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Toxic Causation

Daniel A. Farber*

Since 1970, legal attention to the risks created by toxic substances has increased dramatically. Congress has passed numerous regulatory statutes aimed at preventing future problems or cleaning up current hazards. In the meantime, courts have been faced with an increasing number of tort actions seeking damages for injuries allegedly caused by toxic substances. These cases have presented the legal system with a wide range of novel issues, and have sometimes strained the system to its limits. One of the most intriguing of these toxic

* Professor of Law, University of Minnesota. I would like to thank Professors Roger Findley, Philip Frickey, John Matheson, Donald Marshall, and Judge Richard Posner for their helpful comments.


2. For a list of the relevant federal statutes, see Note, Tort Actions for Cancer: Deterrence, Compensation, and Environmental Carcinogenesis, 90 YALE L.J. 840, 841 n.6 (1981). Materials relating to these statutes are collected in R. FINDLEY & D. FARBER, ENVIRONMENTAL LAW: CASES AND MATERIALS 431-542 (2d ed. 1985).

3. For citations to many of these cases, see infra notes 65-79.


5. See Rabin, Environmental Liability and the Tort System, 24 HOUS. L. REV. 27, 32 (1987) (“mass accident torts . . . put the flexibility of the tort system to the test . . . [b]ut they pose nothing like the challenge of unconfined liability intrinsic to many environmental harms”). The asbestos cases, for example, involve personal injury claims estimated at $30 to $40 billion over the next 30 years; approximately 20,000 suits are now pending. See Rosenberg, Book Review, 99 HARV. L. REV. 1693, 1693 (1986) (reviewing P. BRODEUR, OUTRAGEOUS MISCONDUCT: THE ASBESTOS INDUSTRY ON TRIAL (1985)). For background on the asbestos litigation, see Special Project, An Analysis of the Legal, Social, and Political Issues Raised by Asbestos Litigation, 36 VAND. L. REV. 573
tort issues involves causation. Proof that a toxic substance is harmful often involves evidence on the frontiers of science. In many cases, the most that can be said is that exposure to a substance increased the risk that the plaintiff would contract a disease. Epidemiological evidence often can indicate only the probability that the plaintiff’s injury was caused by the defendant. The difficult problem of how to handle these cases has given rise to extensive scholarly debate.

At present, something of a scholarly consensus exists in favor of making recoveries proportional to the probability of causation. For instance, if there was a thirty percent likelihood of recovery, the plaintiff would receive thirty percent of the compensable amount. However, this approach has been criticized for giving too much weight to statistical evidence and not enough to the subjective experiences of individuals who have been exposed to toxic substances. The debate continues as to the best way to handle these cases, with some arguing for a more subjective approach and others for a more objective one.


9 See, e.g., K. Abraham, supra note 5, at 57-60 (advocating use of a fund to compensate individuals on a probabilistic basis); Delgado, Beyond Sindell: Relation of Cause-In-Fact Rules for Indeterminate Plaintiffs, 70 Calif. L. Rev. 881, 899-902 (1982) (proposing that recoveries be shared pro rata among
hood that the defendant caused the plaintiff's cancer, the plaintiff would receive thirty percent of his total damages.\footnote{For a similar approach to evaluating tort claims for damages covering future consequences, see King, \textit{Causation, Valuation, and Chance in Personal Injury Torts Involving Preexisting Conditions and Future Consequences}, 90 \textit{Yale L.J.} 1353, 1377-81 (1981) (advocating a move beyond the "all-or-nothing" approach).} Proportional recovery spreads compensation over all possible victims, fully compensating no one but paying something even on the weakest claims.

This Article argues that proportional recovery is valid only under limited circumstances. It proposes a new theory (called the MLV or "most likely victim" approach) that is generally more appropriate. Under MLV, those plaintiffs whose injuries were least likely to have been caused by the defendant receive nothing, while those with the highest causation probabilities get full compensation.\footnote{See infra text accompanying notes 107-25.} MLV has the advantage of focusing compensation on those who were most clearly injured by the defendant, while denying compensation to those whose claims are the most speculative.\footnote{MLV maximizes the probability that compensation will be given to those who were actually injured. Thus, if we wish to compensate the actual victims of toxic substances, MLV identifies those most deserving of compensation.} Even where MLV is not directly applicable, the theory illuminates the proper handling of other varieties of toxic tort cases.\footnote{See infra text accompling notes 127-36 ("signature disease" and "no causation" cases) & 152-59 (clinical proof cases).}

Part I of this Article lays the groundwork for discussion of the MLV theory. After a brief survey of toxic tort law, Part I analyzes the leading judicial opinions on toxic causation. Part II turns to the scholarly literature on causation in toxic tort litigation and discusses the MLV approach. Finally, in Part III, a taxonomy of toxic causation issues is presented. The rich diversity of toxics cases precludes any one formula from resolving

all causation problems. Nevertheless, MLV theory is helpful in understanding a broad range of cases.

I. THE EMERGING LAW OF TOXIC CAUSATION

Understanding the causation issue requires some background. This issue arises in the context of toxic tort litigation, which in itself is a new and rapidly changing field. Courts have had more occasion to think about causation in the related field of toxics regulation. In the last few years, however, a substantial number of toxic tort opinions have come out of the lower federal courts. These opinions are useful not only because of what they may indicate about the direction of legal development, but also because they illuminate the diverse factual settings in which the toxic causation issue arises.

A. TOXIC TORTS IN A NUTSHEL

The plaintiff’s first problem is to establish that the defendant’s conduct met the requisite liability standard. Although many toxic tort plaintiffs have brought actions under products liability theories holding manufacturers strictly liable for defective products, the liability standard is less clear in cases not involving manufacturers. The generally accepted liability test

14. See supra notes 2-4 and accompanying text.
15. See, e.g., School Dist. of Lancaster v. Lake Asbestos of Quebec, Ltd., 789 F.2d 996, 999 (3d Cir. 1986) (claims brought under various theories including strict liability against asbestos producers); In re Diamond Shamrock Chems. Co., 725 F.2d 858, 859 (2d Cir. 1984) (plaintiffs’ theories against producers of Agent Orange included strict liability, negligence, breach of implied warranty, intentional tort, and nuisance); Indiana Harbor Belt R.R. v. American Cyanamid Co., 517 F. Supp. 314, 315 (N.D. Ill. 1981) (actions brought under negligence and strict liability theories for spillage of toxic substances); Cities Serv. Co. v. Florida, 312 So. 2d 799, 801 (Fla. 1975) (imposing strict liability on defendant for toxic accident). See also Special Project, supra note 5, at 582 n.23 (stating that most claims against asbestos manufacturers are brought under a theory of strict liability).

Peter Huber, a Washington, D.C. attorney, argues forcefully that courts are insufficiently aware of the possible benefits of new technology and are consequently prone to impose excessive liability. See Huber, Safety and the Second Best: The Hazards of Public Risk Management in the Courts, 85 COLUM. L. REV. 277, 305-29 (1985). But see Stewart, Regulation, Innovation, and Administrative Law: A Conceptual Framework, 69 CALIF. L. REV. 1236, 1364-77 (1981) (stating that regulatory agencies and courts consider economic and social consequences as well as risks of new technologies). As noted earlier, however, this Article is concerned only with the substantive standard for compensation, not with what forum is most appropriate.

16. For general discussions of the liability issue, see Developments, supra note 4, at 1610-17; Comment, Pesticide Torts: Oregon Law on Injuries Caused
for hazardous waste releases is stated in the Second Restatement of Torts. Under this test, liability exists despite the exercise of due care if an activity was "abnormally dangerous." To determine whether an activity is abnormally dangerous, a court must weigh the probability and severity of foreseeable harm, whether the activity is unusual or is in an inappropriate location, and other factors. Thus, fault plays a role in the Restatement assessment.

17. According to the Second Restatement, the following factors are relevant: (a) existence of a high degree of risk of some harm to the person, land or chattels of others; (b) likelihood that the harm that results from [the activity] will be great; (c) inability to eliminate the risk by the exercise of reasonable care; (d) extent to which the activity is not a matter of common usage; (e) inappropriateness of the activity to the place where it is carried on; and (f) extent to which its value to the community is outweighed by its dangerous attributes. Restatement (Second) of Torts § 520 (1977).

18. See Superfund Section 301(e) Study Group, 97th Cong., 2d Sess., Injuries and Damages from Hazardous Wastes—Analysis and Improvement of Legal Remedies, A Report to Congress in Compliance with Section 301(e) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 273 (Comm. Print 1982) [hereinafter Superfund Report] (whenever a balancing of factors is required under a strict liability theory, as in the Restatement, fault is easily implied). Furthermore, liability must be determined on a case-by-case basis. Id. at 272. The official commentary to the Restatement says that “[b]ecause of the interplay of these various factors, it is not possible to reduce abnormally dangerous activities to any definition.” Restatement (Second) of Torts § 520 comment f (1977). For instance, as the commentary to the Restatement makes clear, storing high explosives may or may not be an abnormally dangerous use, depending on the location. Id. § 520 comments g & j. As the Superfund Section 301(e) Study Group said:

[These tests] consider the place where the activity is carried on, or consider alternatives to the activity. Such considerations permit notions of fault to get in by the back door, because the choice of place, the question of appropriateness of the activity to a particular place, or choices in the manner of conducting the activity invariably import notions of duty of care, responsibility and fault. This, in turn, places the heavy burden of proof back on the plaintiff. Superfund Report, supra, at 278. This test differs in some relatively minor ways from alternative tests used by some courts, such as the test adopted by the first Restatement. See Superfund Report, supra, at 273 (the balancing emphasis of the Restatement (Second) of Torts’s test is theoretically different from the initial Restatement test); Prosser and Keeton on Torts § 78, at 551-52 (5th ed. 1984) (stating that courts adopt Rylands v. Fletcher, as had the
In *State v. Ventron Corp.*, the New Jersey Supreme Court imposed strict liability for harm caused by toxic substances escaping from a landowner's property.

When a reasonable medical expert would advise increased surveillance because of exposure, it is hard to see why the firm causing this expense should not be liable, even if the additional risk cannot be quantified. See Ayers, 189 N.J. Super. at 572-73, 461 A.2d at 190; Askey v. Occidental Chem. Corp., 102 A.D.2d 130, 135, 477 N.Y.S.2d 242, 246 (N.Y. App. Div. 1984). See generally Jackson v. Johns-Manville Sales Corp., 727 F.2d 506, 522 (5th Cir. 1984) (Jackson I) (stating that courts can establish the "reasonable necessity and expense of future medical examinations"), aff'd in part, rev'd in part, 750 F.2d 1314 (5th Cir. 1985) (en banc) (Jackson II), aff'd on reh'g, 781 F.2d 394 (5th Cir. 1985) (en banc) (Jackson III), cert. denied, 106 S. Ct. 3339 (1986). Since the purpose is to finance a means of limiting future injury, this remedy can be considered preventive rather than compensatory.

On the other hand, to allow damages for emotional distress caused by fear of possible future injuries, as one commentator has suggested, could expose companies to unforeseeable and potentially crippling liability even when it was ultimately determined that their conduct had not caused any tangible harm. Bohrer, *Fear and Trembling in the Twentieth Century: Technological Risk, Uncertainty and Emotional Distress*, 1984 Wis. L. Rev. 83, 99. Nevertheless, in an asbestos case, the Fifth Circuit upheld an award of damages for the plaintiff's fear of getting cancer, although the court concluded that there was no proof of a "medical probability" that he actually would get cancer. Dartez v. Fibreboard Corp., 765 F.2d 456, 467 (5th Cir. 1985). See also Jackson III, 781 F.2d at 413-15 (upholding damages for fear of cancer where plaintiff already had asbestos disease and had greater than 50% chance of getting cancer); Anderson v. Welding Testing Lab., Inc., 304 So. 2d 351, 353 (La. 1974) (fear of cancer from radiation burns was compensable although the actual risk might be minimal). But see Payton v. Abbott Labs, 386 Mass. 540, 544-47, 437 N.E.2d 171, 174-76 (1982) (rejecting emotional distress damages in a DES case). Another
Even if the defendant’s conduct meets the requisite legal standard for liability, several possible barriers may prevent recovery. Statutes of limitations can create major difficulties in some states. For example, a New York trial judge in 1983 dismissed fifty-four of ninety-one personal injury actions by residents of Love Canal. The judge held that the actions were barred by New York’s statute of limitations because they were filed more than three years after exposure to the toxic chemicals. The statute of limitations problem has also received great attention in the asbestos cases.

Another problem is establishing a link between the defendant and the release of the substance. For example, many hazardous waste generators may have shipped similar materials to the site in question. It may be quite difficult to establish whose containers leaked or in what quantities. A similar issue can arise in products liability cases. In *Sindell v. Abbott Laboratories*, the plaintiff’s mother was administered the drug diethylstilbestrol (DES) during pregnancy. Although DES was routinely given to prevent miscarriage, it is now known to cause a rare form of cancer in some daughters of women who took the drug. After developing such cancer, the plaintiff...
sued eleven of the more than two hundred manufacturers of DES. Although the plaintiff was unable to identify the manufacturer of the particular DES which her mother took, the court held that she had stated a cause of action against manufacturers of the drug using an identical formula. Resting this holding on a broad social policy, the court noted that the defendants were "better able to bear the cost of injury resulting from the manufacture of a defective product." The Sindell court then adopted a novel theory of liability by making each defendant liable for a share of the plaintiff's damages, based on its share of the DES market. Assuming that the Sindell theory or one of its variants becomes the norm in products liability litigation, it could be readily adapted to hazardous waste litigation.

B. THE CAUSATION PROBLEM

Sindell and related theories address the problem of linking the defendant to the chemical exposure. An even more difficult problem is that of linking the exposure to the plaintiff's injury. It is a commonplace that toxic chemical regulation involves matters at the boundaries of scientific knowledge. This

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29. Sindell, 26 Cal. 3d at 593, 602-03, 607 P.2d at 925, 935, 163 Cal. Rptr. at 133, 143.
30. Id. at 610-13, 607 P.2d at 936-38, 163 Cal. Rptr. at 144-46.
31. Id. at 611, 607 P.2d at 936, 163 Cal. Rptr. at 144.
32. Id. at 611-12, 607 P.2d at 937, 163 Cal. Rptr. at 145.
34. See Industrial Union Dept't, AFL-CIO v. American Petroleum Inst., 448 U.S. 607, 610 (1980); Ethyl Corp. v. EPA, 541 F.2d 1, 6-7 (D.C. Cir.) (en banc), cert. denied, 426 U.S. 941 (1976); Reserve Mining Co. v. EPA, 514 F.2d 492, 513 (8th Cir. 1975); see also McGarity, supra note 6, at 736-47 (varying scientific interpretations and inferences make formal rulemaking inadvisable);
scientific uncertainty causes severe problems for government regulators, but even more serious problems result for private plaintiffs who must establish a defendant's liability by a preponderance of the evidence.

In considering compensation, it is important to keep in mind that there are really two causation problems. One is the problem of establishing that the chemical involved is capable of causing the type of harm from which the plaintiff suffers. This is often difficult because the causation of diseases like cancer is so poorly understood. For this reason, medical theory is
relatively unhelpful in filling in gaps in the factual picture. Facts themselves are hard to come by. Many toxic substances are relatively novel, and, given the long latency periods associated with cancer, sufficient evidence concerning health effects is not likely to be available for the foreseeable future. Animal studies, although useful, generally involve much higher doses that are difficult to extrapolate to low doses over prolonged periods; there is also the question of whether extrapolation of results between species is valid. Epidemiological studies are also helpful but often inconclusive regarding the level of risk created by a toxic substance.³⁹

The other problem relating to proof of causation is that of establishing, given that the toxic substance in question can cause harm of the type suffered by the plaintiff, that the plaintiff’s harm did in fact result from such exposure. A chemical may increase the prevalence of a disease enough to leave no doubt that some members of the exposed population were injured by that chemical. Others, however, may have suffered injuries from independent sources, and the two groups may be impossible to distinguish. The statistical association between exposure and illness may be too weak to justify a finding that a particular plaintiff’s disease is causally linked to an exposure to a hazardous substance.

1. Causation in the Regulatory Context

Toxic chemicals are regulated under a number of federal statutes.⁴⁰ A recurring problem has been the difficulty of establishing, given the limits of present scientific knowledge, that a particular substance is indeed a health hazard and therefore subject to regulation.⁴¹

The leading case on the problem of scientific uncertainty in...
this context is Reserve Mining Co. v. EPA. Reserve Mining discharged huge amounts of mining byproducts containing asbestos into Lake Superior, thereby contaminating Duluth's drinking water. In considering the question of risk, the Eighth Circuit was handicapped by a lack of scientific evidence on the danger of ingesting (as opposed to inhaling) asbestos. The plaintiffs' only significant evidence was that workers exposed to asbestos dust suffered from a moderate increase in gastro-intestinal cancer. One possible explanation, according to expert witnesses, was that asbestos workers first inhaled the asbestos dust and then coughed up and swallowed the asbestos particles. The most the court could conclude was that public exposure to asbestos fibers "gives rise to a reasonable medical concern for the public health." The court was unable to conclude, however, that "the probability of harm is more likely than not." Nevertheless, given the potential seriousness of the threat to public health, the Eighth Circuit found the evidence sufficient to justify an order requiring Reserve Mining to eliminate the discharge expeditiously.

The Supreme Court's first encounter with the problem of toxic chemicals was in Industrial Union Department, AFL-CIO v. American Petroleum Institute, generally known as the "benzene case." The case involved an occupational safety regu-

42. 514 F.2d 492 (8th Cir. 1975). For further background on the case, see M. SHAPO, A NATION OF GUINEA PIGS 191-217 (1979). The Reserve Mining approach to risk was followed in Lead Indus. Ass'n v. EPA, 647 F.2d 1130 (D.C. Cir. 1980); Ethyl Corp. v. EPA, 541 F.2d 1 (D.C. Cir.) (en banc), cert. denied, 426 U.S. 941 (1976). See generally McGarity, supra note 6, at 796-808 (examining the appropriate judicial role in reviewing agency decisions on scientific issues).

43. The district court had directed a study of the tissues of long-time Duluth residents to determine whether asbestos fibers were present. Reserve Mining Co., 514 F.2d at 514. The plaintiffs' principal medical witness had testified that the study should disclose the presence of asbestos if orally ingested asbestos is absorbed by the body. Id. Nevertheless, the study failed to indicate that Duluth residents had any greater amounts of asbestos in their tissues than residents of Houston, where the water is free of asbestos fibers. Id. at 514-15. Moreover, animal tests intended to determine whether ingested fibers penetrate into the body were inconclusive. Id. at 515-16.

44. Id. at 516.
45. Id. at 520.
46. Id.

47. Id. at 520, 538-40. On the remedial issue, see Farber, Equitable Discretion, Legal Duties, and Environmental Injunctions, 45 U. Pitt. L. REV. 513, 531-35 (1984).

48. 448 U.S. 607 (1980) ("these are unusually important cases of first impression," id. at 615.).
lation governing benzene, a carcinogen for which a safe level of exposure is not known to exist. The Secretary of Labor had set the permissible exposure level for workers at one part per million (ppm), which he considered the lowest economically feasible level that industries could achieve.\textsuperscript{49} The primary opinion was written by Justice Stevens and was joined in its entirety by only two other Justices.\textsuperscript{50} According to the plurality opinion, the Secretary must make a threshold finding of a “significant risk of harm” before issuing any regulation.\textsuperscript{51} The plurality went to some lengths to rebut the dissent’s charge that this approach would prevent effective regulation until deaths had actually occurred. First, the plurality stated that what constitutes a “significant” risk was a judgment for the agency to make and plainly involved policy considerations.\textsuperscript{52} Second, the plurality noted that the agency’s findings need not be supported by “anything approaching scientific certainty.”\textsuperscript{53} Thus, the plurality concluded that “so long as they are supported by a body of reputable scientific thought, the Agency is free to use conservative assumptions in interpreting the data with respect to carcinogens, risking error on the side of overprotection rather than

\textsuperscript{49} Id. at 613. The Occupational Safety and Health Administration (OSHA) estimated the total cost of compliance as including $266 million in capital investments, $187 to $205 million in first-year start-up costs, and $34 million in annual costs. Id. at 628-29. About 35,000 employees were affected by the regulation. Id. at 629. The Fifth Circuit had struck down the regulation on the theory that the statute implicitly required a cost-benefit analysis by the agency. Id. at 614. On review, only one member of the Supreme Court, Justice Powell, reached this issue, see id. at 667-71 (Powell, J., concurring). Another member of the Court, Justice Rehnquist, concurred in the judgment but based his opinion on his finding that the statute was an unconstitutional delegation of legislative power, id. at 671-88 (Rehnquist, J., concurring). The Court as a whole divided four to four on the issue whether the standards set were based on adequate findings in the administrative record.

\textsuperscript{50} Chief Justice Burger and Justice Stewart joined the primary opinion in its entirety. Id. at 611. Justice Powell also joined parts of the opinion. Id. at 664 (Powell, J., concurring).

\textsuperscript{51} Id. at 642. After close examination of the record, the plurality observed that the industry had argued that the regulation would save at most two lives every six years. Id. at 654. According to the plurality, a risk of one in a billion is clearly insignificant, but a risk of one in a thousand “might well” be considered significant. Id. at 655. The Court declined to determine whether the risk level alleged by industry would be considered significant because OSHA itself had made no finding on this issue, which the plurality thought to be a critical requirement of the Act. Id. at 655.

\textsuperscript{52} Id.

\textsuperscript{53} Id. at 656.
underprotection.”

The benzene case clearly leaves the law in some confusion. Only four members of the Court believed that a “signifi-

54. Id. Chief Justice Burger stressed the limitations of the plurality opinion:

Our holding that the Secretary must retrace his steps with greater care and consideration is not to be taken in derogation of the scope of legitimate agency discretion. When the facts and arguments have been presented and duly considered, the Secretary must make a policy judgment as to whether a specific risk of health impairment is significant in terms of the policy objectives of the statute. When he acts in this capacity, pursuant to the legislative authority delegated by Congress, he exercises the prerogatives of the legislature—to focus on only one aspect of a larger problem, or to promulgate regulations that, to some, may appear as imprudent policy or inefficient allocation of resources. The judicial function does not extend to substantive revision of regulatory policy.

Id. at 663 (Burger, C.J., concurring). The Chief Justice noted, however, that “[p]erfect safety is a chimera; regulation must not strangle human activity in the search for the impossible.” Id. at 664.

55. Unfortunately, the Supreme Court’s only other decision in this area does little to clarify this issue. American Textile Mfrs. Inst., Inc. v. Donovan, 452 U.S. 490 (1981), involved a standard regulating cotton dust, which causes a disease called byssinosis (more commonly known as “brown lung” disease). The benzene case is discussed only in a footnote in American Textile Mfrs. Inst., Inc. See id. at 505 n.25. OSHA had “expressly found that ‘exposure to cotton dust presents a significant health hazard to employees’”; indeed, 25% of all employees in the industry suffered at least low-grade byssinosis. Id. at 506 n.25 (quoting 43 Fed. Reg. 27,350 (1978)). As the Court said, “It is difficult to imagine what else the agency could do to comply with this Court’s decision in the benzene case.” Id.

The primary issue before the Supreme Court was whether the agency had to conduct a cost-benefit analysis before issuing its regulation. In an opinion by Justice Brennan, the Court held that a cost-benefit analysis was not necessary. Id. at 512-13. According to the Court, all that is necessary is a feasibility analysis, that is, an analysis showing that performance is economically possible but not an analysis comparing the cost of compliance with the benefits of the regulation. Id. at 508-12.

The implications of these OSHA decisions for toxic regulation in general remain unclear. The four dissenters in the benzene case have clearly endorsed the approach taken by lower courts in cases like Reserve Mining Co. See supra notes 42-47. The members of the plurality in the benzene case have taken a more cautious view, but apparently are not willing to reject squarely the prevailing approach in the lower courts. One member of the Court, Chief Justice Rehnquist, has never spoken to the merits of any of these issues, while Justices O’Connor and Scalia were not present for the decision of either case. Thus, we can only speculate about the Court’s future direction. Certainly, however, it would be an exaggeration to see the Supreme Court opinions as a repudiation of the doctrines developed by the lower courts in this area. For a useful, recent judicial opinion, see Public Citizen Health Research Group v. Tyson, 796 F.2d 1479 (D.C. Cir. 1986) (reviewing OSHA’s rule limiting exposure to ethylene oxide). For further discussion, see Latin, The “Significance” of Toxic Health Risks: An Essay on Legal Decisionmaking Under Uncertainty, 10 ECOLOGY L.Q. 339 (1982) (addressing the question of how courts
cant risk” finding was required by the Occupational Safety and Health Act. Four members disagreed and a fifth member believed that the statute was completely silent on the problem.\textsuperscript{56} Even the Stevens plurality opinion, however, gave the agency substantial leeway in dealing with scientific uncertainty.

The courts’ relatively liberal attitude toward proof of harm in the regulatory context might appear to argue strongly for a similar attitude in the compensation context. In the regulatory cases, however, the issue is one of prevention. If society can prevent possible injuries in the future by taking sensible preventive action today, clearly society ought to do so even if no one can be sure that any injuries would otherwise occur. Wearing a seat belt makes sense even though you do not know in advance that you will ever be in an accident. Moreover, prevention does not require that the particular victims be identified. Compensation is a different matter. We do not impose liability on a driver who \textit{might} have been involved in a car crash but who was more likely in a different city on the day of the accident. Prevention is always linked to the possibility of a future accident. Compensation, although serving some deterrent purpose, is primarily based on the existence of a past accident.\textsuperscript{57} Thus, the regulatory cases have only limited relevance should respond to factual uncertainty resulting from the absence of reasonable scientific consensus in fields of environmental protection, public health and safety).

\textsuperscript{56} The decisive fifth vote was cast by Justice Rehnquist, who reached his decision on constitutional grounds. Justice Rehnquist argued that the statute was an unconstitutional delegation of legislative authority to the agency. \textit{See Industrial Union Dep’t, AFL-CIO}, 448 U.S. at 672, 675 (Rehnquist, J., concurring). This view is somewhat out of line with the Supreme Court’s decisions over the last half century. Not since the Court’s unsuccessful attempt to block the New Deal has the Court struck down a statute on this basis.

Justice Marshall wrote a stinging dissent, joined by Justices Brennan, White, and Blackmun. Justice Marshall found it incredible that the plurality could read any substantive meaning into the statutory definition of a health standard as one “reasonably necessary” to provide safe employment. \textit{Id.} at 708-13 (Marshall, J., dissenting). In his view, the meaning of the statute was clear: in dealing with any toxic chemical, the Secretary was to set a standard which would \textit{ensure} (to the extent feasible) that no risk would be presented to any employee. \textit{See id.} at 689-90. Justice Marshall’s view does seem to give the most natural reading to the statutory language. \textit{See 29 U.S.C. § 655(b)(5)} (1982) (“The Secretary . . . shall set the standard which most adequately ensures, to the extent feasible . . . that no employee will suffer material impairment of health or functional capacity . . .”).

\textsuperscript{57} As Judge Weinstein explained:

The distinction between avoidance of risk through regulation and compensation for injuries after the fact is a fundamental one. In the former, risk assessments may lead to control of a toxic substance even
to the compensation problem.

2. Tort Litigation

Despite the novelty of tort litigation over toxic causation, clear patterns have already evolved in some areas. Swine flu liability is one such area. In 1976, to head off a possible epidemic, the government implemented a mass immunization program. Vaccination was later suspended because of an apparent connection between the vaccine and an increase in Guillain-Barré Syndrome (GBS). GBS is a rare neurological disease of unknown origin. A study by the Center for Disease Control (CDC) established the existence of a clearly elevated rate of GBS immediately following immunization, tapering off over several months. By ten weeks after immunization, according to CDC, GBS was close to the background rate, that is, the rate among those who were not vaccinated. Through a combination of government stipulation of liability as to some cases and litigation over the others, the following compensation rules emerged:

1. the government is liable for any case of GBS within ten weeks of immunization;
2. the government generally is not liable for any later cases of GBS; and
3. the government usually is not liable for any other diseases, regardless of proximity to immunization.

Though the probability of harm to any individual is small and the studies necessary to assess the risk are incomplete; society as a whole is willing to pay the price as a matter of policy. In the latter, a far higher probability (greater than 50%) is required since the law believes it unfair to require an individual to pay for another's tragedy unless it is shown that it is more likely than not that he caused it.


59. Id. at 308, 317.
60. Id. at 308.
61. See id. at 307 (“the government has stipulated to liability in GBS cases with an onset of ten weeks or less after vaccination”).
62. See id. at 307, 315-16 (finding that the government was not liable when plaintiffs developed GBS 12-1/2 to 13-1/2 weeks after receiving the vaccine); Heyman v. United States, 506 F. Supp. 1145, 1150 (S.D. Fla. 1981) (finding the government not liable when the plaintiff developed GBS 16 weeks after receiving the swine flu vaccine).
63. See Hasler v. United States, 718 F.2d 202, 205-06 (6th Cir. 1983) (finding the government not liable when plaintiff developed rheumatoid arthritis 10 days after receiving vaccine), cert. denied, 469 U.S. 817 (1984); Kubs v. United States, 537 F. Supp. 560, 563 (E.D. Wis. 1982) (finding the government not liable when the only connection between plaintiff's polymyalgia rheumat-
causation problem in mass exposure cases is not necessarily an impossible barrier to recovery.\textsuperscript{54} Litigation about Agent Orange, a defoliant and herbicide used by American forces in the Vietnam War, has provided the most extensive judicial discussion of toxic causation.\textsuperscript{55} Numerous lawsuits were filed against the manufacturers by veterans, their families, and others who contended that Agent Orange had caused various illnesses. Ultimately, the litigation was consolidated in Judge Weinstein's court in the Eastern District of New York.\textsuperscript{66} The weakness of the plaintiffs' causation evidence\textsuperscript{67} persuaded Judge Weinstein to approve a $180 million

\textsuperscript{54} See infra notes 127-36 and accompanying text for further examples.


\textsuperscript{56} The main class action was filed in 1979, and the class was certified in 1980. In re "Agent Orange" Prods. Liab. Litig., 597 F. Supp. at 750, 752. The size of the class was variously estimated at 600,000 to 2,400,000, of whom 2440 opted out. \textit{Id.} at 756. More than a thousand members of the class were heard from concerning the possible settlement. \textit{Id.} at 764. Notices concerning the settlement were sent to over 400,000. \textit{Id.} at 763. Discovery involved more than 200 depositions and "hundreds of thousands of pages of government documents, many of which were formerly considered classified." \textit{Id.} at 757. The final settlement involved a payment of $180 million with interest at the rate of $60,000 per day. \textit{Id.} at 748. Many of the 4500 lawyers who participated have filed appeals. See 54 U.S.L.W. 2095 (Aug. 13, 1985). Because of a dispute about the distribution of the settlement proceeds, the judgment was stayed by the Second Circuit. N.Y. Times, Aug. 28, 1986, \textsection A, at 1, col. 3. The fund had grown to $225 million by August, 1986. \textit{Id.}, Aug. 28, 1986, \textsection B, at 12, col. 1. The settlement approved by Judge Weinstein was upheld by the Second Circuit. N.Y. Times, Apr. 21, 1987, at 14, col. 4. A three-judge panel of the Second Circuit handed down nine opinions, all concerning aspects of the Agent Orange cases, on April 21, 1987. \textit{In re "Agent Orange" Prods. Liab. Litig. MDL No. 381}, slip ops. (2d Cir. Apr. 21, 1987).

\textsuperscript{57} See \textit{In re "Agent Orange" Prods. Liab. Litig.}, 597 F. Supp. at 782. The
settlement, which was considered highly favorable to the defendants. As Judge Weinstein explained, the evidence concerning the possible dangers from Agent Orange would have been enough for a court to uphold an administrative order limiting its use. Emphasizing the distinction between preventive regulatory measures and compensatory legal actions, however, Judge Weinstein noted that "[i]n the latter [case], a far higher probability (greater than 50%) is required since the law believes it unfair to require an individual to pay for another's tragedy unless it is shown that it is more likely than not that he caused it." The key flaw in the plaintiffs' case was that government epidemiological studies showed no statistical link between Agent Orange exposure and significant health effects. Studies by the Air Force, the CDC, and the Australian government all had concluded that no health effects had been demonstrated. Hence, Judge Weinstein agreed that a settlement was in the best interests of the class.

In companion cases, involving opt-outs or individuals never included in the class, Judge Weinstein was forced to rule on the merits of the plaintiffs' claims. Suits also involved extraordinary legal complications. Because of the nationwide nature of the class, at least 50 statutes of limitations were potentially applicable, leaving Judge Weinstein in something of a quandary about the applicable law. Several complex products liability issues were also involved.

68. Id. at 748-49; but see id. at 764-75 ("more than a thousand class members" expressed their views on the settlement, largely unfavorably). The settlement was far below even the medical costs of the class, ignoring other damages. Id. at 782. According to the Second Circuit, the maximum payment to any single class member would be $12,800. In re "Agent Orange" Prods. Liab. Litig., 800 F.2d 14, 20 (2d Cir. 1986). The unusual settlement process is discussed in detail in Shuck, The Role of Judges in Settling Complex Cases: The Agent Orange Example, 53 U. Chi. L. Rev. 337 (1986).


70. Id. at 781.

71. Id. at 787-94.

summary judgment for the defendants despite the plaintiffs' tender of expert testimony linking Agent Orange with health effects. The epidemiological studies played a key role in these decisions. "The numerous epidemiological studies . . . are sufficient to shift the burden to plaintiffs of showing that a material fact exists as to causation." Judge Weinstein ruled the plaintiffs' expert testimony inadmissible, and then granted summary judgment because the plaintiffs had no admissible evidence to counter the defendants' epidemiological studies.

Judge Weinstein's stress on the epidemiological data seems consistent with the pattern of rulings in the GBS cases, in which the CDC epidemiological study was the key to recovery. The D.C. Circuit, however, has permitted recovery solely

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75. Id. at 1256.

76. Id. at 1258-60. Among the key flaws in the plaintiffs' evidence were the following:

1. Much of the expert testimony was based on unreliable questionnaires. Id. at 1246.

2. Animal and industrial studies did not have significant bearing on the kind of exposure involved in the litigation. Id. at 1241.

3. The plaintiffs' experts did not give sufficient attention to other possible causes in individual cases. Id. at 1251-55.

4. The plaintiffs' experts did not take the government's epidemiological studies into account. Id. at 1250. See generally id. at 1234-56.

Judge Weinstein's opinion is highly persuasive as a judgment on the merits. Indeed, it reads very much like the opinion a judge would write after a bench trial. It is not clear, however, whether these factors, which mostly go to the weight of the evidence, should have led to a finding of inadmissibility followed by summary judgment rather than letting the cases go to the jury. See generally Graham, Expert Witness Testimony and the Federal Rules of Evidence: Insuring Adequate Assurance of Trustworthiness, 1986 U. ILL. L. REV. 43 (suggesting that courts should augment the Federal Rules of Evidence with common-law principles to ensure adequate trustworthiness of expert testimony and help the jury evaluate such testimony). The role of the judge in making such evidentiary determinations, and thus limiting the ability of the jury to make the decision about an expert's credibility, is a fascinating topic, but lies outside the scope of this paper. For an introduction to the literature, see Korn, Law, Fact, and Science in the Courts, 66 COLUM. L. REV. 1080 (1966).

77. See supra notes 58-64 and accompanying text.
on the basis of expert clinical assessments despite a lack of statistical evidence. In *Ferebee v. Chevron Chemical Co.*, the court stated:

Thus, a cause-effect relationship need not be clearly established by animal or epidemiological studies before a doctor can testify that, in his opinion, such a relationship exists. As long as the basic methodology employed to reach such a conclusion is sound, such as use of tissue samples, standard tests, and patient examination, products liability law does not preclude recovery until a "statistically significant" number of people have been injured or until science has had the time and resources to complete sophisticated laboratory studies of the chemical. In a courtroom, the test for allowing a plaintiff to recover in a tort suit of this type is not scientific certainty but legal sufficiency.

This language, while not inconsistent with Judge Weinstein's rulings, seems more favorable toward the admission of expert testimony.

Although a few courts have followed *Ferebee's* broader view of admissibility, the law of toxic causation is just beginning to receive judicial attention. Clearly, a "Restatement of the Law of Toxic Torts" would be premature. It is not too early, however, to look for patterns in the cases and to begin to undertake a theoretical analysis of the causation issue.

**II. THEORETICAL PERSPECTIVES ON TOXIC CAUSATION**

Even before the courts had begun to come to grips with the toxic causation issue, a large theoretical literature had developed on the subject. Most of this scholarly literature concerns the use of probabilistic evidence of causation. As this Article explains, however, the accepted approach to determining causation is valid only in very limited circumstances.

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78. 736 F.2d 1529 (D.C. Cir.), *cert. denied*, 469 U.S. 1062 (1984). *Ferebee* was a suit for damages brought by an agricultural worker against an herbicide manufacturer. The proof of causation consisted of testimony by two treating physicians described by the court as "eminent specialists in pulmonary medicine." *Id.* at 1535.

79. *Id.* at 1535-36.

A. THE SCHOLARLY DEBATE ON PROPORTIONAL RECOVERY

Much of the causation debate has revolved around a single paradigm case. In this paradigm case, a chemical is known to have raised the death rate by some specified amount over the background rate for a particular disease. For example, suppose the normal rate of some variety of cancer among the unexposed public is ten cases per 100,000; among the exposed population, the rate is fifteen per 100,000. Under the "preponderance of the evidence" standard, none of the fifteen cancer victims could recover, because two-thirds of them probably would have gotten the disease anyway (although we do not know which two-thirds). Yet, it seems unjust to relieve the defendant of liability, because the defendant very likely did cause five cancer cases.

Several scholars have argued that these plaintiffs should receive a recovery proportional to the probability that they were harmed by the defendant. If the case is brought after the cancer has developed, this can be done by giving each plaintiff in the above example one-third of her damages. If the cancer threat is known earlier, before actual cancer cases have occurred, the defendant may be required either to pay every person exposed to the chemical an amount compensating for decreased life expectancy, or to provide each person with in-

81. See Delgado, supra note 9, at 884-86; Rosenberg, supra note 8, at 855 (In mass exposure cases, "all or at least large and gradable subclasses of those exposed will be similarly situated with regard to their degree of disease risk, their relationship to the firm, and the circumstances surrounding the tortious conduct.").


83. See Delgado, supra note 9, at 900-01; Developments, supra note 4, at 1619-24; Robinson, supra note 9, at 751-53, 764; Note, supra note 8, at 600-01. An essentially identical proposal (but calling for "Gestalt judgments" rather than precise evidence) is made in Note, Causation in Torts: Burdens of Proof, Standards of Persuasion, and Statistical Evidence, 96 YALE L.J. 376, 397-401 (1986).

insurance covering one-third of the damages resulting from this sort of cancer.\(^{85}\) Regardless of the mechanics, the result is to expand compensation beyond the plaintiffs who actually got cancer from the chemical while correspondingly reducing each plaintiff's recovery.

Powerful arguments have been made in favor of proportional recovery. Sindell has already established that a plaintiff may recover without proving a particular defendant was the cause of the injury.\(^{86}\) Proportional recovery inverts Sindell, allowing recovery where the uncertainty concerns the identity of the injured party rather than that of the defendant. A general consensus seems to exist in favor of blurring the causation requirement in the Sindell situation of the "indeterminate defendant." It seems but a small additional step to do so here for the "indeterminate plaintiff."\(^{87}\) Another point in favor of proportional recovery is that it guarantees that the defendant pays the plaintiffs as a class for the full amount of injury done by the chemical. The defendant is thus given a powerful economic incentive to avoid imposing this harm. Without proportional recovery, the defendant would often escape liability altogether because of the causation problems. Economic theory indicates that requiring defendants to "internalize" these costs increases economic efficiency.\(^{88}\) Finally, imposing liability serves the goal


86. See supra notes 26-33 and accompanying text.
87. This line of argument is developed at length in Delgado, supra note 9.
88. See Landes & Posner, supra note 9, at 431-32; Rosenberg, supra note 8, at 865; Shavell, An Analysis of Causation and the Scope of Liability in the Law of Torts, 9 J. LEGAL STUD. 463, 475-85 (1980). Some of the costs of serious
of "loss spreading" by shifting some of the loss from individuals to firms that can often pass on the cost of insurance to their customers. Thus, the general policies of tort law are advanced by allowing proportional recovery.\textsuperscript{89}

Although the great weight of scholarly authority—along with some impressive support from outside the academy\textsuperscript{90}—favors proportional recovery, some dissenters do exist. One counter-argument has been based on objections to basing recovery wholly on probabilistic evidence.\textsuperscript{91} Viewing proportional recovery as a matter of evidence law, as some of its proponents have presented it,\textsuperscript{92} does appear to represent a radical departure from traditional standards of proof.\textsuperscript{93} Proportional recovery does not, however, really change the evidentiary standard.\textsuperscript{94}

\begin{footnotes}
\item[89] See Delgado, supra note 9, at 891-95; Robinson, supra note 9, at 736-49.
\item[91] There is a large, very interesting, but—as we shall see—not very relevant body of literature on the relationship between probability theory and evidence law. For citations to most of the literature, see Cohen, Confidence in Probability: Burdens of Persuasion in a World of Imperfect Knowledge, 60 N.Y.U. L. REV. 385, 390 n.33 (1985); Kaye, The Laws of Probability and the Law of the Land, 41 U. CHI. L. REV. 34 (1979).
\item[92] See Rosenberg, supra note 8, at 869-74.
\item[93] See Wright, supra note 33, at 1826. The problems associated with probabilistic evidence are discussed in detail in Robinson, supra note 9, at 740-49.
\item[94] As Professor Charles Nesson has cogently explained, in cases like Sindell,

\begin{quote}
[T]he courts generated a new definition of what was relevant to a finding of liability and thus generated a new rule of substantive law. Whether the courts generated a good rule depends on one's assessment of the rule and of the process of judicial lawmaking. Casting these issues as problems of proof serves only to obscure them. The cases concern changing the elements of the substantive legal rule; the problem of proof is simply that of generating acceptable conclusions about those elements.
\end{quote}

\end{footnotes}
Plaintiffs must still establish by a preponderance of the evidence the facts needed to recover; namely, their exposure to a toxic substance and the statistical effect of that substance on the cancer rate. Establishing these facts entitles them to a remedy; the link between the established facts and the remedy is more a matter of substantive than evidence law.\textsuperscript{95}

Another argument is that we should compensate only for actual harm, not unrealized risks.\textsuperscript{96} Providing proportional compensation to disease victims need not be viewed, however, as compensation for mere exposure to a risk. Rather, compensation is directed, as precisely as possible given highly limited information, to those who actually suffer injury because of the defendant’s conduct. Because these victims cannot be identified precisely, the “fund” must be spread over a larger class, but this is not inconsistent with the basic purpose of compensating actual victims as fully as possible.\textsuperscript{97} Thus, proportional recovery need not be conceptualized as compensation for risk as such, but rather as a means of compensating for actual harm given limited information about causation.\textsuperscript{98}

The final major argument made against proportional recovery

\textsuperscript{95} This can be seen most clearly when proportional recovery is given ex ante by requiring the defendant to provide cancer insurance to the plaintiff class. Apart from timing, however, there is no difference between this insurance remedy and the ex post proportional remedy.

\textsuperscript{96} Thus, Professor Richard W. Wright argues, we should provide compensation only when, looking backwards, a court can discern that the defendant actually harmed the plaintiff, not when the defendant has merely created a probability of harm. See Wright, \textit{Actual Causation vs. Probabilistic Linkage: The Bane of Economic Analysis}, 14 J. LEGAL STUD. 435, 437-39 (1985); Wright, \textit{supra} note 33, at 1814-16, 1825-26. See also Sherman, \textit{Agent Orange and the Problem of the Indeterminate Plaintiff}, 52 BROOKLYN L. REV. 369, 392-93 (1986) (using statistical probabilities for causation in essence creates a new cause of action).

\textsuperscript{97} See Rosenberg, \textit{supra} note 8, at 882. Proportional compensation is a hybrid: a substantive rule based on evidentiary concerns. The criticisms discussed in the text would be appropriate if proportional compensation were an evidentiary rule or if it had substantive purposes. By combining evidentiary and substantive elements, however, proportional compensation avoids both kinds of attacks.

\textsuperscript{98} Although ex ante compensation (given before the harm materializes) may appear quite different, requiring defendants to provide insurance coverage to those at risk (or cash with which to pay the premiums) is functionally no different from making a payment once the injury has materialized. Logically, no difference exists between compensation for an unrealized risk and compensation to all of those ultimately harmed when the risk materializes. Given smoothly functioning markets, compensation for the risk is equivalent to paying for insurance, which in turn is equivalent to ex post liability. See \textit{Developments}, \textit{supra} note 4, at 1651-53.
In any event, these radical proposals seem too quick to reject the possible deterrent value of the tort system. Although subject to dispute, substantial evidence does exist of this deterrent effect. In toxics cases, deterrence is probably dimin-

99. See Elliott, supra note 8, at 801, 805. A limited version of this proposal is embodied in Minnesota’s recently enacted victim’s compensation law. See 1985 Minn. Laws, 1st Special Sess. ch. 8 §§ 4-16 (H.F. No. 6) (effective July 1, 1985) (codified at Minn. Stat. §§ 115B.25 -.37 (1986)).

100. Elliott, supra note 8, at 802-03, suggests that agencies could perform generic risk assessments which could then be used in processing individual claims. But if solid scientific evidence does not exist, the agency cannot make a valid risk assessment any better than a court. Of course, unlike the court, the agency could finance research. Such research might or might not produce clear findings about risk. Given the existence of limited research funds, however, it seems preferable to give priority to projects on the basis of their contribution to preventing future risks rather than the less urgent matter of compensating past victims.

101. See Mashaw, supra note 8, at 1395; Stewart, supra note 8, at 10,218; Sugarman, Doing Away With Tort Law, 73 CALIF. L. REV. 555, 664 (1985).

102. See Latin, Problem-Solving Behavior and Theories of Tort Liability, 73 CALIF. L. REV. 677, 682-93 (1985) (stating that there is no proof that liability rules influence individuals’ behavior); Mashaw, supra note 8, at 1394 (stating that empirical evidence of the tort system’s deterrent effect is difficult to find); Abel, Book Review, 83 MICH. L. REV. 772, 786-87 (1985) (“Repeated empirical studies over the last half century have shown that liability rules internalize hardly any of the accident costs of entrepreneurial activity and have only the most problematic effect on behavior.”); but see Latin, supra, at 740 (“[M]y analysis points to situations in which problem-solving actors are likely to be influenced by tort liability.”).

103. See Posner, Can Lawyers Solve the Problems of the Tort System?, 73 CALIF. L. REV. 747, 749-50 (1985) (“[S]udies show that liability insurance premiums affect the decision to drive, that the number of automobile deaths has risen as a result of the no-fault movement (perhaps by as much as 15% in some states), and that safety-belt requirements increase the number of pedestrian deaths because people who feel safer drive faster.” (footnotes omitted));
ished by many of the same factors that make causation difficult to prove, such as the long time lags and scientific uncertainty about effects. On the other hand, these factors also pose serious problems for the regulatory system, which is fraught with problems of its own.\textsuperscript{104} It would seem foolhardy to jettison the tort system on the basis of current knowledge.\textsuperscript{105}

Thus, although proportional recovery is a substantial deviation from current practice, the theoretical arguments against it are unpersuasive. A more serious question is how often the factual assumptions underlying proportional recovery are valid.\textsuperscript{106} The key assumption—the paradigm case—is that the only evidence of causation is a single statistic expressing the increased rate of disease (or death) among the exposed population. As it turns out, this assumption is often false. Normally, at least some additional information is available, and a different solution becomes appropriate.

B. THE MLV REMEDY: COMPENSATING THE MOST LIKELY VICTIMS

Generally, all of those exposed to a toxic chemical are not equally at risk. Although the exact relationship between doses and disease rates is often poorly understood, the risk of disease is normally related to the amount of exposure.\textsuperscript{107} The timing of exposure may also be significant; for example, exposure to DES early in pregnancy seems to have been much more dangerous


\textsuperscript{105} See Latin, supra note 102, at 740-41; Posner, supra note 103, at 752-53; Rosenberg, Toxic Tort Litigation: Crisis or Chrysalis?, 24 HOUS. L. REV. 183, 202 (1987); Rosenberg, supra note 5, at 1695, 1704-06. For thoughtful, balanced discussions of these issues, see Pierce, Encouraging Safety: The Limits of Tort Law and Government Regulation, 33 VAND. L. REV. 1281 (1980); Rabin, supra note 5, at 51.

\textsuperscript{106} Professor Richard Delgado seems to suggest that the approach will only apply when an isolated community is exposed to a risk. See Delgado, supra note 9, at 907. This is a serious restriction on the applicability of proportional recovery.

than exposure late in pregnancy.108 Thus, the assumption of a uniform increase above the background rate is generally unrealistic.

Similarly, the assumption of a uniform background rate is valid only when nothing except the link to chemical exposure is known about a disease. Often, however, at least some knowledge of other risk factors exists. For instance, cigarette smokers are more likely to get lung cancer than nonsmokers, and the difference is even greater among asbestos workers.109

Thus, given two individuals who have become ill after exposure to a chemical, some basis often exists for believing that the chemical was more likely to have caused one case than the other. Using a single statistic for the entire group as a basis for proportional recovery thus overcompensates some plaintiffs and undercompensates others. For example, suppose the probability of causation is thirty percent for half the group and ten percent for the other half. Giving them all twenty percent of their damages (the average probability for the group as a whole) undercompensates the thirty-percent subgroup and overcompensates the ten-percent subgroup.

One possible solution would be to divide the group into subgroups composed of individuals with comparable risks.110 As a practical matter, the data may not allow such fine-tuning. There may exist only a qualitative knowledge about the distribution of risk within the group, rather than the quantitative information needed to make each subgroup's recovery proportional to that subgroup's risk. For example, we might know only that the average probability is twenty percent and that the range is about ten to thirty percent. This is not sufficient information to allow the creation of subgroups. More fundamentally, however, proportional recovery is simply inappropriate.

To understand the proper treatment of these cases, it is helpful to begin with a somewhat simplified example. Suppose

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108. See R. APFEL & S. FISHER, TO DO NO HARM: DES AND THE DILEMMAS OF MODERN MEDICINE 142 (1984); Herbst, Poskanzer, Robboy, Friedander & Scully, Prenatal Exposure to Stilbestrol: A Prospective Comparison of Exposed Female Offspring with Unexposed Controls, 292 NEW ENG. J. MED. 334 (1975); Herbst, Ulfelder & Poskanzer, Adenocarcinoma of the Vagina, 284 NEW ENG. J. MED. 878 (1971). Here, as throughout this Article, discussion of particular diseases is meant to be purely illustrative and does not purport to represent any medical expertise whatsoever.

109. See Peto, Seidman & Selikoff, supra note 107, at 132-33 ("These data also illustrate the approximately multiplicative effects of asbestos and smoking for lung cancer." Id. at 133.).

110. See Rosenberg, supra note 8, at 921; Note, supra note 8, at 600-01.
we have a single defendant $D$ and a group of $N$ exposed individuals, $X_1, X_2, \ldots, X_N$. Each individual has suffered one unit of damage due to cancer. For the individual $X_i$, the probability that the defendant caused the individual's cancer is $p_i$, with $p_1 > p_2 > \ldots > p_N$. The total amount of damage actually caused by the defendant is $M$, with $M < N$.

The first question is how much $D$ should pay in damages. For much the same reasons advanced in favor of proportional recovery, the answer would seem to be $M$, the total amount of damage caused by the defendant.\footnote{See supra notes 86-106 and accompanying text.} This amount provides the proper economic deterrent to $D$'s behavior. Even if we do not count depriving $D$ of these funds as an affirmative good, $D$ has very little ground for complaint so long as the damages are not greater than the actual injury. After all, $D$ would clearly be liable for this amount of damages given better evidence of causation. Allowing $D$ to retain this amount might well be considered unjust enrichment. At least, depriving $D$ of money should not count as an error, so long as the amount is no greater than $M$, the total damages.\footnote{Up to this point, no difference exists between proportional recovery and MLV. Both agree that the defendant's total damages should equal the total harm done. As Landes and Posner observe, "[F]rom an economic standpoint, the critical point for deterrence is that the defendant pays, not that the plaintiff receives." Landes & Posner, supra note 9, at 430. The disagreement concerns how to distribute this "fund." Proportional recovery might seem preferable from the perspective of loss-spreading, because fewer injured individuals are left uncompensated. But proportional recovery requires every individual to bear part of her own loss, while MLV may completely shift some individuals' losses to firms. It is not clear that proportional recovery is really superior as a means of spreading losses. Indeed, paying partial compensation may even leave some victims worse off than they would be receiving no tort recovery, because partial recoveries may make it more difficult for them to receive other forms of assistance, such as government aid.}

Next, who should get the money? The answer depends on our purposes. We might, after all, give it to all the plaintiffs equally, or all disease victims, or perhaps the poor. One commentator argues that the individuals who actually were harmed by $D$ have no better claim to the money than all other individuals suffering from the same disease.\footnote{See Mashaw, supra note 8, at 1394 (stating that the tort system provides no reason to distinguish for purposes of compensation between those who were injured by natural toxins and those injured by manufactured toxins).} This position is, to say the least, at odds with common views of morality. If Hand punches Cardozo in the nose at a cocktail party, most people
think that Hand should pay damages to Cardozo, not to Holmes, who broke his nose the same day playing hockey.\textsuperscript{114} And most people would also think that Hand has a somewhat greater moral obligation than the rest of society to pay the medical bills resulting from his assault on Cardozo. This example illustrates the general ethical principle of corrective justice.\textsuperscript{115}

A more difficult question is presented by the argument that individuals should be compensated for exposure to risk, not merely for the harm that results in some instances.\textsuperscript{116} As one of the commentators who argues for risk-based compensation admits, this is a substantial deviation from normal tort law:

\[\text{[J]t is difficult to conceive as a practical matter how one could have an action for the risk of an automobile accident. Either plaintiff has been in an accident or he has not; if he has not it seems queer to think of bringing suit against a negligent driver for a harm that might have occurred but did not.}\textsuperscript{117}

\textsuperscript{114} Suppose Hand narrowly missed hitting Holmes in the nose when he hit Cardozo instead. The fact that Hand created a risk of breaking Holmes's nose seems irrelevant if we know that Holmes's nose was not actually broken until the hockey game later.

\textsuperscript{115} See Rosenberg, supra note 8, at 881. If D's unreasonable conduct has caused physical harm to others, from a nonutilitarian point of view he may be considered to have violated their rights and hence to owe compensation. Furthermore, distributing the fund equally among all disease victims may reward those whose disease was at least partly due to their own choice of lifestyle, see Ames, supra note 37, at 1260 (discussing naturally occurring substances that, if ingested, may inhibit cancer), which society ought not encourage. (To the extent that lifestyle is a likely cause of an individual's illness, it becomes that much less likely that the defendant was the cause, so the individual moves lower on the "MLV list.")

As Dean Calabresi has pointed out, concepts like "causation" are used both to accomplish the articulated goals of the tort system and to incorporate intuitive and ill-understood concepts of justice, which should nevertheless not be ignored. See Calabresi, supra note 89, at 107-08. Such intuitions are likely to play a larger role in deciding on the values to be served by a legal rule than in working out the best means of achieving these values.

\textsuperscript{116} See Landes & Posner, supra note 9, at 428-31; Robinson, supra note 8, at 796-98. Landes and Posner seem as much concerned about the timing of compensation as who receives it; they favor risk-based compensation largely because it can be determined soon after the defendant's conduct. See Landes & Posner, supra note 9, at 431. But MLV is not inconsistent with imposing liability before the injury develops if the relevant probabilities are known. Under MLV, the defendant would purchase full insurance coverage for those plaintiffs who are in the "most likely victim" class. Those among this class who ultimately develop illnesses would receive full compensation; others exposed to the toxic substance would not receive compensation. Thus, the question of timing can be separated from the question of how to distribute the fund.

\textsuperscript{117} Robinson, supra note 8, at 797.
The only real difference between the automobile case and the toxics case is that better information is available about the events in the automobile case whereas the relevant biological events in the toxics case are unobservable. If some method did exist of determining the cause of a particular plaintiff's cancer, courts would presumably follow the normal rules of tort law and award damages only to plaintiffs who could show actual causation. Imperfect information prevents us from implementing this rule, but the compensation scheme should attempt to approximate the result as much as possible.\footnote{118}

Assume, then, that the goal is to compensate those whose injuries were actually caused by the defendant so that each dollar going to such a plaintiff is counted as a success. We may not begrudge the other plaintiffs their money (after all, they have suffered a serious illness), but we would prefer that the money went to $D$'s "actual victims." If we let $S$ be the amount of money successfully distributed to $D$'s actual victims, then the statistically expected value of $S$ is simply $p_1z_1 + \ldots + p_Nz_N$, where $z_i$ is the amount of damages received by the $i$th victim. Presumably, we do not wish to give any plaintiff more than his actual damages (set at one unit). This gives us the simple mathematical problem of maximizing the expected value of $S$.

The solution is to give the $M$ units of damages to the $M$ plaintiffs with the highest probabilities of being actual victims, giving nothing to the remaining plaintiffs. The formal proof is given in the Appendix.\footnote{119} The basic reason, however, is fairly

\footnote{118. From the perspective of economic efficiency, it makes little difference whether compensation is based on risk or actual causation as determined ex post. Primary conduct can only be shaped by the information available ex ante, which must be based on the probability of harm. On the other hand, some efficiency arguments can be made in favor of harm-based liability. First, the number of lawsuits is decreased, which reduces some costs of the legal system. Second, if individuals are risk-averse, as economists commonly assume, they would prefer to be guaranteed compensation for their injuries rather than to be given in advance the actuarial value of the risk. But the common-law's preference for basing compensation on actual injury probably rests more on a concept of fairness than on efficiency. Someone who is subjected to a risk may incur some costs for which compensation is arguably appropriate, such as medical expenses or mental distress, see supra note 21, but the mere existence of the risk does no harm in itself unless the injury materializes. Consider the individual who is subjected to risk of which that individual never becomes aware. The potential harm never materializes. It seems clear that allowing compensation for the existence of the risk would simply provide a windfall to the plaintiff.

119. Appendix, infra p. 1260. Somewhat similarly, Professor David Kaye argues that, when the plaintiff's injury is known but the identity of the defendant is not, error costs are minimized by imposing liability on the most
obvious. If we take a dollar from a plaintiff high on the probability list and give it to one lower down the list, the odds are less that the new recipient is an actual victim. So we can maximize the odds that the money will go to actual victims by loading as much as possible high on the list. Because the only constraint is that no victim should receive more than a unit of damages, we give one unit to the victim with the highest probability and keep going down the list until we run out of money with victim \( M + 1 \). This is the MLV or "most likely victim" approach to compensation.

Obviously, literally ranking all victims is impractical in actual litigation. The MLV solution can be approximated, however, by putting the victims in subgroups, going down the list of subgroups, paying full compensation to each subgroup, until the defendant's total damages have been exhausted.\(^{120}\) Implementing MLV is more difficult if each plaintiff brings a separate case but the problems do not seem insurmountable, as we will see in Part III.\(^{121}\)

An example may help clarify the differences between the various methods of compensation. Suppose we have a group of fifty-one people who have developed cancer after exposure to a drug. Based on the amount of exposure and the individuals' other risk characteristics, we have determined the probability that each individual's cancer was caused by the drug. The first individual has a fifty-one percent probability of causation, the second individual has a fifty percent probability, the third has a forty-nine percent probability, all the way down to the fifty-first person, who has a probability of only one percent. The average probability of causation is twenty-six percent. Each individual has suffered one million dollars in damages. This means that we can expect that the drug caused about thirteen cases of likely defendant. See Kaye, The Limits of the Preponderance of the Evidence Standard: Justifiably Naked Statistical Evidence and Multiple Causation, 1982 AM. B. FOUND. RES. J. 487, 503-08. This is essentially the converse of the MLV approach. Another analogous method is used in cost-benefit problems involving budget restrictions. See E. STOKEY & R. ZECKHAUSER, A PRIMER FOR POLICY ANALYSIS 142-44 (1978).

120. If the last subgroup to be compensated has total damages greater than the amount remaining in the "fund," the members of the subgroup can be given pro rata compensation.

121. One possibility is to adopt MLV directly as the standard of recovery, using it as the basis for expert testimony and jury instructions. Another possibility is to use MLV as the basis for a series of presumptions to apply in individual cases. See infra notes 131-32 and 159-60 and accompanying text for some methods of adapting MLV to individual cases.
cancer (twenty-six percent of fifty-one individuals), or thirteen million dollars in damages.

Under the traditional preponderance standard, only one individual (the highest person on the list) can show that the drug "more likely than not" caused her disease. Hence, she receives one million dollars and the defendant is relieved of any liability for the remaining twelve million dollars of damages caused by the drug. This is an unjustifiable windfall to the defendant.

Under proportional recovery, each individual receives a percentage of his damages. This avoids any windfall to the defendant, but distributes the fund poorly. For example, the individual with a one percent probability of causation gets one percent of his damages, or $10,000. The odds are overwhelming (ninety-nine to one) that this money is going to someone who is not actually a victim of the drug. If we transferred the payment to the top person on the list, we would have better than even odds that the recipient would be an actual victim.

MLV does a better job of targeting victims. Under MLV, we start at the top of the list and pay off the claims in full until we run out of money. This means that the top thirteen people on the list get full compensation; those with causation probabilities below thirty-eight percent get nothing. If we were to move a dollar from the top group to the bottom group, we would necessarily lower the odds that the money was going to an actual victim. Under MLV, the defendant pays out a total of thirteen million dollars, thus avoiding any windfall, and as much as possible of the money is directed to actual victims.

Thus, the MLV approach maximizes the amount of money going to plaintiffs whose injuries were actually caused by the defendant. It has some other advantages over proportional recovery.123 Plaintiffs who are low on the probability list may not really be even "possible victims" of the defendant, let alone actual victims. Probability information is unlikely to be perfectly reliable; the lower the probability assigned a given plaintiff, the more likely that the true probability is zero.123 Also, applying proportional recovery to a heterogeneous group requires reliable quantitative information about subgroups. To apply proportional recovery, we must know not only that members of sub-

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122. Because MLV generally gives each individual plaintiff either no damages or full compensation, it is consistent with the "all or nothing" tradition of the common law. Despite its novelty, this should make it more acceptable than proportional recovery to courts.

123. See Cohen, supra note 91, at 397-404.
group A had higher risks than those in subgroup B, but also the precise amount of the difference in risk in order to calculate the recovery percentages. In contrast, MLV requires only a qualitative ranking of subgroups. Epidemiological knowledge is expensive, hard to obtain, and often imprecise. The less we need to demand of the epidemiologists, the better.

At a more intuitive level, as we go further down the probability list, the possibility that the defendant caused the plaintiff's injury becomes increasingly speculative. It makes sense to compensate those with the strongest claim of injury and cut off the most speculative claims. In a sense, MLV is a form of triage. Rather than spread resources equally over all claimants or divide them in proportion to the strength of the claims, MLV directs compensation to those with the strongest claims.

Two possible objections to MLV should be addressed. First, MLV could be criticized for giving a windfall to some groups while knowingly undercompensating others. Admittedly, MLV does not achieve equity between groups of victims, because some groups known to contain some victims receive no compensation. Unfortunately, any attempt to achieve inter-group equity necessarily increases the amount of money going to individuals whose injuries were not in reality caused by the defendant. Thus, greater equity between groups can only be purchased at the expense of less fairness to individuals.

Second, MLV may strike some readers as counterintuitive. Given two victims with speculative causation cases, why should one get all the money, simply because her causation evidence is a bit less speculative? Suppose that A proves a forty-percent chance of causation, while B proves a twenty-percent likelihood. If each has damages of $100,000, under MLV victim A will get $60,000, that being the statistically expected value of

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124. "Triage" is a commonly used term in medicine, referring to "the sorting of and allocation of treatment to patients and . . . victims according to a system of priorities designed to maximize the number of survivors." WEBSTER'S THIRD NEW INTERNATIONAL DICTIONARY 2439 (1976).

125. MLV relates to the determination of liability. Similar problems arise in two other contexts. First, in settling a class action, a limited fund must be distributed among the class. MLV is in theory the proper solution. The exigencies of negotiation, however, including the need to "buy" the consent of some subclasses, may require some modification in the direction of proportional recovery. Second, the defendant's assets may be less than the total harm, which determines the MLV cut-off point. Once liability is determined under MLV, the bankruptcy laws then determine the distribution of the defendant's limited assets among the claimants.
the total harm caused by the defendant. B gets nothing, and this may seem harsh. If, however, we transfer a dollar from A to B, we double the odds that the dollar is going to someone who, if we knew more about causation, would receive nothing. It seems indefensible to transfer money from A to someone who is only half as likely truly to deserve it.

Thus, in many toxics cases, MLV seems to be the appropriate form of recovery. As we shall see in the next section, however, not all toxic tort cases neatly fit either the MLV or proportional recovery molds, although MLV theory can still give useful guidance in some cases where it cannot be applied directly.

III. A TAXONOMY OF TOXIC CAUSATION CASES

Current understanding of toxic torts is as yet fairly limited. What is clear is that toxics cases come in many forms. So far, the legal literature has failed to take this diversity seriously, focusing instead on selected cases that are assumed to be typical.126 Of the six categories of cases discussed below, only one has received substantial scholarly attention.

A. CONCLUSIVE EVIDENCE ON CAUSATION: “SIGNATURE DISEASE” AND “NO CAUSATION” CASES

The scholarly literature might easily give the impression that toxic causation is invariably mysterious.127 In many cases, however, the causation issue is quite clear-cut.

One group of cases involves so-called “signature” diseases.128 These are diseases that are extremely rare in the gen-

126. One of the few exceptions is the discussion in Elliott, Goal Analysis versus Institutional Analysis of Toxic Compensation Systems, 73 GEO. L.J. 1357, 1369 (1985). Professor E. Donald Elliott’s discussion, however, is wholly concerned with the question of which legal institution—courts, administrative agencies, or legislatures—should address particular toxics problems, rather than what standards should be applied to these problems regardless of the institution considering them. See id. at 1372-75.

127. See, e.g., Note, supra note 2, at 840 (“[C]ancer victims nearly always fail to recover damages in tort because they are unable to meet traditional standards of proof.”). This must have been welcome news to the Johns-Manville Corporation. See also Elliott, supra note 8, at 802 (“It is rare indeed that anything like the information base necessary to make even rough probability estimates [of risk] will exist.”).

128. See K. ABRAHAM, supra note 5, at 22-23 (“[W]hen a particular disease is caused almost exclusively by a particular substance . . . the disease is . . . the substance’s ‘signature,’” id. at 23.). Stewart, supra note 5, at 10,213, notes that “signature diseases” present fewer problems for the legal system.
eral population but far more prevalent among those exposed to a particular substance; the disease in a sense bears the signature of the substance. A classic example is mesothelioma, an unusual, lethal form of cancer. Most cases are associated with exposure to asbestos. The odds of contracting mesothelioma are roughly seventy times greater for asbestos workers than for members of the general population. This means that when an asbestos worker gets mesothelioma, it is almost certainly caused by asbestos.

We might, following the proportional recovery theory, reduce the damages paid each worker by a small fraction to represent the remote possibility that the mesothelioma might not be asbestos-induced. Given the inevitable crudeness of the tort system, such fine-tuning seems somewhat inappropriate, rather like putting velvet gloves on the proverbial bull in the china shop. In view of the small magnitude of the correction, the amount of trial time that might be spent quibbling about the proper adjustment factor, and the likelihood that any overpayment to these plaintiffs is balanced by nonpayment to some plaintiffs with other asbestos-induced diseases, it hardly seems worthwhile to make the correction. Rather, the proper approach would seem to be an irrebuttable presumption of causation in mesothelioma cases.

A similar situation holds in some DES cases. Clear-cell adenocarcinoma is a very rare form of cancer occasionally found in the unexposed population, particularly among older women. The risk of contracting the disease when younger, however, is far higher for DES daughters than for other women. Thus, a presumption of causation seems warranted.

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129. See Black & Lilienfeld, supra note 7, at 758.

130. Thus, it is only a slight exaggeration for legal purposes to say that asbestos is the "only cause" of mesothelioma, Note, supra note 1, at 1304. See Peto, Seidman & Selikoff, supra note 107, at 125 ("Mesothelioma is so rare among those not exposed to asbestos that incidental cases in heavily exposed populations can be neglected.").

131. Lest the reader dismiss this example as too rare to deserve extended discussion, it should be noted that some experts project 19,000 cases by the end of this century. See P. Brodeur, OUTRAGEOUS MISCONDUCT: THE ASBESTOS INDUSTRY ON TRIAL 266 (1985). The estimate of projected cases may be excessively conservative. See id. at 264-67.

132. See Bohrer, supra note 21, at 97 n.48 ("DES daughters suffer a risk 100 times greater than is normal of developing the deadly cancer."); Herbst, Ulfelder & Poskanzer, supra note 108.

133. It is not easy to get accurate statistics for the excess risk because the number of women exposed to DES is not known. The risk that an individual DES daughter will develop clear-cell adenocarcinoma by age 24 is about
The MLV approach strengthens the argument for an irrefutable presumption of causation. Victims of “signature diseases” are clearly in the category of “most likely victims.” Hence, MLV theory indicates that their claims should be paid in full, while cutting off speculative claims at the other end of the spectrum.

Causation also poses no great conceptual problem in another set of cases. These are the cases in which the evidence affirmatively disproves the possibility of a causal link. To date, the most important example is found in the Agent Orange cases, in which Judge Weinstein found no admissible evidence of causation and powerful epidemiological evidence disproving causation. Although the correctness of his admissibility ruling may be debatable, Judge Weinstein’s opinion makes it clear that the weight of the evidence was strongly against the plaintiffs. Apparently, Agent Orange simply did not pose long-term risks to its users. These “no causation” cases may involve difficult matters of proof and may raise real concerns about jury control, but they do not require any conceptual inquiry into the role of causation in tort law.

B. “Purely Statistical” and “Statistics Plus” Cases

The first of these categories corresponds to the proportional recovery paradigm discussed in section A of Part II. As was shown there, proportional recovery is normally the proper

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1/1000. But the total cancer death rate for women between 20 and 25 is 4/100,000. See Payton v. Abbott Labs, 386 Mass. 540, 542-43, 437 N.E.2d 171, 173-74 (1982); R. APFEL & S. FISHER, supra note 108, at 48. If we assume (conservatively) a mortality rate of only 33%, this would give an overall cancer rate in this age group of 12/100,000, and a clear-cell adenocarcinoma rate of 100/100,000. (Any error in these figures is probably more than offset by the relatively small contribution of clear-cell adenocarcinoma to the overall cancer rate.) So, if a woman in this age group who was exposed to DES has adenocarcinoma, we can conservatively give odds of about ten to one that DES was the cause. There must be any number of criminal defendants convicted every year on weaker evidence under the standard of “proof beyond a reasonable doubt.” (The usual disclaimer applies: this discussion is meant to be merely illustrative and reflects no claim to medical expertise.)

134. See supra note 76.


136. Affirmative findings of “no causation” are not limited to mass tort cases like the Agent Orange cases, but are also made in individual personal injury actions. See, e.g., Dawsey v. Olin Corp., 782 F.2d 1254, 1261 (5th Cir. 1986); Richardson v. Richardson-Merrell, Inc., 15 Prod. Safety & Liab. Rep. (BNA) 32 (D.D.C. Dec. 19, 1986).
remedy if our only information is a uniform increase in a uniform background rate. It is rather difficult, however, to find any examples of this situation.

The "statistics plus" cases are much more common. In these cases, we have statistics demonstrating an overall increase in the incidence of a disease, as well as information indicating varying degrees of increased risk within the exposed group. For example, the risk of lung cancer among asbestos workers is apparently affected by the type of asbestos used in an industry, the length and degree of exposure, and cigarette smoking (even taking into account the direct effect of smoking on lung cancer). In these cases, the proper solution is the MLV remedy. We should pay full compensation to those with the highest risks attributable to asbestos, for example, cigarette smokers with high asbestos exposure in high-risk industries, and no compensation to those with the lowest risks, for example, nonsmokers with low exposure in low-risk industries.

Such an outcome is suggested by the results of the swine flu litigation. Those who contracted GBS within ten weeks of inoculation were the most likely victims and received full compensation from the government. Those who contracted GBS after the ten-week period generally received nothing.

C. DIFFUSE RISKS

Another category of cases involves very small increases to existing widespread risks. For example, some estimates indicate that carcinogens in drinking water may cause roughly a thousand cases of cancer nationwide annually. Such infor-

137. See Council on Environmental Quality, supra note 1, at 224; Peto, Seidman & Selikoff, supra note 107. Exposure and risk seem to vary among workers in different industries, see, e.g., Flatt v. Johns Manville Sales Corp., 488 F. Supp. 836, 840 (E.D. Tex. 1980) (noting that "[d]ifferences in end uses of . . . products, percentage of asbestos content of the products, and environmental conditions present when the products were used are all [relevant] factors"). This may be a useful means of making MLV determinations.

138. Cf. Dartez v. Fibreboard Corp., 765 F.2d 455, 471 (5th Cir. 1985) (denying recovery against a defendant where exposure period was slight and industry had low asbestos emission rate). With respect to cigarette smoking, the discussion puts to the side the complex issue of victim care discussed in Landes & Posner, supra note 9, at 432-34. For further discussion, see Rosenberg, supra note 5, at 1703-04; Note, Plaintiffs' Conduct as a Defense to Claims Against Cigarette Manufacturers, 99 Harv. L. Rev. 809 (1986).

139. See supra note 62 and accompanying text.

mation may provide a sufficiently reliable basis for government regulation.\textsuperscript{141} For three reasons, however, compensation for such diffuse risks, whether administered by courts or administrative agencies, is far more problematic.\textsuperscript{142}

First, because of the difficulties of conducting epidemiological studies of these diffuse risks, the estimates of risk are extremely unreliable.\textsuperscript{143} For example, in the drinking water example, risk estimates varied by an order of magnitude. Other regulatory cases contain estimates varying over even greater ranges.\textsuperscript{144} Even when the estimates are available at the time of a chemical’s release, their extraordinary unreliability would make it extremely difficult for the discharger to foresee the extent of future liability. This makes any deterrent effect highly speculative at best.

Further, because the level of risk is often quite low in these cases,\textsuperscript{145} even under a proportional liability scheme the individual recoveries could be very small—perhaps on the order of one to ten percent of an individual’s damages.\textsuperscript{146} Thus, com-


\textsuperscript{142} Professor Elliott suggests the possibility of a broad-based tax and compensation scheme to avoid the administrative difficulties, but ignores the limited utility of such a scheme, given the other two factors discussed in the text: the unreliability of the risk assessments and the small degree of loss spreading generally possible. See Elliott, supra note 126, at 1370-71. If we are interested in spreading the loss of such widespread risks, we would probably be better off instituting a general welfare state rather than tying compensation to any particular cause of an injury.

\textsuperscript{143} See Elliott, supra note 8, at 802 (observing that “[i]t is rare indeed that anything like the information base necessary to make even rough probability estimates will exist”).

\textsuperscript{144} The National Academy of Science estimated that the total number of bladder cancers caused by a lifetime of exposure to saccharin ranged from less than one case to one million per year. Id.

\textsuperscript{145} Consider the recent estimate, made after a thorough study, that the number of injuries annually caused by hazardous wastes in Minnesota is “in the tens of persons.” Prince, supra note 4, at 673.

\textsuperscript{146} An illustration is suggested by recent estimates of the risks created by waterborne carcinogens. If the “low” risk estimate for waterborne carcinogens turned out to be correct, about 1% of all cancers, or 4% of urinary and gastrointestinal cancers, would be attributable to this source. Under proportional recovery, victims would receive either 1% or 4% of their damages, depending on which figure was deemed most relevant. See Page, Harris & Bruser, supra note 140, at 215. On the other hand, if the high estimate of risk turned out to
Compensation for diffuse risks often would not substantially serve the goal of loss spreading.\textsuperscript{147} Moreover, in cases involving extremely low-risk levels, the vast majority of recipients would be individuals who were not in fact harmed by the chemicals. Thus, in these cases, compensation has little to recommend it even from the "victim's perspective."

Finally, for many diffuse risks, any compensation scheme would involve high transaction costs. To take the example of drinking water, the cost of compensation would have to be somehow allocated among thousands of municipalities and industrial sources. Some method would have to be devised for distributing the proceeds among the enormous group\textsuperscript{148} of cancer patients in this country. The entire proceeding would be complicated still more, of course, by the high degree of uncertainty about the total risk and how it is distributed among the populations, what chemicals create the greatest part of the risk, which individuals are most affected, and so forth.\textsuperscript{149} In a system with unlimited resources, it might be worth confronting these difficulties, but both the administrative and judicial systems have higher priorities than this.

As information about particular toxic substances expands, some risks may be well enough understood to allow the creation of a sensible compensation system based on the MLV the-

\textsuperscript{147} See Stewart, \textit{supra} note 8, at 10,214-15.

\textsuperscript{148} The average annual cancer mortality rate in the United States is about 1673 per million for all cancers, and 536 for gastrointestinal and urinary tract cancers. See Page, Harris & Bruser, \textit{supra} note 140, at 215. Thus, there are over 100,000 deaths annually from the latter forms of cancer.

\textsuperscript{149} There are many thousands of organic chemicals in drinking water. Already identified are over 700, which represent only 15 percent by weight of all organic matter found in drinking water. Only a few have been tested for carcinogenicity in the usual animal tests. The agency has conducted several surveys of water from different systems and has found that the levels of measurable chemicals vary widely from system to system and even from day to day. It would therefore be difficult to derive a risk estimate based on this fragmentary occurrence data, even for those measurable chemicals that have been tested for carcinogenicity. The agency has not been able to think of any way to estimate the risk to public health posed by compounds that cannot be measured or that have not been tested for carcinogenicity. Nor do methodologies exist for dealing with the potential effects of human exposure to mixtures of carcinogens, including possible synergistic effects.

At present, however, most diffuse risks cannot be meaningfully made the subject of compensation. This means, unfortunately, that some individuals whose injuries are actually due to these risks will be unable to obtain compensation, simply because we have no way to identify likely victims among the huge crowd of possibilities. Although compensation rules can be adapted to deal with less than certain knowledge of causation, there comes a point at which uncertainty becomes overwhelming. Any attempt to press compensation beyond that point is counterproductive.

D. CLINICAL PROOF CASES

Some toxics cases do not fit the statistical mold of the cases we have discussed so far. Rather than relying on statistical evidence, the plaintiff may simply present the testimony of experts familiar with the facts of the case, giving their opinion that toxic exposure was the cause of the injury. If they contradict more rigorous epidemiological evidence, these clinical assessments should be given little weight. Often, however, more reliable information is unavailable.

A scientist might well find such clinical judgments an inadequate basis for drawing firm conclusions about causation. Experience has shown many ways in which clinical judgments can go awry. Nevertheless, this does not mean that the clinical judgment is more likely false than true; it means only that the scientist considers the likelihood of falsity unacceptably high. Given the difference in purposes and institutional settings, the acceptable level of error for scientific judgments may well be lower than the forty-nine percent the law tolerates. Thus, a per se rule excluding compensation based on clinical judgments seems unwarranted.

On the other hand, such clinical judgments present real
risks even in a nonadversary setting. These risks are magnified by the prospect of "expert shopping" by plaintiffs. Moreover, juries may be prone to base plaintiffs' verdicts on inadequate evidence. While administrative agencies may have greater expertise (depending on the agency), in some cases they also may have a bias toward compensation. Consequently, such clinical evidence should be subject to searching scrutiny, and reviewing courts should exercise some degree of caution in upholding compensation awards.

Although MLV theory is not directly applicable to these cases (given the lack of statistical data), MLV is nevertheless relevant. The goal still should be to compensate the most likely victims. Even where quantitative information is not available, this goal can still be implemented. Among the class of potential plaintiffs exposed to a hazard, successful plaintiffs should be those with the relatively strongest claims. Thus, they should have relatively high exposures and should not exhibit other risk factors that would tend to explain the disease.

CONCLUSION

The most intriguing of the causation cases involve statistical proof that the plaintiffs' injuries may be due to the defendant, but at a level of probability well below certainty. For these cases, previous writers have suggested some form of proportional recovery. Proportional recovery is actually appropriate, however, only when the risk is uniform across the class of plaintiffs.

This Article proposes a new approach to cases involving


156. See supra note 76, at 44-47.

157. On the need for jury control, see Dore, supra note 7, at 437-38, 439-40 and sources cited supra note 76. See also Black & Lilienfeld, supra note 7, at 742-43 (Some courts "draw conclusions from information found to be inadequate by experts, a rule that leaves little basis for a rational analysis of the legal sufficiency of evidence.").

158. The workers' compensation cases making awards for cancers supposedly caused by workplace traumas are a dramatic illustration. Agencies have made many awards clearly inconsistent with scientific knowledge of cancer, and these awards have generally been upheld by the courts. See Black & Lilienfeld, supra note 7, at 744-49.

159. For a judge's views on the need for jury control, see Weinstein, supra note 90, at 1389-90.
nonuniform risks. When different plaintiffs have different probabilities of having been injured by the defendant, the MLV ("most likely victim") approach is more appropriate than proportional recovery. This approach allocates the total damages the defendant has caused to a subset of plaintiffs, those whose injuries were the most likely to have been caused by the defendant.

Perhaps the most striking characteristic of toxic causation cases is their diversity. In some, the defendant's responsibility for the plaintiff's injury is nearly indisputable; in others, defendants may be clearly innocent of causal responsibility. Some cases involve individual plaintiffs who were exposed to rare chemicals; others involve thousands of plaintiffs and imperil the financial stability of entire industries. It is the beginning of wisdom to realize that no one approach can do justice under such diverse circumstances.

160. See supra notes 121-25 and accompanying text.
161. See supra notes 126-36 and accompanying text.
162. See supra note 5.
APPENDIX

The main purpose of this Appendix is to establish the MLV results discussed in the text. We begin by setting up the term to be maximized. Let \( x_1, x_2, \ldots, x_N \) be the individual awards (all assumed nonnegative), with associated probabilities of \( 1 > p_1 > p_2 > \ldots > p_N \).

**Def. 1** If \( x_i \leq 1 \), let \( e(x_i) = x_i p_i \).

If \( x_i > 1 \), let \( e(x) = p_1 - (x_i - 1) \).

**Def. 2** \( E(x) = e(x_1) + \ldots + e(x_N) \).

**Theorem 1.** If \( 1 < x_1 + \ldots + x_N = M < N \), then \( E(x) \) has its maximum value for \( z_1 = 1, \ldots, z_M = 1, z_{M+1} = 0, \ldots, z_N = 0 \) (e.g., \( z_i = 1 \) unless \( i > M \), in which case \( z_i = 0 \)).

**Lemma 1.** \( z_i < 1 \).

**Proof.** Suppose \( z_i > 1 \). Then
\[
E(z) = e(z_1) + \ldots + e(z_i) + \ldots + e(z_N) < e(z_1) + \ldots p_i - (z_i - 1) + \ldots + e(z_N) = e(z_1) + \ldots + e(z_i') + \ldots + e(z_N)
\]
where \( z_i' = 1 \). Thus, the initial assignment of \( z_i \) did not maximize \( e(z) \), a contradiction.

**Lemma 2.** \( z_1 = 1 \).

**Proof.** By Lemma 1, \( z_i < 1 \). Suppose \( z_1 < 1 \).

Using Lemma 1 and Defs. 1 and 2, we can write
\[
E(z) = p_1 z_1 + \ldots + p_N z_N.
\]
Since the sum of the \( z_i \) is \( M > 1 \), we must have \( z_i > 0 \) for some \( i > 1 \).

Let \( z_i' = z_i + a, z_i' = z_i - a \), where \( a = \min(1 - z_i, z_1) \). Recall that \( p_i > p_1 \). Then \( E(z') = E(z) + p_1 a - p_i a > E(z) \), a contradiction.

**Proof of Theorem 1.**

By induction. **Lemma 2** establishes the theorem for \( N = 1 \). Suppose the theorem is true for \( N \). We must now prove it for \( N + 1 \).

(a) Suppose \( M < N \). By the induction assumption, we can maximize \( e(x_1) + \ldots + e(x_{N-1}) \) with \( z_i' \). Then set \( z_i = z_i' \) for \( i < N \), and \( z_N = 0 \). This maximizes \( E(z) \). (For if \( z_N > 0 \), we must have \( z_j < 1 \) for some \( j < N \). Then proceed as in the proof of **Lemma 2**, setting \( z_j' = z_j + a, z_N' = z_N - a \).

(b) Suppose \( M = N \). By **Lemma 1**, we have \( z_i < 1 \). We also have \( z_1 + \ldots + z_N = N \). Since the \( z_i \) are by assumption nonnegative, we must have \( z_1 = 1 \).

We now relax the assumption that \( M \) is an integer.
Theorem 2. If $1 < x_1 + \ldots + x_N = w < N$, then $E(x)$ has its maximum value for $z_1 = 1, \ldots, z_k = 1, z_{k+1} = \lfloor w \rfloor, z_{k+2} = 0, \ldots, z_N = 0$, where $K = \lfloor w \rfloor$, the largest integer less than $W$, and $\{w\} = K - \lfloor w \rfloor$.

Sketch of proof: Note that neither lemma used the assumption that $M$ was an integer, so both still hold. First set $M = \lfloor w \rfloor$ and apply Theorem 1 to get a vector of values $z_i$. Now allocate the remaining fraction, $\{w\}$. The first $K$ slots are all "filled up," and slot $K + 1$ has the highest $p$ of any remaining slot. A simple modification of the induction method of Theorem 1 establishes that this maximizes $E(z)$.

We now add an error term for $D$ along the lines suggested in the text:

**Theorem 3.** Let $p_1 + \ldots + p_N = P$. Let $E^*(x) = E(x) - h$; where $h = 0$ if $x_1 + \ldots + x_N < P$, otherwise $h = x_1 + \ldots + x_N - P$. Then $E^*(z)$ is maximized where the $z_i$ are chosen as in Theorem 2, with $w = P$.

Proof. Note that $z_1 + \ldots + z_N = P$, and $E^*(z) = E(z)$. Let $x_1, \ldots, x_N$ maximize $E^*$. Lemma 1 still holds, so we can restrict ourselves to $x_i < 1$. Suppose $x_1 + \ldots + x_N > P$. $E(x_i) - E(z_i) = p_1(x_i - z_i) + \ldots + p_N(x_N - z_N) \leq p_1(x_1 + \ldots + x_N - P)$.

So, $E^*(x_i) - E^*(z_i) \leq p_1(x_1 + \ldots + x_N - P) - h = (p_1 - 1)(x_1 + \ldots + x_N - P)$. But $p_1 < 1$, so $E^*(x_i) < E^*(z_i)$.

Hence, we must have $x_1 + \ldots + x_N \leq P$. Note that $P < N$, since $1 > p_i$ by assumption; so some $x_j < 1$. The possibility that $x_1 + \ldots + x_N < P$ can readily be eliminated; since some $x_j < 1$, we could increase $E^*$ if we set $x_j = x_j + a$, where $a = \min[1 - x_j, P - (x_1 + \ldots + x_N)]$. Hence, $E^*(z)$ is maximized by setting $x_1 + \ldots + x_N = P$, which gives $h = 0$. Now we need merely apply Theorem 2.

These theorems have obvious extensions to the more general cases where the individuals' damages are not all equal and where some individuals have identical probabilities of being actual victims.

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163. Thus, $P$ is the expected damage done by the defendant.

164. Since $E^*(z) = E(z) - h$, simply subtract $h$ from each line in the proof of Lemma 1. We can also make the results more general by changing Definition 1 to remove the penalty for excessive compensation in the second line of the definition. Thus, if $x_i > 1$, we would set $e(x_i) = p_i$. This complicates the proof of Lemma 1 slightly, but leaves the results substantially unchanged.