AN ENVIRONMENTAL STIMULUS FOR SUDDEN DEATH IN INFANCY?

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ABSTRACT

This paper contains a review of the environmental conditions that may be associated with Sudden Infant Death Syndrome (SIDS), and notes a probable association in Utah between SIDS and atmospheric temperature inversions accompanied by a gentle breeze. These conditions also enhance the strength of low frequency sound in rooms; moreover it is only in certain-size rooms and moving automobiles (another low frequency sound environment) that SIDS has been observed. The author argues that such sound could be one of the links in SIDS, perhaps through direct transmission into the skull via an infant's not-yet-closed fontanelle.

Sudden Infant Death Syndrome (SIDS) - the sudden death of any infant or young child, which is unexpected from its medical history, and in which a thorough post-mortem examination fails to demonstrate an adequate cause for death [1] - is the most common cause of post-neonatal mortality and accounts for about 1/3 of all infant deaths between the ages of 1 week and 1 year, or about 0.3% of live births [2]. It seems to be a common occurrence throughout history, the many accounts written suggesting that its frequency today may be no greater than it was in the past.

Some of the earliest SIDS investigation was by Dr. Charles Templeman [3] who, as a result of his investigation into infant death in the town of Dundee in Scotland, considered local crib deaths had been caused by suffocation. The theory persisted until the 1950's when pathologist Francis Camps, and virologist Sir Samuel Bedson, finally proved this was not the case. Following Templeman's theory, there was a host of other theories ranging from allergies to inhalation of toxic fumes, and from parental smoking to the after-effects of the birth control pill - besides those possible medical causes put out by responsible scientific researchers, a comprehensive listing for the latter being given in Reference 4.

After many years of research, an organic cause still eludes us. But research has tended to concentrate on the organic side rather than on an environmental cause or stimulus that may be of equal importance. This is not saying that the environment has been totally neglected, only that less emphasis has been placed on its possible involvement than on other causes. In terms of the physical environment, certain combinations of temperature, pressure and wind velocity [5,6] have been postulated to be significant. In terms of epidemiology, there is much ongoing work perhaps stimulated by the pioneering work of pathologist Professor John Emery of the University of Sheffield. His environmental investigations [7] concentrate on 8 main factors; mother's age, mother's blood group, the length of labour, the state of the amniotic fluid in the womb, the presence of any urinary infection, the weight and gestation time, the baby's food, and the number of previous pregnancies of the mother. The State of Utah is carrying out such an investigation under the direction of the Medical Examiner, and including many more parameters with some limited data on the physical environment as well.

The western countries, with their great concern for health and welfare, keep detailed statistics, which in the context of SIDS are very interesting: The death rate attributed to SIDS is reasonably constant at about 0.3% of live births, except in the Netherlands and Scandinavia, where it is under 0.1% of live births [8], and in Finland, where it would appear to be almost nonexistent. (Admittedly, these differences could be due to differences in reporting.) Strangely, the latter country has by far the greatest occurrence of heart failure anywhere [9] which may, or may not, be relevant. Scandinavian communities in the United Kingdom and in the United States do not seem to be less prone to SIDS than the indigenous population. This too suggests that environmental influences may be of great importance in SIDS.

In cooperation with the Utah State Department of Health Council on Sudden Infant Death Syndrome, the local chapter of the SIDS Foundation, and the Office of the Medical Examiner, some initial investigation of SIDS occurrence has been undertaken over a two year period.

In the State of Utah, by law [10] all unexpected infant deaths must be referred to the Medical Examiner. There were 36 SIDS occurrences in 1975, 48 in 1976 and 48 in 1977. All have been documented in detail by the Medical Examiner. Examination of these show a pattern that suggests a strong environmental component in the syndrome.

1) The very thorough autopsies always undertaken found no apparent reason for any of the deaths. For those occurring in an automobile, the presence of carbon monoxide or other exhaust gas was an obvious choice for investigation. But no suggestion of any such cause was found in child or automobile.

2) Examination of the "Emery Parameters" together with such items as: the position and orientation of the child in the crib, bed or seat, the clothing worn and its composition, the food and feeding history, past medical history, the mothers'

feeding history, mothers' immediate past medical history, drugs taken by the mother (this has been reported in detail elsewhere), recent air pollution, ventilation, calidity, genetics, etc., differed from case to case such that no connections were evident between any of these parameters and SIDS.

3) But in Utah, the occurrences are not spread randomly throughout the inhabited areas of the state, nor do they follow the lines of greatest population density. Although the majority of cases do occur in Utah's three largest cities, most cities and towns remain clear. Just over 91% of occurrences are within a narrow band less than 3 miles wide broken into three areas with a combined length of less than 45 miles. This band runs north-south down the centre of a valley bordered on the east by the Wasatch Mountains, and on the west by the Oquirrh Mountains and the Great Salt Lake.

4) The bounded area is prone to temperature inversions, the visual pollution of the valley making the demarcation very obvious in these conditions. With the cases examined and correlated with the weather conditions of the time - comprehensive data supplied by the Utah Department of Meteorology and the weather services of KUTV (Salt Lake City) with extra details from the National We ther Service - every case, except those in automobiles, occurred in conditions of a strong temperature inversion and a very gentle breeze.

5) Within this band, there is a proliferation of cases in two distinct areas of Salt Lake City - not the centres of dense population.

6) There is a fairly large incidence of multiple occurrence. In one 12 hour period, Salt Lake City had 4 cases of Sudden Infant Death (and a number of suicides). The occurrence of suicides is being investigated by the Medical Examiner's Office to see if there is any correlation with the times of SIDS occurrences. Data on this is not yet at hand. But this is of greatest interest because in some parts of the world the occurrence of some natural climatic phenomena results in a spate of irrational behaviour with a very significant increase in suicides. For example, it is understood that, in West Germany, many works close down when the Foehn Wind blows because of the severe effect of the apparently related irrational human behaviour on production.

7) Of all these cases of Sudden Infant Death in Utah, all but 3 occurred in the family residence, the exceptions taking place in a nursery room of a sports pavilion in the city, and in automobiles. Although Utah has extensive recreational facilities, and there is a very large family involvement in the outdoors, no occurrence of SIDS - in 8 years of documenting - has been found in any recreational home, i.e. in any travel trailer or small caravan, tent, motorhome, small houseboat, or cabin cruiser, and none from any Indian Community still inhabiting primitive dwellings such as hogans. The same result appears from inquiries made in

other countries and states. In view of the fact that the average healthy western infant spends a significant proportion of its time in an environment other than a house or car, if SIDS is a disease unrelated to the physical environment, it is reasonable to expect some deaths elsewhere.

8) Extensive inquiries among bus companies, airlines, railway companies and shipping lines failed to find any SIDS occurrence. Help was given in these inquiries by the Greyhound Bus Company, Continental Trailways, Western Airlines, Amtrak and the Cunard Shipping Company. The death of a child is not uncommon in travel, but no circumstances it was felt suggested the occurrence of the Syndrome.

9) Preliminary investigations carried out by the local public health nurses show that in all the cases in residences (during the last three years in Utah) the room was of medium to large size. No case occurred in a room of small dimensions - less that about 800 cu. ft.

10) The occurrences seem quite independent of the socioeconomic status of the family, but not necessarily independent of the lifestyle of the family. Whether the mother is a home-maker or not may be a factor but there is not enough data yet in hand to make any preliminary conclusion on this.

11) In the child's sleeping quarters, windows and doors generally were closed with only a small electric night-light in operation, if any light at all. Inevitably there are reports of badly fitting windows and some draughts - which may, or may not, be significant.

12) Of those parents who were willing to talk to the nurse about the child's death, all reported their child did seem unduly "fussy" in its sleep and cried during the late evening and/or night; for some of the children this was unusual. (This of course increases the parent's feelings of guilt making an investigation much more difficult.)

13) Lengthy discussions have been had with the curators and the pathologists of some of Western America's largest and famous zoological gardens. These included San Diego, Denver and Hogle zoological gardens. The discussions also included several veterinary surgeons in the State of Utah. These discussions revealed that there appears to be no analogy to SIDS in animals. The pathologist at the San Diego Zoo felt that SIDS in animals ought to be a real possibility and that his extensive records over the past 12 years should be examined in detail before a definite statement of "SIDS does not occur in animals other than man" were made. There were no recent (last 3 years) cases that fell within the category and certainly none amongst the primates. But just because SIDS was not apparent in this period, he felt (quite rightly) it should not be ruled out. Other zoos - Hogle being one - had no cases of infant animal deaths which their authorities felt might not have a straightforward medical cause.

The question may be asked, "If Sudden Infant Death Syndrome is a 'disease', why is it so selective that it strikes only in certain physical situations?" The results of these investigations do not support a 'disease' theory alone, but point to an environmental parameter as a prime contributor towards the death. By no means does this rule out a disease being necessary. It merely suggests it is not a disease alone. The author is led to believe that a chain of events and circumstances leads to the final event of death and that an initial stimulus may be a parameter of the physical environment.

In our atmosphere there are a large number of physical parameters. But the range is reduced significantly when one isolates those parameters that may occur not only in a house, but also in a moving automobile, and not elsewhere. Of those physical parameters that we understand - and we must face the fact that there may be others of which we are totally unaware - some obviously call for examination: parameters such as static electricity, noise and vibration.

Noise is so far the only one of these to be investigated in Utah - because of the difficulties in forming a measurement technique for the other two - but some of the findings suggest there is a strong case for suspecting it to be very relevant. One of the few things in common with a medium sized room (as distinct from a small room) and a moving automobile is the natural low frequency resonance possible. In a car the low frequency sounds, it has been suggested [11], can be strong enough to affect the reaction time of the driver, but in a house one would not expect such intensities unless there is a source of such sound, and some enhancement (amplification) mechanism to make the sound effectual at a particular point and time. There is such a source of natural sound in the atmosphere that does disturb a large number of people [12] occurring, for reasons unknown, during peroods when there is a temperature inversion and gentle breeze, and rarely at other times. But the sound levels are extremely low (30 - 40 dB in the 31.5 Hz octave band) and the majority of people cannot hear the sound at all.

In a room, some enhancement is possible if the design and construction of the room, together with the temperature of the internal air, match the characteristics of the incoming sound. While high pitch sounds behave like light rays, being constantly reflected and re-reflected by the walls and ceiling of a room until finally they die away, low frequency sounds behave in a rather different way [13]. When the wavelength of sound is the same as one of the room dimensions, a "standing" wave can be set up in this dimension, in which case the sound in the room behaves rather like a pendulum whose rate of swing is determined by the length of the room and whose motion tends to persist for a fairly long time. It applies to all three main dimensions of the room - and also to any recess or in combination with furniture wherever facing flat surfaces occur - and even to the diagonals of the room.

For a room of any given size there are a number of sound frequencies which receive enhancement and die out much more slowly than other frequencies. These are called "eigentones" or "normal modes".

The sound pressure of such a normal mode in a room is not uniform across the room but has certain positions in the dimension where the sound pressure level is a maximum and a minimum. If the dimensions of the room are such that a natural eigentone matches incoming low frequency noise from the atmosphere (and in many areas all over the world, in a temperature inversion such low frequency noise is readily measurable), then the room will respond to the sound, creating elevated sound pressure levels at specific positions in the room - thus constituting an enhancement mechanism. Further enhancement results if the sound enters the room (as a large cavity) through a narrow opening such as a small or partially open window [14]. Even so the levels produced from naturally occurring low frequency sound are still very low (in the order of 50 dB in the 31.5 Hz octave band) and inaudible to most people.

However, in Utah, in those rooms in which a SIDS had occurred, every room that could be examined had a normal mode frequency of between 35 and 45 Hz (depending on the temperature), matching those produced inside a small car in motion. Perhaps more relevant, a position of maximum sound pressure was found in the approximate location of the child, as far as can be ascertained from the evidence. Physical excitation and measurement was not possible for obvious (psychological) resaons, although it is hoped that in the near future such may be possible in the right circumstances.

One, of course, may justifiably be skeptical that such a low sound level could set off a chain reaction resulting in death. Elder children (over 18 months of age) are apparently quite unaffected, as are grown-ups, and one wonders how such a noise could affect a small child, if indeed it is the noise that acts as the initial stimulus. With just this one parameter being identified so far in all the 130 cases examined, and no similar occurrence of any of the other parameters examined, it does suggest the possibility of a relationship between the sound and the event. But the author is finding it difficult to plan how best to proceed with the investigation when there appears to be so much antipathy to finding a cause and hence planning preventative measures.

The mechanism for such a noise affecting a child to cause SIDS remains an enigma. But, some years ago, the author investigating an area of severe disturbances from such a low intensity, low frequency sound in the atmosphere, found a possible relation between the geographical limits of the sound disturbance and endemic mild dysentry [15]. Following the research he amplified a recording of the sound (which actually he could not hear at all without significant amplification) and experienced extreme vibration within the head and an immediate significant hearing loss. Little recovery in the succeeding week led to hospital admission and major surgery to repair damage that the author put

down to the noise exposure. (Regrettably there is no medical proof of such a causal relationship.) Analysis of the recording located a distinct spectral pattern in the 40 Hz region, a pattern that seems to be duplicated in all the Utah homes examined in connection with SIDS.

This leads the author to believe that natural low frequency sound is a candidate for being the initial stimulus to a chain of events/reactions that lead to Sudden Death in Infancy, if the child is "receptive" to such a stimulus - a behavioural or medical condition or disease. When he experienced the severe internal vibration from the amplified sound - a variation of which, most regrettably, is believed to be in use by the military of several Western powers for crowd control - the author felt that entry was via direct conduction through the skull rather than through the auditory system. Up to the age of about 18 months, a young child's skull is not fully developed and awaits closure of the fontanelle - a condition common to all the SIDS victims examined. This may act as the easy entry point for the low intensity sound wave into the cavity producing slightly amplified sound inside. But at the moment this is pure speculation, for research work involving acoustic examination of the infant cadaver head was refused authorization and has not gone ahead.

The author is well aware that consideration of a mere 130 cases in Utah is circumstantial, hardly representative of the world at large, and by no means can provide valid medical evidence. Much more is required in other countries and states, and research is going ahead in this direction with sound as one of a number of physical parameters being investigated. Any constructive criticism or ideas how best to proceed would be very welcome.

If such a chain of events is involved, the removal or weakening of one of the links could decrease the incidence of this major cause of infant death.

REFERENCES

1. Beckwith, J. B. "Discussion of Terminology and Definition of Sudden Infant Death Syndrome" in Proceedings of the Second International Conference on Causes of Sudden Infant Death. Seattle 1970. University of Washington Press.

2. Valdes-Dapena, M. A. "Progress in Sudden Infant Death Research" in Proceedings of the Second International Conference on Causes of Sudden Death in Infants. Seattle 1970. University of Washington Press.

3. Templeman, C. "Two Hundred and Fifty Eight Cases of Suffocation in Infants". The Medical Journal, Edinburgh vol 38 p 322 1893.

4. Beckwith, J. B. "The Sudden Infant Death Syndrome" U.S. Department of Health, Education and Welfare. HSA 75-5137

5. Steele, R. "Sudden Infant Death Syndrome in Ontario, Canada: Epidemiologic Aspects" Proceedings of Second International Conference on Causes of Sudden Death in Infants. Seattle 1970. University of Washington Press.

6. Kraus, A. S. et al. "Further Epidemiologic Observations on Sudden Unexpected Death in Infancy in Ontario". Canadian Journal of Public Health vol 62 p 210 1971.

7. Emery, J. L. and Carpenter, R. G. "Clinical Aspects of the Sheffield Prospective Study of Children at Possibly Increased Risk" Toronto. Canadian Foundation on the Study of Sudden Infant Death. 1974.

8. 'The Listener' U.K. report on Sudden Death in Infancy: "Why Did Stuart Die" BBC 2 Horizon documentary May 1976.

9. Sunday Times demographic report of morbidity, December 1976, and Readers Digest report, also December 1976.

10. Law of Utah 26-20-7 "#2 and #8" Annotated 1953. Repealed and reennacted under provisions of section 26-20-8 of the Law of Utah 1973.

11. Evans, M. J. and Tempest, W. "Some effects of infrasonic noise in transportation." Journal of Sound and Vibration Vol 22 (1) pp 19-24. 1972.

12. Dickinson, P.J. "Noise in the Environment" Proceedings of Institute of Biology Conference. January 1973. London.

13. Parkin, P. H. and Humphreys, J. R. "Acoustics, Noise and Buildings:. Faber 1958. p 47.

14. Guy, Roger W. Concordia University, Montreal, Private Communication.

15. Dickinson, P. J. "Low Frequency Noise Disturbance at Hereford" Report to Medical Officer of Health, Hereford, U. K. Institute of Sound and Vibration Research, Southampton. 1971.

SOUND ECONOMY

REPORT BY A MANAGEMENT CONSULTANT ON A CONCERT AT THE ROYAL FESTIVAL HALL, LONDON

For considerable periods the four oboe players had nothing to do. Their numbers should be reduced, and the work spread more evenly over the whole concert, thus eliminating peaks and troughs of activity. All twelve violins were playing identical notes. This seems unnecessary duplication. The staff of this section should be drastically cut; if a large volume of sound is required it could be obtained by means of an electronic amplifier.

Much effort was observed in the playing of the demi-semi- quavers. This seems an excessive refinement. It is recommended that all action should be rounded up to the nearest semi-quaver. If this were done, it should be possible to use trainees and lower grade operatives more extensively.

There seems to be too much repetition of some musical passages. Scores should be drastically pruned. No useful purpose is served by repeating on the horns a passage which has been handled by the strings. It is estimated that if all redundant passages were eliminated, the whole concert time of two hours could be reduced to twenty minutes, and there would be no need for an interval.

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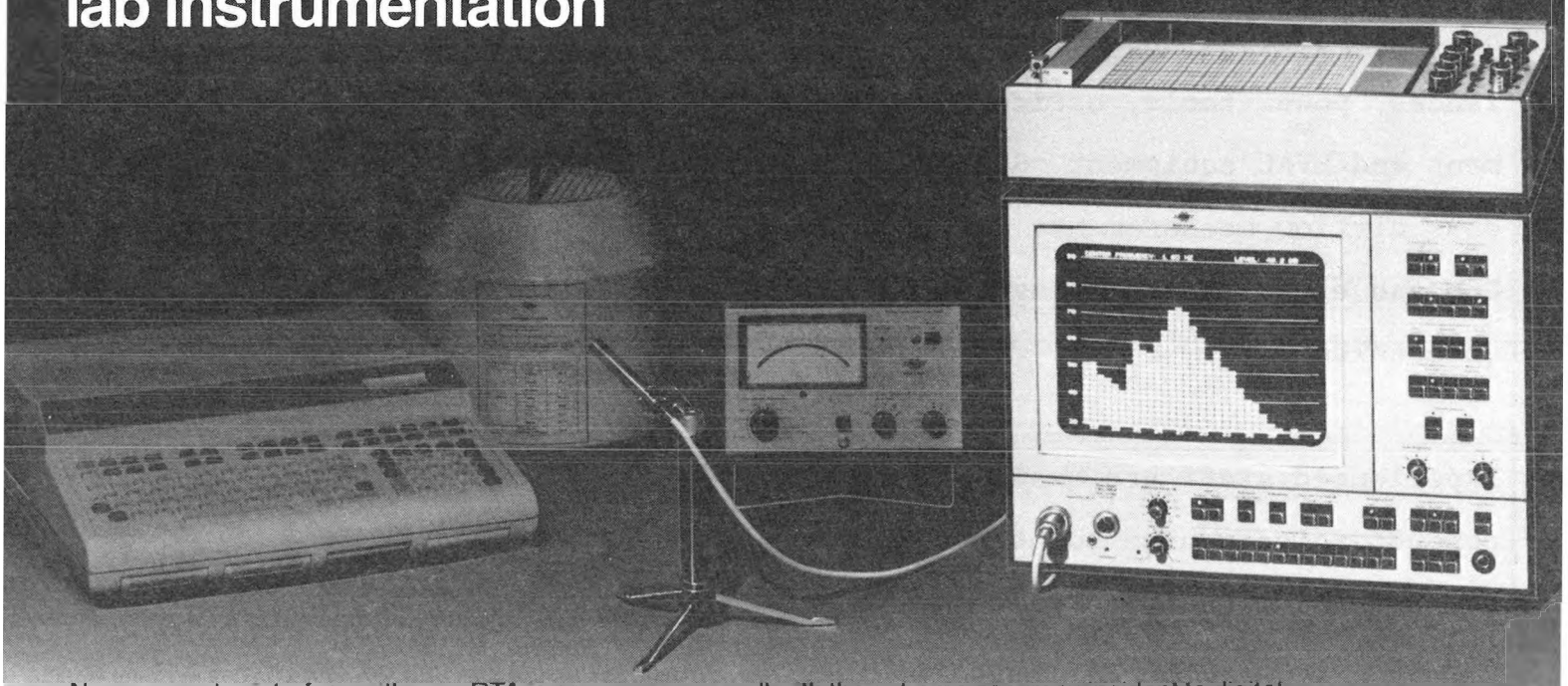

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