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PROBABILITY THEORY MEETS RES IPSA LOQUITUR

David Kaye*†

Day in and day out, attorneys, judges, and jurors must estimate probabilities. No, the jury decides, it is not very likely that the fashionable physician murdered his elderly patients to expedite his receipt of their legacies. Yes, the prosecutor insists, the senator must have known that the cash contribution he accepted was the gift of a foreign national. No, the expert witness testifies, chances are that the plane crash that left the plaintiff a penniless widow was the result not of pilot error but rather of an unexpected summer squall.

To be sure, we rarely quantify such estimates of probability and almost never adopt the terminology and mathematics of probability theory to resolve such matters. Nevertheless, the mathematical theory of probability¹ can be, and has been, applied to legal problems in various ways. Some have used the theory descriptively, to model the reasoning of jurors² or the rules of evidence.³ Others have used it normatively, to urge reforms in

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1. By the mathematical theory of probability, I mean the axiomatic description of probability spaces conventionally accepted by mathematicians. See, e.g., H. BRUNK, AN INTRODUCTION TO MATHEMATICAL STATISTICS 21-31 (1965). On the epistemological problems with the concept of probability, see, e.g., T. FINE, THEORIES OF PROBABILITY: AN EXAMINATION OF FOUNDATIONS (1973); H. KYBURG, THE LOGICAL FOUNDATIONS OF STATISTICAL INFERENCE (1974).

2. See, e.g., Iversen, *Operationalizing the Concept of Probability in Legal-Social Science Research*, 5 LAW & SOC. REV. 331 (1971); Simon & Mahan, *Quantifying Burdens of Proof: A View from the Bench, Bar and Classroom*, 5 LAW & SOC. REV. 319 (1971); Simon, "Beyond a Reasonable Doubt"—An Experimental Attempt at Quantification, 6 J. APPLIED BEHAVIORAL SCI. 203 (1970).

3. See, e.g., L. COHEN, THE PROBABLE AND THE PROVABLE (1977) (arguing that a non-standard theory of inductive probability must be developed to describe the rules of evidence); Boole, *On the Application of the Theory of Probabilities to the Question of the Combination of Testimonies or Judgments*, 21 TRANSACTIONS OF THE ROYAL SOCIETY OF EDINBURGH 597 (1857); Schum, *On the Behavioral Richness of Cascaded Inference Models: Examples in Jurisprudence*, in COGNITIVE THEORY 149 (N. Castellan ed. 1977).

the treatment of quantitative evidence⁴ or in the framing of legal rules.⁵ Still others have used it heuristically, to explain rules governing proof of facts.⁶

This Article uses probability theory normatively in an effort to clarify one aspect of the famous tort doctrine known as *res ipsa loquitur*. It does not urge that jurors be instructed in probability theory or be equipped with microprocessors. Rather, it seeks an accurate statement of the *res ipsa* doctrine in ordinary language. In particular, this Article will show that the conventional formulation of the doctrine is misleading at best, and should be replaced with a more careful statement of the conditions warranting the *res ipsa* inference.⁷ To this end, Section I briefly surveys

4. See, e.g., Fairley, *Probabilistic Analysis of Identification Evidence*, 2 J. LEGAL STUD. 493 (1973); Finkelstein & Fairley, *A Bayesian Approach to Identification Evidence*, 83 HARV. L. REV. 489 (1970); Note, *The Evidentiary Uses of Neutron Activation Analysis*, 59 CALIF. L. REV. 997 (1971).

5. See, e.g., Lempert, *Uncovering "Nondiscernible" Differences: Empirical Research and the Jury Size Cases*, 73 MICH. L. REV. 643 (1975); Zeisel, . . . *And Then There Were None: The Diminution of the Federal Jury*, 38 U. CHI. L. REV. 710 (1971); Note, *The Effect of Jury Size on the Probability of Conviction: An Evaluation of Williams v. Florida*, 22 CASE W. RES. L. REV. 529 (1971).

Probability calculations are sometimes used in another, arguably normative sense; in appropriate cases, they are introduced to prove disputed facts, such as the presence of discrimination in the selection of a jury venire or in the hiring of employees. For examples and discussion of jury venire cases, see *Alexander v. Louisiana*, 405 U.S. 625 (1972); *Salary v. Wilson*, 415 F.2d 467 (5th Cir. 1969); De Cani, *Statistical Evidence in Jury Discrimination Cases*, 65 J. CRIM. L. & CRIMINOLOGY 234 (1974); Zeisel, *Dr. Spock and the Case of the Vanishing Women Jurors*, 37 U. CHI. L. REV. 1 (1969); Finkelstein, *The Application of Statistical Decision Theory to the Jury Discrimination Cases*, 80 HARV. L. REV. 338 (1966). For discussions of employment discrimination cases, see Shoben, *Differential Pass-Fail Rates in Employment Testing: Statistical Proof Under Title VII*, 91 HARV. L. REV. 793 (1978); Shoben, *Probing the Discriminatory Effects of Employee Selection Procedures with Disparate Impact Analysis Under Title VII*, 56 TEXAS L. REV. 1 (1977); Note, *Beyond the Prima Facie Case in Employment Discrimination Law: Statistical Proof and Rebuttal*, 89 HARV. L. REV. 387 (1975).

6. See, e.g., Lempert, *Modeling Relevance*, 75 MICH. L. REV. 1021 (1977); Kaplan, *Decision Theory and the Factfinding Process*, 20 STAN. L. REV. 1065 (1968); Kornstein, *A Bayesian Model of Harmless Error*, 5 J. LEGAL STUD. 121 (1976); cf. Note, *A Probabilistic Analysis of the Doctrine of Mutuality of Collateral Estoppel*, 76 MICH. L. REV. 612 (1978) (upholding mutuality through heuristic use of probability theory). This use of probability theory as a heuristic device combines the descriptive and normative modes of discourse. Where the mathematical model accounts for the legal rules, it tends to justify the law; where the legal phenomena cannot be reconciled with the model, the law tends to be perceived as irrational and in need of revision.

7. In discussing how the *res ipsa* doctrine should be phrased, and hence what a jury should be told (or what standard a judge as factfinder should use), this Article assumes that rationality — as generally defined in decision theory or economic theory — is the only relevant normative criterion. See, e.g., W. BAUMOL, *ECONOMIC THEORY AND OPERATIONS ANALYSIS* (4th ed. 1977); J. VON NEUMANN & O. MORGENSTERN, *THEORY OF GAMES AND ECONOMIC BEHAVIOR* (2d ed. 1947). As has been noted elsewhere, although we arguably

the legal doctrine, or, more precisely, the aspect of the doctrine that will be criticized. Section II develops a mathematical apparatus and uses it to expose the weakness in the current version of *res ipsa loquitur*. Finally, Section III summarizes and elaborates the conclusions reached in Section II — conclusions that suggest which cases should reach a jury and what instructions the jury should receive.

Despite the introduction of mathematical terminology, these conclusions are by no means the product of a rigorous, impregnable argument. They rest on the sort of rough generalizations about people and things that are common to all legal arguments. Furthermore, the version of the *res ipsa* doctrine advocated here does not correspond exactly to the ideal mathematical formulation. But even if the recommended changes in the *res ipsa* doctrine are controversial, this excursion into the mathematics of probability will compel us to think clearly about a subject often beset with beguilingly simple but potentially confusing phraseology. Indeed, it may be in this regard that we can gain most from the exercise.

I. THE LEGAL DOCTRINE

The latinism “*res ipsa loquitur*” appears to have been introduced into the law of torts by Chief Baron Pollock more than a century ago. In *Byrne v. Boadle*,⁸ a case brought by a hapless pedestrian injured by a barrel of flour that tumbled from a window in the defendant’s warehouse, Pollock observed: “There are certain cases of which it may be said *res ipsa loquitur* [T]he mere fact of an accident’s having occurred is evidence of negligence”⁹ As this seminal statement of the doctrine makes plain, *res ipsa loquitur* is a rule of circumstantial evidence.¹⁰ It permits a jury to infer from a circumstance — the

employ jurors in large part to inject concerns other than rationality into the factfinding process, the normative model embodied in *homo economicus* is the one appropriately used in most discussions of jury factfinding. See Lempert, *supra* note 6, at 1023 n.14.

8. 2 H. & C. 722, 159 Eng. Rep. 299 (Ex. 1863).

9. 2 H. & C. at 725, 159 Eng. Rep. at 300 (oral argument), reprinted in W. PROSSER, J. WADE & V. SCHWARTZ, *CASES AND MATERIALS ON TORTS* 251, 252 (6th ed. 1976) [hereinafter cited as PROSSER, WADE & SCHWARTZ]. For recent cases applying *res ipsa* to falling objects, see, e.g., *Jackson v. H.H. Robertson Co.*, 118 Ariz. 29, 574 P.2d 822 (1978); *Bond v. Otis Elevator Co.*, 388 S.W.2d 681 (Tex. 1965).

10. See, e.g., *Eaton Fruit Co. v. California Spray-Chem. Corp.*, 103 Ariz. 461, 463, 445 P.2d 437, 439 (1968); *Gilbert v. Korvette’s, Inc.*, 457 Pa. 602, 611, 327 A.2d 94, 99 (1974); 2 F. HARPER & F. JAMES, *THE LAW OF TORTS* § 19.5, at 1079 (1956) [hereinafter cited as HARPER & JAMES].

injury to the plaintiff — that the defendant was negligent.¹¹ In the abstract, this inference seems reasonable enough. Surely, *some* accidents could hardly happen unless someone is at fault.¹²

The problem for developing a workable legal doctrine lies in specifying *which* accidents are of this character. The all-but-universally accepted formulation, codified in section 328 D of the Restatement of Torts, provides:

It may be inferred that harm suffered by the plaintiff is caused by negligence of the defendant when . . . the event is of a kind which ordinarily does not occur in the absence of negligence. . . .¹³

11. This, at least, describes the general rule. See, e.g., *Johnson v. United States*, 333 U.S. 46, 49 (1948); RESTATEMENT (SECOND) OF TORTS § 328 D, Comment b, at 157 (1965) [hereinafter cited as RESTATEMENT]. The procedural effect of the inference varies somewhat among jurisdictions and fact situations. See, e.g., *Mobil Chem. Co. v. Bell*, 517 S.W.2d 245, 251-52 (Tex. 1974); RESTATEMENT, *supra*, § 328 D, Comment d, at 158 & Comment m, at 165; PROSSER, WADE & SCHWARTZ, *supra* note 9, at 278-79.

12. In some instances, *res ipsa* may be applied even though this empirical foundation is lacking. The ability of defendants in similar cases to supply probative evidence, combined with the inability of plaintiffs to do so, may support a rule that permits an inference against defendants. Suppose, for instance, that commercial aircraft frequently crash despite reasonable care on the part of the carrier, and that negligence rather than strict liability governs the cause of action. A court might still wish to allow the inference of negligence to encourage commercial carriers to install recording equipment that might be salvageable and might suggest the causes of at least some crashes. Most cases that have held *res ipsa* inapplicable to unexplained airplane crashes, however, have simply rejected the premise that aircraft frequently crash only if someone has been negligent. See, e.g., *Higginbotham v. Mobil Oil Corp.*, 545 F.2d 422, 429-30 (5th Cir. 1977), *revd. on other grounds*, 436 U.S. 618 (1978); *Cox v. Northwest Airlines, Inc.*, 379 F.2d 893 (7th Cir. 1967), *cert. denied*, 389 U.S. 1044 (1968); *Widmyer v. Southeast Skyways, Inc.*, 584 P.2d 1, 14 (Alaska 1978). For a commentary emphasizing the superior knowledge rationale for *res ipsa*, see, e.g., M. SHAIN, *RES IPSA LOQUITUR* (1945); Jaffe, *Res Ipsa Loquitur Vindicated*, 1 BUFFALO L. REV. 1 (1951); Carpenter, *Res Ipsa Loquitur: A Rejoinder to Professor Prosser*, 10 S. CAL. L. REV. 467 (1937).

13. In addition, the *Restatement* contains provisos linking the defendant with the inferred negligence. Section 328 D also requires that "(b) other responsible causes, including the conduct of the plaintiff and third persons, are sufficiently eliminated by the evidence; and (c) the indicated negligence is within the scope of the defendant's duty to the plaintiff." RESTATEMENT, *supra* note 11, § 328 D, at 156. In speaking of "sufficiently eliminating" some other possible causes apparently compatible with reasonable care by everyone involved, subsection (b) overlaps subsection (a).

The *Restatement* formulation or minor variations of it are ubiquitously followed. See, e.g., *Widmyer v. Southeast Skyways, Inc.*, 584 P.2d 1, 11 (Alaska 1978); *Jackson v. H.H. Robertson Co.*, 118 Ariz. 29, 574 P.2d 822 (1978); *Renfro v. J.D. Coggins Co.*, 71 N.M. 310, 378 P.2d 130 (1963); *Brannon v. Wood*, 251 Or. 349, 444 P.2d 558 (1968); *Gilbert v. Corvette's, Inc.*, 457 Pa. 602, 327 A.2d 94 (Pa. 1974); ARIZ. REV. STAT. ANN. § 12-561 (1976). One common variant is supplied by both Prosser and Wigmore. Those authors state that for the inference of negligence to be permitted,

(1) the event must be of a kind which ordinarily does not occur in the absence of someone's negligence; (2) it must be caused by an agency or instrumentality within the exclusive control of the defendant; (3) it must not have been due to any volun-

This formulation seems so obviously correct and so well entrenched as to be beyond the pale of serious criticism. Indeed, it serves well enough in the preponderance of cases. Nevertheless, courts have generated a bewildering variety of verbiage in determining what makes an accident the type that does not ordinarily occur in the absence of someone's negligence.¹⁴ Some have suggested that all possible causes of the accident except for negligence must be "excluded,"¹⁵ or "sufficiently eliminated,"¹⁶ or that the likelihood of these other causes must be "so reduced that the jury can reasonably find" negligence,¹⁷ or that the plaintiff must exhibit a "balance of the probabilities" favoring negligence.¹⁸

tary action or contribution on the part of the plaintiff.

W. PROSSER, *HANDBOOK OF THE LAW OF TORTS* § 39, at 214 (4th ed. 1971); 4 J. WIGMORE, *EVIDENCE* § 2509 (1st ed. 1905). See also HARPER & JAMES, *supra* note 10, § 19.5, at 1081.

14. The *Restatement* conspicuously fails to supply any standard for ascertaining when an event is of this kind. The commentary to § 328 D explains only that there must be "a basis of past experience which reasonably permits" this conclusion. *RESTATEMENT*, *supra* note 11, § 328 D, Comment c, at 158. Similarly, most courts have been content to rely on the proposition that "general knowledge" or expert testimony is sufficient to make the necessary showing. *E.g.*, *Williams v. United States*, 218 F.2d 473, 476 (6th Cir. 1955); *Widmyer v. Southeast Skyways, Inc.*, 584 P.2d 1, 14 (Alaska 1978); *Jackson v. H.H. Robertson Co.*, 118 Ariz. 29, 32, 574 P.2d 822, 825 (1978); *Cox v. Wilson*, 267 S.W.2d 83, 84 (Ky. 1954); *Mobil Chem. Co. v. Bell*, 517 S.W.2d 245, 252 (Tex. 1974). See also *RESTATEMENT*, *supra* note 11, § 328 D, Comment d, at 158-59.

15. *E.g.*, *Weaver v. Shell Co.*, 13 Cal. App. 2d 643, 57 P.2d 571, 572-73 (1936); *Martin v. Powell*, 101 So. 2d 610 (Fla. App. 1958); *Frank Fehr Brewing Co. v. Corleyn*, 265 Ky. 308, 96 S.W.2d 860, 865 (1936).

16. *E.g.*, *Gilbert v. Korvette's, Inc.*, 457 Pa. 602, 614, 327 A.2d 94, 101 (1974); *cf.* *RESTATEMENT*, *supra* note 11, § 328 D (1) (b) (incorporating a similar requirement).

17. *Mobil Chem. Co. v. Bell*, 517 S.W.2d 245, 251 (Tex. 1974).

18. *E.g.*, *St. Paul Fire & Life Mar. Ins. Co. v. Watkins*, 261 Or. 473, 477, 495 P.2d 265, 267 (1972); *Siverson v. Weber*, 57 Cal. 2d 834, 372 P.2d 97, 22 Cal. Rptr. 337 (1962); *Tucker v. Lombardo*, 47 Cal. 2d 457, 465, 303 P.2d 1041, 1046 (1956); *Zentz v. Coca-Cola Bottling Co.*, 39 Cal. 2d 436, 442, 247 P.2d 344, 347 (1952). Of all the articulations of what must be "generally known" or attested to by an expert, the most popular seems to be this "balance of the probabilities" test. Certainly, most modern cases that analyze *res ipsa* in such detail seem to propound that approach. See, *e.g.*, *Hakensen v. Ennis*, 584 P.2d 1138, 1139 (Alaska 1978); *Riedisser v. Nelson*, 111 Ariz. 542, 544, 534 P.2d 1052, 1054 (1975); *Brannon v. Wood*, 251 Or. 349, 444 P.2d 558 (1968). Furthermore, commentary appears to favor the "balance of the probabilities" test. See, *e.g.*, HARPER & JAMES, *supra* note 10, § 19.5, at 1078. When courts adopt this nomenclature, however, they may be referring to either of two balances: (1) the balance between (a) the probability that an accident will occur if someone is negligent and (b) the probability that an accident will occur if no one is negligent; or (2) the balance between (c) the probability that defendant was negligent given that the accident occurred and (d) the probability that defendant was not negligent given that the accident occurred. Most courts seem to contemplate the second relationship when they talk of balancing probabilities. See, *e.g.*, *Hakensen v. Ennis*, 584 P.2d 1138, 1139 (Alaska 1978); *Mobil Chem. Co. v. Bell*, 517 S.W.2d 245, 252 (Tex. 1974) ("It is sufficient if . . . the negligence . . . probably occurred, so that the reasonable probabilities point to the defendant. . . ."); *RESTATEMENT*, *supra* note 11, § 328 D, Comment e, at

Even more distressingly, the very phrase "ordinarily does not occur in the absence of negligence," if taken literally, inaccurately specifies when the res ipsa inference of negligence is empirically well-founded.

The difficulty with the phrase "ordinarily does not occur in the absence of negligence" is most evident in cases concerning accidents that take place only infrequently. In the bulk of these cases, the courts recognize that the rarity of the injury does not alone imply negligence. For instance, in one well-known case, *Brannon v. Wood*,¹⁹ a man went into a hospital to have a tumor (specifically, a meningocele) removed from the back of his chest and came out paralyzed from the waist down. The paralysis resulted from emergency measures taken to halt internal hemorrhaging at the site of the excised tumor, near the spinal cord.²⁰ The trial court not only refused to instruct the jury along res ipsa lines, but also propounded the defendant physician's proposed instruction that the mere existence of the injury was no evidence of negligence. The Oregon Supreme Court affirmed, purportedly because the plaintiff had not shown that his injury was the sort that "ordinarily does not occur in the absence of someone's negligence."²¹ "The test," the court emphasized, "is not whether a particular injury rarely occurs, but rather, when it occurs, is it ordinarily the result of negligence."²² "Ordinarily the result of

159 ("Where the probabilities are at best evenly divided between negligence and its absence, it becomes the duty of the court to direct the jury that there is no sufficient proof. . . . It is enough that the facts proved reasonably permit the conclusion that negligence is the more probable explanation."). A number of courts, however, can be understood to concern themselves with the first two probabilities, apparently assuming that if probability (a) is greater than probability (b), then probability (c) is large enough to support a finding of negligence. This Article disputes that assumption.

19. 251 Or. 349, 444 P.2d 558 (1968), reprinted in PROSSER, WADE & SCHWARTZ, *supra* note 9, at 257-62.

20. Many medical procedures, like the surgery in *Brannon*, are generally accepted as appropriate therapy although they carry some risk of serious complications. Cancer chemotherapy is potentially immunosuppressive and may impair important host defenses. Bakemeier, *Principles of Medical Oncology and Cancer Chemotherapy*, in CLINICAL ONCOLOGY FOR MEDICAL STUDENTS AND PHYSICIANS 90, 94 (4th ed. 1974). Pertussis vaccine sometimes induces brain damage, convulsions, and a strange screaming phenomenon in infants. Mortimer, *Immunization Against Infectious Disease*, 200 SCIENCE 902, 906 (1978). Renal transplantation may be followed by persistent hyperparathyroidism, necessitating further surgery. Merril & Carpenter, *Transplantation*, in HARRISON'S PRINCIPLES OF INTERNAL MEDICINE 359, 365 (7th ed. 1974). Prolonged treatment with antipsychotic medications can result, irreversibly, in the movement disorder tardive dyskinesia. Berger, *Medical Treatment of Mental Illness*, 200 SCIENCE 974, 977 (1978).

21. 251 Or. at 355, 444 P.2d at 561.

22. 251 Or. at 358, 444 P.2d at 562 (citation omitted).

negligence," the court finally stated, means simply "more likely the result of negligence than some other cause."²³ Since neither general knowledge nor expert testimony revealed that the paralysis was more likely to result from negligence than from another cause, the court concluded that the plaintiff invoked *res ipsa loquitur* in vain.²⁴

In a number of cases, however, the courts treat the question of what "ordinarily" occurs in the absence of negligence quite differently. In *Dacus v. Miller*,²⁵ for instance, the Oregon Supreme Court again considered a plaintiff who had suffered paralysis following surgery.²⁶ This time, however, the plaintiff had secured an expert to testify that if due care were exercised in the type of operation involved, paralysis would not "ordinarily occur."²⁷ Apparently bemused by the words "ordinarily occur," the court held that this testimony was adequate to establish negligence.²⁸ Thus, *Dacus* creates telling evidence of malpractice from the mere fact that complications of surgery are rare, and

23. 251 Or. at 361, 444 P.2d at 563.

24. For comparable cases, see, e.g., *Siverson v. Weber*, 57 Cal. 2d 834, 372 P.2d 97, 22 Cal. Rptr. 337 (1962); *Sommers v. Sisters of Charity*, 277 Or. 549, 554-55, 561 P.2d 603, 606-07 (1977); *Austin v. Sisters of Charity*, 256 Or. 179, 187-88, 470 P.2d 939, 943 (1970).

25. 257 Or. 337, 479 P.2d 229 (1971).

26. The defendant physician had performed a radical mastoidectomy revision, during which he removed a mass of cholesteatoma. He admitted that during this surgery, the plaintiff's left facial nerve was injured, causing partial facial paralysis, but contended that such injury to the facial nerve was an inherent risk of the surgery. There was no claim that the surgery itself was unnecessary or that the patient had not been adequately informed of the risk.

27. 257 Or. at 339-41, 479 P.2d at 230-31. The surgeon who performed the corrective surgery testified that he had performed 1,500 to 2,000 middle ear surgeries, including about 35 operations to correct facial nerve injuries. 257 Or. at 340 nn. 1 & 3, 479 P.2d at 230 n.1, 231 n.3. Several experts testified that injury to the facial nerve was an "inherent risk" in radical mastoidectomies, but rarely occurred. 257 Or. at 341, 479 P.2d at 230-31.

28. 257 Or. at 339-41, 479 P.2d at 230-31. The trial court refused to give a *res ipsa* instruction, and the jury found for the defendant. The plaintiff appealed, urging in part that an adequate foundation for *res ipsa* had been laid. The supreme court agreed, but nonetheless affirmed on the theory that the instruction requested by the plaintiff was defective in form and, for that reason, should not have been given. 257 Or. at 341-44, 497 P.2d at 231-32.

One member of the court, Chief Justice O'Connell, recognized that the expert testimony about what "ordinarily" occurs did not imply that injury to the facial nerve in radical mastoidectomies is more likely the result of negligence than of "inherent risk" in the operation. His concurring opinion follows the *Brannon* logic in substituting, without explanation, the latter consideration for the canonical "ordinarily does not occur in the absence of negligence." Compare 257 Or. at 345-46, 479 P.2d at 233 (O'Connell, C.J., concurring) with *Brannon v. Wood*, 251 Or. 349, 360-61, 444 P.2d 558, 563 (1968).

hence do not "ordinarily" occur if reasonable care is exercised.²⁹

This reasoning from the premise that an injury is unusual to the conclusion that it does not ordinarily occur in the absence of negligence — reasoning by no means confined to medical malpractice cases³⁰ — is surely suspect. Yet the fallacy is not easily exposed by recourse to the traditional "ordinarily does not occur in the absence of negligence" language. Contrary to the *Brannon* court's pronouncement, this phrase is not quite the same as "more likely the result of negligence than some other cause." To explain why not in detail is the burden of the next Section, but it may be helpful to sketch a facet of the difficulty here. Suppose we try to rewrite each proposition as a statement about probabilities. The proposition that an injury does not ordinarily occur in the absence of negligence is equivalent to the proposition that the injury is rare if reasonable care is exercised. This statement, in turn, means that the probability of the injury given reasonable care is small,³¹ and it is what was testified to in *Dacus*. On the other hand, the proposition that an injury is more likely the result of negligence than of some other cause — the proposition that the court said was not made out in *Brannon* — seems to express a relationship between two quite different probabilities. This *Brannon* proposition seems to mean that, given the injury, the probability that the defendant was negligent exceeds the probability that the defendant exercised reasonable care.³² Or that same proposition may relate to the converse of those conditional probabilities; it would then state that the probability of injury given negligence is larger than that of injury given reasonable

29. In a footnote, the *Dacus* court evinced some uncertainty over the relationship between the *Mayor-Dacus* line of cases and *Brannon*. 257 Or. at 340 n.2, 479 P.2d at 230 n.2.

30. See, e.g., *Widmyer v. Southeast Skyways, Inc.*, 584 P.2d 1, 14 (Alaska 1978); *St. Paul Fire & Life Mar. Ins. Co. v. Watkins*, 261 Or. 473, 477, 495 P.2d 265, 267 (1972).

31. It could be maintained that "ordinarily does not occur" is not equivalent to "rarely occurs," but only to "occurs less than half the time." Cf. *Higginbotham v. Mobil Oil Corp.*, 545 F.2d 422, 430 & n.10 (5th Cir. 1977), *revd. on other grounds*, 436 U.S. 618 (1978) (*res ipsa* applied to one of several defendants). Reliance on this weaker sense of "ordinarily" only makes the problem worse. Unless complications arise more often than not, they "ordinarily" do not occur in the weak sense of the word. If they "ordinarily" do not occur, then certainly they "ordinarily" do not occur when reasonable care is taken. Hence, on this interpretation of "ordinarily does not occur," *res ipsa* is available for any medical procedure except one that is beset by complications in more than 50% of its applications.

32. This is tantamount to saying that the probability of negligence given the fact of injury exceeds one-half. See note 53 *infra*.

care.³³ In either case, it does not sound like the interpretation of “ordinarily does not occur” implicit in *Dacus*.

Now you might think that all these cumbersome statements about probabilities reduce to the same thing. In the next Section, however, I will show that they do not, just as the anticlinal quality of *Brannon* and *Dacus* would suggest. You might also object that the interpretation of “ordinarily does not occur” that I believe undergirds *Dacus* is too simplistic or literalistic, and that the putatively strained exegesis in *Brannon* is more faithful to the *res ipsa* doctrine, properly understood. Perhaps so. But to embrace this view is to concede that the “ordinarily does not occur” language — the core of the *res ipsa* doctrine as conventionally formulated — is replete with ambiguity. Furthermore, this latent ambiguity is of a more than perverse academic interest, for it can manifest itself in disconcerting ways, as the juxtaposition of cases like *Brannon* and *Dacus* reveals.

I trust, therefore, that it is not too late to suggest that the phrase “ordinarily does not occur in the absence of negligence” can be clarified and improved, and that it is appropriate to pay careful attention to the possible meanings of the phrase and their implications. To express the conceivable meanings with precision and clarity, the language of mathematics is, perforce, invaluable. Consequently, the next Section of this Article will amplify the possible interpretations of the “ordinarily does not occur” notion and translate them into a simple and convenient symbolism. After a brief discussion of the problem of quantifying the preponderance-of-the-evidence standard, a simple formula called Bayes’s Theorem, which relates the pertinent probabilities, will be derived. Finally, I will apply Bayes’s Theorem to reach a reasonably accurate and workable specification of what is properly meant by the “ordinarily does not occur in the absence of negligence” requirement.

II. THE APPLICATION OF PROBABILITY THEORY

A. Notation

As we have seen, “ordinarily does not occur in the absence of negligence” might mean any number of things. It could be, and arguably has been, taken to signify (1) that the probability of the injury given the exercise of reasonable care is quite small, (2) that

33. See note 18 *supra*.

the probability of the injury given reasonable care is smaller than the probability of the injury given negligence, or (3) that the probability of the injury given reasonable care is much smaller than the probability of the injury given negligence. A few symbols can express these possible interpretations succinctly. The probability of injury given reasonable care will be denoted by $P(I|R)$, and the probability of injury given negligence by $P(I|N)$. It will also be helpful to represent the (unconditional) probability of injury by $P(I)$, the probability of negligence by $P(N)$, and the probability of negligence given the fact of the injury by $P(N|I)$.³⁴

In medical malpractice cases like *Brannon* and *Dacus*, then, $P(I)$ stands for the chance that a patient like the plaintiff will be injured during the surgery. $P(N)$ represents the probability that the defendant surgeon will be negligent in performing the operation. It may be thought of, in the retrospective context of litigation, as a best estimate of the chance that the defendant acted negligently, given all the information in the case about the surgeon, the surgery, and the patient, but not yet considering that the plaintiff was injured by the surgery and that no direct evidence of negligence has been adduced. In other words, $P(N)$ denotes the best assessment of the probability of defendant's negligence on the basis of everything but the plaintiff's *res ipsa* argument.³⁵ $P(I|R)$ is the likelihood that a surgeon who exercises rea-

34. Negligence and reasonable care are defined so as to be mutually exclusive and collectively exhaustive. That is, either defendant exercised reasonable care, or defendant was negligent, so that

$$P(N) + P(R) = P(N) + P(-N) = 1,$$

where "-N" means "not negligent." It follows that

$$P(N|I) + P(R|I) = 1.$$

See note 53 *infra*.

35. For reasons that will be evident when Bayes's Theorem is introduced, $P(N)$ can be called the "prior probability" of negligence, and $P(N|I)$ the "posterior probability" of negligence. As a first approximation, $P(N)$ might be based entirely on the incidence of malpractice among local surgeons. A more refined estimate might depart from the overall incidence of malpractice to take account of, among other things, the medical school attended by the surgeon, performance as an intern and resident, and the timing of the operation (early or late shift, early or late in the week).

As one departs from the general category and moves to the details of the particular operation, the "objective" or "frequency" approach to measuring $P(N)$ must be replaced with a "subjective" or "personalistic" definition. See generally, e.g., T. FINE, *supra* note 1; H. KYBURG, *supra* note 1; Carnap, *Two Concepts of Probability*, in READINGS IN THE PHILOSOPHY OF SCIENCE 438 (1953). The "subjective" interpretation of probability statements is perhaps the most conducive to a description of legal factfinding. See, e.g., Ball, *The Moment of Truth: Probability Theory and Standards of Proof*, in ESSAYS ON PROCEDURE AND EVIDENCE 84 (1961); Cullison, *Probability Analysis of Judicial Fact-Finding: A Preliminary Outline of the Subjective Approach*, 1 U. Tol. L. Rev. 538 (1969). *Contra*, L.

sonable care will injure the patient, while $P(I|N)$ is the probability that a negligent surgeon will injure the patient. Since, by definition, reasonable care should diminish the probability of injury and negligence should enhance it,³⁶ one would expect $P(I|R)$ to be less than $P(I|N)$, and $P(I)$ — the overall probability of injury associated with the medical procedure, as administered by the surgeon in question, for patients like the plaintiff — to fall somewhere between the two. Finally, $P(N|I)$ denotes the probability that the surgeon was negligent, taking into account the fact of injury to the patient (in addition to the information considered in assessing $P(N)$).

With this notation, and using the symbol “<” to denote “less than” and “<<” to denote “much less than,” the interpretations of “ordinarily does not occur in the absence of negligence” that were enumerated above can be written as follows:

$$\begin{aligned} P(I|R) &<< 1 && (1) \\ P(I|R) &< P(I|N) && (2) \\ P(I|R) &<< P(I|N) && (3) \end{aligned}$$

If we designate the ratio of $P(I|R)$ to $P(I|N)$ by the letter f , then the three interpretations can be expressed as:

$$\begin{aligned} P(I|R) &<< 1 && (1) \\ f &< 1 && (2) \\ f &<< 1 && (3) \end{aligned}$$

Significantly, the *res ipsa* doctrine is concerned with none of these probabilities directly. The correctness of the *res ipsa* inference — inferring negligence from the fact of injury — depends instead on $P(N|I)$, the likelihood that the defendant surgeon was negligent, given the plaintiff's injury.³⁷ If this probability is too small, the *res ipsa* inference is inappropriate;³⁸ if it is large

COHEN, *supra* note 3. Under this interpretation, statements about the frequency of negligence, for example, can be transcribed into statements about the certitude of a rational juror's belief in negligence. See, e.g., H. PAZER & L. SWANSON, *MODERN METHODS FOR STATISTICAL ANALYSIS* (1972). Given a few plausible postulates (that in effect define the normative notion of rationality, see note 7 *supra*), these subjective probabilities obey the rules derived from the standard axioms of probability theory. See, e.g., L. SAVAGE, *FOUNDATIONS OF STATISTICS* (2d ed. 1972); Tribe, *Trial by Mathematics: Precision and Ritual in the Legal Process*, 84 HARV. L. REV. 1329, 1347-49 (1971).

36. See, e.g., *United States v. Carroll Towing Co.*, 159 F.2d 169, 173 (2d Cir. 1947); Posner, *A Theory of Negligence*, 1 J. LEGAL STUD. 29 (1972).

37. Regarding $P(N|I)$ as the crucial probability is something of an oversimplification, but it is helpful for preliminary analysis and is corrected in text at notes 64-75 *infra*.

38. But see note 12 *supra*.

enough, the inference is justified.³⁹ When cases like *Dacus* profess that the inference is proper as long as injuries do not ordinarily occur if reasonable care is exercised, they are in effect asserting that as long as condition 1 holds, $P(N|I)$ is large enough to support the inference.⁴⁰

To test this assumption, we must first clarify the meaning of "large enough," a task that can be accomplished by looking to the burden of proof that the law imposes on the plaintiff. In tort cases, plaintiffs are said to have the burden of proof: they must establish all the essential elements of the tort by a preponderance of the evidence if they are to prevail. It would seem that an element is established by a preponderance of the evidence if, after weighing all the evidence, a reasonable juror is persuaded that it is more likely than not that the element exists.⁴¹ Thus, a jury should favor the plaintiff on the issue of negligence if and only if it reasonably believes the probability of negligence given the evidence adduced at trial exceeds one-half. For the plaintiff to avoid a directed verdict for the defendant where sole reliance is placed on *res ipsa*, $P(N|I)$ likewise must exceed one-half.⁴² This result may also be derived from more basic assumptions, using the concept of utility.⁴³

39. Subject to the caveat of note 12 *supra*, the converse proposition should also hold. An adequate statement of the *res ipsa* doctrine should express the necessary and sufficient conditions for the inference of negligence to be justified. For brevity, however, I shall mostly ignore stating and proving converses.

40. On the other hand, cases like *Brannon*, which require a "balance of the probabilities" in favor of negligence, are either stating that the *res ipsa* inference is proper if $P(N|I) > .50$, or they are assuming that if condition 2 holds, $P(N|I)$ is large enough to warrant the conclusion of negligence. See note 18 and text at note 34 *supra*. Under this first interpretation, the "balance of the probabilities" test merely states the standard of proof generally used in civil litigation. See text at notes 41-43 *infra*. Under the second interpretation, the test is misconceived, for condition 2 does not imply that $P(N|I)$ is large enough to support the inference. See Subsection II.B. *infra*.

41. See, e.g., Ball, *supra* note 35; Cullison, *supra* note 35, at 569-71; Lempert, *supra* note 6, at 1034 n.38; Winter, *The Jury and the Risk of Nonpersuasion*, 5 LAW & SOC. REV. 335, 337 (1971). *Contra*, L. COHEN, *supra* note 3, at 75.

42. A more refined analysis would require that $P(N|I \& F) > .50$ where F is the fact that the plaintiff relied on *res ipsa*. See text at notes 58-60 *infra*. To a first approximation, however, the statement in the text is accurate.

For additional discussion of the relation of $P(N|I)$ to directed verdicts, see Tribe, *supra* note 35, at 1339 n.33, 1361 nn.101-02. For cases that can be read as holding that negligence may be found if $P(N|I) > .50$, see, e.g., *Hakensen v. Ennis*, 584 P.2d 1138, 1139 (Alaska 1978); *Riedisser v. Nelson*, 111 Ariz. 542, 544, 534 P.2d 1052, 1054 (1975); *Siverson v. Weber*, 57 Cal. 2d 834, 372 P.2d 97, 22 Cal. Rptr. 337 (1962); *Sommers v. Sisters of Charity*, 277 Or. 549, 555, 561 P.2d 603, 606-07 (1977); *Austin v. Sisters of Charity*, 256 Or. 179, 187-88, 470 P.2d 939, 943 (1970); *Brannon v. Wood*, 251 Or. 349, 358, 444 P.2d 558, 562 (1968); *Mobil Chem. Co. v. Bell*, 517 S.W.2d 245, 251 (Tex. 1974).

43. If the utilities of correct and mistaken verdicts do not depend on whether the verdicts favor plaintiffs or defendants, it can be shown that utility will be maximized by

B. Bayes's Theorem

1. Derivation

Knowing what value of $P(N|I)$ is "large enough" to justify the *res ipsa* inference,⁴⁴ we can turn to the problem of relating this

the following decision rule: decide for the plaintiff if $P(N|I) > .50$; otherwise, decide for the defendant. Such derivations are presented in, e.g., Ball, *supra* note 35, at 101; Kaplan, *supra* note 6, at 1071-72; Lempert, *supra* note 6, at 1032-35; Tribe, *supra* note 35, at 1278-81.

Although the mathematics of maximizing utility is not unduly complicated in this context, how the magnitude of these entities might be determined is a deep problem. In thinking about the design of legal rules, one can posit rational judges or legislators who state legislative preferences — what they think is best for society — for outcomes with differing risks. If these risk-related preferences obey a few plausible axioms (which explicate the notion of rationality), von Neumann-Morgenstern (N-M) utilities can be used to construct the matrix. These utilities do not presuppose any natural, universal unit for the measurement of utility, and the numerical scale that is derived from the N-M "standard gamble" procedure is arbitrary in that it can always be stretched and shifted by a linear transformation. See, e.g., W. BAUMOL, *supra* note 7, at 420-36; cf. Tribe, *supra* note 35, at 1379-80 (obtaining numerical values for N-M utility functions).

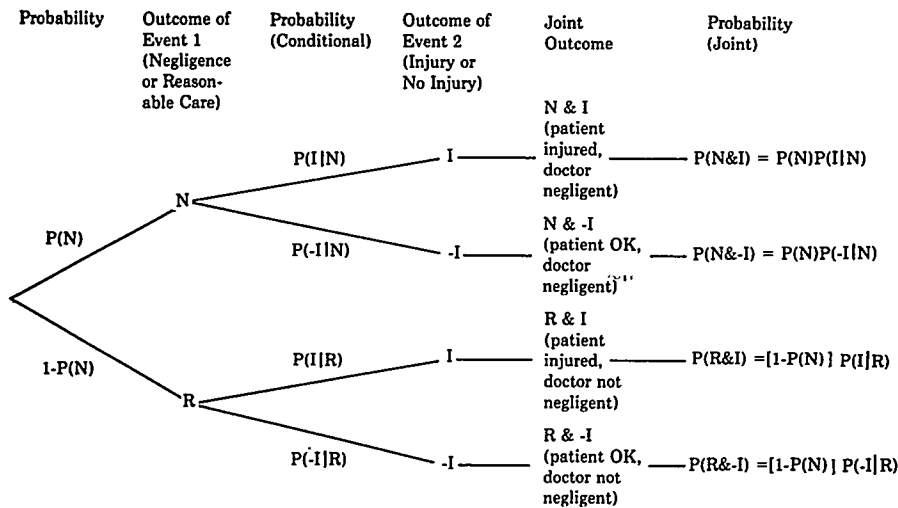
The utilities could also be cast in neoclassical terms. Rather than merely ranking preferences, the utility functions would then measure the actual strength of preferences. Even though these utilities might be normalized (emphasizing that they are measured only in relative units) once this scale is established, meaning would have to be attributed to differences in magnitude. Although economists tend to eschew this neoclassical conception of utility, some philosophers interested in the design of legal and other basic social institutions find such cardinal utility functions helpful. See, e.g., R. SARTORIUS, *INDIVIDUAL CONDUCT AND SOCIAL NORMS* (1975). The "regret matrices" employed in some discussions of jury fact-finding also lend themselves to a cardinal interpretation. See, e.g., Lempert, *supra* note 6, at 1032.

In important instances, however, $P(N|I) > .50$ is not sufficient to warrant the inference of negligence. This is so because the equations displayed so far make no provision for the legitimate doubt that can arise when plaintiff relies only on the circumstances of the injury to prove negligence although he has access to evidence that would permit a more particularized showing. This argument from nonproduction, as I call it, is considered in detail in text at notes 58-69 *infra*. Its significance in these direct *res ipsa* cases is discussed in note 68 *infra*. An analogous argument helps explain the reluctance of courts to permit exclusive reliance on statistical evidence in many circumstances. See, e.g., Kaye, Book Review, 89 YALE L.J. 601 (1980) (forthcoming); Kaye, *The Paradox of the Gatecrasher and Other Stories*, 1979 ARIZ. ST. L.J. 101. But see M. FINKELSTEIN, *QUANTITATIVE METHODS IN LAW* 59-78 (1978); Tribe, *supra* note 35, at 1360.

Professor Tribe is highly skeptical of this entire utility approach. See Tribe, *supra* note 35, at 1378-86. However, most of his criticisms are peculiar to the criminal context in which he advances them. His suggestion that utilities may be functions of probability is reminiscent of Professor Allais's critique of the N-M utility functions on which decision theory relies. W. BAUMOL, *supra* note 7, at 428 n.8; H. RAIFFA, *DECISION ANALYSIS: INTRODUCTORY LECTURES ON CHOICE UNDER UNCERTAINTY* (1968). This objection, even if valid, would not detract from the analysis presented here, which requires only that for every probability level, the utility matrix be symmetric with equal diagonal elements.

44. Although a fair amount of effort was expended to establish that $P(N|I) > .50$ warrants an inference of negligence from the fact of injury, it turns out that the conclusion

probability to the three probabilistic interpretations of the crucial phrase "ordinarily does not occur in the absence of negligence." To see the connection in a concrete case, consider the possible outcomes of surgical procedures like the ones in *Brannon* and *Dacus*. At the outset, the surgeon performs the operation either negligently or with reasonable care. In the notation introduced earlier, the probability of negligence is $P(N)$, and that of reasonable care is $P(R) = 1 - P(N)$. Now, if the doctor is negligent, two things can happen: the patient can be injured, or the patient can be fortunate and sustain no injury. The probability of injury, given negligence, we designated $P(I|N)$; that of no injury despite negligence can be denoted $P(-I|N)$. Similarly, if the physician is not negligent, the same two outcomes, injury or no injury, are possible, and the respective probabilities can be written $P(I|R)$ and $P(-I|R)$. The probabilities of each of the four possible outcomes are now easily computed, as shown in the tree diagram below:



to be drawn as to the proper meaning of "ordinarily does not occur in the absence of negligence" is not very sensitive to this value. Demanding that $P(N|I)$ exceed .40 or .60, for example, would not affect the results that will be obtained.

The probabilities at the right are called "joint" probabilities because they concern outcomes determined by two different events (negligent or not; injured or not) occurring in combination. To write these expressions for the joint probability of each outcome I have used the definition of conditional probability: the probability of an outcome A conditional on outcome B is defined as the probability of the joint occurrence of A and B divided by the probability of B.⁴⁵ In symbols:

$$P(A|B) = \frac{P(A\&B)}{P(B)} \quad (4)$$

Using this definition of conditional probability further, we can express $P(N|I)$ — the single probability on which the *res ipsa* inference turns — in terms of the probabilities in the tree diagram. If, in equation 4, A stands for negligence (N) and B for injury (I), the definition states that

$$P(N|I) = \frac{P(N\&I)}{P(I)}$$

Multiplying numerator and denominator by $P(N)$ and substituting $P(I\&N)$ for $P(N\&I)$ ⁴⁶ yields

$$P(N|I) = \frac{P(N)}{P(I)} \frac{P(I\&N)}{P(N)}$$

Recognizing that $P(I\&N)/P(N) = P(I|N)$,⁴⁷ we obtain

$$P(N|I) = \frac{P(N)P(I|N)}{P(I)} \quad (5)$$

Looking at the branches of the tree diagram terminating in outcome I, we find that $P(I) = P(\text{either } N\&I \text{ or } R\&I) = P(N\&I) + P(R\&I) = P(N)P(I|N) + (1-P(N))P(I|R)$. Substituting this into equation 5 gives the popular version of Bayes's Theorem:⁴⁸

45. This formula may be interpreted as stating that the probability of A given B is the frequency with which A occurs out of all cases in which B occurs. Another way to view this definition, which may make its meaning more transparent, is to express it in the equivalent form $P(A\&B) = P(A|B)P(B)$. This statement reads that the probability that the outcomes A and B will occur is equal to the probability that A will occur if B occurs times the probability that B occurs. To borrow an illustration, suppose that A stands for a warm day and B for a sunny day. Then the definition of conditional probability tells us that the probability that it will be both warm and sunny equals the probability that it will be warm if it is in fact sunny times the probability that it will be sunny. Lempert, *supra* note 6, at 1022 n.10.

46. Since the joint outcome I & N is identical to the joint outcome N & I, the associated probabilities are the same. For example, the probability that tomorrow will be warm and sunny equals the probability that tomorrow will be sunny and warm.

47. This follows from equation 4, with $A = I$ and $B = N$.

48. For other versions and derivations of Bayes's rule, see, *e.g.*, Bayes, *An Essay*

$$P(N|I) = \frac{P(N)P(I|N)}{P(N)P(I|N) + (1-P(N))P(I|R)} \quad (6)$$

Next, we divide both the numerator and denominator by $P(N)P(I|N)$:

$$P(N|I) = \frac{1}{1 + \frac{(1-P(N)) P(I|R)}{P(N) P(I|N)}}$$

Letting f stand for the fraction $\frac{P(I|R)}{P(I|N)}$

as we did in expressions 2 and 3, we find

$$P(N|I) = \frac{1}{1 + \frac{(1-P(N)) f}{P(N)}}$$

which in simpler form reads:

$$P(N|I) = \frac{1}{1-f + f/P(N)} \quad (7)$$

2. Application

With this form of Bayes's Theorem, we can outline the conditions under which a jury should be permitted to conclude that $P(N|I)$ exceeds .50, *i.e.*, that the defendant was probably negligent. Two distinct situations support the inference of negligence from the fact of injury. In what might be termed the *direct res ipsa* cases, no recourse to the probabilities $P(I|N)$ and $P(I|R)$, which determine $P(N|I)$, is required. Instead, $P(N|I)$ itself is the immediate subject of speculation or testimony. This probability is estimated directly, on the basis of what the courts call "common experience"⁴⁹ or, in some cases, expert testimony.⁵⁰

Toward Solving a Problem in the Doctrine of Chances, With Richard Price's Foreward and Discussion, 53 PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY 370 (London 1763), reprinted in FACSIMILES OF TWO PAPERS BY BAYES (W. Deming ed. 1963); H. BRUNK, *supra* note 1, at 28-29; J. FREUND, MATHEMATICAL STATISTICS 52-58 (1962); G. BOX & G. TIAO, BAYESIAN INFERENCE IN STATISTICAL ANALYSIS (1973); H. RAIFFA, *supra* note 43. The over-enthusiastic use of Bayes's rule has often been criticized. See, e.g., 1 W. FELLER, AN INTRODUCTION TO PROBABILITY THEORY AND ITS APPLICATIONS 114 (2d ed. 1957); Brilmayer & Kornhauser, *Review: Quantitative Methods and Legal Decisions*, 46 U. CHI. L. REV. 116 (1979).

49. See cases cited in note 14 *supra*.

50. In the medical malpractice area, the courts tend to reject lay estimates and insist on expert testimony pertinent to $P(N|I)$. See, e.g., *Riedisser v. Nelson*, 111 Ariz. 542, 544, 534 P.2d 1052, 1054 (1975). See also *Funke v. Fieldman*, 212 Kan. 524, 537-38, 512 P.2d 539, 550 (1973).

Brannon, for example, is a case of this type.⁵¹ That decision's reference to the "balance of the probabilities" can best be understood as stating the usual civil burden of proof in the *res ipsa* context.⁵² The proposition that the probabilities point to negligent causes rather than nonnegligent causes is equivalent to the condition that $P(N|I) > .50$ and therefore justifies a finding of negligence.⁵³

In another type of *res ipsa* case, however, the testimony bears on $P(N|I)$ only *indirectly*, through estimates of other conditional probabilities. In *Dacus*, for instance, the court allowed that $P(N|I)$ could be taken to exceed .50 merely because paralysis rarely results from a carefully executed mastoidectomy, *i.e.*, because $P(I|R) \ll 1$. In these indirect *res ipsa* cases, one must go beyond the traditional observation, central to the direct cases, that "[a]ll that is needed is evidence from which reasonable men can say that on the whole it is more likely that there was negligence associated with the cause of the event than that there was not."⁵⁴ One must ask which of the possible interpretations of "ordinarily does not occur in the absence of negligence" permits

51. A useful illustration of this mode of argument in a *res ipsa* case not involving malpractice is provided by *Hakensen v. Ennis*, 584 P.2d 1138 (Alaska 1978). Mr. and Mrs. Simonsen set off with their two grandchildren by car to Seattle. Only Mrs. Simonsen knew how to drive. The remnants of Mr. Simonsen's body were found on a sandbar in a river in British Columbia. Neither the car nor the other bodies were located. Alleging that Mrs. Simonsen's negligence resulted in the automobile's plunging into the river, the mother of the two grandchildren brought a wrongful death action. The defendant's motion for summary judgment was granted. The plaintiff appealed, arguing that she was entitled to bring the case before the jury by virtue of *res ipsa loquitur*. The state supreme court observed that there were a variety of possible explanations for the disappearance, and that many of these, such as brake failure, the actions of another driver, or criminal activity, did not involve negligence. It reasoned that the probability of injury due to such nonnegligent causes ($P(-N|I)$) was at least as large as the probability of injury due to defendant's negligence ($P(N|I)$). Hence, the court, on its evaluation of the probabilities, correctly affirmed the summary judgment for defendant. For another discussion of the probabilities and their application to unexplained car accident cases, see Jaffe, *supra* note 12, at 2-6.

52. See notes 18 & 40 *supra*.

53. For the probabilities to favor negligent causes over nonnegligent ones, $P(N|I) > P(-N|I)$. Since $P(-N|I) = 1 - P(N|I)$, it follows that $P(N|I) > .50$. That $P(-N|I) = 1 - P(N|I)$ is established by the following elementary proof:

$$\begin{aligned} P(I) &= P(I) \\ P(I) &= P((-N \& I) \text{ or } (N \& I)) \\ P(I) &= P(-N \& I) + P(N \& I) \\ P(-N \& I) &= P(I) - P(N \& I) \\ P(-N \& I)/P(I) &= 1 - P(N \& I)/P(I) \\ P(-N|I) &= 1 - P(N|I) \end{aligned}$$

54. W. PROSSER, *supra* note 13, § 39, at 218.

reasonable persons to say that it is more likely that negligence caused the injury than not. Does this conclusion that $P(N|I) > .50$ follow from condition 1, $P(I|R) \ll 1$, which asserts that injuries are unusual when reasonable care is employed? Is it validly drawn on the strength of condition 2, $f < 1$, which states that injuries are less frequent when reasonable care is taken than when negligence is at work? Or is it best predicated on the stronger condition 3, $f \ll 1$, which demands that injuries be *far* less frequent when reasonable care is taken? I shall argue that, except in a limited class of cases, condition 3 is the most appropriate standard for permitting the res ipsa inference.

According to equation 7, whether $P(N|I)$ exceeds .50, as it must to justify the res ipsa inference, depends on both $P(N)$, the prior probability of negligence, and f , the ratio of the relevant conditional probabilities. In fact, $P(N|I)$ is determined by these variables in such a way that unless $P(N)$ is very small, none of the conditions 1 through 3 strictly implies $P(N|I) > .50$.⁵⁵ For example, imagine that nine out of ten doctors performing surgery

55. If $P(N)$ is very small, then condition 3 best justifies the inference of negligence. The proof is straightforward. For $P(N|I)$ to exceed .50, it follows from equation 7 that

$$f < \frac{P(N)}{1-P(N)}$$

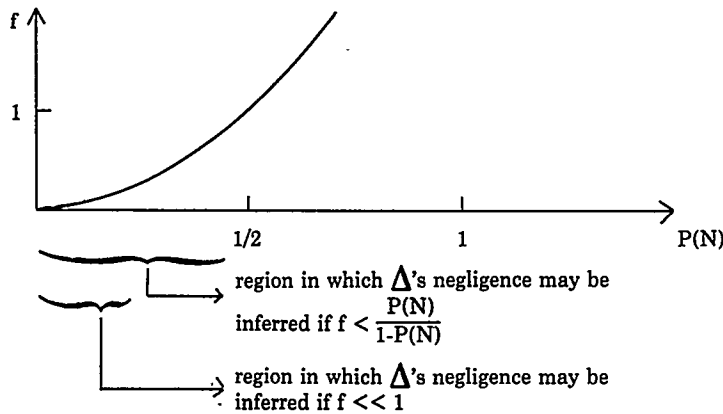
For very small $P(N)$, the denominator $1-P(N)$ can be approximated by 1, and we have

$$f < P(N)$$

Finally, since by hypothesis, $P(N)$ is itself much less than one, this last equation becomes

$$f \ll 1.$$

In effect, by focusing attention on a small portion of the f - $P(N)$ plane, we have been able to overlook the dependence of $P(N|I)$ on $P(N)$ without sacrificing much accuracy:



to remove meningoceles exercise reasonable care and nothing suggests that the operation in question departs from the usual. Then $P(N) = .10$. Assume also that if reasonable care is not taken, the chance of injury to the patient is quite high, say, $P(I|N) = .90$. Finally, suppose that the operation is a dangerous one even with the best of care, so that $P(I|R) = .80$. This gives $f = .80/.90 = .87 < 1$, so condition 2 is satisfied. Inserting these values into equation 7 gives $P(N|I) = .11$. If we have confidence in these hypothetical values for the variables, we should *not* conclude that the defendant had been negligent simply because the patient was injured. Thus, condition 2 — that $f < 1$ — is not sufficient to establish defendant's negligence at a high enough probability to meet the appropriate burden of proof. Comparable counterexamples eliminating conditions 1 and 3 can also be constructed.⁵⁶

Nevertheless, there are grounds for preferring condition 3 over 1 or 2. To begin with, we can dispose of the literalist view of "ordinarily does not occur" expressed in condition 1 as the least suitable of the trio. Equation 7 reveals that $P(N|I)$ is not influenced as much by $P(I|R)$ in isolation as by the ratio f of $P(I|R)$ to $P(I|N)$. Consequently, conditions 2 and 3 are both more closely connected to the crucial probability $P(N|I)$, and we are left to choose between (2) $f < 1$ and (3) $f \ll 1$ as a better statement of the *res ipsa* doctrine.⁵⁷

To make this choice, we must advert to a facet of *res ipsa* cases we have not yet considered. Thus far, we have modeled the *res ipsa* inference by a single equation that shows how knowledge of the plaintiff's injury should transform the prior probability of negligence, $P(N)$, into the posterior probability of defendant's negligence, $P(N|I)$. In effect, we have assumed the judge or jury has some unarticulated estimate of the likelihood of defendant's

56. Imagine now that as before $P(N) = .10$, that $P(I|N) = .90$, but that $P(I|R) = .10$. In other words, the operation is not so inherently risky. Then both $P(I|R)$ and f are small, but the posterior probability of negligence still does not exceed (although it happens to equal) .50.

57. I am assuming that a verbal translation of the equation

$$f < \frac{-P(N)}{1 - P(N)}$$

which satisfies the constraint $P(N|I) > .50$, see note 55 *supra*, is unsuitable for reasons of policy and practice. For a detailed discussion of problems engendered by requiring a juror to quantify $P(N)$, $P(I|R)$, and $P(I|N)$, and to reason explicitly as Bayes's rule prescribes, see Finkelstein & Fairley, *supra* note 4; Finkelstein & Fairley, *A Comment on "Trial by Mathematics,"* 84 HARV. L. REV. 1801 (1971); Tribe, *A Further Critique of Mathematical Proof,* 84 HARV. L. REV. 1810 (1971); Tribe, *supra* note 35.

negligence based on all the available information except that relating to the res ipsa aspect of the case, and we have shown how this probabilistic judgment should be modified to take account of plaintiff's injury and the circumstances under which it occurred. Although useful, this simple model omits an important aspect of the res ipsa problem: the factfinder has more information than is reflected in $P(N|I)$. He also knows the plaintiff has relied on the res ipsa doctrine and has not brought forward independent, direct evidence of defendant's negligence.⁵⁸ Unless this failure to produce direct evidence of negligence is explained or explicable, the factfinder would seem justified in revising his estimate of the probability that defendant's negligence caused plaintiff's injuries.⁵⁹

One way to account for this aspect of the res ipsa problem in mathematical terms is to treat plaintiff's failure to come forward with direct evidence of negligence (which we may call F) as an additional datum that modifies $P(N|I)$. If we let N^* stand for $N|I$, and R^* stand for $R|I$, then the probability on which the res ipsa inference turns is no longer $P(N|I)$, but rather $P(N^*|F)$. This expression for $P(N|I)$ as modified by F thus represents the probability that the defendant was negligent, given everything known about the accident *and* the additional fact that the plaintiff has not pointed to any particular act of negligence by the defendant.⁶⁰ Only if *this* probability exceeds .50 is the inference of negligence warranted.

This new quantity $P(N^*|F)$ can be expanded as prescribed by Bayes's rule. Analogous to equation 7, we have

58. Sometimes, however, a plaintiff may attempt to prove specific allegations of negligence while simultaneously relying on res ipsa. *E.g.*, *Widmyer v. Southeast Skyways, Inc.*, 584 P.2d 1, 11 (Alaska 1978); W. PROSSER, *supra* note 13, § 40, at 232-33; Carpenter, *supra* note 12, at 176-77.

59. For general commentary on the significance of a party's failure to produce favorable evidence, see, *e.g.*, authorities cited in Beaver, *Nonproduction of Witnesses as Deliberative Evidence*, 1 U. PUGER SOUND L. REV. 221, 221 n.1 (1978); Saltzburg, *A Special Aspect of Relevance: Countering Negative Inferences Associated with the Absence of Evidence*, 66 CALIF. L. REV. 1011 (1978). For Bayesian analysis of spoliation evidence, see Kaplan, *supra* note 6; Kaye, *supra* note 43, at 106-08.

60. This probability can also be written as $P(N|I\&F)$ — explicitly denoting the probability that the defendant was negligent given that the injury has occurred (I) *and* that the plaintiff has failed to point to specific negligence on the part of the defendant (F). See Lempert, *supra* note 6, at 1044-45. As this notation suggests, $P(N^*|F)$ does not generally equal $P(N|F)$. See *id.* at 1042.

$$P(N^*|F) = \frac{1}{(1-f^*) + f^*/P(N|I)} \quad (8)$$

$$\text{where } f^* = \frac{P(F|R^*)}{P(F|N^*)} \quad (9)$$

According to equation 9, the magnitude of $P(N^*|F)$ depends on $P(N|I)$, the probability of the defendant's negligence considering everything in the case except for plaintiff's failure to adduce evidence of specific negligence, and f^* , the ratio of two conditional probabilities pertaining to this gap in the plaintiff's case. This equation thus relates the new probability $P(N^*|F)$, which takes account of all facets of a res ipsa case, to the probability $P(N|I)$ discussed in this simpler model. As we saw from equation 7, $P(N|I)$ is partly determined by f ; accordingly, we have at hand a formula to connect the competing interpretations 2 and 3 of "ordinarily does not occur in the absence of negligence" (which pertain to f) to the final probability $P(N^*|F)$ (which determines the validity of the res ipsa inference). In particular, for $P(N^*|F)$ to exceed .50 and thereby justify an inference of negligence, $P(N|I)$ must be large enough to satisfy the inequality⁶¹

$$P(N|I) > \frac{f^*}{1+f^*} \quad (10)$$

61. Equation 8 states that

$$P(N^*|F) = \frac{1}{1-f^* + f^*/P(N|I)}$$

For $P(N^*|F)$ to exceed .50 we must have

$$.50 < \frac{1}{1-f^* + f^*/P(N|I)}$$

Crossmultiplying,

$$1 - f^* + \frac{f^*}{P(N|I)} < 2$$

$$f^* \left[\frac{1}{P(N|I)} - 1 \right] < 1$$

$$\frac{1}{P(N|I)} - 1 < \frac{1}{f^*}$$

$$\frac{1}{P(N|I)} < \frac{1}{f^*} + 1 = \frac{1+f^*}{f^*}$$

$$P(N|I) > \frac{f^*}{1+f^*}$$

Substituting the expansion of $P(N|I)$ given by equation 7 and solving for f establishes that $P(N^*|F)$ exceeds .50 only if⁶²

$$f < \frac{1}{f^*} \frac{P(N)}{1-P(N)} \quad (11)$$

This result is identical to that derived from the simple model in all respects save one. Under equation 7, it can be shown that $P(N|I)$ exceeds .50 whenever

$$f < \frac{P(N)}{1-P(N)}$$

Expression 11 thus contains the multiplicative factor $1/f^*$ missing from the simpler model, so that the critical size of f is inversely proportional to f^* . As a consequence, whenever the plaintiff's reliance on *res ipsa* itself suggests an $f^* > 1$, especially small f 's will be required to warrant an inference of negligence. Unless $P(N)$ is very large indeed, any f^* that is substantially larger than one will necessitate that f be considerably less than one.⁶³ The conclusion to be drawn from expression 11, then, is that in the indirect *res ipsa* cases in which we can usually expect f^* to be large, the frequency of correct decisions should be enhanced by adopting condition 3 — that $f \ll 1$ — and not the weaker condition 2 — that $f < 1$.

62. Substituting the expression for $P(N|I)$ given in equation 7 into equation 10 gives

$$\frac{1}{(1-f) + f/P(N)} < \frac{f^*}{1 + f^*}$$

Inverting the fractions,

$$1 - f + \frac{f}{P(N)} < \frac{1 + f^*}{f^*} = \frac{1}{f^*} + 1$$

Simplifying further,

$$f \left[\frac{1}{P(N)} - 1 \right] < \frac{1}{f^*}$$

$$f < \frac{1}{f^*} \frac{1}{1/P(N) - 1} = \frac{1}{f^*} \frac{P(N)}{1 - P(N)}$$

63. If the prior probability of negligence is .50 and it is 3 times more likely that the plaintiff would fail to produce direct evidence of negligence if the defendant was not in fact negligent despite the injury to the plaintiff, then $P(N) = .50$ and $f^* = 3$. Inequality 11 then tells us that f must be less than $1/3$ if $P(N^*|F)$ is to be greater than .50. That is, the probability of injury to the plaintiff must be at least 3 times higher if negligence is assumed than if it is absent in order for it to be more likely than not that the defendant was actually negligent.

But when should we consider f^* sufficiently large to insist that the accident be much more likely to occur given negligence than in the absence of negligence? The answer depends on whether the plaintiff has access to direct evidence of the defendant's negligence. Two situations may be distinguished.⁶⁴ The first is where the only evidence presented is of the injury and its circumstances, and other evidence of negligence should have been available to the plaintiff. Here, it would seem substantially more likely that the plaintiff would fail to offer such direct evidence if that evidence were damaging — *i.e.*, if the defendant acted reasonably — than if the defendant were negligent. But this is to say that $P(F|R^*) \gg P(F|N^*)$. Hence, from equation 9, $f^* \gg 1$, and, to counterbalance this consideration, the injury must have been much more likely with negligence than with reasonable care.

In the second situation, the plaintiff offers evidence only of the injury but lacks access to any other evidence bearing on the probability of negligence.⁶⁵ Here, we cannot always surmise that $f^* \gg 1$. Under such circumstances, the probability that the plaintiff would fail to adduce such evidence is roughly the same whether or not the defendant was negligent. In symbolic terms, $P(F|R^*)$ is approximately equal to $P(F|N^*)$, and therefore the ratio f^* is close to one. Accordingly, the plaintiff's nonproduction

64. I am indebted to Richard Lempert for suggesting a similar categorization.

65. A variety of factors may block a plaintiff's access to evidence of specific negligent acts. For a sampling of ways in which the plaintiff might explain a failure to make a particular showing and thereby justify treating f^* as small, see, *e.g.*, Beaver, *supra* note 59, at 229-47.

Some jurisdictions go so far as to require that knowledge of the causes of the injury be more accessible to the defendant than the plaintiff. *See, e.g.*, SPEISER, THE NEGLIGENCE CASE: RES IPSA LOQUITUR § 2:26, at 83-84 (1972). Some commentators have insisted that such superior knowledge on the defendant's part is essential to the application of the doctrine. *See, e.g.*, Carpenter, *supra* note 12, at 472; Jaffe, *supra* note 12. Although, in some instances, this consideration might justify imposing liability in the absence of a .50 probability of negligence (*see* note 12 *supra*) and the defendant's superior access ordinarily would justify taking f^* to be no greater than one, f^* should also be close to one where neither party has superior access. The defendant's superior access therefore seems too stringent a limitation to the res ipsa doctrine, and many courts are satisfied as long as each side has equal access to evidence of the causes of the accident. *See, e.g.*, Widmyer v. Southeast Skyways, Inc., 584 P.2d 1, 12-13 (Alaska 1978).

Of course, where a defendant does have superior access to knowledge of the causes of the injury and yet fails to introduce any evidence tending to disprove negligence, the inference of negligence seems to be strengthened. In this situation, we need not require $f \ll 1$. *Cf.* Tribe, *supra* note 35, at 1339 n.3 (arguing for directed verdicts in these circumstances). The mathematics of this situation is analogous to that expressed by equation 11. The likelihood ratio f however, would relate to defendant's failure to come forward with evidence to which he has superior access. Still, given modern discovery procedures, a defendant may only rarely have such superior knowledge. *But see* Jaffe, *supra* note 12.

does not alone warrant a requirement that $f \ll 1$. Even in this situation, however, we may appropriately require $f \ll 1$ in an important subclass of cases. Where the defendant offers evidence tending to disprove negligence, this reduces the value of $P(N)$.⁶⁶ If it makes $P(N)$ very small, neither $P(N|I)$ nor $P(N^*|F)$ will be greater than .50 unless f is also very small.⁶⁷ Although a jury should not necessarily be bound by defendant's evidence, it must weigh it; if the evidence is at all credible, it would be unreasonable to accept a *res ipsa* theory unless $f \ll 1$.

To illustrate this logic, consider the case of a light plane that disappears in fair weather. The widow of the passenger sues the estate of the pilot and invokes *res ipsa*. She argues that, in general, light aircraft are so well engineered and maintained that the chance of a mishap is slight when they are flown carefully, while the chance of an accident is somewhat larger when the pilot errs (for example, by not performing a complete preflight instrument check or taking on enough gasoline for the flight). Because the "balance of the probabilities" thus favors negligence, plaintiff contends that a jury should find defendant liable.

As presented, this is an indirect *res ipsa* case.⁶⁸ The probabil-

66. Where the evidence directly negates specific acts of negligence (for example, testimony of ground control personnel shows that the pilot of a plane that collided with another was flying at the designated altitude), presentation of such evidence may indicate that the plaintiff should have been able to offer direct evidence if negligence (given injury) was indeed present. If so, the case is of the first type — the plaintiff appears to have access to the evidence that would have enabled a particularized showing of negligence. In these circumstances, the values reasonably assigned to both f^* and $P(N)$ necessitate $f \ll 1$ to support a *res ipsa* theory.

67. See note 55 and equation 11 *supra*. It is tempting to think that $P(N)$ could always be taken to be small in *res ipsa* cases, thereby justifying the $f \ll 1$ standard without recourse to be more complex argument about $P(N^*|F)$. Isn't reasonable care, after all, defined by reference to the norm (the "ordinary man") and negligent conduct identified in terms of abnormal or unusual behavior? The blanket assumption that $P(N) \ll 1$, is shaky, however, for two reasons. First, there are situations in which the normally (or even universally) observed precautions do not amount to reasonable care. See, e.g., *Low v. Park Price Co.*, 95 Idaho 91, 503 P.2d 291 (1972); *Morris, Custom and Negligence*, 42 COLUM. L. REV. 1147 (1942). Second, even if reasonable care does predominate in an activity, the evidence, while not directly revealing a specific act of negligence, may suggest that defendant is more likely to have been negligent than the average (randomly selected) person, or that he is more likely to have been negligent at the time in question. Consider, for instance, $P(N)$ for an inexperienced physician — say a United States citizen who received his medical training in Mexico. Even if a juror were convinced that $P(N)$ is small for physicians in general, he might well select some large value to characterize this defendant's activities in a malpractice case. For such reasons, the analysis offered here takes $P(N)$ to be much less than one only in those cases in which defendant's evidence justifies this premise.

68. If the plaintiff's argument is slightly recast, however, a direct *res ipsa* case results.

ities being compared are the probability of injury given reasonable care, $P(I|R)$, and the probability of injury given negligence, $P(I|N)$. The plaintiff asserts that since the first probability exceeds the second ($f < 1$), chances are that the defendant was negligent ($P(N|I) > .50$). But $f < 1$ is not enough to support *res ipsa* in this situation. The stronger condition $f \ll 1$ is more appropriate, for it appears that the plaintiff had access to information that might have revealed specific acts of negligence yet did not produce that evidence. Rather than asking the jury to speculate about whether the pilot took on sufficient gas, for instance, the plaintiff could have produced the airport employee who was dispensing gasoline when the pilot took off. That the plaintiff did not do so strongly suggests that the testimony would not have helped establish negligence ($f^* \gg 1$). Of course, the testimony might not have disproved negligence (if it did, the defendant presumably would have offered it); but the plaintiff's failure to make a particularized showing of this kind attenuates the implication of negligence and thus justifies a verdict for the defendant unless the jury finds that the probability of airplane crashes is not slightly higher but *far* higher if pilots are negligent ($f \ll 1$). If this latter condition is fulfilled, then there are good grounds for concluding that the defendant was probably negligent ($P(N^*|F) > .50$) despite the plaintiff's evidentiary shortcomings.⁶⁹

Suppose, however, that the plane was last seen flying over an island at a low altitude. The wreckage of the craft is found, nose down, in tidal water. The defendant's expert witness testifies that

Suppose that an expert formerly employed by the FAA as an investigator of the causes of aircraft mishaps testifies that in his experience 60% of all light airplane crashes that occurred in good weather were the result of one simple pilot error — failing to maintain a sufficient supply of gasoline in the fuel tank. Unless some evidence is adduced to show that the pilot in this case took on enough fuel, plaintiff could argue that the "balance of the probabilities" favors negligence because the testimony indicates (directly, without recourse to Bayes's Theorem) that $P(N|I) = .60 > .50$.

The argument from nonproduction applies here, however, and suggests that we may wish to demand an especially high $P(N|I)$ to permit the inference of negligence. Using the notation previously explained in the text, we are actually interested in $P(N^*|F)$ rather than $P(N|I)$. According to equation 10, $P(N^*|F) > .50$ only if

$$P(N|I) > \frac{f^*}{1 + f^*}$$

In the illustration here, $P(N|I)$ is estimated on the basis of the expert statistical testimony to be .60. For all $f^* > 1.5$, $P(N|I) = .60$ is therefore not large enough to justify the inference of negligence.

69. The circumstances under which directed verdicts are appropriate in *res ipsa* cases depend on the procedural significance of the inference. See note 11 *supra*.

the weather was unstable the day of the flight and that a snow squall was observed in the vicinity of the flight path. The expert suggests that the pilot was proceeding in clear air when he encountered the storm and was attempting to land when the craft was struck by a sudden gust of wind. The plaintiff argues that this scenario, while possible, is not probable. She contends that, especially in bad weather, negligence enhances the probability of a crash. Because the likelihood of the accident given negligence exceeds the likelihood in the absence of negligence, the plaintiff urges that the pilot was probably negligent.

Here, a jury may justifiably find for the plaintiff. The inference of negligence is not attenuated by the plaintiff's failure to delineate what took place in the minutes before the crash, for no one can do this. Here $f^* \cong 1$, and $P(N^*|F) \cong P(N|I)$; hence, $P(N^*|F)$ can easily exceed .50 if f is merely less than 1.

On the other hand, if the defendant introduces further evidence tending to disprove negligence, the plaintiff should not prevail simply because negligence usually enhances the risk of injury. Imagine that in our second hypothetical incident, the defendant calls to the stand an expert on aviation in the region who testifies that the pilot, whom he had supervised and trained, was skilled, attentive to problems of unstable weather in the area, and had approximately 3,000 hours of flight experience. Such a pilot is less likely to be negligent (diminishing the value of $P(N)$), and it is therefore appropriate to require the plaintiff to show that a crash like that which occurred is *far* more likely to happen due to negligent pilot error than in the absence of negligence ($f \ll 1$).

In short, when a plaintiff attempts to prove negligence indirectly, by testimony or argument directed to the frequency of accidents in the absence or presence of negligence, it is generally necessary to show that the likelihood of injury is substantially larger with negligence than without, and not merely that the "balance" of these conditional probabilities slightly favors injury given negligence or that injuries are rare without negligence. The only exception to requiring that f be much less than one would seem to be where the plaintiff has no access to any other evidence and the defendant offers no evidence tending to disprove negligence.

III. CONCLUSION

The argument developed in this Article has been complex and, I fear, slightly lengthy. It may be advisable to restate my

essential points and to elaborate briefly on their implications. We began by observing that “ordinarily does not occur in the absence of negligence” — the traditional, indeed canonical, formulation of the grounds for inferring negligence from the fact of injury — sounds simple, clear, and correct. Yet, it is none of these. Beneath its superficial simplicity lurks a multiplicity of possible meanings. And the most natural interpretation countenances, if not encourages, opinions like *Dacus* that permit a finding of negligence merely because the accident in question occurs but rarely.⁷⁰

We therefore turned to some elementary probability theory to specify the proper grounds for the *res ipsa* inference. The first major step in the probabilistic analysis was the recognition that it is the probability of negligence given injury, $P(N|I)$, which, at least for a first approximation, forms the empirical foundation for the inference of negligence. Whenever $P(N|I)$ exceeds .50, inferring negligence will produce fewer mistaken verdicts than refusing to infer negligence. Ordinarily, an estimate of this probability either is within the direct knowledge of the jury or can be reached through expert testimony. The typical jury instructions — asking whether accidents of the kind at bar are more likely to result from negligence than from other causes — adequately convey this idea.

But emphasis on $P(N|I)$ does not exhaust the content of the *res ipsa* inference. Indeed, if that were all there is to it, one might well wonder why courts and commentators ever thought it important to speak of what “ordinarily does not occur in the absence of negligence.” Bayes’s Theorem, used as a scalpel to dissect the inference, suggests a possible motivation for the “ordinarily does not occur” language. The theorem reveals that the decisive probability $P(N|I)$ can be expressed as a function of other probabilities; accordingly, one can think of the phrase “ordinarily does not occur” as a way to get at these probabilities. Unfortunately, the traditional phraseology fails to elucidate the relationship. Instead, it seems to murmur, *sotto voce*, that the defendant may be found liable as long as injuries are infrequent when reasonable care is taken.⁷¹ Yet, the basic teaching of Bayes’s formula is that this factor must be considered *in conjunction with* the frequency of injuries given negligence.

We therefore asked what relationship between these two probabilities most likely indicates that $P(N|I)$ exceeds .50. The

70. See text at notes 25-31 *supra*.

71. *Id.*

analysis was complicated by the fact that the so-called prior probability of negligence also affects $P(N|I)$. We sought to circumvent that complication by considering the potential access of the plaintiff to more particularized evidence. That additional datum led us to replace $P(N|I)$ with $P(N^*|F)$ as the crucial probability in res ipsa cases. Analysis of this new quantity $P(N^*|F)$ then supported the general requirement that the jury find an injury to be *much* more likely to result with negligence than without. In particular, using Bayes's Theorem iteratively, we justified the "much more likely" standard for all cases but those where the plaintiff has no access to any evidence that would permit a particularized showing of negligence and the defendant introduces no evidence tending to disprove negligence.⁷²

In sum, talk of what "ordinarily does not occur in the absence of negligence" should always be avoided. In one major category of cases all that is involved is a direct estimate of $P(N^*|F)$. In these direct cases, reference to what "ordinarily does not occur" amounts to surplusage, and potentially misleading surplusage at that. Instead, the jury should simply be instructed to find for the plaintiff if it is more probable that the accident was caused by some negligent act of the defendant than by some other cause. In the other major category of res ipsa cases, the plaintiff relies on common experience or on evidence concerning the relative frequency of accidents with and without negligence. In these indirect cases, "ordinarily does not occur in the absence of negligence" is ambiguous, and seems to include but one of two vital ingredients in the indirect estimation of $P(N^*|F)$. The belief that an accident is unlikely to occur if reasonable care is taken (or that it is slightly more likely to occur if negligence is present) is insufficient to support a verdict for the plaintiff. With limited exceptions, for an accident to warrant the conclusion that $P(N^*|F)$ exceeds .50, it must be the kind of accident that is *substantially* more unlikely to occur when reasonable care is observed.

Of course, it may be that not many verdicts will change if these recommendations are adopted. But there is ample basis to

72. Furthermore, we noted that this logic also militates in favor of modifying the conventionally accepted standard in the direct res ipsa cases. As in the indirect cases, if probabilities are estimated solely on the basis of the frequencies of negligence and reasonable care in other accidents of the same type, and if there is an unexplained lack of particularized proof, then negligence should not be inferred unless the probability that the accident resulted from defendant's negligence is *substantially* greater than the probability that the injury was a consequence of some other cause. See notes 53 & 68 *supra*.

hope that the quality of decisions in *res ipsa* cases will be enhanced. Surely, the attempt to improve on the traditional formulation of *res ipsa loquitur* is worth the bother. The justification lies both in the pedantic but real concern for clarity, consistency, and correctness in propositions of law, and in the professional faith that pursuit of these goals will produce, when all is said and done, fairer results for all litigants.