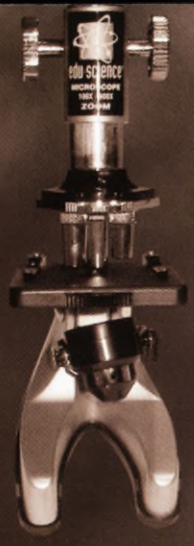
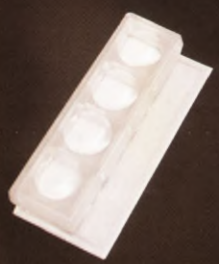




Epidemiology evidence and causation

Epidemiological evidence is crucial in the resolution of many forms of litigation – principally because of its role in establishing, or casting doubt upon, causation.

Ian Freckelton is a barrister based at Owen Dixon Chambers in Melbourne.
PHONE (03) 9225 7666 **EMAIL** I.Freckelton@latrobe.edu.au

Cases in which epidemiology has proved influential[1] include matters dealing with allegedly carcinogenic or teratogenic (birth defect-causing) drugs, product liability cases, toxic tort litigation generally, personal injury litigation, cases involving public health issues, criminal matters characterised by allegations of risk to life, and administrative law disputation such as entitlements to pensions.[2] This article analyses the role of epidemiology in establishing causation, probes its limitations and discusses how it can be used most constructively in the tort reform era.

THE ESSENCE OF EPIDEMIOLOGY

The United States (US) Federal Judicial Center's *Reference Manual on Scientific Evidence*[3] defines 'epidemiology' as 'the field of public health that studies the incidence, distribution and etiology of disease in human populations and applies the findings to alleviate health problems'. Along similar lines, in the important US decision of *Manko v The United States*,[4] epidemiology was judicially described as:

> 'The study of the available data to determine whether a causal relationship exists between an event and the outbreak of a disease. The first step in analysing whether there is a causal relationship between an event and the outbreak of a disease is to determine whether the causal relationship is biologically possible ... the next enquiry is whether there is a statistically significant relationship ... The association is determined by mathematical computation that produces a ration for the relative risk of contracting the disease.'

Spigelman CJ in *Seltsam Pty Ltd v McGuiness*[5] summarised the status of epidemiology evidence in a not dissimilar way:

> 'Epidemiology is the study of the distribution and determinants of disease in human populations. It is based on the assumption that a disease is not distributed randomly in a group of individuals. Accordingly, subgroups may be identified which are at increased risk of contracting particular diseases.
>
> Epidemiological evidence identifies associations between specific forms of exposure and the risk of disease in groups of individuals. Epidemiologists do make judgements about whether a statistical association represents a cause-effect relationship. However, those judgements focus on what is sometimes called in the epidemiological literature 'general causation': whether or not the particular factor is capable of causing the disease. Epidemiologists are not concerned with 'specific causation': Did the particular factor cause the disease in an individual case? ...
>
> Epidemiology evidence provides two types of material: first, the statistical measurement of an association between exposure and disease and, secondly, interpretation of the data to determine general causation. The second function may be performed by an epidemiologist who had no association with the study or studies which provide the raw data.'

In what is commonly an absence of full understanding of pathological and disease mechanisms that explain the development of disease, epidemiological evidence has been viewed by courts as the most valid form of scientific evidence of toxic causation.[6] Generally, the use of epidemiology in litigation raises the following issues for consideration:

> 'Were the research methods trustworthy?
>
> If so, is exposure to the agent associated with the disease?
>
> If the agent is associated with the disease, is it a causal relationship?

There is an additional legal question that arises in most toxic substances cases. That issue is whether and how population-based epidemiological evidence can be used to infer specific causation.'[7]

THE PARAMETERS OF EPIDEMIOLOGY

Epidemiology studies generally identify the strength of an association by a measure described as 'relative risk', which is the ratio of the incidence of the disease in exposed people compared with those who are not. The court in *Gaul v United States*[8] put it as follows:

> 'Relative risk, or relative risk ratio, describes the relationship between the risk of an occurrence, such as contracting a disease, in a population exposed to a certain stimulus, and the risk of the occurrence in a population not exposed to the stimulus. It is the ratio of the former risk to the latter. It is another way of explaining how much more likely a person exposed to the stimulus is to get a disease than an unexposed person. For example, using hypothetical numbers and facts, if one in every 100,000 vegetarians contracts stomach cancer while five in every 100,000 meat eaters contract this disease, the relative risk of contracting cancer among meat eaters would be 5/1, or 5. In other words, the risk of getting stomach cancer would be five times greater for meat eaters than vegetarians, assuming all other factors are held constant.'

If the relative risk equals 1.0, the risk is the same in exposed as in non-exposed people. By contrast, if it is higher than 1.0, an inference of causation *may* be able to be drawn.[9] From both a scientific and a legal point of view, the point at which inferences can legitimately be drawn is important. A relative risk of 2.0 means that a disease occurs among the population subject to the event under investigation twice as frequently as it does among the population not subject to the event under investigation. 'Phrased another way, a relative risk of "two"means that, on the average, there is a 50% likelihood that a particular case of the disease was caused by the event under investigation and a 50% likelihood that the disease was caused by chance alone. A relative risk greater than "two" means that the disease more likely than not was caused by the event.'[10]

Key decisions in the US have demanded a relative risk ratio of greater than 2.0 to establish causation on the balance of probabilities. For instance, in *Daubert v Merrell Dow Pharmaceuticals*[11] the US Court of Appeals for the Ninth Circuit held that a relative risk of less than two *suggested* teratogenicity 'but it actually tends to disprove legal causation' as it showed that the allegedly teratogenic drug did not double the likelihood of birth defects. Similarly, in a case dealing with whether exposure to asbestos was a cause of colon cancer, where the plaintiff relied on epidemiological evidence alone, the US District Court for New York[12] held that the balance of probabilities test required a relative risk of greater than 2.0. It is clear from subsequent US authority that, where other evidence exists, epidemiological evidence falling short of 2.0 may suffice if the other evidence is 'clinical or experimental evidence which eliminates confounding factors and strengthens the condition between the causal factor and the disease specifically in the circumstances surrounding the plaintiff's case of [the disease].'[13] However, the issue remains controversial, some writers even asserting that courts should require a minimum relative risk of 3.0 to establish causation.[14]

However, before the NSW Court of Appeal decision in *Seltsam v McGuiness*, no clear authority existed on the subject in Australia.

AUSTRALIA'S LEADING AUTHORITY: *SELTSAM V MCGUINNESS*

From 1950 until 1984, the respondent worked at a factory in which asbestos was used, among other things, ▶

"Evidence needs to be given by experts who can explain alienating and intimidating concepts in a way that is accessible and compelling."

in the manufacture of fibro-cement sheeting and mouldings. In the early years of his employment, he probably came in contact with both crocidolite (blue asbestos) and chrysotile (white asbestos) but for the most part he encountered chrysotile. In 1993, he commenced legal action after being diagnosed as having pleural plaques that were presumed to have been asbestos-related. They remained benign and were not incapacitating. However, in 1997 he was diagnosed as suffering from renal cell cancer of the left kidney, which was a fast-growing malignancy. It had spread to his spine and was invading his lung. At the time of his trial he had only a short time to live.

The key question in the litigation was causation – it was common ground that he would have inhaled, and may have ingested, asbestos fibres and dust.[15] In addition it was agreed that, although renal cell cancer is one of the less frequent cancers, it is common throughout the population, particularly among men of the respondent's age. Although its cause generally is unknown, two factors were accepted by all parties to the litigation as having a causal relationship with renal cell cancer. One was obesity, from which the respondent had suffered throughout most of his life; the other was smoking. He was a moderate smoker.

There was an important conflict in the case between the epidemiological evidence called on behalf of the parties. The respondent's epidemiological evidence concluded, on the basis of analysis of some 200 cases, that there was a relative risk of 1.4, with a 95% confidence interval ranging from 1.1 to 1.8, in relation to people exposed to asbestos and later experiencing kidney cancer. The experts said that asbestos increases the risk of kidney cancer but that further research of asbestos-exposed workers was needed to demonstrate a relationship with either duration of employment or amount of exposure before a causal association could confidently be concluded.

The Court of Appeal decided by majority (with Stein JA dissenting) that epidemiological evidence that exposure to a substance is a possible cause of an injury may be used to establish that exposure to be the legal cause of the injury. Not surprisingly, it held that the balance of probabilities test is not satisfied by evidence that fails to do more than establish a possibility, and that causation is not established by showing that a defendant's act or omission increased the risk of injury to a plaintiff when the risk had not eventuated. It determined that epidemiological evidence about the effects on populations of exposure to a substance is circumstantial evidence that may form part of the process of inference.

Spigelman CJ and Davies AJA held that the trial judge had erred in not taking into account the strength or quality of the epidemiological evidence, including the strength of association identified in, and inconsistencies between, the various studies. They held that the evidence did not support a finding that asbestos exposure caused or materially contributed to the respondent's renal cell carcinoma. They accepted the traditional distinction between the 'general causation' question ('is the agent capable of causing the disease?') and the question in which the law is more interested, the 'specific causation' question ('did the agent cause the disease in the particular case?') Spigelman CJ noted that the conflicting epidemiology evidence – both the statistics and the interpretation – played a role in respect of each question. He found that the trial judge should have taken into account the strength of the association between asbestos exposure and renal cell carcinoma, and other aspects of the quality of the epidemiological research, particularly inconsistencies among the various studies. It is especially this aspect of the decision that provides the important guidance for other legal contexts.

Spigelman CJ (with Davies AJA agreeing) held that the fact that epidemiology evidence only establishes possibility does not preclude admissibility. Stein JA agreed in this regard, rejecting the suggestion that the evidence was to be equated to the speculation evidence that was castigated by the High Court in *HG v The Queen*.[16] The associated question is the use that can be made of 'possibility epidemiology evidence'. Spigelman CJ held that when evidence only goes so far as to establish possibility, it must be weighed in the balance with other factors in determining whether or not on the balance of probabilities an inference of causation in a particular case could or should be drawn.[17] He held that where the whole of the evidence, incorporating the epidemiology evidence, does not rise above the level of possibility (either alone or cumulatively), an inference of causation cannot be drawn.[18]

The Chief Justice found that the test for the particular case in respect of causation was whether, on the basis of primary facts, it was reasonable to draw the inference that the nexus existed on the balance of probabilities.[19] He held that evidence of possibility, including epidemiological studies, should be regarded as circumstantial evidence that has the potential, alone or in combination with other evidence, to establish causation in the particular case.[20] He stressed that causation, like any other fact, can be established by a process of inference which combines primary facts like 'strands in a cable' rather than 'links

in a chain'. He and Davies AJA found that the primary facts consisted in large measure of the epidemiological studies which established that that nexus could possibly exist. This, he found, was not necessarily a bar to the respondent's success, as epidemiological studies and expert opinions based on such studies can form strands in a cable of a circumstantial case.[20] The question was whether the studies showed the connection between the inhalation of asbestos and renal cell carcinoma to be 'sufficiently close' to warrant a reasonable mind to conclude that the possible cause was the actual cause.

In investigating this question, they found that the issue before the court was whether an increased risk caused, or materially contributed to, the injury actually suffered. They held that the test of actual persuasion in respect of causation does not require epidemiological evidence showing a relative risk of 2.0, even when that is the only evidence available to a court. However, the Chief Justice noted that 'the closer the ratio approaches 2.0, the greater the significance that can be attached to the studies for the purposes of drawing an inference of causation in an individual case. The 'strands in the cable' must be capable of bearing the weight of the ultimate inference.'[21] He applied what he classified as 'uncomplicated statements of commonsense propositions' for the interpretation of epidemiological evidence, summarised as follows:

'1. *Strength of the Association*. In general the higher the risk estimate, the less likely the finding is a result of confounding or bias ...
2. *Dose Response Effect*. If the risk of the disease rises with increasing exposure, a causal interpretation of the association is more plausible ...
3. *Time Sequence*. The exposure or risk factor must precede the disease ...
4. *Consistency*. Results from other epidemiological studies of the exposure-disease association should be similar. If similar results are found in different populations using various study designs, the plausibility of a causal interpretation is increased. An alternative explanation of bias or confounding would have to be apply to each of the different studies, a highly implausible explanation.
5. *Biological Coherence*. Does the exposure-disease association make biological sense given what is known of the natural history of the disease? Do animal experiments support the association? Do other types of collateral evidence support the association, such as secular trends of the exposure factor in the disease. Unfortunately, for many diseases little is known about their aetiologies, so the informational background by which to judge biological coherence is often limited. Thus, failure of this broad principle does not necessarily weaken the plausibility of a causal interpretation.

The first three principles can be applied to an individual study and used to assist the findings. The last two principles referred to results outside their particular study and relate more to external issues of coherence or consistency. All of the criteria or principles should be viewed as guidelines. Except, perhaps, for time sequence, none is required for a causal interpretation.'[22]

He held that these criteria could be taken into account in determining whether or not a court should infer, on the balance of probabilities, that a particular exposure caused injury. However, he noted that, while the evidence of epidemiologists with respect to identifying and applying the criteria may be of assistance because of their reasoning, they did not constitute a scientific opinion that the court was bound to accept. Significantly, too, he found that when assessing expert evidence on causation, the legal concept of causation requires the court to approach the matter in a distinctively different manner 'which may be appropriate in either philosophy or science, ▶

including the science of epidemiology. The commonsense approach to causation at common law is quite different from a scientist's approach to causation[23] ... An inference of causation for purposes of the tort of negligence may well be drawn when a scientist, including an epidemiologist, would not draw such an inference.'[24] Tantalisingly, he did not expand on these comments.

Chief Justice Spigelman noted that in the case before the court, no issue was raised with respect to 'time sequence' or 'biological coherence' but that there was disagreement among the experts on the 'strength of association' and 'consistency' criteria. They had also referred to the absence of a 'dose response' relationship. He classified the differences of opinion among the experts as affecting both the direct use of their studies as strands in the cable and the extent to which reliance could be placed on the opinions, based on the studies, with respect to causation in the case.

"The use of epidemiological evidence in law is complicated by the new statutory formulations of causation."

Chief Justice Spigelman and Davies AJA agreed that the trial judge had erred in failing to consider the strengths and quality of the results of the epidemiological tests that were put before him. They found that whether or not the inference of causation should be drawn depends on the quality of the underlying facts, particularly in terms of the degree of possibility involved. They found that the trial judge had erred in taking into account that asbestos is a 'known carcinogen': the evidence establishing a more sophisticated analysis in respect of asbestos was necessary.

Moreover, the trial judge's references to 'heavy exposure' and 'heavy asbestos infection' were held by Spigelman CJ to suggest that he had applied 'an intuitive judgment that the greater the exposure to asbestos, the more likely it would have the particular consequence'.[25] On the contrary, he found that the available evidence did not suggest that the dose response relationship existed; if anything, it suggested the opposite.

Further, the trial judge's analysis was found to constitute reasoning that the scope of the relevant causal factors was limited to a choice between smoking and asbestos exposure. However, nothing in the medical or the epidemiological literature suggested that the issue came down to such a dichotomy. The fact that one known risk factor is of diminished significance says little, if anything, about any other alleged risk factor.

Spigelman CJ found that the epidemiological studies established that the increased risk, where detected at all, was generally low to moderate; and that many studies showed no increased risk.[26] He emphasised that this evidence applied to human populations generally and that application of the information to the case of a specific individual required a separate and distinct step by way of inference.

For Davies AJA, one of the significant flaws in the trial judge's reasoning was that he treated the epidemiological evidence as a contest between the epidemiologists, instead of considering the possibility that the epidemiological material before the court was inconclusive.[27] Davies AJA found that the current state of the epidemiological evidence disclosed that a causal relationship between asbestos and renal cell cancer had not been established, the link being no more than possible and insufficient to justify an inference of causation.

The bottom line for both Spigelman CJ and Davies AJA was that the extent of increased risk indicated by all but one, or perhaps two, of the epidemiological studies was too small to justify an inference of causation, either alone or in combination with other factors including biological plausibility, the laboratory experiments and the expressions of professional opinion which were, in large measure, based on epidemiological evidence. Chief Justice Spigelman summarised his decision as follows:

> 'Epidemiological studies and expert epidemiological opinion evidence on general causation go no further than establishing a possibility. Applying a common sense test of causation to the evidence of possibility in the present case does not, justify an inference of causation on the balance of probabilities in the individual case.'[28]

A difficult issue addressed by the judgments of Stein JA and Spigelman CJ was the proposition earlier enunciated by McHugh J, and of great significance to plaintiffs, that 'If a wrongful act or omission results in an increased risk of injury to the plaintiff and that risk eventuates, the defendant's conduct has materially contributed to that injury occurring.'[29] This led Stein JA to conclude that the evidence was sufficient, the injury having materialised; and that the increased risk of injury had caused the respondent's injury. The approach of Spigelman CJ, however, was different. He found that the likelihood of the increased risk had to be proved at least on the balance of probabilities:

> 'The starting point of McHugh J's analysis was that it had been established on the balance of probabilities that the conduct did create or increased the risk of injury, 'and *that* risk had eventuated.' This starting point is the very matter in issue in the present case. Was there evidence on the basis of which the trial judge could conclude, on the balance of probabilities, that there was an increased risk of injury and that *that* risk had 'eventuated' in the

specific disease of the respondent? If there was such evidence, then ... the tribunal of fact was "entitled" to find that the conduct which increased risk, materially, contributed to the injury – entitled, but not, of course, required to so find."[30]

Thus, for Spigelman CJ, the case before him was distinguishable from *Chappel v Hart*,[31] *Naxakis v Western General Hospital*,[32] and *McGhee v National Coal Board*[33] on the basis that in those cases there had not been expert disagreement about whether the increased risk actually caused or materially contributed to the injury on the balance of probabilities.

"Key decisions in the US have demanded a relative risk ratio of greater than 2.0 to establish causation on the balance of probabilities."

FAIRCHILD V GLENHAVEN FUNERAL SERVICES LTD

This latter issue, and thus an important application of epidemiology evidence, was revisited in the important decision of the House of Lords in *Fairchild v Glenhaven Funeral Services Ltd*[34] where the questions to be determined were: if

'C was employed at different times and for differing periods by both A and B, and

- A and B were both subject to a duty to take reasonable care or to take practicable measures to prevent C inhaling asbestos dust because of the known risk that it might cause mesothelioma, and
- both A and B were in breach of the duty to C during their employment of C with the result that he inhaled excessive quantities of asbestos, and
- C is found to be suffering from a mesothelioma, and
- any cause of C's mesothelioma other than asbestos inhalation at work can be effectively discounted, and
- C cannot (because of the current limits of science) prove on the balance of probabilities that his mesothelioma was caused by A or B,
- was C entitled to recover against either or both?'

Because of current medical and epidemiological knowledge, it was impossible for the claimants to prove on the balance of probabilities that their illness had been caused by the inhalation of fibres while working with any particular employer. Ultimately, the House of Lords held that this was not a complete impediment to their actions.

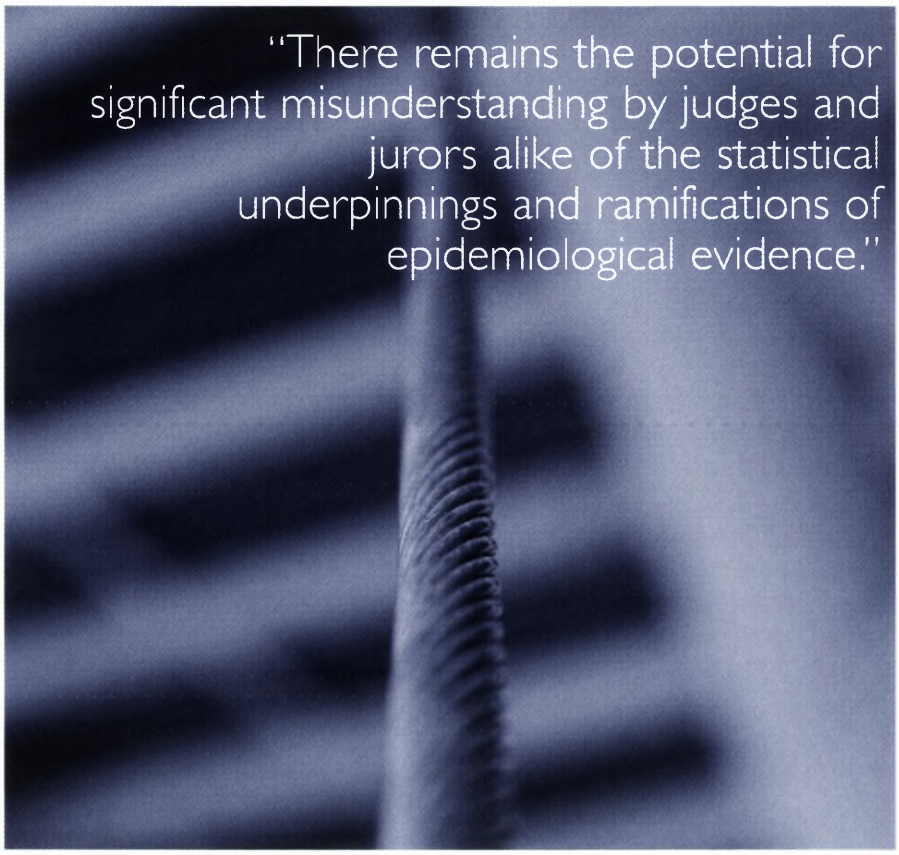
Lord Bingham of Cornhill held that it was just, and in accordance with common sense, to treat A and B's conduct in exposing C to a risk to which he should not have been exposed as materially contributing to C's contraction of a condition against which it was their duty to protect him. Lord Nicholls of Birkenhead rejected language of inferences, stating that such 'phraseology tends to obscure the fact that when applying the principle ... the court is not, by a process of inference concluding that the ordinary "but for" standard of causation is satisfied. Instead, the court is applying a less stringent test.'[35] Lord Hutton commented that a process whereby a layperson, applying broad common sense, draws an inference that the doctors as scientific witnesses are not prepared to draw is permissible.[36] The essence of the decision was a determination that where a defendant materially increases the risk of contracting a disease, the plaintiff is taken to have proved that the defendant has materially contributed to their illness.[37] For policy reasons, an elision takes place conceptually between increasing the risk and materially contributing to an adverse outcome.

The approaches of the High Court and of the House of Lords are travelling in a similar direction but remain conceptually different; in particular, it is still unclear what role the presumption or inference plays in Australia in easing the not insignificant burden of proof for the plaintiff.

DILEMMAS IN THE USE OF EPIDEMIOLOGY EVIDENCE

Epidemiological evidence can often help to determine whether there is a relevant statistical correlation between the exposure of people to a potentially harmful agent or scenario and their subsequently suffering a particular kind of illness. Two important questions arise.

The first is how to determine the point at which such evidence becomes useful or even compelling. There is a risk of misunderstanding or misevaluating the evidence – particularly in respect of the nexus between the general scenario and the specific instance. This difficulty is often exacerbated, as it was in *Seltsam* and *Fairhaven*, where the epidemiological evidence is limited in terms of its ability to distinguish between various risks and their relative contributions. ▶



In the US an arbitrary, but clear, rule has been developed: the threshold for concluding that an agent is more likely than not the cause of a disease is a relative risk of greater than 2.0. As the Federal Judicial Center *Manual on Scientific Evidence* points out, 'When the relative risk reaches 2.0, the agent is responsible for an equal number of cases of disease as all other background causes. Thus, a relative risk of 2.0 implies a 50% likelihood than an exposed individual's disease was caused by the agent.'[38] This rule has been applied in the context of determining the teratogenicity of a morning sickness medication,[39] the likelihood of asbestos causing colon cancer,[40] the likelihood of swine flu vaccine causing Guillain Barre syndrome,[41] the likelihood of pelvic inflammatory disease having been caused by an intra-uterine device[42] and the impact of Agent Orange upon a variety of diseases suffered by Vietnam veterans and their offspring,[43] to name just a few examples. The advantage of such a rule is its clarity. The risk of an approach which permits epidemiological evidence that falls some distance short of 2.0 is that courts will seek refuge in the imprecise language of 'possibility' and 'commonsense' which can result in inexact and impenetrable reasoning.

The NSW Court of Appeal has rejected the US rule and opted to factor epidemiology evidence falling short of the 2.0 relative risk ratio into the mix of factors that can be considered in determining in civil matters whether causation is proved on the balance of probabilities. That this approach is fraught with difficulties is exemplified by the terms on which the Court of Appeal was itself divided, as well as by the criticisms levelled by the majority at the trial judge; in particular, that he inadequately evaluated the complex and conflicting epidemiology evidence adduced before him.

The second important question is the relevance of epidemiological evidence to the particular case, especially where other risk factors for incurring the disease or injury are claimed by the litigant to be attributable to the defendant's negligence. A substantial series of factors personal to the plaintiff may heighten their susceptibility. In turn, epidemiological evidence can help to evaluate the significance of such factors and provide statistical likelihoods of the plaintiff suffering the illness or sustaining the injury, but for the exposure to agent.

The situation is complicated by the new statutory formulations of causation. In general terms, these provide that legal causation is not established unless the negligence played a part in bringing about the harm ('factual causation') and the plaintiff can prove that the person responsible for the harm was under a duty to avoid it ('scope of liability').[44] New tests for the scope and content of the duty of care have made it more difficult to establish defendants' fault; and it appears to have been the intention of legislatures to ease the burden for plaintiffs in overcoming 'the evidential gap'[45] in establishing causation. However, the new provisions have imported policy considerations into the causation determination in a way that will make decision-making – at least in the short term – inconsistent.[46] This will especially be so in cases where epidemiology evidence takes plaintiffs only a part of the way toward establishing causation.

There remains the potential for significant misunderstanding by judges and jurors alike of the statistical underpinnings and ramifications of epidemiological evidence. An example is the potential for erroneous equation of the magnitude of relative risk with statistical significance.[47] Three things, though, are clear. The first is that plaintiffs who rely on epidemiological evidence alone do so at considerable peril to their forensic prospects. The second is that courts are likely to continue to struggle with the science-law interface, especially when epidemiology evidence is adduced both in relation to the general and the specific issue. The third is that the evidence

relating the general risk-ratio evidence to the particular plaintiff and the specific facts asserted must be pertinent and compelling in order to make feasible a finding by a court that causation is proved on the balance of probabilities in the case before it. Moreover, forensic epidemiology evidence needs to be both scientifically and medically sound, as well as statistically comprehensible. The evidence needs to be given by experts who have a facility in explaining otherwise alienating and intimidating concepts in a way that is accessible and compelling. Even then, though, epidemiological evidence will take plaintiffs only part of the distance towards proving causation; much remains to be done by that dangerous and ill-defined creature – what Mason P has described as the 'glib submission that causation is a question of fact and a matter of common sense'.[48] PL

Endnotes: **1** See S Loue, *Case Studies in Forensic Epidemiology*, Kluwer Academic, New York, 2002. **2** See, for instance, Veterans Review Board decisions in relation to entitlement to pensions following the contracting of cancer as a result of soldiers taking up smoking in the context of the stresses of war. **3** US Government Printing Office, Washington DV, 1994, at p125. **4** 636 F Supp 1419 at 1433-1434 (1986), affirmed in relevant part 830 F 2d 831 (8th Cir 1987) and subsequently quoted with approval in *DeLuca v Merrell Dow Pharmaceuticals Inc*, 911 F 2d 941 at 958-959 (3rd Cir 1990). **5** [2000] NSWCA 29 at [59]-[62]. **6** See, for instance, *Richardson v Richardson-Merrell, Inc*, *857 F 2d 823 at 830 (DC Cir 1988)*. **7** *Federal Judicial Manual*, at p128. **8** 582 F Supp 1122 at 1125, n9 (D Del 1984). **9** See Christie, 'Toxic Tort Disputes: Proof of Causation and the Courts' (1992) 8 *Environmental Planning and Law Journal* 302; Marley and McMichael, 'Disease Causation: the Role of Epidemiological Evidence'; *Federal Judicial Manual* at p147ff. **10** *Manko v The United States*, 636 F Supp 1419 at 1433-1434 (1986). **11** 43 F 3d 1311 at 1321 (9th Cir). **12** *Re Joint Eastern and Southern District Asbestos Litigation*, 758 F Supp 199 at 202-3. **13** *Re Joint Eastern and Southern District Asbestos Litigation*, 52 F 3d 1124 at 1128 (2nd Cir 1995). **14** 2 B Black, J A Jacobsonm E W Madeira Jr and A See, 'Guide to Epidemiology' in B Black and PW Lee (eds), *Expert Evidence: A Practitioner's Guide to Law, Science and the FJC Manual*, West Group, St Paul, Minnesota, 1997. **15** 3 See, further, G Edmond and D Mercer, 'Rebels Without a Cause?: Judges, Medical and Scientific Evidence and the Uses of Causation' in I Freckelton and D Mendelson (ed), *Causation in Law and Medicine*, Ashgate, Dartmouth, 2002; C Miller, 'Coal Dust, Causation and Common Sense' (2000) 63 *Modern Law Review* 763. **16** (1999) 160 ALR 554. **17** Ibid, at [79]. **18** Ibid, at [79]. **19** Applying *Layton v Vines* (1952) 85 CLR 352 at 358. **20** At [98]. **21** At [137]. **22** J K McLaughlin and R Brookmeyer, 'Epidemiology and Biostatistics' in McCunney (ed), *A Practical Approach to Occupational and Environmental Medicine*, 1994, utilising the criteria of A B Hill, 'The Environment and Disease: Association or Causation' (1965) 58 *Proceedings of the Royal Society of Medicine* 295. **23** Citing *National Insurance Co of New Zealand Ltd v Espagne* (1961) 105 CLR 569 at 591; *March v E & MH Stramare Pty Ltd* (1991) 171 CLR 506 at 509, 522, 530-531; *Chappel v Hart* (1998) 195 CLR 232 esp at [6]-[7], [23], [62-[64], [93], [111], [122]. See generally I Freckelton and D Mendelson (ed), *Causation in Law, Medicine and Science*, Dartmouth, Ashgate, 2002. **24** At [142]-[143]. **25** At [161]. **26** At [172]. **27** At [282], [290]. **28** At [183]. **29** *Chappel v Hart* (1998) 195 CLR 232. **30** At [107]-[109]. **31** (1998) 195 CLR 232; see further J Doyle CJ, 'Causation in the Context of Medical Practitioners' Liability for Negligent Advice' in I Freckelton and D Mendelson (ed), *Causation in Law and Medicine*, Ashgate, Dartmouth, 2002, at p396ff. **32** (1999) 73 ALJR 782. **33** [1973] 1 WLR 1. **34** [2002] 3 WLR 89; [2002] UKHL 22. **35** At [45]. **36** At [100]. **37** In so doing it affirmed the approach of the House in *McGhee v National Coal Board* [1973] 1 WLR 1. See further *Gregg v Scott* [2002] EWCA 1471. **38** *Federal Judicial Manual*, at p168. **39** *De Luca v Merrell Dow Pharmaceutics Inc*, 911 F 2d 941 at 958-959. **40** *In Re Joint E & S Dists Asbestos Litig*, 758 F Supp 199 at 203 (SDNY 1991). **41** *Manko v United States*, 636 F Supp 1419 at 1434 (WD Mo 1986). **42** *Marder v GD Searle & Co*, 630 F Supp 1087 at 1092 (D Md 1986). **43** *In re 'Agent Orange' Prod Liab Litig*, 597 F Supp 740 at 835-837 (EDNY, 1984). **44** See *Civil Liability Act* 2002 (NSW), s5D and, to a lesser degree, *Wrongs Act* 1936 (SA), s34(2); *Civil Law (Wrongs) Act* 2002 (ACT), s45(2). **45** See J Stapleton, 'Scientific and Legal Approaches to Causation' in I Freckelton and D Mendelson (ed), *Causation in Law and Medicine*, Ashgate, Dartmouth, 2002, at p21ff. **46** See D Mendelson, 'Australian Tort Reform: Statutory Principles of Causation and the Common Law' (2004) 11 *Journal of Law and Medicine* 492. **47** See for example, *In re Joint Eastern and Southern Asbestos Litigation*, 827 F Supp 1014 (1993, SDNY), reversed 52 F 3d 1124 (2d Cir 1995). **48** K Mason, 'Fault, Causation and Responsibility: Is Tort Law Just An Instrument of Corrective Justice?' in I Freckelton and D Mendelson (ed), *Causation in Law and Medicine*, Ashgate, Dartmouth, 2002.