U.S., U.K., Denmark, Germany, New Zealand, Australia [pre-1980]) [6] and 20 annual data sets from Australia grouped as 1981-1990 and 1991-2000 [16], and their combined distribution. Table 2 reports SIDS ages for England and Wales for 1979-1983 by gender as well as for the cases of SUDI where SIDS was mentioned on the death certificate as a possible cause that was not chosen [17]. These reported cases are virtually all autopsied because it is legally mandated for a sudden unexpected death of an infant. These data sets have four independent sources of error: Measurement error: False positive and false negative SIDS can occur because the autopsy diagnoses are based on absence of a finding of a sufficient cause of death that depends upon the expertise and experience of the pathologists and death scene investigators. For example, infantici de by gentle suffocation with a soft pillow is virtually impossible to distinguish from SIDS. Øyen et al. [18] found that between 1967 and 1988 in Norway, 567 cases of aspiration and suffocation, minor findings of lower respiratory tract infection and nonlethal congenital effects as causes of death could be reclassified as definite or probable SIDS.

1. Definition and Truncation error: Operative definitions of SIDS have changed over time and also vary between countries [19, 20]. Many SIDS studies in 2005 did not even report which definition of SIDS they used [21]. Whereas the local pathologist death-certifiers may list several contributing causes, the underlyng cause of death and ICD code is often ascribed independently at a regional or national level. In England and Wales it was assigned by Office of Population Censuses and Surveys [22], "usually as the most precise cause of death," following World Health Organisation (WHO) rules. SIDS at ages above one year were most often not reported as SIDS (ICD 9th revision 798.0) as in England and Wales whereas they were assigned 798.1 (Instantaneous death), and when not reported with SIDS, their total must be estimated by extrapolation as discussed below. Some authors also do not include SIDS below 7-days of age in their analyses due to the difficulty of neonatal autopsy. The global data from the 15 studies used in the meta-analysis [6] were all collected during the pre-1991 period before the back-to-sleep campaign when the prone sleeping position was more common and the Beckwith [1] SIDS definition was operative. Although the only data shown in this paper from after the national back-to-sleep campaigns and proposed changes in SIDS definition are from Australia [16] we note that Blair et al. [23] and Pollack [24] also found that the SIDS age distributions remained constant in the U.K. and U.S., respectively.

2. Age reporting error: There is no uniformity in the reporting of age at death in units of month of life attained because a month can range in size from 28 to 31 days. Consequently, we accept the use of the month as the authors provided it. Where age data in days, weeks and mid-month intervals (e.g., nur between 1.5 and 2.5 months) were converted to


<table>
<thead>
<tr>
<th>Age at death m., Month attained</th>
<th>Number of SIDS in 15 data sets, U.S., U.K., etc. n, pre-1990</th>
<th>Number of Australian SIDS n, 1981-1990</th>
<th>Number of Australian SIDS n, 1991-2000</th>
<th>Total Number of SIDS in all 35 combined sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,164</td>
<td>299</td>
<td>186</td>
<td>1,649</td>
</tr>
<tr>
<td>2</td>
<td>3,840</td>
<td>991</td>
<td>402</td>
<td>5,233</td>
</tr>
<tr>
<td>3</td>
<td>4,446</td>
<td>1,160</td>
<td>447</td>
<td>6,053</td>
</tr>
<tr>
<td>4</td>
<td>3,709</td>
<td>867</td>
<td>324</td>
<td>4,900</td>
</tr>
<tr>
<td>5</td>
<td>2,401</td>
<td>524</td>
<td>222</td>
<td>3,147</td>
</tr>
<tr>
<td>6</td>
<td>1,468</td>
<td>321</td>
<td>177</td>
<td>1,966</td>
</tr>
<tr>
<td>7</td>
<td>1,022</td>
<td>229</td>
<td>85</td>
<td>1,336</td>
</tr>
<tr>
<td>8</td>
<td>669</td>
<td>170</td>
<td>86</td>
<td>925</td>
</tr>
<tr>
<td>9</td>
<td>467</td>
<td>129</td>
<td>47</td>
<td>643</td>
</tr>
<tr>
<td>10</td>
<td>279</td>
<td>79</td>
<td>28</td>
<td>386</td>
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<tr>
<td>11</td>
<td>182</td>
<td>38</td>
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<td>247</td>
</tr>
<tr>
<td>12</td>
<td>114</td>
<td>28</td>
<td>18</td>
<td>160</td>
</tr>
<tr>
<td>13-41*</td>
<td>220</td>
<td>58</td>
<td>37</td>
<td>315</td>
</tr>
<tr>
<td><strong>Total All ages</strong></td>
<td><strong>19,975</strong></td>
<td><strong>4,893</strong></td>
<td><strong>2,086</strong></td>
<td><strong>26,950</strong></td>
</tr>
</tbody>
</table>

*Estimated by linear extrapolation of Log(n) vs full month of life attained from 4 to 12 months.

### Table 2. England & Wales SIDS and SUDI*, 1979-1983 [17] and personal communication (C. Osmond, MRAC Southampton).

<table>
<thead>
<tr>
<th>Age at death m., Month attained**</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Month (m)</strong></td>
<td><strong>Number SIDS (n)</strong></td>
<td><em><em>Number SUDI</em> (n)</em>*</td>
</tr>
<tr>
<td>1</td>
<td>1,164</td>
<td>299</td>
</tr>
<tr>
<td>2</td>
<td>3,840</td>
<td>991</td>
</tr>
<tr>
<td>3</td>
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<td>3,709</td>
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<td>669</td>
<td>170</td>
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<td>467</td>
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<td>10</td>
<td>279</td>
<td>79</td>
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<td>11</td>
<td>182</td>
<td>38</td>
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<tr>
<td>12</td>
<td>114</td>
<td>28</td>
</tr>
<tr>
<td>13-41*</td>
<td>220</td>
<td>58</td>
</tr>
<tr>
<td><strong>Total All ages</strong></td>
<td>3165</td>
<td>649</td>
</tr>
</tbody>
</table>

* SUDI = SIDS mentioned on death certificate as a possibility but other possible cause assigned.
** Calendar months (i.e., birth Feb 1, 1979 to death March 1, 1979 = 2nd month of life attained).
*** Estimated by linear extrapolation of Log(n) versus month of life attained from 4 to 12 months.
DISCUSSION

This study is based upon the statistical tabulations of the monthly ages of SIDS cases shown in Tables 1 and 2. Table 1 lists the numbers of SIDS by age from 15 combined global datasets (U.S., U.K., Denmark, Germany, New Zealand, Australia [pre-1980]) [6] and 20 annual data sets from Australia grouped as 1981-1990 and 1991-2000 [16], and their combined distribution. Table 2 reports SIDS ages for England and Wales for 1979-1983 by gender as well as for the cases of SUDI where SIDS was mentioned on the death certificate as a possible cause that was not chosen [17]. These reported cases are virtually all autopsied because it is legally mandated for a sudden unexpected death of an infant. These data sets have four independent sources of error:

Measurement error: False positive and false negative SIDS can occur because the autopsy diagnoses are based on absence of a finding of a sufficient cause of death that depends upon the expertise and experience of the pathologists and death scene investigators. For example, infantici de by gentle suffocation with a soft pillow is virtually impossible to distinguish from SIDS. Øyen et al. [18] found that between 1967 and 1988 in Norway, 567 cases of aspiration and suffocation, minor findings of lower respiratory tract infection and non-lethal congenital effects as causes of death could be reclassified as definite or probable SIDS.

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Age reporting error: There is no uniformity in the reporting of age at death in units of month of life attained because a month can range in size from 28 to 31 days. Consequently, we accept the use of the month as the authors provided and 4.35 weeks per month were used, and these data were

CONCLUSION

The SIDS age distribution appears to be universal because two independent large sample studies are well represented by the same Johnson SB probability model. Many of these 35 independent subsets of SIDS ages (15 global and 20 Australian annual) when viewed alone may not appear to follow the same SB distribution because of the four sources of error noted in the Materials and Methods section. However, by the Law of Large Numbers, as the sample size increases by pooling them, the properties of the total sample are expected to approach those of the underlying distribution by regression to the mean. The finding that the two Australian SIDS age distributions (1981-1990 prone preferential and 1991-2000 supine preferential) have the same lognormal form is predicted by the Johnson SB model [10]. The findings that male and female SIDS have the same SB age distribution and that SIDS and SIDS-like deaths called SUDI have the same SB age distribution are predicted by Cramér’s theorem and imply that they are the same phenomenon [27] as also posited in a recent study [15]. Therefore SIDS appears to be a univer...
This study is based upon the statistical tabulations of the monthly ages of SIDS cases shown in Tables 1 and 2. Table 1 lists the numbers of SIDS by age from 15 combined global datasets (U.S., U.K., Denmark, Germany, New Zealand, Australia [pre-1980]) [6] and 20 annual data sets from Australia grouped as 1981-1990 and 1991-2000 [16], and their combined distribution. Table 2 reports SIDS ages for England and Wales for 1979-1983 by gender as well as for the cases of SUDI where SIDS was noted on the death certificate as a possible cause that was not chosen [17]. These reported cases are virtually all autopsied because it is legally mandated for a sudden unexplained death of an infant. These data sets have four independent sources of error: Measurement error: False positive and false negative SIDS can occur because the autopsy diagnoses are based on absence of a finding of a sufficient cause. These reported cases are virtually all autopsied because it is legally mandated for a sudden unexpected death of an infant. These data sets false negative SIDS can occur because the autopsy diagnoses are based on absence of a finding of a sufficient cause.

RESERENCES