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A review of role of rosta data and evidence of attendance in cases of suspected excess deaths in a medical context.

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Abstract

Several cases are reviewed where medical practitioners and carers have been accused of harming those in their charge. A particular focus of attention has been the ‘evidence of attendance’ where the numbers of deaths over a period of time exceed those normally expected in comparison with historical death rates in relation to a particular medical professional or carer. The logical structures underpinning the evidential reasoning are examined from the legal and scientific standpoints, and the issues involved in the use of statistical evidence of association are discussed.

Introduction

The dramatic arrest, trial and conviction of Dr. Harold Shipman on the 30th January 2000 for the murder of 15 patients raised awareness amongst the British public that both physicians and nurses occasionally abuse their professional position to harm patients in their care. The criminal career of Shipman had potentially spanned 25 years. Estimates as to the total number of murders committed range from 350 to 1000; more sober estimates put the number at 116.

Shipman does not present a unique case. In recent years there have been several instances of carers and medical practitioners who have been suspected of, and, in some cases, convicted of, the illegal killing of their patients. In December 1999 nurse Orville Lynn Majors¹ was convicted of the murder of 6 patients at Vermillion County Hospital, Clinton, Indiana, USA, between 1993 and 1999. It is thought that Majors was associated with up to 130 unnatural deaths of hospital patients. In January 2001 Efren Saldivar² was detained on six charges of murder committed whilst he was a respiratory therapist

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in Los Angeles between 1996 and 1997. It is thought he may be associated with between forty and fifty such suspicious deaths. Kristen Gilbert³ was convicted for the murder of four patients at Springfield Veterans Association Hospital, Massachusetts, USA between 1983 and 1997. Dr. Michael Swango⁴ was convicted of the murder of four inmates of Ohio State University Hospital. It is thought he was responsible for up to 130 deaths throughout the USA, and in Africa where he had worked for a short while. However, the phenomenon of medical practitioners taking the lives of patients is anything but new. Kinnell⁵ relates the murderous activity of Dr. Edme Castaing who dispatched two of his patients with what was then a new drug, morphine, in 1823, presumably motivated by financial gain from their deaths as he had forged their wills in his favour. A different approach was taken by US citizen Dr. Thomas Graves who persuaded a rich widowed patient to make her will out in his favour, then sent her a poisoned bottle of whiskey. He subsequently poisoned himself in his cell in 1893.⁵

Compare these cases with the most notorious serial killers. David Berkowitz, the self styled 'Son of Sam', killed six young women between July 1976 and August 1977. Ted Bundy is thought to have murdered 36 women between December 1973 and February 1978. John Wayne Gacy Jr. killed as many as 33 young men between 1972 and 1978. If the numbers of possible victims are to be believed, then it is only the most prolific of serial killers who match the sheer numbers of victims of suspects who are based in a clinical environment. Also, in high profile cases where serial killing has been suspected there are no reported instances of charges against a person who is not a member of a medical profession being dropped, or of a case not being tried on the basis of insufficient evidence. However, in cases where the suspect is a physician, or nurse, then there are several instances of charges being dropped, or the suspect being acquitted, or even of the case not being tried at all. Anecdotal evidence suggests that there may be many such cases,⁶ implying that it is more difficult to pursue a case where a nurse or physician is the suspect. In this paper, this phenomenon is examined by looking at the relative importance of various types of evidence in cases where the defendants have been employed in a medical, caring, or parental position with respect to their victims.

An important measure of association between the presence of a carer and the occurrence of an event of interest (e.g., death) is the relative risk. A description of this measure and some of the issues involved in its estimation are given in Appendix 1.

Case studies

Case Study 1 - Nurse Jessie McTavish, Glasgow, Scotland, 1973.

On Monday 7th October 1974 Jessie McTavish was sentenced to life imprisonment for the murder of a patient in Ward 5 at Ruchill Hospital, Glasgow⁷. The indictment also featured a number of other charges of administering a variety of substances with intent to cause harm. The evidence consisted of toxicological assays from several victims, one of which was found to contain pethidine, the others soluble insulin. Apparently the change to the use of soluble insulin was inspired by the US television series 'A Man Called Ironside', which McTavish was said to have discussed with colleagues in the context of an untraceable agent for homicide. Colleagues told the court of how McTavish injected a patient (not the murder victim) with an 'excessive' dose of phenobarbitone, making no record of the fact, and McTavish saying that '... Doctor likes them to go quietly'. Testimony was given by various members of staff that McTavish was in the habit of giving injections without recording these events in the patients' case notes. Finally, there were admissions by McTavish against her interest whilst under police custody where McTavish admitted administering insulin without authorisation. Following her conviction Jessie McTavish successfully appealed on the grounds that the jury were misled by the court's decision to admit evidence of her admission of guilt. In 1976 Jessie McTavish married, becoming Jessie Gordon. In 1984 she was restored to the Professional Register of the United Kingdom Central Council for Nursing, Midwifery and Health Visiting.

Case Study 2 - Nurses Narciso & Perez, Michigan, USA, 1975.

In the summer of 1975 the rate of cardiopulmonary arrests at a Veterans Administration Hospital in Ann Arbor, Michigan, USA quadrupled^{8,9} from their usual rate. No changes in background circumstances were identified except for the presence of two nurses, Filipna Narciso and Leonora Perez in the Intensive Care Unit (ICU). At their trial the prosecution presented eyewitness evidence from other patients that the suspects were the only people present when a muscle relaxant had been injected into the victims. This evidence was used to support the case that the defendants had administered a muscle relaxant without prescription, and that the injections were responsible for patients' deaths through respiratory arrest. The eye-witness testimony was said to be 'confusing' and 'inconsistent', but the jury eventually found that the defendants were associated with some of the deaths. However, this verdict was set aside as it was felt by the court that the prosecution case had to some extent been misstated, and that it encouraged the jury to engage in 'a speculative combination of charges'. The court instructed the jury to not regard evidence from one charge as being relevant to any other charge (i.e. each charge should be considered separately). This led to a position where the suspects were only '*not excluded*' from consideration for each possible offence, any legitimate use of an overall correspondence between all events and the presence of the two suspects being precluded from consideration. The case was dismissed.

Case Study 3 - Nurse A, Toronto, Canada, 1981.

Buehler¹⁰ reports an epidemic in the cardiology unit of a Toronto children's hospital in the period July 1980 to July 1981. During this period the mortality rate nearly quadrupled, compared to the preceding 54 months. 76% of the deaths occurred between midnight and 6:00 a.m. as compared with 10% of the deaths in a separate 27 month period for which figures were available. Nearly all of the deaths occurred in patients with serious congenital heart conditions. The deaths associated with the epidemic had abnormal timings in terms of their disease progression and the deaths were consistent with digoxin toxicity. Four patients were examined and blood digoxin measurements were consistent with an intravenous overdose shortly before death. The nursing schedules revealed a relative risk of 64.6 for children connected with a particular nurse (Nurse A) after all innocent explanations for the deaths had been excluded[†]. Originally, another nurse (Susan Nelles) had been arrested as the two nurses together had been associated with the largest number of deaths. However, the relative risks for patient mortality, calculated from nursing staff attendance data, suggested the involvement of Nurse A individually and Susan Nelles was released. Nurse A was never arrested.

Case Study 4 - Sandra Pankow, Wisconsin, USA, 1980-1982.

Sandra Pankow⁸ ran a baby-sitting service from her home in Wisconsin, USA. Eyewitness accounts state that infants were sometimes confined in their play-pen or crib by the placement of a sheet, blanket, or board across the top. Other children were gagged with towels across their mouths. Two deaths of infants in her care (one in 1980 and one in 1982) were attributed to Sudden Infant Death Syndrome (SIDS). A third death in 1985 was found to be due to asphyxia. The coroner ordered exhumation of the previous two infants and they were also found to have died from asphyxia. Pankow was convicted of the murder of two of the children on a wide range of evidence from various pathologists. Statistical evidence on the probability of observing three or more SIDS deaths in the five year period assuming 20 children permanently and perpetually in care, was given as 0.91×10^{-13} from a binomial distribution with $n = 20$ and $p = 0.00002$, where n corresponded to the number of children and p denotes the probability of death from SIDS amongst a population of otherwise healthy children.

A defence criticism at the time was that a Poisson distribution may have been a more suitable model because of the rarity of a SIDS death, but no further details were given. In particular, it does not seem to have been recognised that the Poisson distribution is simply an approximation to a Binomial distribution in this mathematical context. The children were from unrelated families so an assumption of independence amongst the

[†]A relative risk (see Appendix 1) of 64.4 means that children on the ward were 64.4 times as likely to die whilst Nurse A was on duty as when Nurse A was off duty.

deaths was reasonable as any underlying biological predisposition towards SIDS within a family did not need to be considered.

Case Study 5 - Nurse Geneene Jones, Texas, USA, 1981-1982.

In the period April 1981 to June 1982, the Paediatric Intensive Care Unit (ICU) of San Antonio Medical Centre, Texas, experienced an epidemic of cardiopulmonary arrests¹¹. Gregory Istre, the investigating epidemiologist, established that the deaths could not be attributed to the clinical status of the patients, and that the risk of death when one nurse, Geneene Jones⁸, was on duty, was 10.7 times that when the same nurse was off duty. There was also a 25-fold increase in the risk of a cardiopulmonary arrest when Jones was on duty. Jones was indicted on the charge of injuring a particular child (one who had suffered repeated cardiac arrests, but who had not died as a result of them)¹¹ by the repeated injection of large doses of heparin. The appeal court did accept that there was no direct evidence of Jones' involvement with the deaths at San Antonio. However, circumstances changed when a separate case featured Jones' involvement with a number of respiratory arrests at a paediatric clinic in Kerrville, Texas, in August 1982. There it was found that Jones had injected six infants with succinylcholine chloride leading to death. Jones was then charged with a single murder, and no statistical analysis was undertaken. Despite only one charge being brought against Jones the court admitted evidence from all the earlier incidents, and eventually sentenced her to a prison term of 99 years.

Case Study 6 - Nurses 18/7, 1984, Florida, USA.

Sacks¹² details the investigation into a number of deaths at a nursing home over a period of a fortnight in November 1984. The expected number of deaths for the institution was 2.5, this figure had risen to 12. The investigators eliminated all innocent sources such as water supply and infectious disease, and concentrated their investigation around the members of staff. Relative risks were calculated for all members of staff. Insulin administration was suspected by the medical examiner so relative risks were also calculated for all members of staff with a displacement of up to eight hours to account for the length of time taken for insulin to cause a terminal decline in health. The analysis highlighted a strong positive association between two members of staff, nurses identified as numbers 18 and 7, and the deaths of patients. One nurse was subsequently arrested.¹³ She pleaded guilty to four charges of manslaughter and one charge of attempted murder.

Case Study 7 - Nurse Jane Bolding, Maryland, USA, 1984.

There was an unusually high number of cardiopulmonary resuscitation incidents in the ICU at Prince George's Hospital Centre, in Maryland, USA, in late 1984. Some patients had multiple arrests and hyperkalemia,^{‡14} and all were under the individual care

[‡]high levels of blood potassium

of nurse Jane Bolding. In March 1985, after one patient suffered six arrests on Bolding's shifts, Bolding was suspended from work and a police investigation started. Two weeks later Bolding admitted killing two patients, and was charged with one murder, but the charge was later dropped because there were doubts about the admissibility of the confession.⁸ Upon presentation of a Centre for Disease Control (CDC) report¹⁵, a Grand Jury indicted Bolding on two charges of murder using Potassium Chloride (KCl) injections to precipitate cardiac arrest in patients. There was a relative risk of 47.5 for the occurrence of an arrest for Bolding's patients relative to patients of other nurses. The probability of the large number of cardiac arrests seen during the evening shift at the time was $\approx 10^{-16}$ based on shift specific, pre-epidemic rates for cardiac arrests in the ICU. Writing on this case Sacks *et al.*¹⁴ cautioned that 'statistical analysis cannot address such factors as exclusive access to patients or intent', but an expert consultant commented that the symptoms were consistent with 'unexplained hyperkalemia' which has been taken to mean the potassium levels found in those arrested patients were caused by deliberate and unauthorised administration of KCl.⁸ Although the court admitted the evidence of association, and the pathological evidence, it eventually granted a motion for acquittal and Jane Bolding was never convicted. However, the timings and consistency with disease course suggest Bolding may have been associated with up to 23 arrests, 17 of which resulted in death.¹⁴

Case Study 8 - Nurse Terri Rachals, Georgia, USA, 1985.

In the autumn of 1985 cardiac arrests amongst patients at a hospital in Georgia (USA) showed a large increase over normal expectations.⁸ Adelle Franks, the investigating epidemiologist, examined the overall frequency for these types of arrests and found that the usual monthly frequency was between zero and four. In November 1985 eleven cardiac arrests were recorded, and all occurred on an early morning shift (3:00 to 11:00 a.m.). Franks is reported as estimating the probability of this occurrence at $\approx 10^{-13}$. All the deaths had occurred whilst the patient was in the care of surgical nurse Terri Rachals, who was subsequently charged with causing six deaths by the administration of potassium chloride, and twenty other charges of aggravated assault. The jury found Rachals not guilty on all six murder charges, but Rachals had admitted a mercy killing of an individual patient in her charge. Franks' analysis revolved around the calculation of a 'rate ratio' (which appears simply to be a relative risk) for each of the 24 nurses employed. For all other nurses, the rate at which their cardiac patients suffered arrests whilst they were on duty, compared to when they were off duty, was ≈ 1 . For Rachals the 'rate ratio' was 26.6, which meant that a patient in her care was 26.6 times more likely to suffer an arrest when she was on duty than when she was off duty. The court held 'serious reservations about mathematical computations as to the probability of guilt', but given the additional fact that KCl was found in the intravenous tubing of a feed Rachals had

just commenced, Rachals was convicted of aggravated assault, but whilst mentally unbalanced, and was sentenced to seventeen years imprisonment^{13§}. The jury may have been troubled by the prosecutor's fallacy. This is a fallacy in which a small probability for the evidence, if the defendant is innocent, is confused with a small probability of innocence. The evidence here is the relative risk and the small probability is the probability of observing a relative risk value of 26.6 if Rachals were truly innocent. Further discussion of this is given in Appendix 1.

Case Study 9 - Nurse Beverley Allitt, Lincolnshire, England, 1991.

From February 1991 until nurse Beverley Allitt was arrested in May 1991, Ward 24 at Grantham and Kesteven General Hospital, Lincolnshire, England, suffered an unprecedented increase in deaths and incidences of cardiac and pulmonary arrests among child patients¹⁶. Post-mortem examinations carried out on the victims revealed nothing except in the case of one child where blood tests indicated that the child had been wrongfully injected with a massive dose of insulin prior to pulmonary arrest. All innocent causes for the spate of illnesses in the ward were eliminated, and it became clear that a member of staff had been harming the children. A police investigation was started and it was established that Allitt was connected with most of the cardiac and pulmonary arrests and deaths. Allitt was arrested in May 1991 and convicted in May 1993 of the unlawful killing of four children by insulin injections, potassium chloride injections, and by smothering. She was also convicted of the attempted murder of three children and the grievous bodily harm of six children. The conviction was based largely on Allitt's confession, all pathological, toxicological, and statistical evidence being used only in a supporting role. Allitt was found to be suffering from Munchhausen Syndrome by Proxy¹⁷ and was sentenced to 13 life sentences.

Case Study 10 - Sally Clark, Cheshire, England, 1996-1998.

On the 27th of November 1999 Sally Clark was convicted of the murder of two of her sons, Harry by smothering or shaking on the 26th January 1998, and Christopher by smothering in December 1996¹⁸. The evidence revolved around whether the injuries supposedly observed during the post-mortems were due to some form of assault or resuscitation attempts, or even whether there were any injuries at all. Both prosecution and defence were supported by the testimony of expert pathologists. The only statistical evidence was from the prosecution pathologist who testified to the probability of observing two

[§]It should be noted that relative risk does not relate directly to the probability of guilt. The relative risk is concerned with the relative rates of an event happening when some other event was, or was not, happening. The examples here concern deaths when a carer was, or was not, on duty. Evidence needs to be thought of in terms of it's value, which is the ratio of two probabilities: the probability of the evidence if the suspect is guilty, and the probability of the evidence if the suspect is innocent. The calculation of relative risk makes no assumptions about the guilt, or innocence, of the suspect.

SIDS deaths from a single couple as $\approx 10^{-8}$, assuming that the two single deaths were independent. This value was criticised in the appeal on the basis of the inherent independence assumption.^{19,20} The appeal judges considered that the probabilistic testimony of the pathologist for the prosecution, although possibly incorrect, did not in itself form grounds for appeal as they thought that the stated probability had little effect on the decision of the jury. Evidence which seemed to have a greater affect on the appeal judges was that of potentially misleading testimony concerning the movements of the defendant's husband. Sally Clark's appeal was dismissed.¹⁹

Case Study 11 - Dr. Harold Shipman, Manchester, England, 1974-1998.

In January 2000 Dr. Harold Shipman was convicted of the murder of fifteen patients.²¹ There was good evidence to show that he had murdered a further 23 patients, and, given the total number of deaths, it seems reasonable to conclude that in total he killed about 250 people in a career of some 25 years from 1974 to 1998.²¹ Shipman was apprehended when he amateurishly forged a will of one of his victims. The will was investigated by the victim's daughter, who concluded that the will was a forgery and called in the police. A full investigation was undertaken which revealed, not only the suspicious death of this particular victim, but the considerable extent of Shipman's activities over many years. From the toxicological examination of some of Shipman's suspected victims who had been buried rather than cremated, it was established that the victims had suffered from massive single doses of morphine. Departures from the normal pattern of deaths for a GP included a higher proportion of deaths of those aged over 65 years and female, those dying at home, and those dying during weekdays rather than weekends, compared with other neighbouring medical practitioners. Shipman was convicted on the 31st January 2000, and sentenced to 15 concurrent life sentences.

Case Study 12 - Nurse Kristen Gilbert, Leeds, Massachusetts, USA, 1995-1996.

On the 14th March 2001 a Federal Jury found Kristen Gilbert, a nurse at Leeds Veterans Association Hospital, guilty of four murders and two assaults with intent to murder using the heart stimulant epinephrine.²² The prosecution case was centred around the eyewitness evidence of two of Gilbert's colleagues, who said they had witnessed Gilbert with a syringe in hand minutes before the heart of a patient she had been treating stopped. Medical opinion offered conflicting views on the medical prognoses of the victims prior to death, and toxicological evidence to demonstrate the victims had all died from the administration of epinephrine was withdrawn after inconsistencies were found in the analyses.²³ Other evidence consisted of a missing quantity of epinephrine ampules, and various eyewitness statements describing Gilbert as being in possession of various substances in unexpected circumstances, and three textbooks on drugs and their effects on the body.

Some other cases for which fewer details are available

Case Study 13 - Nurse Jani Adams, Las Vegas, USA, 1980.

On the 2nd April 1980 a nurse from Sunrise Hospital, Las Vegas, USA, was indicted by a grand jury with causing death by tampering with equipment in order to increase the odds in a sweepstake being run on when patients would die¹³. There was no evidence for any cluster of deaths in the hospital in which the nurse worked, and no additional evidence, so all charges were dropped.

Case Study 14 - ICU nurse, California, USA, 1980s.

At some date before 1988 several Californian patients died showing symptoms of lidocaine poisoning.¹³ Up to 27 related deaths from two different hospitals were correlated with the shifts of a single ICU nurse. The nurse's home was searched and lidocaine recovered. The nurse was convicted on twelve charges of murder.

Case Study 15 - Charge nurse, New York, USA, 1987.

Twenty-five patients died following pulmonary arrest during a six week period in 1987.¹⁷ A particular charge nurse was always on duty when this happened, and thus was always the first to initiate resuscitation. Quoting the suspect one survivor told another nurse that the charge nurse had administered 'something to make you feel better' via the IV tube. The patient had immediately experienced breathing difficulties. The hospital authorities were informed and an investigation ensued. Investigators found traces of Pavulon in blood, urine and IV tubing. Vials of Pavulon were found during a search of the charge nurse's home. The charge nurse was eventually convicted of four varied charges of illegal killing.

The use of evidence

The cases briefly described in the preceding section varied in their outcome. This variation can be attributed to three factors: the court's approach to the evidence, based to some degree on local rules of evidence; the strength of the evidence; the type of evidence presented and the court's response to it. It is this third factor which appears to be the most significant.

Most jurisdictions discriminate between differing types of assault and unlawful killing. Many of the differences depend on the intent of the suspect. Acts which are perpetrated with the intent of taking life are seen as criminally more reprehensible than intentional acts which lead to the unintentional taking of life. These, in turn, are considered worse than unintentional acts which lead to the unintentional taking of life. As each one of

these is categorised differently in law it is important that there is evidence which is capable of supporting conclusions which shed some light on the intention of the suspect so that appropriate charges can be brought.

Regardless of the specific set of charges any court has to ascertain two facts, first that a crime took place, and secondly that the suspect carried out the crime. Failure to prove both these two strands of the prosecution case must result in an acquittal for the defendant.

In these medical cases the assessment of the evidence does not include the assessment of the evidence of contact between the victim and suspect, as it would in many cases of criminal assault, because it is entirely expected that the suspect, being the victim's medical practitioner or carer, would have been in close contact with the victim. Consequently many lines of conventional forensic evidence will have little evidential value. In many other cases of criminal assault conventional types of forensic evidence do have persuasive power because it is possible to demonstrate a small probability of innocent contact between suspect and victim. Despite this there are seven basic types of evidence which occur in the case studies, one or more being used in each. Each of these types of evidence is discussed in connection with its ability to persuade, and the aspect of the case it purports to demonstrate.

Toxicology

Most of the instances of chemical assault in the cases above have been with some substance which would be unexpected for treatment of the patient at the relevant stage of their medical condition. For Nurse A in Toronto it was digoxin, KCl for Rachals and Bolding, and insulin for Nurses 18/7. Lidocaine, pavulon and succinylcholine chloride have all made unexpected appearances. Morphine, as used by Shipman, may have been expected to be found in a few of his patients, but not all of them. The evidence from hair in the toxicological study of nine of Shipman's victims demonstrated that the morphine had not been prescribed over a period of time, but had been administered in large amounts very shortly before death.²¹

In the other cases it was for a toxicologist to notice any unusual substance in the tissue of the victim and to exclude any innocent reason for the presence of this substance, such as treatment of any medical condition which the victim may have been undergoing as a patient. The toxicologist then has to establish that the levels of substance would have led to death, either on its own, or by exacerbating an already dangerous condition. If so, then an assessment has to be made as to whether or not the substance actually has made

a contribution to the death, or continued ill health, of the patient. This was the case with one of Allitt's victims who was found to have a small amount of lidocaine in her blood. This quantity was consistent with a massive dose administered intravenously to bring on the heart arrhythmia which killed her, but was also consistent with a therapeutic dose sometimes used to correct abnormal heart rhythms.⁸ An oddity is the case of Kristen Gilbert (Case Study 12) who used epinephrine on patients suffering from heart conditions, a substance which might be expected to be employed in their treatment; however, as the toxicological evidence was withdrawn it is impossible to tell whether the dosage was inconsistent with the patients' treatment.

In many ways the presence of unexpected substances associated with the patients' deaths makes toxicological interpretation less equivocal than the pathology of other injury types. None of the substances employed are found in the environment, the only access to them is through a member of a medical profession. It is therefore a plausible inference that, if one of these substances has been found to have caused a patient's death, it is a member of staff who, either through mistake or malice, has administered it. Given the controls put upon the availability of such substances in hospitals, and the many thousands of substances available, it is unlikely that a patient would be able to secure a supply, and administer a lethal dose, of one of a small number of substances known to be lethal, and to have the opportunity to repeat this on many different occasions.

Chemical assault may occasionally provide indirect information about a suspect's intent. Large levels of potassium found in the patients of Bolding (Case Study 7) and Rachals (Case Study 8), heparin in the case of Jones (Case Study 5) and insulin in the case of Nurses 18/7 (Case Study 6) gave no indication of the intent of the suspects. The evidence is more persuasive in cases, as with the Charge Nurse from New York, or the Californian ICU nurse, where the substance employed is found in the possession of the suspect at home. The inference by the prosecution is that the suspect has been accumulating the drug in advance of administration though even here the evidence is not direct. A better toxicological case is the detection of an inappropriate substance in hair. Hair has the property of providing a toxicological history of the person.²⁴

Pathology

Where a victim has been physically assaulted, the case for deliberation on the part of the assailant is clearer than with chemical assault. There is no such thing as therapeutic shaking, or smothering, and the presence of such factors does not have the same ambiguity of interpretation as an overdose of KCl, or injections of an inappropriate substance, which could be ascribed to incompetence. There is still, however, the potential

for disagreement as to whether a physical assault took place, for instance in Clark's trial experts in pathology appeared for both prosecution and defence.

Pathological evidence has the potential to shed light upon a suspect's intentions. Sustained injuries can distinguish between long term abuse or repeated instances of physical assault and a single violent event which might have resulted from an accident. A long history of abuse is more persuasive for an intentional act than for an accidental act or a single violent episode. Some of the pathological evidence in the prosecution of Clark considered the presence of 'old blood' in the lungs of one son, and an 'old fracture' to a rib in the other. Both of these were interpreted by the court as evidence of a history of abuse.

Repeated instances in separate institutions

One situation where statistical evidence has been compelling to a court is where a member of staff can be traced from institution to institution with an epidemic following them. This happened in the case of Jones (Case Study 5). Despite statistical evidence at the first institution, no criminal action was taken against Jones. Instead, Jones moved to another position where a similar series of paediatric deaths occurred. She was convicted without any further analyses being undertaken, the court obviously being convinced by the improbability of the same set of symptoms occurring with such coincidence in two separate places. A similar example occurred with the Californian ICU nurse (Case Study 14) who had operated in the same way at two different hospitals.

This particular evidence type may be seen as part and parcel of the legal principle of 'similar facts' in UK jurisdictions. However, where evidence of attendance (see below) is also presented as part of a prosecution, or defence case, the principle of 'similar fact' has to be invoked again. The evidence types may be treated under the same legal principle, but are to some degree separate. The repeated instances in separate institutions when it has been used in prosecution has always resulted in successful prosecution, and it would appear a that court is more persuaded by two or more fairly improbable occurrences in different locations, than one extremely improbable occurrence in a single institution.

Inconsistencies in defence statements

Because the defence need not put forward a case at all, relying on weaknesses in the prosecution case, most successful prosecutions rely upon inconsistency between the picture of events presented by the defence with what can be proven by the prosecution. In the case of Sally Clark (Case Study 10) much was made of the fact that the defence state-

ment indicating Clark's husband being present during the events leading to the death of her second child was shown to be false, as Sally Clark's husband had been travelling home from work at that time. Likewise Shipman (Case Study 11) on several occasions stated he was not present to administer treatment prior to the deaths of some of those he was later convicted of killing, but multiple eyewitness statements convincingly contradicted Shipman's account of his whereabouts on those occasions.

Although in the case of Shipman the evidence for his murdering patients was overwhelming, much of the pathological evidence against Sally Clark was robustly contested by the defence, leaving what amounted to a blatant lie[¶] about the presence of her husband as a dishonest attempt to add weight to the defence case.

Confession

Of four incidents where members of medical staff admitted criminal action under questioning, three were subsequently convicted. The fourth (Bolding: Case Study 7) was acquitted. Although statistical and toxicological evidence was available in Bolding's case, the court considered the confession to be inadmissible. In the two cases where the prosecution was successful (Rachals: Case Study 8 and Nurses 18/7; Case Study 6) there was also statistical and toxicological evidence available; however, it was not necessary as the confessions were accepted by the courts.

It has been suggested that the types of criminal actions described here are precipitated by a psychological condition called Munchausen by Proxy Syndrome (MHBP). The types of individuals who manifest this condition tend to be intelligent and dominant, and regard the suffering inflicted on others as of less importance than the secondary attention given to them indirectly through their patient's condition. Forrest⁷ examines the various factors which can lead to confession and concludes confession would be a relatively rare occurrence amongst these individuals. This is certainly reflected in the cases above with only four instances of confession.

No matter how rare, confessions are still a valuable source of information as they can constitute evidence of intent, and allow appropriate charges to be levelled. However, confessions can be retracted or declared inadmissible. Bolding's confession was disallowed by the court because of the way in which it was taken. Rachals⁸ admitted one 'mercy killing' from the six of which she was accused. The confession by McTavish (Case Study

[¶]Clark's husband had provided an eyewitness statement about the actions of Sally Clark at the time of the death of her second child. A taxi receipt demonstrated that he actually arrived home some time after the period covered by his statement, thus could not have been present during the period.

1) was the basis for her successful appeal and underlines the difficulties which can occur if confession evidence is relied upon as a primary piece of evidence in these cases.

Eyewitness

Direct testimony as in the case of the New York charge nurse is usually regarded by courts critically, but with few fundamental problems. In that case, a patient informed another nurse of an injection by the suspect which gave the patient breathing difficulties. Less direct, but still compelling, are the statements given by the families of survivors of Pankow's (Case Study 4) baby-sitting service relating to the use of gagging and confinement of children. The evidence is of those examples of Pankow's care techniques which did not bring about death or injury, and not of the cases which did. Nonetheless, the evidence was of behaviour likely to harm the child and appeared to have considerable persuasive power. In the other case where eyewitness evidence was used (Charge Nurse, New York) intent could not be established as it is perfectly possible that the nurse had simply made a mistake in administering pavulon under the honest impression that the substance was a mild sedative. Likewise in the case of Kristen Gilbert where suspicious colleagues saw Gilbert administer an injection to which, it later transpired, authorisation had not been given. Gilbert claimed the injections had been distilled water 'to make them (patient) feel better', the eye witnesses had not seen Gilbert administer epinephrine, and in the absence of a admissible toxicological report there were no solid reasons to infer epinephrine, but nonetheless the court must have believed epinephrine was the substance injected, otherwise Gilbert's conviction would not have been possible.

Other

Other evidence mentioned in the reports discussed above are those types which demonstrate an association between the crime and the suspect, but not necessarily direct association. Particular examples are those of the ICU nurse in California and the Charge nurse in New York. Both these nurses used some form of chemical assault upon their victims (lidocaine and pavulon respectively). The homes of both suspects were searched and supplies of the relevant substance found. A highly compelling piece of evidence in the Shipman case was the forged will of his final victim; it was this, not the preceding numbers of deaths, which convinced the authorities to commence investigations. Kristen Gilbert was seen in possession of ampules of epinephrine, and had been heard to ask a colleague who complained of tiredness whether they wanted a dose of 'epi'.

The emphasis placed upon the discovery of substances related to the crime in the suspect's domestic environment carries a high persuasive value. However, on their own,

the finding of such substances in that environment means little as the criminal activities were alleged to have occurred at the suspect's place of work. Their presence only confirms that the suspect had access to the means necessary for criminal activity. An exception is the Shipman case (Case Study 11) where the prosecution alleged that the substances were being collected and stored prior to redeployment in the place of work. In other cases, the suspects were employed as nurses in hospitals and ease of access, relative to lay people, to these substances can be assumed.

The evidence of attendance

In all but two of the case studies above an important element of the prosecution case has been whether the presence of a member of medical staff in the institution has been associated with the deaths of patients. This makes this type of evidence by far the most frequently occurring of the seven defined types. In many ways this is the most difficult type of evidence, both from a legal, and epistemological point of view. Unlike many other types of evidence there is little which is tangible, but instead is an evidence type which is usually examined using statistical methods alone. Many investigators have used a statistic called the relative risk, a fuller explanation being given in Appendix 1. The underlying logic is more akin to scientific justification than legal reasoning in that statistical methods are used to examine whether there is some probabilistic association between a particular member of an institution's staff and the deaths of patients. Epistemological difficulties stem from the fact that even a high level of association between deaths and an individual are evidence only for the availability of that individual to have committed some action against the patients, not direct evidence the patients have actually been assaulted in some manner, or been assaulted by that particular member of staff. Although a high level of association in science will lead to a reinforced belief in a causal factor, applied to criminal proceedings high association is neither evidence that a crime has been committed, nor that the individual with the high association has committed the crime.

Evidence of attendance has further problems in that it sits uneasily with the legal principle of 'similar facts'. The 'similar fact rule' governs cross-admissibility between two or more instances of a crime which an individual is suspected of having committed. For instance, of the cases outlined above there would have been insufficient evidence to convict Sally Clark were each killing taken as a separate offence and tried individually. However, because both deaths were similar they were considered jointly. Evidence from one could then be seen in relation to the other, hence, in effect, a doubling of the evidence.

The case which established the 'similar facts rule' in common law jurisdictions is

Makin.²⁵ In this case the accused were the Makins, a couple who ran a ‘baby farm’^{||}. After children in their care disappeared their back garden was excavated and the skeletal remains of a number of infants found. Other locations inhabited by the Makins were similarly excavated, and more infant skeletons found. Altogether a total of 13 were discovered. The Makins were charged with the murder of two of the infants. After conviction the Makins appealed to the Privy Council on the basis that evidence from instances for which they were not charged should not have been part of the original prosecution case. Lord Herschell disagreed saying the discovery of the other bodies was evidence of intent, and that the two deaths for which the couple were convicted were not accidental.

This interpretation of the ‘similar facts rule’ is one where the proof leads to the inference that the events were not coincidence. This form fits quite well, and indeed is a direct analogy, with the ‘repeated instances in separate institutions’ type of evidence discussed above. However, its application to association type evidence is problematic. With association evidence there has been no evidence that an event of a given class has taken place. With the *Makin* interpretation of ‘similar facts’, the similar facts simply demonstrate those events are not accidental, not that they took place at all.

An update to the ‘similar facts rule’ came about through the House of Lords *Boardman*.²⁶ Boardman was the Headmaster of a language school. He was charged with one offence of buggery and another of incitement to buggery with partners aged under 21. The judge at the trial had recommended the case of buggery could be taken into consideration during the deliberations on the incitement charge and *vice versa*. On appeal the judge’s approach was upheld, Lord Salmon saying that ‘strikingly similar’ facts pointing to the guilt of a suspect could reasonably be used to support the claim that the suspect was in fact responsible for the criminal charge levelled against him.

Evidence of association does not quite fit under this interpretation of the ‘similar facts rule’ unless the information that an individual member of staff was in the vicinity during the death of a patient can be held to be an event similar enough to imply some association between the member of staff and the patients’ death.

Although evidence of association between the presence of a member of staff in an institution, and the death of patients is unproblematic and easily approached from a scientific and epidemiological point of view, there is no principle in law which can easily be applied to this type of evidence. In scientific epistemology it is sufficient to demon-

^{||}A private institution whereby individuals would receive some payment in exchange for looking after unwanted infants

strate an association which will then apply irrespective of time or place. In law the position has to be clearer. It is not sufficient to demonstrate that an individual was responsible for some unspecified deaths, or some deaths from a range of deaths. It is necessary to specify which deaths, and for this it is necessary to have not just a number of deaths, but deaths of which there is good reason to think were the result of illegal actions.

If it can be shown that certain deaths have been deliberately caused then the persuasive force of association lies in the Sherlock Holmes aphorism "*It is an old maxim of mine that when you have excluded the impossible, whatever remains, however improbable, must be the truth.*"²⁷ Thus if crimes were committed then they must have been committed by someone, the individual responsible must have been someone with opportunity as it is impossible for someone without opportunity to commit the crime. If only a single person has opportunity, then it must be that this individual committed the crimes. Unfortunately for this line of reasoning in a legal context it is often far from obvious whether a crime has been committed. In the case of deaths in a hospital, or intensive care unit, it is difficult to say which of those deaths are attributable to criminal action, evidence of association alone being unable to determine which specific deaths are the result of criminal actions.

Despite the persuasive power from an epidemiological point of view, ambiguities inherent in the 'evidence of attendance' evidence type are reflected in the ways in which courts in various jurisdictions have regarded it. The judge in the Jones case, unwilling to be persuaded by attendance evidence, went as far as to say '*...unless we accept mere presence as evidence of guilt ...*'⁸, when commenting on the absence of more direct evidence from the San Antonio paediatric intensive care unit.

Discussion

Evidence of attendance may be regarded with some difficulty in law, however, inspection of the final column in Table 1 reveals a slight trend towards conviction in cases involving the taking of human life by carers over the period covered. In part this trend could be due to increased prosecutor experience in the handling, and presentation, of the types of evidence which support this case type. However, another influence could be the exposure of the general public to media stories of these types of cases, which makes such behaviour seem less incredible to jurors.

In the process of evidence evaluation it is becoming more common to consider the ratio of two probabilities, the probability of the evidence if the suspect is guilty and

the probability of the evidence if the suspect is innocent. This is a likelihood ratio and requires models for the data in the case of guilt and in the case of innocence. It is also complicated by the possibility that some of the deaths may be natural and only some unnatural (unlawful killing). In such a situation the probability models have to reflect this but this extension to the basic ideas of the paper is not discussed further.

For the moment consider the probability of the evidence if the suspect is innocent and assume that this probability is small. In some instances this probability may be smaller than the probability of similarities of trace evidence between a suspect and a crime scene when the suspect is innocent that obtain in consideration of scientific evidence. However, the former probability does not appear to have the same persuasive power as the latter. This is illustrated in the Shipman case. The number of death certificates issued by Shipman reached a number some three times greater than those of adjoining practises before the number was considered suspicious in 1998 by a neighbouring practitioner²¹. Intuitively, the probability of such an occurrence was very small.

It is worth considering the likelihood ratio further, and is best done with the help of some notation.

- G : the defendant is guilty,
- \bar{G} : the defendant is innocent,
- E : the evidence.

Then, a theorem known as Bayes' Theorem, relates E , G and (\bar{G}) as follows:

$$\frac{Pr(G | E)}{Pr(\bar{G} | E)} = \frac{Pr(E | G)}{Pr(E | \bar{G})} \times \frac{Pr(G)}{Pr(\bar{G})}.$$

The expression on the left-hand-side of the equation is known as the posterior odds in favour of the guilt of the suspect, after (or *posterior to*) the presentation of the evidence E . The second of the two expressions on the right-hand-side of the equation is known as the prior odds in the favour of the guilt of the suspect, before (or *prior to*) the presentation of the evidence. The first of the two expressions on the right-hand-side of the equation is the likelihood ratio. Thus it is straightforward to note that an $LR > 1$ lends support to the prosecution case since it leads to a posterior odds greater than the prior odds. The evidence has led to an increase in the odds in favour of the guilt of the suspect.

Bayes' Theorem illustrates well why more evidence may be needed before a case is brought against a member of the caring professions than against a lay member of the

public. The prior odds in favour of guilt are less for members of the caring professions than for lay members of the public as there is some notion that members of the medical and caring professions enter their vocations through a sense of duty to mankind. Thus to reach the same value for the posterior odds, that required to find someone guilty *beyond reasonable doubt*, the likelihood ratio for a member of the caring profession has to be greater than for a member of the lay public. However, with more and more high profile cases where members of the caring and medical professions have been reported in the media over the last twenty years or so, the public perception of those professions has changed, from one in which it was inconceivable for a nurse or physician to maliciously kill patients, to a position where the medical and caring professions can attract a small number of psychopaths who wish to exploit their position to inflict harm upon others. This is illustrated by the Kristen Gilbert cases (Case Study 12) where it was not even convincingly demonstrated before the court that epinephrine was present in her purported victims.**

Conclusions

It has been argued that of the seven basic types of evidence presented in criminal cases where members of medical and caring professions are accused of harming patients, the evidence of attendance is the type most often used in court. Although sound and convincing from a scientific and epidemiological point of view, this evidence type has deficiencies when employed as evidence in court because of the poor way it fits into the established 'similar facts' principle of evidence, and this underlines the depth of the epistemological disjuncture between what can be said in science, and what is held to be true in law. In an empirical science it is sufficient to demonstrate that there is an association between action and event, whereas in law one must demonstrate that there is association between specific actions and specific events. This disjuncture is built upon the respective paradigms of science and law. Science assumes that the universe is uniform, in that any effect from action will always be the same effect regardless of time and location, law cannot, and does not, make this assumption. In law it is not sufficient to be able to demonstrate that a suspect has committed a murder, the prosecution must point to a specific victim

Despite this it appears (from Table 1) that since the mid 1980s it is more probable that a case of this nature will end in a conviction of the suspect. It is suggested that this is partially due to the greater prosecutorial competence as experience grows in these

**A toxicological report did clearly indicate high levels of epinephrine, but was never brought before the court

cases, but that the changing public perception of the makeup of medical and caring professions is influencing the prior probability of guilt, thus making conviction more likely for a given amount, and quality, of evidence.

Many calls for the constant monitoring of medical staff in clinical environments have been made in the past^{10,11,12,14,21}, and this challenge is being taken up by medical institutions with the implementation of systems such as SASHA and CRESCENDO,^{28††} the purpose of which is ongoing medical and staff audit. These types of system should lead to cases being detected earlier, and appropriate action being taken against suspected members of staff. Early detection, despite fewer incidents occurring, will result in fewer convictions as the total evidence indicating criminality will be less, and medical institutions will tend to move individuals to other positions in an effort to avoid becoming embroiled in criminal proceedings the outcome of which will be uncertain, but which will harm the reputation of the medical establishment concerned. The corollary of fewer hospital based incidents will be an increase in the proportion of cases from nursing homes and other caring environments^{‡‡} where the auditing systems may not be as well developed as in the larger hospitals.

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^{‡‡}The ideal institution for a psychopath to lurk would be a hospice as the prognosis for any patient is poor to start with.

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Appendix: relative risk

A common measure of association between a postulated causal factor and the death of a patient is the *relative risk*. Examples of the relative risk in the context of the problems discussed here are given in Buehler *et al.*¹⁰, Istre *et al.*¹¹ and Sacks *et al.*^{14,12}. The relative risk is the ratio of the rate of death per unit time in the presence of the postulated causal factor to the rate of death per unit time in the absence of the postulated causal factor. In the examples discussed here the postulated causal factor is staff member N; 'presence' is the presence of N on duty, 'absence' is N off duty. It may be written as:

$$\text{relative risk} = \frac{a/b}{c/d}$$

where:

- a* number of deaths or declines whilst N was on duty,
- b* total time on duty by N,
- c* number of deaths or declines whilst N was off duty,
- d* total time off duty by N.

Denote the time period over which these rates are determined as T_1 .

A relative risk (RR) greater than one implies that the death rate when a particular nurse N was on duty is greater than the death rate when N was off duty. When N is off duty other nurses are on duty. Identify all the nurses as N_1, \dots, N_k , so the total number of nurses is k (N is just one of k). For each nurse, N_i , it is possible to determine a

relative risk r_i . By the nature of random variation, these relative risks will not all be the same. It will be possible to order them. Denote the ordering of the relative risks as $r_{(1)}, \dots, r_{(k)}$ where

$$r_{(1)} \leq \dots \leq r_{(k)}$$

and the corresponding nurses as

$$N_{(1)}, \dots, N_{(k)}.$$

Thus $N_{(k)}$ is the staff member on duty with the highest relative risk. It is important to note that this is not of itself sufficient to suggest $N_{(k)}$ is guilty of wrong-doing.

In particular, consider a new time period T_2 , which does not overlap with T_1 and the simple (unlikely) case where the staffing is exactly the same as in T_1 . The ordering of relative risks will almost certainly be different. Thus, evidence that a particular staff member has the highest relative risk over a particular time period is, in itself, inconclusive and would not warrant any investigation of wrong-doing.

However, if the highest relative risk ($r_{(k)}$) is very much greater than the second highest relative risk ($r_{(k-1)}$) then this may be sufficient to warrant an investigation. Of course, there can be discussion as to what is meant by 'very much greater' and it is this that is the remit of statistical analysis. For example, it may be possible to determine a probability distribution $F(r)$ for the values of relative risk to be expected in a certain hospital ward under normal working conditions (and note again that the type of ward and what is meant by 'normal working conditions' are open to debate). Given the probability distribution $F(r)$ it is possible to determine the probability of observing a relative risk greater than $r_{(k)}$. If this probability is extremely small (another matter of subjective judgement) then an investigation may be warranted. (Note: the study of extremes is a large area of research. Examples include storms, droughts, floods, wave heights, wind strength.)

Note the various areas of subjective judgement in the above description

- type of ward,
- normal working conditions,
- measure of smallness,
- choice of time period,
- choice of staff to include,
- identification of staff, particularly with more than one staff member on duty at any one time.

Different time periods are also of concern. It is possible to determine the probability that the largest observation (relative risk) is greater than a certain value within a particular time period. This largest value is, perforce, associated with a particular staff member. If this staff member is associated with the largest relative risk in several independent time periods (and no other, or few, staff members are associated with the largest relative risk in other (independent) time periods) then there is again evidence which may warrant an investigation.

Consider also the difference between the probability (1) that some unidentified staff member has the highest relative risk and the probability ($1/k$) that an identified staff member has the highest relative risk over a particular time period. Another important question which has then to be considered is 'has the staff member under investigation been identified because of the high relative risk or for some other, independent, reason?' If the member has been identified because of the high relative risk then the value of the relative risk as evidence is considerably lessened than if the member had been identified for some other reason. The value is lessened but not zero because some consideration has to be given to a measure of how extreme it is, as outlined above.

Note, also, that the relative risk compares death rates during a period of interest T_1 : the rate whilst N is on duty within T_1 with the rate whilst N is off duty within T_1 . Another paper under preparation examines evidence of the death rate whilst N is on duty within T_1 with the death rate within an historical period T_h . The period T_h does not intersect with T_1 though T_h may immediately precede T_1 . Also, T_h may be considerably longer than T_1 , with T_h of the order of several years and T_1 of the order of several months. Staff member N may, or may not, have been on duty during T_h . Another area of subjective judgement is then the definition of the period of interest T_1 (consider Case Study 2 and Case Study 3 where reference is made in both cases to the quadrupling of the rate of events (cardiopulmonary arrests in Case Study 2, mortality in Case Study 3) from what is called their 'usual' rate).

Table 1: Summary table for case, evidence type, and outcome for the cases referred to in this paper. An \times marks the presence of evidence of that type. (i) Pathology is evidence from physical injury, (ii) toxicology is evidence of a chemical attack, (iii) repeated evidence is whether the same occurrence associated with a member of staff happened in more than one institution, (iv) inconsistent evidence is whether the explanations offered by the suspect in their defence were consistent either internally, or with other evidence, (v) confession evidence refers to whether the suspect admitted any offence to the investigating authorities. (vi) eyewitness evidence is the existence of an eyewitness to the alleged criminal activity, (vii) other evidence is that such as the possession of substances such as KCL or morphine outside the place of work. (viii) attendance is the evidence attainable from rosta and institution work schedules. Conviction is the final outcome of the investigation (N for found not guilty, Y for found guilty). In the case of McTavish a conviction was initially given, but later quashed on appeal.

		pathology	toxicology	repeated	inconsistent	confession	eyewitness	other	attendance	conviction
McTavish	1973		\times			\times	\times	\times		N
Narciso & Perez	1975		\times						\times	N
Nevada USA	1980									N
Nurse A	1981		\times						\times	N
Sandra Pankow	1982	\times					\times		\times	Y
Geneve Jones	1982		\times	\times					\times	Y
Nurses 18/7	1984		\times			\times			\times	Y
Jane Bolding	1984		\times			\times			\times	N
Teri Rachals	1985		\times			\times			\times	Y
ICU nurse	1980's		\times	\times				\times	\times	Y
Charge nurse	1987		\times				\times	\times	\times	Y
Beverley Allitt	1991	\times	\times			\times			\times	Y
Sally Clark	1998	\times			\times				\times	Y
Harold Shipman	2000		\times		\times			\times	\times	Y
Kristen Gilbert	2001						\times	\times		Y