

SALLY CLARK APPEAL

Statement of Professor A. P. Dawid

I. PREAMBLE

1. I am Professor Philip Dawid, of the Department of Statistical Science, University College London. I have been a Professor of Statistics for over 20 years, and have published over 100 research papers. I have been a vice-President of the Royal Statistical Society, and Editor of the *Journal of the Royal Statistical Society* Series B (Methodological) and of *Biometrika*. I am currently President of the International Society for Bayesian Analysis. In recent years I have had a special interest in the use and misuse of Probability and Statistics in legal evidence, and have given expert evidence on these issues in a number of court cases, as well as having written several research papers relating to them.
2. My attention has been drawn to the use of evidence and arguments relating to probabilities in the trial of Sally Clark. I have been asked to comment on the appropriateness of these.
3. In his evidence at trial, Sir Roy Meadow testified that the probability of there being two deaths from SIDS (sudden infant death syndrome) in one family was about 1 in 73 million. This figure was based on a report “Sudden Unexpected Deaths in Infancy” (SUDI) which has since been published by The Stationary Office.
4. I wish to address two aspects relevant to this evidence:
 - The calculation of the figure “1 in 73 million”.
 - The relevance of any such figure to the case at issue.

Of these, the second point is by far the more important. However, I shall begin by considering the first point.

II. CALCULATION OF THE QUOTED PROBABILITY

5. The SUDI study was conducted between February 1993 and March 1996 in a study area consisting of five regions of the country, having a total population of nearly 18 million. During the study period there were around 470,000 live births in the study area. 456 of these babies suffered sudden unexpected death in infancy (SUDI), 363 of these deaths being classified as cases of SIDS. Of these, 325 were subjected to further analysis. For each of the 325 “index cases”, four “control” babies, born at around the same time but not suffering

SUDI, were identified by the health visitor. For both index and control cases, a number of possibly relevant characteristics of the family, baby, etc. were measured. Statistical analyses were conducted with the aim of discovering differences between such characteristics, which might distinguish the index (SIDS) babies from the control (non-SIDS) cases.

6. The figures presented in court were based on Table 3.58 of the SUDI report, which purported to classify the risk of SIDS according to “the three prenatal factors with the highest predictive value”:

- Anybody smokes in the household
- No waged income in household
- Mother less than 27 years and this child not her first.

An incidence rate of SIDS was given for various possible states of information about these factors:

- Presence or absence of each of these factors, considered individually
- Presence of none of these factors
- Presence of exactly one of these factors
- Presence of exactly two of these factors
- Presence of exactly three of these factors

In the case of Sally Clark, none of the above factors was present. For such a case, the table gave a rate of 0.117 SIDS cases per 1000 live births, i.e. **1 in 8,543 live births**. The figure of 1 in 73 million mentioned at 3 above was calculated by squaring this ($8,543 \times 8,543 = 73 \text{ million, approximately}$). I address the relevance of this calculation in paragraph 11 below.

7. On the basis of the report, the SUDI study appears to have been carefully planned and executed. However, there is insufficient detail in the report for me to fully understand the basis for the calculation of the figures in its Table 3.58, or to fully assess their likely accuracy. The three factors tabulated were themselves selected, by routine statistical methods, on the basis of the study data. Whereas such methods may be appropriate for suggesting broad general hypotheses about the relationship between the outcome studied (here SIDS) and possible explanatory factors, it can be very misleading to use them to construct precise numerical formulae for predictive or explanatory purposes. This is because any statistical study is affected by natural variability in the population, so that repeat studies might well identify different sets of variables as being most relevant. Those identified in any particular study will, by the very nature of the variable selection process, classify the cases in that study most accurately; but this accuracy will drop, often substantially, when the same formulae are applied beyond the confines of that particular study.
8. The report does not make it clear how the estimated rate of 0.117 per 1000 live births was calculated, but by making some rough and ready assumptions I can get an idea of the precision that might reasonably be attached to this estimate. This rate bears a ratio of around 0.15 to the overall rate of 0.768 per 1000 observed in the study population. Because the study is of the “case-control”

variety, constructed to have an artificial rate of 1 SIDS case in 5, adjustment has to be made for this. Taking this into account, the following is a set of possible (though purely speculative) figures obtained from the study that could have led to this estimate:

	SIDS	CONTROL
NO FACTORS	4	100
AT LEAST ONE FACTOR	321	1200

If we now apply simple statistical techniques for assessing the precision of an estimate based on limited sample data, we find that a reasonable interval of plausible values for the SIDS rate among cases having no factors goes from **0.04 to 0.32 deaths per 1000 live births**. In particular, there is no reason to exclude a rate of about 3 times that quoted. When squared, this would lead to a figure of about 1 in 9 million, rather than 1 in 73 million.

If further details were made available of the actual data used and calculations conducted, I could conduct a similar analysis. Although the results might differ from the speculative ones above, the general point remains that there is considerable statistical uncertainty attached to the figures quoted.

9. Taking further account of the fact that the factors were themselves selected on the basis of the study data (see paragraph 7 above) is likely to extend still more greatly the range of plausible values for this figure. The resulting additional uncertainty might well completely swamp that identified above. Given access to the original data, and some intensive and non-trivial computation, some assessment of the effect of this could in principle be made.
10. Over and above the question of the accuracy of the quoted rate, there is the still more important question of its appropriateness to the specific case of Sally Clark. Births can be classified according to a large number of characteristics, some of which were included in the study, and others, of necessity, excluded. To the extent that a SIDS death rate is considered relevant at all, it should be tailored as closely as possible to *all* the characteristics of the Sally Clark case — not just the three that were picked out on the basis of the statistical study. This adds yet another major source of uncertainty (albeit difficult to quantify) to the quoted estimate.
11. I now turn to consider the appropriateness of squaring the figure 1 in 8,543 (here considered, purely for the sake of illustration, to be correct) to obtain the figure of 1 in 73 million for the probability of two babies dying of SIDS. This would be relevant if, and only if, the SIDS death rate for the second child remained at 1 in 8,543, even after it was known that the first child had died of SIDS. The SUDI report is misleading on this issue. On page 92 it says “Since the factors will generally remain the same..., the risk of SIDS to a subsequent child in a family in which one infant has already died will range from 1 in 214” (the estimated rate when all three of the chosen risk factors are present) “to 1 in 8,543. This does not take account of possible familial

incidence of factors other than those included in Table 3.58.” But it is vital to take account, at least informally, of such other factors, since it is highly plausible that there are unmeasured characteristics, be they genetic or environmental, that will be shared between the two babies, and whose presence would predispose to SIDS. Then, after learning that one baby has died from SIDS, it becomes much more likely that such predisposing factors were present in that baby, and, therefore, also in the other — thus raising, perhaps greatly, the probability that the second baby will die of SIDS, and leading to a probability of two SIDS deaths which is very much larger than the figure of 1 in 73 million based on squaring.

The argument for squaring might be that the implicitly assumed independence of the two deaths is a default position, appropriate when further information is lacking. However, this is far from the case — it is a very extreme and *a priori* unreasonable position, which should not be assumed without justification.

12. Taking into account all the above considerations, whether or not easily quantifiable, the general message must be that the quoted figure of 1 case in 73 million for two babies dying of SIDS must be regarded as, at the very best, a “ball-park” estimate subject to very considerable uncertainty. There is a very wide range of possible values consistent with the data, and it would be hard to rule out a figure of 1 in one million, or even much higher.

III. RELEVANCE OF THE QUOTED PROBABILITY

13. It might be thought that, so long as the probability of two children in one family dying of SIDS is very small, its exact value is of little relevance. This is entirely mistaken. The vital issue is: just what use is to be made of such a probability? — an issue that was not even raised in the original trial.
14. One must infer that the “logic” implicitly applied at trial was as follows. A certain event (deaths of two babies in one family) has occurred. We are unsure of the cause. One possible cause is that both babies died of SIDS. However, the probability of two babies in the same family both dying of SIDS is extremely tiny. Therefore, we can exclude that possibility (and, in consequence, accept that the babies were murdered — if that is the only alternative).
15. This entirely fails to take account of the fact that the event observed is extremely improbable under **any** of the possible causes: fortunately, cases in which two babies in the same family die, of any cause whatsoever, are extremely rare. We could equally well have applied the above “logic” to deduce that the babies could not have been murdered – since families in which two babies have been murdered are also extremely rare. We could even have argued that the observed event, of two babies in the same family both having died, could not really have happened — since such an event is extremely rare. These clearly ridiculous conclusions demonstrate that the “logic” of paragraph 14 above is entirely fallacious.

16. The following spurious argument should serve to emphasise this. In 1996 there were 649,489 live births in the England and Wales. On these babies, 14 were later classified as having been murdered in the first year of life. If we were to take the ratio $14/649,489$ as our estimate of the probability that a single baby will be murdered in the first year of life, and manipulate it in exactly the same way as we did the SIDS rate, we would calculate that the probability of two babies in one family both being murdered is $(4/649,489)$ times $(4/649,489)$, which gives 1 in 2,152,224,291. On this basis, the “logic” of paragraph 14 above would imply that we could essentially exclude the possibility that Sally Clark’s two babies were murdered.
17. What, then, is the appropriate logic, and what figures would be needed to put it into effect? First, it is clearly inadequate to concentrate on a single cause of death. If we make an assessment of the probability of two babies in one family both dying from SIDS, we must equally make a similar assessment of the probability of two babies in one family both being murdered (and so on, for any other causes that may be under consideration). I do not advocate simply using the illustrative figure given in paragraph 16 above for this probability — its realistic estimation would be subject to all the caveats and cautions that have already been sounded above for the case of estimating the probability of two deaths from SIDS. Nevertheless, this figure is clearly tiny also.
18. The laws of probability now focus attention on, not the absolute values of these probabilities of the two deaths in one family arising from the different causes considered, but on their **relative** values. Purely as an illustration, suppose that the probability of two deaths in one family from SIDS was taken to be 1 in 5 million, while that for two deaths in one family from murder was 1 in 15 million. That means that the cause “SIDS” is three times more likely than the cause “murder”. We have observed two deaths in one family in the case of Sally Clark. If we can exclude any other possible causes than SIDS and murder (and ignoring for the moment any other evidence in the case), we know that one of these must be the cause of the observed event, so we can deduce that the probability that the babies both died from SIDS is three quarters, while the probability that they were both murdered is one quarter.
19. To elaborate the above argument, consider a hypothetical population containing (say) 150 million families, essentially identical with that of Sally Clark. Out of these, we would expect to find about 30 (i.e., 1 in 5 million) in which both babies died of SIDS; and about 10 (i.e., 1 in 15 million) in which both babies were murdered — a total of 40 families in which two babies died. Now we know that, in Sally Clark’s family, both babies died, so it is one of these 40 families. In the absence of any further evidence, we have no reason to consider it more likely to be any one rather than any other of these 40 families. Since in 30 of these 40 cases death is due to SIDS, the relevant probability that Sally Clark’s babies died of SIDS is thus $30/40$, i.e. three quarters; and similarly the probability that they were murdered is one quarter.
20. We next have to take account of the other, medical, evidence in the case. While I have no expertise to evaluate this evidence, I can explain the logic of

how it should be quantified and combined with the purely statistical evidence which has been the subject of discussion so far.

21. It is necessary to make an assessment (formal or informal) of the probability of observing the medical evidence, under each of the two causes under consideration. The relevant figure to extract is then the ratio of these probabilities. Thus, again purely for illustration of the necessary calculations, suppose that the probability that the specific medical signs observed would in fact be observed, on the hypothesis that the babies were murdered, was assessed at 1 in 20; while the probability of these same signs being observed on the hypothesis that they died of SIDS was taken to be 1 in 100. The ratio of these figures is 5. Before taking account of the medical evidence, we might have judged (as in paragraph 18) that the probability of the cause murder was one-third that of the cause SIDS. The effect of the medical evidence is to multiply this ratio by the new ratio of 5. The final ratio is thus 5:3 for murder as against SIDS — leading to a final probability of five eighths (0.625) that the babies were murdered. Justification for this calculation can be provided in a very similar fashion to that given in paragraph 19 above.
22. Lest it seem that I am trespassing where I have no expertise, I once again emphasise that the illustrative figures used in the above calculations are entirely artificial, and should not be taken as part of my evidence. They are that merely to illustrate the form of the logically correct calculations of probabilities in this case. I could have avoided suspicion of foisting my own unjustified numbers on the court by expressing the argument purely in terms of algebraic symbolism — but I feel that the above explanation, if taken in the purely illustrative fashion intended, is far more likely to be of value.

IV. CONCLUSION

The figure “1 in 73 million” quoted in Sir Roy Meadow’s testimony at trial, as the probability of two babies both dying of SIDS in a family like Sally Clark’s, was highly misleading and prejudicial. The value of this probability has not been estimated with anything like the precision suggested, and could well be very much higher. But, more important, the figure was presented with no explanation of the logically correct use of such information — which is very different from what a simple intuitive reaction might suggest. In particular, such a figure could only be useful if compared with a similar figure calculated under the alternative hypothesis that both babies were murdered. Even though assessment of the relevant probabilities may be difficult, there is a clear and well established statistical logic for combining them and making appropriate inferences from them, which was not appreciated by the court.