An investigation of infant deaths following initial hepatitis B vaccination based on the Vaccine Adverse Event Reporting System (VAERS), 1992-2002

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Abstract

Purpose: To examine Sudden Infant Death Syndrome (SIDS) and hepatitis B neonatal vaccination. **Results:** 170 reports related to neonatal hepatitis B vaccination were filed with the Vaccine Adverse Event Reporting System (VAERS) during 1992-2002. Of the 38 (22.4%) death reports, 29 were unexplained; 24 were classified as SIDS in the United States National Vital Statistics, and 4 were attributed to unknown causes. **Conclusion:** A systematic review of neonatal SIDS and other unexpected infant deaths following the initial dose of hepatitis B vaccination should be undertaken at the international level.

Keywords: SIDS, sudden death, vaccines

1. Introduction

Sudden *unexpected* death in infancy and early childhood was defined prior to 1969 as "the death of a child who was thought to be in good health or whose terminal illness appeared to be so mild that the possibility of a fatal outcome was not anticipated." [1] Such definition was usually applied to children under 2 years of age [1,2]. Before 1963 and the First International Conference on Causes of Sudden Death in Infants [3], few professionals other than forensic pathologists were aware of this phenomenon.

It was only at the Second International Conference on Causes of Sudden Death in Infants in 1969 that "Sudden Infant Death *Syndrome*", or SIDS, was first defined as "the sudden death of an infant which was unexpected by history and in which a thorough postmortem examination failed to demonstrate an adequate cause of death." [4]

Until then sudden *unexpected* deaths with *known* causes were mixed with truly sudden and *unexplained* deaths [5].

Since 1989 SIDS has been defined in the United States as "the sudden death of an infant under 1 year of age which remains unexplained after a thorough case investigation, including performance of a complete autopsy, examination of the death scene, and review of the clinical history." [6]

There was no code for SIDS in International Classification of Diseases (ICD) before 1973 [7], although related ICD-7 and ICDA-8 codes and causes of sudden *unexpected* deaths were published elsewhere [8,9]. SIDS has been housed in ICD chapter "Symptoms, Signs, and Ill-Defined Conditions" since 1973 and coded 795.0 under ICDA-8, 798.0 under ICD-9, and R95 under ICD-10. ICDA-8 and ICD-9 were used in the U.S. in 1968-78 [7] and in 1979-1998 [10], respectively. ICD-10 was implemented in the U. S. since 1999 [10].

A SIDS investigative and autopsy protocol was published and recommended for medical examiners and coroners in 1976, but was not mandated at the state and local levels. It never required review of the vaccination history [11].

In California, the SIDS protocol required an autopsy since 1974, and an inquiry about administered vaccines since 1990 [12,13].

The Centers for Disease Control and Prevention (CDC) and the National Institute of Child Health and Human Development (NICHHD) released a generic protocol of the Sudden *Unexplained* Infant Death Investigation Report Form (SUIDIRF) in 1996. Only California, Minnesota, Missouri, and New Mexico had written SUID investigation protocols before 1996 [14]. Although the form required taking a vaccination history, its use was never enforced [15,16].

In 2006 the CDC reported that "some SUIDs are not investigated and, when they are, cause-of-death data are not collected and reported consistently." [17] The CDC and other organizations revised the 1996 form and released a new Sudden *Unexplained* Infant Death Investigation (SUIDI) Reporting Form that requires taking the vaccination history on March 1, 2006 [18].

2. SIDS and vaccine injury compensation

In order to protect the vaccine manufacturers and health care providers, the U.S. Congress passed the National Childhood Vaccine Injury Act (NCVIA) in 1986.

Amendments to the act established the National Vaccine Injury Compensation Program (NVICP) in 1988 [19]. The Food and Drug Administration (FDA) and the CDC launched the Vaccine Adverse Event Reporting System (VAERS) in July 1990 in response to NCVIA [20].

Ridgway [21] reviewed 786 claim disputes from the start of the NVICP in 1988 through June 1996. Of the 786 claims, 107 (13.6%) resulted from DTP-related adverse events that led to early death and 73 (68.5%) of those were awarded compensation. In 50 of those 73 compensated claims, autopsy findings were interpreted as SIDS; 9 cases had "non-specific findings", 4 had "other specific diagnosis", 3 had pneumonia, 1 had encephalitis, and 6 were not autopsied.

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Evidently the U.S. Court of Claims was convinced that the deaths were related to vaccine injury and wrongly classified as SIDS.

Only 8 infant deaths were attributed to vaccine adverse events in 1979-1996 [10], suggesting that most SIDS cases compensated through NVICP in 1988-1996 retained their SIDS code in the corresponding U.S. annual mortality files.

There were 12 *postneonatal* deaths attributed to vaccine adverse events in 1979-2002. Two deaths occurred annually in 1983, 1985, and 1999 and one in each of 1984, 1986, 1992, 1995, 2000, and 2001. [10] The underlying cause of one infant death (UCOD) in 1986 was "adverse reaction to pertussis vaccine including combinations with a pertussis component"; other conditions mentioned on the death certificate were "SIDS" and "Serum reaction other" [22].

Two often-quoted studies on SIDS and vaccines published prior to 1990 focused on DTP vaccine and SIDS beyond age 2 weeks [23] and *postneonatal* SIDS [24]. Pediatric pathologists do not consider infant deaths attributed to SIDS in the first 2 or 3 weeks of life to be "classical" SIDS suitable for SIDS research purposes [23,25]. Despite this, approximately 300 to 400 neonatal deaths were attributed to SIDS in the U. S. annually from 1979-1991 [10].

This investigation concerns neonatal SIDS and hepatitis B vaccination in reports to VAERS from the time of endorsement of the universal vaccination of newborns against hepatitis B in late 1991 [26] through the end of 2002. The Hepatitis B vaccine is the only vaccine licensed for and administered to neonates in the U.S.

Neonatal SIDS had declined in the U. S. from 11.9/100,000 live births in 1979 [10] to 7.0/100,000 in 1991 (Table 6).

In June 1992, the American Academy of Pediatrics (AAP) recommended placing all healthy infants in non-prone position during sleep to reduce the risk of SIDS [27]. After the implementation of the "Back to Sleep" campaign, the greatest decline in SIDS occurred among 1 to 6 month-old infants [28]. The *neonatal* SIDS rate per 100,000 live births declined from 7.3 in 1992 to 5.5 in 1996, and decline was statistically significant, but changes in rates of *neonatal* SIDS were not statistically significant in 1997-2004. Rates of *neonatal* SIDS during 1997-2004 ranged from 5.2 in 1999 to 4.6 in 2001-2003. (Table 6). The failure of neonatal SIDS to decline, concomitant with the increased use of the birth dose of hepatitis B vaccine, and the report by Silvers *et al.* [29] that some infant deaths reported to VAERS as SIDS from July 1990 to June 1997 would not have met the current SIDS case definition [6], provided the motivation for this investigation.

3. Materials and methods

We used VAERS data available for online search [30]. Few neonatal U.S. VAERS reports were filed prior to January 1, 1992. From January 1, 1992 to December 31, 2002, there were 170 distinct neonatal reports filed with VAERS. Of these, 38 (22.4%) were death reports. In order to determine the UCOD, these 38 reports were matched by date of death and age at death with mortality data from the U.S. National Vital Statistics (NVS).

The documentation enclosed with the main mortality files for years 1992-1994 [31-33] and the perinatal mortality files for years 1995-2002 [34-41] describes the file characteristics and the available data. We obtained available history and autopsy data for some infants from the review by Niu *et al.* [42] and from VAERS reports.

4. Results

Nine out of 38 deaths were due to known causes. Of 29 deaths reported as unexplained, 24 were attributed to SIDS, 4 to unknown/unspecified causes and one report remained unmatched (see Table 1, footnote "a"). Seventeen were boys out of the 29 infants whose death was "unexplained"—a male-to-female ratio of 1.4 which is similar to the male/female ratio in the highly vaccinated U. S. general population. There were approximately 1,214,556 males and 1,156,701 females born during 7 months in 1992 [10]. Since approximately 90% of SIDS deaths occur before age 7 months, and deaths of 2,836 male and 1,834 female infants under age 7 months were classified as SIDS in 1992 [31], incidence of SIDS in the first 7 months is 234 (95% C.I., 225 to 242) per 100,000 live born males and 159 (95% C.I., 151 to 166) per 100,000 live born females. The male-to-female SIDS incidence rate ratio of 1.47 (95% C.I., 1.39 to 1.56) is statistically significant (since the confidence interval does not include 1.0). Since there are no data on male-to-female SIDS incidence rate ratio in the cohort of the infant population that was not vaccinated, it is uncertain whether SIDS naturally occurs 1.5 times more among males compared to females.

Four of the 29 infants expired within 24 hours of vaccination and four others expired during the following 24 hours. Two infants who developed symptoms consistent with a vaccine reaction within hours of vaccination, were hospitalized, placed on life support, and died on day 3 and 4 post vaccination.

We extracted and reviewed all available information on county of residence of all recorded cases between 1992 and 2002. Because maternal smoking during pregnancy is a recognized risk factor of SIDS, we reviewed these data. Since perinatal mortality files and linked birth/infant death data sets were not available for years 1992-1994, information on maternal smoking was only available for years 1995-2002. In California, Indiana, South Dakota, and New York (excluding New York City) maternal smoking during pregnancy is not mentioned on birth certificates [43].

The data from the 29 VAERS reports are summarized in Tables 1 and 2. States in Tables 1 and 2 are denoted according to official U.S. postal abbreviations. Table 1 contains reports that included hepatitis B vaccine lot number. The column "Number of reports" in Table 1 contains the number of reports submitted to VAERS from each hepatitis B vaccine lot. Table 2 contains reports in which hepatitis B vaccine lot number was not reported.

4.1 Lot Numbers

Cases 10, 11 and 12 received vaccines from lot 0165D. Case 11 was vaccinated on the day he was born, received no other vaccines, and died at age 55 days. Cases 2 and 3 resided in the Philadelphia (PA) City area, received a dose of hepatitis B vac-

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cine from lot 1116A2 and lot 116A2, respectively. We believe these doses were from the same lot and that a recording error occurred.

Cases 20 and 21 received vaccines from lot 2930A2. This lot generated 3 reports of unexplained infant deaths, two of which were classified as SIDS and in the third, the death was attributed to "other ill-defined and unspecified causes of mortality" in NVS with ICD-10 code R99. The third infant received other vaccines concomitantly. Other hepatitis B vaccine lots in Table 1 that generated 2 or 3 infant death reports involved the same uncertainty.

4.2 SIDS in New Hampshire

Silvers *et al.* [29] reported that from July 1990 through June 1997, New Hampshire had the highest VAERS reporting rate of infant deaths in any state: 2.73 reports per 10,000/year; Oregon was second with 1.16 per 10,000/year.

Of the 29 unexplained infant deaths reported after the neonatal dose of hepatitis B vaccine, 15 (51.7%) were from New Hampshire, a state with 14,041 to 17,569 live births in 1990-2002 (Table 4). This is a concern as it suggests significant underreporting from other states. Cases 8, 10, 11, 12, 13, 15, 23, 24, and 25 resided in New Hampshire, Hillsborough County.

An inquiry by one of us (FEY) to the NH Bureau of Maternal and Child Health revealed that any infant death that is referred as a possible SIDS from the Office of the Chief Medical Examiner to the NH SIDS Program is also referred to the NH Immunization Program for their follow up as a possible vaccine adverse event. Once the final diagnosis was made, a copy of the death certificate was sent to the NH Immunization Program, which then contacted VAERS from 2 months to more than a year after the infant's death.

Tables 3 and 4 list SIDS and "infant deaths due to unknown causes" in New Hampshire during the periods 1979-1990 and 1991-2002, or twelve years before and after universal neonatal hepatitis B vaccination. Table 4 shows the number of unexplained infant deaths reported from New Hampshire to VAERS by December 31, 2002.

There were 23 unexplained neonatal deaths in New Hampshire during 1979-1990—before routine hepatitis B vaccination was recommended and the prone sleeping position discouraged. There were 25 unexplained neonatal deaths during 1991-2002, of which 12 were reported to VAERS as possible adverse outcomes of hepatitis B vaccination.

4.3 Available History for Cases Listed in Tables 1 and 2

Infants born to mothers who smoked during pregnancy included cases 9, 12, 13, 15, 20, 21, 23, 24, and 25.

There were nine reports of infants co-sleeping with one or both parents during the last sleep: cases 7, 12, 13, 15, 19 through 23 [42,44]. Accidental smothering or overlying was not mentioned in any case.

Case 22 had a skull fracture (with no other information).

Three infants were found with blood around the nose: cases 3, 5, and 7. Case 7 also had some blood in the mouth [42].

Unless stated otherwise, the UCOD in the corresponding annual mortality file was SIDS.

Infant case histories presented below are ones that did not meet the definition of SIDS and/or unexplained death or had autopsy findings suggesting other diagnoses.

Case 3. This 15-day-old infant was brought to the ER in full arrest less than 48 hours following vaccination. Petechiae on the thymus, pericardium and pleura in addition to a fatty liver were seen at autopsy.

Case 5: This 20-day-old infant expired on the day following vaccination. Autopsy revealed: "Thymic cyst, right lobe; lungs: recent focus alveolar hemorrhage, focus squamous aspiration; liver: moderate microvascular changes, extramedullary hematopoiesis with focal neutrophilia; kidneys: urate deposit in collecting ducts, focal nephrosclerosis; adrenal glands: involution with focal calcification; pancreas: nesidiodysplasia; thymus: moderate eosinophil deposition." [42]

Case7: This infant was vaccinated at age 14 days and died 10 days later. Autopsy revealed: "cyst, edema brain, hemorrhage, lung disease".

Case 8: This infant who was vaccinated at age 3 days, developed gastroesophageal reflux (GER) and was on ampicillin plus antibiotic eye drops. She died at age 22 days. Death was reported to VAERS as "SIDS", but ultimately attributed to "other unknown and unspecified cause" in NVS, ICD-9 code 799.9.

Cases 12, 14, and 15 were vaccinated on the first day of life.

Case 12: This premature infant (35 weeks gestation/ 2240 g) who developed jaundice expired at age 19 days [42].

Case 13: This infant (34 weeks gestation / 1829 g) had feeding difficulties and prematurity-related apnea. She was discharged from the hospital on an apnea monitor. She was vaccinated at the age of 13 days, was hospitalized 5 days later and expired 4 days after that. She was off the apnea monitor during her last sleep, co-slept with her mother on a couch and was found supine on the floor [42].

Because preterm infants with a birth weight below 2000 g have a decreased immune response to hepatitis B vaccination, it has been recommended that vaccination be delayed until the age of 1 month. [45]. It is not known why this infant was vaccinated earlier than recommended.

Case 14: This baby with "sudden agitation, screams" and frequent vomiting episodes following vaccination expired at the age of 39 days.

Case 15: This infant developed a cold 2-3 days before death and died at age 16 days. Autopsy revealed "hepatic infarct with hyperemic border". [42]

Case 19: A few hours after he was vaccinated at the age of 18 days, this infant became sweaty and inconsolable and the injection site appeared swollen. He was put to sleep in parents' bed at 2:00am, and was found dead at 4:00am, 16 hours after vaccination. "SIDS" was mentioned on the report.

Note: There were 11 reports of ER visits following vaccination with hepatitis B vaccine lot 2612A2. One report was about a 5-year old boy from Louisiana, who received a dose from the same hepatitis B vaccine lot (and no other vaccine) on 7/20/1998, had a grand mal seizure 2 days later and 37 more seizures within 2 weeks. The child developed epilepsy and was placed on Tegretol.

Case 27: This infant had fever, vomiting, and diarrhea 2.5 hours after vaccination and improved. He was found apneic and

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pulseless in the crib approximately 20 hours after vaccination. He was hospitalized and ventilated for 2 days until absence of brain activity was confirmed. The autopsy revealed "Massive myocardial infarction and diffuse ischemic encephalopathy" [42] yet the case was reported to VAERS as "SIDS".

Case 28: This infant was vaccinated at age 7 days and died 4 days later. She had no congenital anomalies. The autopsy revealed both cerebral and pulmonary edema.

By December 31, 2002, there were also 30 VAERS reports listing cerebral edema after administration of hepatitis B vaccine alone or with other vaccines. 6 of the 19 individuals who died had received the recombinant hepatitis B vaccine alone.

Deaths of 3 infants were classified as SIDS in NVS: cases 7 and 28 above, and a case with VAERS ID 120390, an infant who died approximately 16 hours after the second dose of hepatitis B vaccine.

According to the SIDS histopathology atlas, cerebral edema is in the "gray zone" of SIDS, although it is a significant and potentially fatal finding by itself. [46] Was cerebral edema in all 3 cases a terminal event of a *coincidental* SIDS death, or was the death directly related to the hepatitis B vaccination that was administered 1, 4 or 10 days earlier?

Case 29: This jaundiced 2-day-old infant became irritable and developed grand mal seizures a few hours after vaccination. He later went into acute respiratory failure and cardiac arrest. At the hospital, he was diagnosed with acute anoxic encephalopathy, status epilepticus, acute respiratory failure and syndrome of inappropriate anti-diuretic hormone (ADH) secretion.

Of note is the fact that in cases 27 and 29, the deaths were attributed to unknown cause (ICD-9 code 799.9 and ICD-10 code R99 respectively) in NVS and not to anoxic encephalopathy.

5. Discussion

None of the recognized risk factors of SIDS is actually a cause of SIDS and there are no specific symptoms associated with SIDS. [7] Minor respiratory system inflammatory infiltrates, intrathoracic petechial hemorrhages, congestion and edema of the lungs are often reported autopsy findings, but are not pathognomic of the syndrome [7,47].

Beyond infancy, any death with one or more pathological findings observed in SIDS is not attributed to SIDS. The assumption that intrathoracic petechiae result from breathing against an obstructed upper airway remains theoretical and unproven because it has never been established how and where the alleged obstruction occurred [47]. Kalokerinos and Dettman have proposed that subclinical scurvy can be an alternative explanation for the intrathoracic petechiae seen in SIDS. [48] Overlooked factors requiring research include the perturbation of clotting cascade, toxic or immunological damage to the capillary basement membrane and other molecular events that accompany toxic or septic shock. [47] No effort has been made to determine the predictive value of a particular pathological finding to help confirm or exclude SIDS except for the thymic and intrathoracic petechiae [47].

Several cases had eosinophilia at various sites. Case 5 had eosinophilic deposition in the thymus. Case 12 had "chronic, eosinophilic triaditis" of the liver and "mild peripheral eosinophilia at cerebellum/dentate nucleus and spleen". [42]

Eosinophils are an important component of inflammation in bronchial asthma [49]. A study of 48 infants who died of SIDS and 30 who died of other, non-pulmonary, causes showed three times more eosinophils accompanied by increased T lymphocytes and B lymphocytes in the lungs of infants who died of SIDS, but the vaccination status of the study subjects was not mentioned [50].

Osborn stated in 1943 that acute hemorrhagic pulmonary edema is fatal if it persists for more than a few minutes and should be regarded as the cause of death. [51] In case 7, the site of hemorrhage was not specified in the report.

Reporting the sudden death of three infants with scurvy, Follis observed that the "liver was yellowish" and "showed atrophy of the central cells and a good deal of fatty infiltration". [52] Fatty liver was often the only abnormal finding in Australian Aboriginal children who died suddenly and unexpectedly soon after vaccination. Such deaths were greatly reduced when Kalokerinos administered parenteral vitamin C concomitantly with the vaccine, and after vaccination [53].

Griffin *et al.* [24] reported a case of a death that occurred within 3 days of a DTP vaccination. The infant had gastrointestinal bleeding and a fatty liver and the death *was not attributed* to SIDS. Reye's syndrome is another condition that results in fatty liver.

Oronasal bleeding [1] and frothy, blood tinged mucus secretions [11] accompany pulmonary pathology seen in both vaccinated and unvaccinated infants who have died suddenly and unexpectedly [1], but these findings are less common than thymic and intrathoracic petechiae. Kalokerinos did not observe these findings in the Australian Aboriginal children he has evaluated. [53,55].

From January 1992 through December 2002, there were approximately 60 reports of bleeding and approximately 700 reports listing liver problems filed with VAERS following Hepatitis B vaccination.

Cheraskin [54] quoting Kalokerinos [53], mentioned that smokers are likely to have lower blood ascorbate levels compared to non-smokers and suggested that additional research was needed to assess infant serum ascorbate level and its relationship to SIDS.

In this sample, six infants born to smoker mothers (cases 15, 12, 20-24) were vaccinated within the first 48 hours of life. Because the blood ascorbate levels of newborns are not routinely checked and vaccination is known to result in increased utilization of vitamin C [55], we hypothesize that those infants may have been born with relatively low level of ascorbate and an increased risk of adverse reactions to vaccination.

Silvers *et al.* [29] collected information on birth weight for children under 5 years of age whose deaths were reported to VAERS from July 1990 to June 1997, and determined that the mean birth weight of the study population (3090 g) was less than the mean birth weight of the U.S. general population (3400 g). 16.8% of the study cases were considered "low birth weight infants"(LBW). The percentages of LBW infants in the U. S. general population were 7.1% in 1991 [56] and 7.5% in 1997. [57] In our sample 2 out of 29 neonates were premature and had birth weight under 2500 g. There have been several reports of

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apnea and bradycardia in some small premature babies shortly after vaccination with DTP and Hib [58-62].

There was no mention of hepatitis B immunoglobulin administration to any of the 29 neonates. This suggests that they were born to mothers who were HBsAg negative and therefore at no risk for vertical transmission of the disease. It certainly would have been safe to delay the vaccination in all these cases.

Case 15 had a minor illness before expiring. Kalokerinos reported that some of the infants he studied and who went into shock after vaccination or developed a serious illness such as pneumonia, had a minor illness when vaccinated [53,55].

The CDC has posted the following information regarding SIDS and vaccines: "The age at which infants begin their primary course of vaccinations (2 to 4 months old) is also the peak age for the incidence of sudden infant death syndrome (SIDS)." [63]

We disagree with this statement since most infants are presently vaccinated shortly after birth.

The CDC also states that: "The incidence of SIDS is declining in the United States due to public education campaigns regarding infant sleeping position, reduced exposure of infants to cigarette smoke and fewer potentially hazardous sleeping environments" and that SIDS rates decline despite the increase in vaccinations, therefore routine vaccinations do not contribute to SIDS [63].

Table 5 contains counts of U.S. resident births and infant deaths for years 1989-2004. Data from Table 5 are used to calculate mortality rates given in Table 6. The fact that both SIDS and all-cause infant mortality rates declined in 1992-1998 (Table 6) suggests that the decline in SIDS in 1992-1998 was genuine. However, all-cause *postneonatal* mortality rate reached a plateau and remained at 2.3 per 1000 live births in 1999-2002, declined to 2.2 in 2003 and returned to 2.3 in 2004. While "SIDS" continued to decline, deaths attributed to accidental mechanical suffocation and to unknown/unspecified cause increased in 1999-2002 [64,65]. The increasingly similar age at death distributions among SIDS, cause unknown/unspecified, and accidental suffocation provide *additional* evidence that there was a change in the reporting of SIDS [67].

All-cause *neonatal* mortality rate per 1000 had a statistically significant decline from 4.7 in 1999 to 4.5 in 2001 (Table 6). The 2002 increase in neonatal mortality rate was attributed to increase in the number of less than 750-gram and 500-gram live births and the high mortality among such extremely immature infants. [66] Decrease of neonatal mortality in 2004 was significant compared with neonatal mortality in 2002, but not significant in comparison with neonatal mortality in 2000, 2001, and 2003 (Table 6).

From 1989 to 1991, SIDS (among infants aged <28 days) comprised 6.4% (1051/16400; 95% C.I., 6.0% to 6.8%) of the cases. From 1999 to 2001, SIDS in this same age group comprised 8.1% (599/7405; 95% C.I., 7.5% to 8.7%). (Table 5) The incidence rate ratio of the 1999-2001 rate to the 1989-1991 rate is 1.26 (95% C.I., 1.14 to 1.40) indicating a statistically significant increase in proportion of neonatal SIDS since implementation of universal vaccination of newborns against hepatitis B and gradual increase in coverage by the birth dose.

Several epidemiological studies [23,24,67-70] concluded that vaccinations are *not a risk factor* of SIDS, and may even lower the risk. [67,69] One of the authors (VAS) presented a detailed analysis why case-control studies showed no association between SIDS and vaccines [71].

SIDS case definition in the cohort study [24] did not require an autopsy. Whether the 47 out of 109 (43%) non-autopsied post-DTP infant deaths were indeed SIDS will never be known. This study, however, was cited in 2005 as a "proof" of absence of association between SIDS and vaccines [72].

Epidemiological studies on SIDS and vaccines did not disprove that a small number of post-vaccination infant deaths in general population was classified as unexplained even though the infants either experienced adverse vaccine reactions before expiring, or had serious and potentially fatal pathological findings as described in VAERS reports. Such signs, symptoms, and findings cannot be regarded as terminal events of *coincidental* unexplained deaths.

This review and previous analysis of fatalities reported to VAERS [29] support suggestions of Kalokerinos [73] and Clemetson [74] to postpone vaccination of premature or sick infants and to supplement vitamin C around the time of vaccination in order to reduce the number of adverse events and to lower infant mortality.

6. Conclusion

In most of the reviewed cases, the history, the symptoms and or the pathologic findings did not support the classification of death as unexplained or SIDS. All cases of "SIDS" occurring shortly after vaccination should be reported to VAERS.

The risks of vaccinating premature, small or slightly ill infants should be weighed against the benefits of each vaccine, particularly in cases where the vaccine is not even needed.

The role of low serum ascorbate in SIDS should be further investigated particularly since the number of recommended pediatric vaccines is constantly increasing.

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Table 1. Unexplained neonatal deaths following hepatitis B vaccination given alone with corresponding vaccine lot numbers reported to VAERS, Jan. 1992 – Dec. 2002

Case no.	VAERS ID	Sex	State	Lot number	Number of reports[b]	Vaccination date	Days since vaccination	Age at death (days)
1	46348[a]	M	VA	1032A4	1	10/08/92	2	15
2	51067	M	PA	1116A2	9 (3)	03/15/93	1	28
3	51688	F	PA	116A2	1	03/29/93	2	15
4	51976	F	SC	01554V	1	03/17/93	14	30[c]
5	51982	M	PA	1112A2	10 (2)	04/02/93	1	30[c]
6	52816	F	MD	1119A2	6 (1)	05/14/93	2	6
7	59322	F	SC	0942W	32 (2)	11/30/93	10	24
8	70603	F	NH	1547W	32 (3)	06/24/94	19	22
9	87649	M	OR	1189B	15 (2)	06/28/96	2	14
10	91425	M	NH			09/05/96	21	24
11	97016	M	NH	0165D	14 (3)	09/02/96	54	55
12	108796	M	NH			01/02/97	18	19
13	96889	F	NH	1289A	18 (3)	09/24/96	9	22
14	107414	F	OH	1611B	22 (1)	04/3/96	38	39
15	108795	F	NH	1163A	28 (1)	04/13/96	15	16
16	112250	F	NY	2587A2	15 (1)	06/15/98	<1	21
17	113478	M	NH	0424E	1	11/24/97	32	34
18	117475	M	NH	1559E	9 (1)	10/24/98	25	27
19	118117	M	WV	2612A2	28 (1)	05/29/98	1	19
20	122713	M	NH	2930A2	20 (3)	03/3/99	18	20
21	123168	M	NH			03/24/99	31	32
22	126759	M	NH	0987H	13 (3)	11/07/98	11	13
23	133751	M	NH	2948A2	24 (1)	05/27/99	16	17
24	171973	F	NH	1947J	3 (1)	05/7/00	20	21
25	171370	F	NH	ENG518A2	4 (2)	02/26/01	6	26
26	200120	M	NH	5286A2	26 (1)	12/19/02	5	7

[a] Reported age at death was 15 days [42], but no such corresponding death record from Virginia was found in the 1992 mortality file [31].
[b] Number of death reports from each lot is listed in the parentheses.
[c] Age at death is 1 month in 1993 main mortality file [32].

Table 2. Lot Number not reported

Case No.	VAERS ID	Sex	State	Vaccine date	Days since vaccination	Age at death(days)
27	100366	M	MS	070/6/97	4	20
28	150249	F	NJ	02/28/00	4	11
29	182530	M	IN	10/29/01	3	5

Table 3. Cases of unexplained infant deaths, New Hampshire, U.S., 1979-1990 (Underlying cause of death codes 798.0 and 799.9 respectively, ICD-9)

Year	Live births	Neonatal cases SIDS and 799.9	Postneonatal cases SIDS and 799.9	Total
1979	12,845	1	16	17
1980	13,745	1	12	13
1981	13,517	2	22	24
1982	14,087	0	9	9
1983	13,799	3 and 1	17 and 1	22
1984	14,250	2	15 and 1	18
1985	15,453	1	19	20
1986	15,895	4	15	19
1987	17,032	5	15 and 1	21
1988	17,364	1 and 1	25 and 2	29
1989	17,809	1	26 and 1	28
1990	17,569	0	18 and 4	22

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Table 4. Cases of unexplained infant deaths (UID), New Hampshire, U.S., 1991-2002 (ICD-9 codes are 798.0 and 799.9 for 1991-1998; R95 and R99 respectively since 1999, ICD-10)

		Neonatal Cases		Postneonatal Cases					
		SIDS and 799.9/R99		SIDS		799.9/R99		Total UID reported to VAERS	
Year	Live births	All	Reported to VAERS	All	Reported to VAERS	All	Reported to VAERS		Total
1991	16,341	2	0	14	2	4	1	3	20
1992	15,990	1	0	13	2	3	1	3	17
1993	15,436	0	0	15	4	1	0	4	16
1994	15,106	1	1	14	4	3	1	6	18
1995	14,665	3	0	12	3	1	1	4	16
1996	14,520	4	3	5	2	0	0	5	9
1997	14,313	1	1	4	4	3	2	7	8
1998	14,429	4	2	4	2	0	0	4	8
1999	14,041	2	2	3	2	0	0	4	5
2000	14,609	3	1	4	3	5	2	6	12
2001	14,656	1	1	7	0	0	0	1	8
2002	14,442	3	1	6	2	0	0	3	8

Table 5. U.S. Resident Births and Infant Deaths, 1989-2004

		Death Counts			
		SIDS		All Causes	
Year	No. of births	0-27 Days	28-364 Days	0-27 Days	28-364 Days
1989	4,040,958	398	5,236	25,168	14,487
1990	4,158,212	367	5,050	24,309	14,042
1991	4,110,907	286	5,063	22,978	13,788
1992	4,065,014	298	4,593	21,849	12,779
1993	4,000,240	287	4,382	21,174	12,292
1994	3,952,767	258	3,815	20,250	11,460
1995	3,899,589	219	3,178	19,155	10,428
1996	3,891,494	213	2,837	18,572	9,915
1997	3,880,894	182	2,809	18,524	9,521
1998	3,941,553	188	2,634	18,918	9,453
1999	3,959,417	208	2,440	18,728	9,209
2000	4,058,814	204	2,319	18,776	9,259
2001	4,025,933	187	2,047	18,265	9,303
2002	4,021,726	185	2,110	18,747	9,287
2003	4,089,950	190	1,972	18,893	9,132
2004	4,112,052	210	2,036	18,593	9,343

Table 6. Neonatal and Postneonatal Mortality Rates for SIDS and All Causes per 1,000 Live Births, 1989-2004

	SIDS Mortality Rates		All Causes Mortality Rates	
Year	0-27 Days (95% C.I.)	28-364 Days (95% C.I.)	0-27 Days (95% C.I.)	28-364 Days (95% C.I.)
1989	0.098 (0.089, 0.108)	1.296 (1.260, 1.331)	6.228 (6.151, 6.305)	3.585 (3.527, 3.644)
1990	0.088 (0.079, 0.097)	1.214 (1.181, 1.248)	5.846 (5.772, 5.920)	3.377 (3.321, 3.433)
1991	0.070 (0.062, 0.078)	1.231 (1.198, 1.266)	5.590 (5.517, 5.662)	3.354 (3.298, 3.410)
1992	0.073 (0.065, 0.082)	1.130 (1.097, 1.163)	5.375 (5.303, 5.446)	3.144 (3.089, 3.198)
1993	0.072 (0.063, 0.080)	1.095 (1.063, 1.128)	5.293 (5.221, 5.365)	3.073 (3.018, 3.127)
1994	0.065 (0.057, 0.073)	0.965 (0.935, 0.996)	5.123 (5.052, 5.194)	2.900 (2.846, 2.952)
1995	0.056 (0.049, 0.064)	0.815 (0.787, 0.843)	4.912 (4.842, 4.982)	2.674 (2.623, 2.726)
1996	0.055 (0.047, 0.062)	0.729 (0.702, 0.756)	4.772 (4.704, 4.841)	2.548 (2.498, 2.598)
1997	0.047 (0.040, 0.054)	0.724 (0.697, 0.751)	4.773 (4.704, 4.842)	2.453 (2.404, 2.503)
1998	0.048 (0.041, 0.055)	0.668 (0.643, 0.694)	4.800 (4.731, 4.868)	2.398 (2.350, 2.447)
1999	0.052 (0.045, 0.060)	0.616 (0.592, 0.641)	4.730 (4.662, 4.798)	2.326 (2.278, 2.373)
2000	0.050 (0.043, 0.057)	0.571 (0.548, 0.595)	4.626 (4.560, 4.692)	2.281 (2.235, 2.328)
2001	0.046 (0.040, 0.053)	0.508 (0.486, 0.530)	4.537 (4.471, 4.603)	2.311 (2.264, 2.358)
2002	0.046 (0.039, 0.053)	0.525 (0.502, 0.547)	4.661 (4.595, 4.728)	2.309 (2.262, 2.356)
2003	0.046 (0.040, 0.053)	0.482 (0.461, 0.503)	4.619 (4.553, 4.685)	2.233 (2.187, 2.279)
2004	0.051 (0.044, 0.058)	0.495 (0.474, 0.517)	4.522 (4.456, 4.587)	2.272 (2.226, 2.318)

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