Direct Inference in the Lost Chance Cases: Factfinding Constraints Under Minimal Fairness to Parties

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DIRECT INference IN THE LOST CHANCE CASES: FACTFINDING CONSTRAINTS UNDER MINIMAL FAIRNESS TO PARTIES

Vern R. Walker*

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#### I. INTRODUCTION

Confusion over the meaning of probability and over the rationale for probabilistic inference has led many courts to dismiss “lost chance” lawsuits unfairly, or to modify unnecessarily the traditional concepts of causation or compensable injury. In this Article, I attempt to clarify the legal concept of probability, and I propose a theory for when we are warranted in drawing a “direct inference” from objective statistical data about groups to a subjective assessment of probability for a particular plaintiff. I then show that a number of legal problems in the lost chance cases can be resolved without radical modifications to traditional concepts. Perhaps more importantly, I argue that direct
inference in a legal context is warranted and compelled not by a logical theory, but rather by a policy of minimal fairness to the parties.

In a typical "lost chance" case, a patient is initially at risk for some injury or perhaps death, through no fault of the defendant.1 Some negligent act by the defendant, however, causes the plaintiff to incur an increase in risk for that same injury, and the plaintiff in fact subsequently suffers the injury. The most difficult cases are those in which the plaintiff had a very high initial risk of injury (over 50%), and experts are unable to testify that the defendant's negligence (as opposed to the pre-existing condition) probably caused the plaintiff's injury.2 Under traditional judicial doctrines, it might seem that such cases should not reach the jury because the plaintiff is unable to produce sufficient evidence on the issue of causation so that a jury could reasonably find that the defendant's negligent act probably caused the injury.

The lost chance cases present difficult and interconnected problems involving statistical evidence, causation, compensability of risk as injury, public policy on medical malpractice, and fairness, and therefore present great opportunity for confusion. With respect to causation, there are questions about the meaning or nature of causation,3 the legal sufficiency of statistical evidence about causation,4

1. See, e.g., Falcon v. Memorial Hosp., 462 N.W.2d 44, 49 (Mich. 1990) (stating that survival rate from amniotic fluid embolism would have been only 37.5% even if intravenous line had been connected prior to onset); Kallenberg v. Beth Israel Hosp., 45 A.D.2d 177, 179 (N.Y. App. Div. 1974), aff'd, 337 N.E.2d 128 (N.Y. 1975) (only 20% to 40% opportunity of survival with proper treatment); Hershkovits v. Group Health Cooper., 664 P.2d 474, 475 (Wash. 1983) (stating that there was only a 39% chance of survival when lung cancer was misdiagnosed; however, by the time the patient was diagnosed with cancer, his chances of survival had been reduced to 25%).

2. See cases cited supra note 1; DeBurkarte v. Louvar, 393 N.W.2d 131, 136-37 (Iowa 1986) (citing nine prior cases). The less difficult lost chance cases present a similar problem of distinguishing between a baseline case and a defendant-caused injury, but the relatively low baseline risks have allowed courts to send the cases to the jury. E.g., Rewis v. United States, 503 F.2d 1202, 1207-08 (5th Cir. 1974) (referring to testimony that a child was more likely than not to have survived salicylate poisoning if defendant had properly diagnosed and treated the illness); Glickich v. Spievack, 452 N.E.2d 287, 291 (Mass. App. Ct. 1983) (recounting plaintiff's evidence that upon a proper diagnosis of her breast cancer she would have had a 94% chance of surviving 10 years, which was reduced to "a 50% or less chance of ten year survival" by defendant's negligence; this was sufficient evidence of causation to create a question for the jury); Hamil v. Bashline, 392 A.2d 1280, 1283 (Pa. 1978) (referring to testimony that patient had a 75% chance of surviving his heart attack if he had been properly treated when admitted to the hospital).

3. For example, there is a question as to whether the appropriate test of causation should be "but for" or "substantial factor." Compare, e.g., Sharp v. Kaiser Found. Health
and the legal significance of uncertainty about causation.⁵ With re-

Plan, 710 P.2d 1153, 1155 (Colo. Ct. App. 1985) (substantial factor) and Evers v. Dollinger, 471 A.2d 405, 413-15 (N.J. 1984) (substantial factor) and Herskovits, 664 P.2d at 477-78 (substantial factor) with Cornfeldt v. Tongen, 295 N.W.2d 638, 640 (Minn. 1980) (but for) and Cooper v. Sisters of Charity, Inc., 272 N.E.2d 97, 104 (Ohio 1971) (issue of proximate cause to be submitted to jury only if sufficient evidence that without negligence “the patient probably would have survived”).

There is also a question as to whether causation should be an “all-or-nothing” hurdle for the plaintiff, or whether the courts should adopt “proportional causation.” Compare, e.g., Kallenberg, 45 A.D.2d at 178 (plaintiff recovered full damages for wrongful death) with Herskovits 664 P.2d at 486-87 (Pearson, J., concurring) (criticizing standard “but for” test of causation, allowing all-or-nothing recovery, as arbitrary, ineffective in allocating loss, and inequitable because it allows defendant to have the benefit of the uncertainty in causation created by defendant’s own negligent conduct); cf. Dumas v. Cooney, 1 Cal. Rptr. 2d 584, 589-92 (Ct. App. 1991) (discussing without distinction the traditional rule of “probability” as “more likely than not” caused by defendant and a “not-better-than-even chance” of survival absent negligence, and declining “to establish a more lenient standard of causation . . . to account for the theory of lost chance”); DeBurkarte, 393 N.W.2d at 137-38 (stating that allowing recovery for all damages would be “an extreme position” and less equitable than allowing only a proportion of damages).

4. Compare, e.g., Herskovits, 664 P.2d at 478 (“Where percentage probabilities and decreased probabilities are submitted into evidence, there is simply no danger of speculation on the part of the jury. More speculation is involved in requiring the medical expert to testify as to what would have happened had the defendant not been negligent.”) with Fennell v. Southern Md. Hosp. Ctr. Inc., 580 A.2d 206 (Md. 1990) (granting defendant’s motion for summary judgment because a 40% lost chance of surviving bacterial meningitis was insufficient evidence that defendant caused plaintiff’s death) and Herskovits, 664 P.2d at 487-91 (Brachtenbach, J. dissenting) (stating that statistical evidence alone is not sufficient to prove causation); cf. Cooper v. Hartman, 533 A.2d 1294, 1299-300 (Md. 1987) (holding that because plaintiff’s chances for a recovery from osteomyelitis absent defendant’s negligence were only “possible,” plaintiff failed to prove causation by a “probability,” where court defined “probability” as “greater than 50% chance”).

5. Compare, e.g., Falcon, 462 N.W.2d at 49-50 & n.20 (allowing recovery in part because but for defendants’ negligence, there would have been no uncertainty whether defendants’ omissions caused patient’s death) and Thompson v. Sun City Community Hosp., Inc., 688 P.2d 605, 615-16 (Ariz. 1984) (adopting rule that permitted case to go to jury on opinions of experts “unwilling or unable to quantify” the lost chance and stating only that there would have been a “substantially better chance” absent the negligence, but jury instructions still required defendant verdict unless jury finds “a probability that defendant’s negligence was a cause of plaintiff’s injury”) and Kallenberg, 45 A.D.2d at 179 (recounting testimony that failure to administer proper medication was a “producing, contributing factor” to the patient’s death and deprived patient of “a 20, say 30, maybe 40% chance of survival” was sufficient evidence to support a jury verdict finding defendant a legal cause of plaintiff’s death) with Dumas, 1 Cal. Rptr. 2d at 595 (rejecting lost chance theory as awarding damages for mere possibilities without proof that defendant, rather than the underlying illness, caused the injury) and Fennell, 580 A.2d at 211, 214 (holding that plaintiff can only recover when plaintiff proves defendant’s negligence probably caused plaintiff’s injury; the greater than 50% preponderance of the evidence standard must be maintained) and Cooper, 272 N.E.2d at 104 (holding that since the issue of proximate cause can be submitted to the jury only if sufficient evidence that absent defendant’s negligence patient “probably” would have survived, expert opinion that patient’s expectation of survival was “may . . . around 50%” was legal-
spect to the injury, there are questions about whether an increased risk or a lost chance for a good outcome is in itself an injury to a protected interest, and therefore compensable (and if so, which lost chances are compensable), the necessity of producing quantitative evidence of the magnitude of the chance lost, and how the value of the lost chance should be determined. Each of these problems is difficult independently, and they also create confusion collectively because they all involve resolving the relevance of statistical evidence and the legal significance of uncertainty as to proof.

The lost chance cases present in a compelling form the general problem posed by the presence of "residual baseline risk," a problem that I have elsewhere discussed as the "baseline risk paradox." Re-
idual baseline risk occurs when a particular plaintiff's injury might have been caused by the defendant or might have been caused by other (baseline) causes. If we consider persons in a similar situation as the plaintiff with respect to risk factors for the relevant injury (i.e., those in the "reference situation"), some subset would have injuries caused by the defendant's negligence, while the remainder are "baseline cases" whose causes are to be found in the risk factors other than the defendant's negligence. In cases in which there is residual (non-zero) baseline risk, the task for the finder of fact is to determine whether the particular plaintiff at bar is a baseline injury or a defendant-caused injury.

Although the lost chance cases are merely examples of cases involving residual baseline risk, they constitute a special and important species of such cases because in them the proportion of persons in the reference situation with defendant-caused injuries is often directly estimable. The proportion of defendant-caused injuries is "directly" estimable in the sense that the risk of death or injury can be estimated for the time of the negligence (e.g., when a misdiagnosis was made of an underlying cancer) and then again for a later time (the time when the correct diagnosis is made and acted on), with the difference between the two risks being attributed to the defendant's negligence. For example, if at the time of a defendant's negligent misdiagnosis the plaintiff had a 61% chance of death within 5 years from the pre-existing lung cancer that the defendant misdiagnosed, and 6 months later, at the time the correct diagnosis was made, that

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11. The "reference situation" can be defined as consisting of all the factors present in the plaintiff's/patient's situation that influence the likelihood of the injury occurring, including any negligent conduct of the defendant. Thus, it is a conjunction of all the relevant risk factors in the plaintiff's case. See Walker, supra note 10, at 643.

12. In the more general toxic tort case involving residual baseline risk, exemplified by a plaintiff who was exposed by the defendant to a toxic agent and who subsequently developed a non-specific kind of cancer, it is first necessary to determine whether the defendant caused any additional cancer cases at all over the baseline, and if so, how many, before reaching the question whether this plaintiff was one of those cases. Typically, the toxic tort plaintiff might rely upon epidemiologic evidence of a statistically significant increased relative risk of those in the reference situation exposed by the defendant's negligence, as compared with those otherwise in the reference situation except not so exposed, in order to establish that defendant-caused cases exist and to estimate the proportion of defendant-caused cases to baseline cases. These two determinations are subject to conceptual, measurement, sampling, modeling, and causal uncertainty. See Walker, supra note 10, at 647-65. Therefore, in the typical toxic tort case involving residual baseline risk, the plaintiff's evidence will contain significant uncertainties that are minimized in the lost chance cases.
risk had increased to 75%, then the defendant's negligence is held responsible for an increased risk of 14 percentage points. Because the reference situation is defined as the set of all relevant risk factors, including the defendant's negligence, the proportions can be estimated from the time of the correct diagnosis: at that time, 25% are still expected to survive longer than 5 years, 61% could be expected to die within 5 years of the pre-existing cancer (and would be expected to do so even in the absence of negligence), and 14% are expected to die within 5 years because of the delay in treatment brought about by the misdiagnosis. Given proof that a particular plaintiff actually suffered the alleged injury, the question is whether the plaintiff's injury is a baseline injury or a defendant-caused injury.

There is, however, a paradox associated with this inference from the generic risks to the particular plaintiff. In trying to classify the particular individual as a baseline case or a defendant-caused case, we intuitively search for additional information about this plaintiff that provides a basis for the classification. The paradox is that, regardless of how much distinguishing evidence is introduced, the existence of continued baseline risk after that new information has been taken into account still renders the classification speculative or arbitrary. If it would have been arbitrary at the outset to assert that the particular plaintiff's injury was caused by the defendant's culpable act, then (paradoxically) additional information that does not entirely eliminate residual baseline risk seems not to eliminate that arbitrariness.


14. Thus, a point estimate of the relative risk of death from being in the reference situation (with defendant's negligence), as compared to the risk from being in the reference situation but absent the defendant's negligence, is 75/61 = 1.23, approximately—an elevated relative risk, but one substantially smaller than 2.0 (at which point the increase due to defendant-caused risk equals the baseline risk). See Walker, supra note 10, at 651-57.

15. I have elsewhere discussed the "baseline risk paradox," Walker, supra note 10, at 665-72, namely that assigning the particular plaintiff to membership in either of these two exclusive sets appears to be epistemologically arbitrary.

Additional information about the particular plaintiff's risk factors does not eliminate the problem unless it eliminates all residual baseline risk (thus resulting in no baseline cases). If we had additional information about this plaintiff that would seem to indicate that she is in one set or the other (e.g., that she had a genetic history of a certain sort), then that information about the plaintiff would also be a risk factor and as such included in the reference situation. In other words, taking such "new" information into account might well lead us to adjust our proportions for defendant-caused and baseline cases. See, e.g., Rewis v. United States, 503 F.2d 1202, 1205-11 (5th Cir. 1974) (concluding that, in case of misdiagnosis of aspirin poisoning in child, it is essential that there be examination at trial of assumptions concerning aspirin ingestion rate, absorption rate into bloodstream, and elimination rate from
Many courts have handled this problem of residual baseline risk by using a "bright line rule" of simply comparing the relative size of the defendant-caused risk and the residual baseline risk. On this approach, if the residual baseline risk is less than the defendant-caused risk, then motions attacking the sufficiency of the plaintiff's evidence will be denied and the case will automatically go to the jury. On the other hand, if the residual baseline risk exceeds the defendant-caused risk, then some courts have concluded that the plaintiff has not produced sufficient evidence to create a jury issue—at least under traditional theories of causation and liability. It is this latter type of

blood in particular patient, because if she did not fit the assumed characteristics on these factors "there is at least an equal chance that she would have fallen below the line indicated [the line above which fatalities are likely to occur], in which event she would have shown up on the chart as one patient who survived"); cf. Chudson v. Ratna, 548 A.2d 172, 179-80 (Md. Ct. Spec. App. 1988) (stating that where more specific evidence is not possible, courts, whether using the "more probable than not" or "some lesser standard," have allowed juries "to determine probabilities based directly or indirectly on universal statistics or even on the expert's general experience with other patients," either out of necessity or "based upon a tacit recognition that even estimates of probabilities tailored specifically to a given patient are ultimately derived from generally accepted statistical norms"), cert. denied, 552 A.2d 894 (1989).

As long as residual baseline risk remains (that is, as long as the new information does not reduce the baseline injuries to zero), the problem persists of how to place this plaintiff in one set or the other in a way that is epistemologically nonarbitrary. The paradox is that any new information that merely shifts the proportions and does not eliminate the baseline cases does not seem to save the ultimate decision from being epistemologically arbitrary. Therefore, an exploration of the lost chance cases will also shed light on this paradox. See infra parts II, III. Part of the problem to be explored is the logical relevance of the size of the proportions of defendant-caused and baseline cases, and the rationale for why size might remove or reduce arbitrariness.

16. See, e.g., Dumas v. Cooney, 1 Cal. Rptr. 2d 584, 589 (Ct. App. 1991) (stating that where testimony establishes a better-than-even chance of survival absent negligence, "a finding for the plaintiff is consistent with existing principles of proximate cause"); Cooper v. Hartman, 533 A.2d 1294, 1299-300 (Md. 1987) (under "traditional rule" governing burden of proof as to causation, plaintiffs have burden of proving patient "had a better than 50% chance of full recovery absent the malpractice"). It is noteworthy that courts have not offered guidance on how the jury is supposed to use this evidence to reach a valid determination of causation. If the only reasonable approach were to use this same decision rule to make the ultimate determination, plaintiffs might be entitled to a favorable determination as a matter of law. The problem of what decision rule the jury should employ, in addition to the issue of this Article.

17. See, e.g., Gooding v. University Hosp. Bldg., 445 So.2d 1015, 1020 (Fla. 1984) (holding that defendant was entitled to directed verdict as matter of law unless plaintiff produces "evidence of a greater than even chance of survival" absent negligence); Fennell v. Southern Md. Hosp. Ctr., Inc., 580 A.2d 206, 211 (Md. 1990) (finding that 40% lost chance of surviving bacterial meningitis insufficient evidence that defendant caused plaintiff's death); Cornfeldt v. Tngen, 295 N.W.2d 638, 641 (Minn. 1980) (holding that plaintiff must show that it was more probable than not that death resulted from defendant's negligence).
case that presents the most compelling plea for fairness, and these lost chance cases have led courts to rethink various traditional doctrines in an effort to allow at least some such cases to be sent to the jury.

I argue, however, that in either type of case—whether the defendant-caused risk is greater than the baseline risk or less than the baseline risk—there is a fallacy underlying the "bright line rule" itself, regardless of the size of the baseline risk. The appropriate reasoning is far more complicated than merely comparing the relative size of these two risks. We recognize that the frequency of defendant-caused cases of injury might be very small, relative to the number of baseline cases, but the plaintiff's injury might still be caused by the defendant. The issue is not relative size, but the probability that this plaintiff's injury is in fact a defendant-caused injury or a baseline injury. On the other hand, it is not enough merely to point out that the relative size of the two risks is not as determinative as many courts have suggested. Relative size of risk does seem relevant to the determination. And if the relative size of the defendant-caused risk to the baseline risk is not a direct determinant of the probability that the plaintiff's injury was a defendant-created instance rather than a baseline case, what exactly is the logical relationship involved? And when are we warranted in making a "direct inference" from generic statistics about groups to a probability for classifying a particular plaintiff's injury as baseline or defendant-caused?

In this Article, I use the lost chance cases to examine the logical conditions for such a warranted direct inference in legal factfinding. I first set out various interpretations of what "probable" means when used in the lost chance cases. This is the topic of part I. In part II, I use this discussion of the meaning of probability, together with an examination of two contemporary epistemological theories of direct inference, to propose an analysis of the appropriate conditions for the type of direct inference central to resolving the lost chance cases. My

18. One court has made this point in a compelling way, although it shed no light on the correct resolution of the inference problem:

To say that a patient would have had a ninety-nine percent opportunity of survival if given proper treatment, does not mean that the physician's negligence was the cause in fact if the patient would have been among the unfortunate one percent who would have died. A physician's carelessness may, similarly, be the actual cause of physical harm although the patient had only a one percent opportunity of surviving even with flawless medical attention.

proposal is that the direct inference is not warranted by any epistemological guarantee of validity, but is required under certain conditions by minimal fairness to the parties. In part III, I use this proposed theory of warranted direct inference to reconceptualize a number of the important legal issues involved in the lost chance cases, and I suggest guidelines for deciding motions for summary judgment or directed verdict and for framing jury instructions in such cases. In particular, I suggest that a number of the fairness concerns that courts have sought to address by modifying the legal concepts of causation or compensable injury are no longer pressing, once certain confusions about direct inference have been cleared away. More traditional means of achieving justice are available within lost chance cases, without tampering with causation or compensable injury.

II. POSSIBLE MEANINGS FOR PROBABILITY STATEMENTS IN THE LOST CHANCE CASES

In lost chance cases, as in most civil cases, the required findings about the particular plaintiff need not be made with certainty, but only on the basis of the preponderance of the evidence. In trying to explain the meaning of the preponderance standard of proof, most courts and commentators incorporate some notion of probability. It is important to understand how this interpretation of the preponderance standard in terms of probability leads courts to the confusions and fallacies involved in the "bright line rule" discussed above.

First, perhaps all courts regard the preponderance standard as meaning that the factfinder must decide a factual issue for the party bearing the burden of persuasion if, but only if, the weight of evidence shows that the proposition espoused by that party is "probable," or "probably true." This is sometimes expanded to state that the prop-

19. See, e.g., Fennell, 580 A.2d at 210-14 (holding that "traditional rules of causation" and preponderance standard require proof that "it is more probable than not that defendant’s act caused" the injury); Cooper v. Sisters of Charity, Inc., 272 N.E.2d 97, 103-04 (Ohio 1971) (stating that "probability" in standard of proof is "most often defined as that which is more likely than not").

One reason for turning to "probability" is to focus the jury’s attention on the quality of the evidence presented in the case. The jury should be concerned with evaluating the quality of the evidence, not just the "simple volume of evidence or number of witnesses." 2 KENNETH S. BROUN ET AL., MCCORMICK ON EVIDENCE § 339, at 438 (4th ed. 1992) [hereinafter MCCORMICK ON EVIDENCE]; see Flemming James, Jr. ET AL., CIVIL PROCEDURE § 7.14, at 339 (4th ed. 1992). The jury should also determine the extent to which the evidence presented deserves to be believed, and not simply rely on their private subjective "hunches" and preconceived notions.
osition must be found to be "more probable" than its negation.\textsuperscript{20} This first level of interpretation considers probability as an ordinal concept (allowing an ordering of alternatives as "more probable" and "less probable"), but not one that is fully quantitative.\textsuperscript{21} 

A number of courts have gone further, however, and have interpreted or explained the meaning of preponderance on a second level, using the quantitative terminology of mathematical probability. These courts have held that a "preponderance" of evidence means having a probability of truth greater than 0.5, or having a "greater than 50% chance" of being true.\textsuperscript{22} This position considers the mathematical calculus of probability as an appropriate model for what is meant in

\begin{itemize}
  \item \textsuperscript{20} See, e.g., 2 MCCORMICK ON EVIDENCE, supra note 19, § 339, at 439 ("[t]he most acceptable meaning . . . seems to be proof which leads the jury to find that the existence of the contested fact is more probable than its nonexistence"); Ronald J. Allen, On the Significance of Batting Averages and Strikeout Totals: A Clarification of the "Naked Statistical Evidence" Debate, the Meaning of "Evidence," and the Requirement of Proof Beyond a Reasonable Doubt, 65 Tul. L. Rev. 1093, 1093 (1991) (acknowledging that "the conventional conception of civil trials involves comparing the probability of a plaintiff's case to its negation"). I assume here this conventional view that the comparison is between the probable truth of the proposition and the probable truth of its negation, and do not engage in the discussion of whether this conventional view is incorrect. See, e.g., Ronald J. Allen, A Reconceptualization of Civil Trials, 65 B.U. L. Rev. 401, 425-31 (1986) (discussing a system of comparing the probabilities of the accounts of the parties, not a proposition with its negation) [hereinafter Civil Trials].
  \item \textsuperscript{21} For a discussion of the distinction between ordinal variables and scalar or fully quantitative variables, see Vern R. Walker, The Siren Songs of Science: Toward a Taxonomy of Scientific Uncertainty for Decisionmakers, 23 Conn. L. Rev. 567, 577-78 (1991). While ordinal variables rank or order the things to be classified by reference to an increase of the property under consideration, scalar variables are fully quantitative in the sense that they classify by some quantitative measure of incremental frequency, degree or amount of the relevant property.
  \item \textsuperscript{22} See, e.g., United States v. Schipani, 289 F. Supp. 43, 55-57 (E.D.N.Y. 1968), aff'd, 414 F.2d 1262 (2d Cir. 1969), cert. denied, 397 U.S. 922 (1970); Cooper v. Hartman, 533 A.2d 1294, 1299-300 (Md. 1987) (holding that plaintiff must prove patient "had a better than 50% chance of full recovery absent the malpractice"); "probability" means "greater than 50% chance" and "possibility" is "less than 50% chance"); Cooper, 272 N.E.2d at 103-04 ("probable" in connection with standard of proof "is more than 50% of actual"); Sir Richard Eggleston, The Probability Debate, 1980 CRIM. L. REV. 678, 680; David Kaye, The Limits of the Preponderance of the Evidence Standard: Justifiably Naked Statistical Evidence and Multiple Causation, 1982 Am. B. Found. Res. J. 487, 493 ("Under the preponderance-of-the-evidence standard, all that is required is that the probability in question exceed 1/2"); Glanville Williams, The Mathematics of Proof—I, 1979 CRIM. L. REV. 297, 297, 303; Ralph K. Winter, Jr., The Jury and the Risk of Nonpersuasion, 5 LAW & SOC'Y REV. 335, 336-39 (1971) (proposing that the jury must find "probabilities, not facts": "the need is only to form an actual belief as to the balance of probability—that is, a belief as to which side enjoys the 50%- advantage"); cf. Dumas v. Cooney, 1 Cal. Rptr. 2d 584, 589-92 (Ct. App. 1991) (discussing without distinction the traditional rule of "probability" as "more likely than not" caused by defendant and a "not-better-than-even chance" of survival absent negligence).
the law by "probability." The probabilities to be determined by the jury can be compared in a fully quantified or cardinal way, and not merely ordinarily.\textsuperscript{23}

Courts that use this fully quantitative interpretation might then conclude, as a corollary, that if the baseline risk of the plaintiff's injury is greater than the defendant-caused risk, then the defendant-caused risk must be less than 0.5 or 50%, and the defendant should be entitled to judgment as a matter of law.\textsuperscript{24} Thus, when faced with a lost chance case and a baseline risk greater than 50%, the court might grant a defendant's motion for summary judgment or directed verdict, giving as a reason the legal insufficiency of the plaintiff's evidence. It does so because it concludes that any reasonable jury must infer that probably (with probability greater than 0.5) the patient died due to the pre-existing condition, not the defendant's negligence.\textsuperscript{25}

Each of these steps seems reasonable. The aggregate result, however, can be devastating to plaintiffs and can create a systematic windfall to negligent defendants in the lost chance cases. This prospect has led to the judicial quandary about what justice requires in these cases. One goal of this Article is to show exactly where and how the above chain of reasoning goes astray. Briefly, I propose that the first and second levels of interpretation can be fruitful provided the probability statements about specific plaintiffs are interpreted subjectively and as imposing minimal fairness constraints on factfinding. I will argue, however, that the third step, the further inference to the 50%-baseline-risk rule, is invalid as a "bright line rule," although under certain conditions a sufficiently strong direct inference might be warranted. But before moving to these conclusions, which I argue for in part III, a conceptual foundation must be

\textsuperscript{23} See, e.g., Cooper, 272 N.E.2d at 104 (stating that under the standard of proof in civil cases, "[i]t is legally and logically impossible for it to be probable that a fact exists, and at the same time probable that it does not exist") (quoting Davis v. Guarnieri, 15 N.E. 350, 361 (Ohio 1887)). For example, a proposition with a probability of 0.6 is twice as probable as a statement with a probability of 0.3. The mathematical calculus of probability is discussed below, see infra part II.B.1.

\textsuperscript{24} See cases cited supra note 17.

\textsuperscript{25} E.g., Fennell v. Southern Md. Hosp. Ctr., Inc., 580 A.2d 206, 211, 214 (Md. 1990) (refusing to create a "new tort" allowing full recovery for causing death by causing a loss of "less than 50% chance" of survival); Cooper, 533 A.2d at 1299-300 ("[p]robability exists when there is more evidence in favor of a proposition than against it (a greater than 50% chance that a future consequence will occur") (quoting Pierce v. Johns-Manville Sales Corp., 464 A.2d 1020, 1026 (Md. 1983)).
laid by surveying the types of probability statements found in the lost chance cases, the mathematical calculus of probability used to interpret the meaning of those statements, and the major competing interpretations of that calculus.

A. Uses of Probability in Lost Chance Cases

Before addressing possible meanings that might be given to the terms "probable" and "probability," it is important to appreciate several different uses of the terms in the lost chance cases. In this part, therefore, I describe several types of uses, all of which are intricately involved in lost chance cases. The objective here is largely definitional, merely setting forth distinctions that will be useful in the ensuing discussion.

1. The Probable Truth of Propositions and Propositions About Event Probability

Determining the probability of a proposition's being true is one of the principal tasks of the finder of fact. A typical example from the lost chance cases is the proposition that the defendant's negligence caused the plaintiff's death. This is an "ultimate issue of fact" to be determined by the jury, but it can also be the subject of expert opinion. Any proposition about events such as causation can be said to have a probability of being true or false.

While all propositions can be said to have a probability of being true, not all propositions are about the probability of events occurring. An example of the latter is when, in a lost chance case, an expert witness testifies that a person in a situation similar to that of the plaintiff at the time of the misdiagnosis has a 61% chance (0.61 probability) of not surviving beyond 5 years, even with accurate diagnosis and normal treatment. The expert is making a statement about the probability of events. The probability of the event is logically distinct from the probability of the proposition's being true or false.26 For example, a proposition that some event occurs 90% of

26. Some epistemologists prefer to talk about "physical probabilities" and "epistemic probabilities." See, e.g., JOHN L. POLLOCK, CONTEMPORARY THEORIES OF KNOWLEDGE 96 (1986). "Physical probabilities" are said to be about "the structure of the physical world," to be "independent of knowledge or opinion," "discovered by observing relative frequencies," and "the subject matter of much of statistics." Id. "Epistemic probabilities," by contrast, are about propositions (not observable events) and purport to measure their "degree of justification." Id. It seems to me, however, that talking about the probability of a statement being true and the probability asserted within the statement's content makes the relevant distinction
the time might have a very low probability of being true.\textsuperscript{27} As should become clear, overlooking this distinction may be part of the problem behind the tendency to develop a “bright line rule” of 50%.

2. Probabilistic, Statistical and Categorical Content

The content of statements can be probabilistic (e.g., “the probability that the plaintiff’s cancer was caused by the defendant’s act is 0.7”), statistical (e.g., “50% of people exposed to that amount of radiation develop skin cancer”), or categorical (e.g., “the defendant’s negligence caused the plaintiff’s cancer”). Statements about probabilities make assertions either about the probability of events or about the probability of a proposition’s being true, as discussed in the previous subsection. Statements with statistical content take as their subjects or predicates statistical concepts—such as percentages, proportions, means, or statistical associations (e.g., correlation).\textsuperscript{28} Categorical statements, for present purposes, take as both their subjects and predicates concepts that are neither statistical concepts nor probabilities.\textsuperscript{29} Moreover, to reiterate the point made in the previous subsection, the probability of a proposition’s being true is logically distinct from its content—whether that content is probabilistic, statistical, or categorical.

\textsuperscript{27} Without the unneeded suggestion that there are two kinds of “probability.” There is no reason at this point to assume that we need different interpretations of probability simply to accommodate these two uses.

Moreover, I will talk about the probability of “truth” of the proposition, as opposed to its degree of “justification,” simply because the former is more common and intuitive, and because this Article is not the place to try to make or use that important epistemological distinction. For a discussion of this distinction and its importance, see id. at 7-10.

\textsuperscript{28} By “statistical concepts”, I mean the rather open-ended set of descriptive and inferential concepts being developed in the field of statistics to address such problems as data description, sampling, and modeling. For a discussion of statistical concepts related to measurement, sampling, and modeling uncertainty, see Walker, supra note 21, at 580-608.

\textsuperscript{29} The typical kind of categorical statement is one using concepts that scientists would consider “qualitative” or “nominal” variables. For a discussion of different kinds of variables, see Walker, supra note 21, at 574-80. My goal is not to define these categories in any rigorous way, because that is unnecessary here. My present objective is merely to underscore that the evidentiary statements found in lost chance cases come in at least three varieties that are worth distinguishing on the basis of their content.
3. Generic and Specific Propositions

A third important distinction is that between generic and specific propositions. This distinction is based on the subjects of the propositions: "generic" propositions are about groups or classes of objects, while "specific" propositions are about particular individuals.\(^{30}\) Propositions about certain types of people (for example, those with a certain kind of pre-existing cancer) are generic, while propositions about the particular plaintiff in the particular case are specific.\(^{31}\)

With respect to causation determinations in tort cases, the evidence usually includes both kinds of propositions: specific statements about the causes of the particular plaintiff's specific injury, as well as generic statements about the classes or types of individuals relevant to the plaintiff's case (such as the class of persons who have the same kind of injury as the plaintiff or who have been exposed to the same type of negligent act as the plaintiff). Moreover, the law requires the jury to reach a determination about the causes of the specific plaintiff's injury ("specific causation"),\(^{32}\) not merely about the types

\(^{30}\) Some epistemologists prefer the terminology of "definite probabilities" and "indefinite probabilities" to make the same distinction as "specific" and "generic" propositions, respectively. See, e.g., POLLOCK, supra note 26, at 97. Pollock clearly has the same distinction in mind, however:

Definite probabilities are the probabilities that particular propositions are true or that particular states of affairs obtain. Indefinite probabilities, on the other hand, concern concepts or classes or properties rather than propositions. We can talk about the indefinite probability of a smoker contracting lung cancer. This is not about any particular smoker—it is about the class of all smokers, or about the property of being a smoker and its relationship to the property of contracting lung cancer.

\(^{31}\) This distinction is shown in traditional predicate logic to model the two kinds of propositions. Individual things (usually represented by lower-case letters from the beginning of the alphabet—a, b, c) can be the subject of specific predication: for example, "Jones has cancer and was misdiagnosed" might be symbolized by "Ca & Ma," in which "C" represents the predicate " . . . has cancer" and "M" represents " . . . was misdiagnosed." Generic predications are about things that are not identified specifically other than by the predicates or class names actually used in the proposition, and are represented by lower-case letters from the end of the alphabet—x, y, z. For example, "if anyone had cancer, then she was misdiagnosed" would be normally represented by "(\(\forall x\)(Cx \(\supset\) Mx))" and "at least one person had cancer and was misdiagnosed" by "(\(\exists x\)(Cx \& Mx))." E.g., MARK SANSBURG, LOGICAL FORMS: AN INTRODUCTION TO PHILOSOPHICAL LOGIC 141-47 (1991).

of causes generally associated with the relevant class of persons ("generic causation").

There is relatively little difficulty in interpreting the meaning of a generic statistical statement that 61% of persons in the plaintiff's situation would not survive 5 years, or even in understanding a generic probability statement that the probability of survival for people in those circumstances is 0.61. There is, however, considerably more difficulty in interpreting the statement that the probability for the specific plaintiff is 0.61. This latter problem of interpretation or meaning will be discussed below in part II.B.

4. Types of Substantive Uncertainty Underlying Causation

Statements about causation—whether those statements are probabilistic, statistical, or categorical in content, and whether they are about classes of individuals or specific persons—possess many types of inherent uncertainty, which are usually impossible to eliminate. I have elsewhere initiated a taxonomy of such types of inherent uncertainty, identifying six logically distinct types: conceptual, measurement, sampling, modeling, causal, and epistemic uncertainties. Scientists who study causation (e.g., epidemiologists or toxicologists) use statistical and other methodological techniques to try to reduce these types of uncertainty as much as possible. The residual amount of each type of uncertainty associated with any particular causation statement will depend upon the content of the statement itself and its supporting evidence.

It is reasonable to assume that the probability of truth of a causal determination in litigation is a function of the types and amounts of residual uncertainty associated with its supporting evidentiary statements. An adequate substantive theory of evidence (in contrast to the procedural evidence familiar to most attorneys) would provide guidance on how a probability should be assigned to an ultimate determination on the basis of that evidence. Such a substantive theory of evidence has grown geometrically over the last 25 years and includes most of the debate over the use of Bayes' Theorem by judges or juries. Representative of this stream of literature is: L. JONATHAN COHEN, THE PROBABLE AND THE PROVABLE (1977); Ronald J. Allen, The

33. Expert opinions about causation can also be classified as opinions either about "specific causation" (the causation actually at work in the plaintiff's particular case) or about "generic causation" (the capability to cause effects in certain persons, such as the potential of a certain chemical to cause damage to genetic material in humans).

34. Walker, supra note 21.

35. The legal literature addressing issues involved in such a substantive theory of evidence has grown geometrically over the last 25 years and includes most of the debate over the use of Bayes' Theorem by judges or juries. Representative of this stream of literature is: L. JONATHAN COHEN, THE PROBABLE AND THE PROVABLE (1977); Ronald J. Allen, The
evidence would respect methodological differences in particular types of scientific proof, would integrate specific categorical evidence and generic statistical evidence, would incorporate theories of statistical inference, and would provide a theory for combining probabilities for underlying evidence into a probability for the ultimate determination. However, such a substantive theory of evidence is well beyond the scope of this Article. As I discuss the meaning of probability statements and later propose a theory for warranted direct inference involving probability statements, I do so with the recognition that there are many kinds of underlying uncertainty, not all of which are obviously quantifiable. I must simply assume, for purposes of the discussion in this Article, that it is possible rationally to assign probability values to factual determinations on the basis of uncertain evidence. I believe that my conclusions in this Article do not depend in any way upon the adoption of any particular theory about how ultimate probabilities should be derived from evidence—with the exception of the direct inference itself, discussed at length in part III.

B. Analyzing the Meaning of Probability Statements

As I discussed in the previous subsection, "probability statements" come in various types. Some are statements about the probability of a proposition's being true—whether the content of that proposition is probabilistic, statistical, or categorical, and whether the subject of that proposition is a generic class or a specific individual. In addition, some are statements about the probability of an event occurring, and in these statements the concept of probability is predicated about events, not propositions. All of these types of "probability statements" play important roles in the lost chance cases. In this part, I lay out alternative theories of meaning for these various types of probability statements, and provide the foundation for the argument in part III that the direct inference central to lost chance reasoning employs more than one interpretation of probability.

1. The Formal Meaning: Satisfying the Probability Calculus

The "probability calculus" is an axiom system intended to capture the formal meaning of probability statements.36 That calculus is


In the formulation that follows, the letters a, b, c stand for particular propositions in some set of propositions S, the letters x, y, z stand for any unidentified proposition in the set, and compound propositions can be formed by using the logical connective of disjunction "x v y," which symbolizes an inclusive "or." Inclusive "or" is truth-functional disjunction, such that the compound proposition "a v b" is false just if a and b are both false; it is true if a is true, b is true, or both are true.

The three axioms or requirements can be stated as follows, using the symbol "Pr(x)" to refer to the probability that any proposition x in S is true:

(I) For every proposition x in S, Pr(x) ≥ 0;
(II) If x is a tautology, Pr(x) = 1; and
(III) If x and y are logically inconsistent, then

Pr(x v y) = Pr(x) + Pr(y).

In prose, these requirements are, first, that every proposition must be assigned a probability that is greater than or equal to zero. Second, if any proposition is a tautology (that is, it is necessarily true regardless of the facts, such as the proposition that "either sentence x or its contradictory is true"), then it has a probability of 1. Third, if two propositions are logically inconsistent (that is, logically incompatible, such that they cannot both be true at the same time), then the probability of the inclusive disjunction of those two propositions is equal to the sum of their independent probabilities.
conventionally used to capture the "formal" meaning or "syntax" of probability: values assigned to propositions or events are "probabilities" if, and only if, they satisfy the axioms of the probability calculus. The axiom system provides a formal calculus defining the probability of logically compound statements (such as negations, disjunctions, or conjunctions) as a function of the probabilities of component statements.\textsuperscript{37} Numerical values between zero and one that "behave" as the calculus requires are considered probabilities in what I referred to earlier as the fully quantitative sense.\textsuperscript{38}

The so-called "unconditional probability" of some proposition \(x\), symbolized "\(\text{Pr}(x)\)," is the probability that the proposition \(x\) is true. In contrast to "unconditional" probability, the "conditional" probability for two sentences \(x\) and \(y\) is the probability that sentence \(x\) is true on the condition that sentence \(y\) is true. This is called "the conditional probability of \(x\) given \(y\)," and is symbolized "\(\text{Pr}(x | y)\)."\textsuperscript{39} When the concept of conditional probability is joined to the axioms for unconditional probability, one important and useful theoretical result is Bayes' Theorem.\textsuperscript{40}

The axioms are formally identical whether the argument values \(x\) and \(y\) are taken as referring to propositions (as above) or events (as in set theoretic formulations). \textsc{Howson \& Urbach, supra} at 17-19; see \textsc{Henry E. Kyburg, Jr., Probability and Inductive Logic} 11-14 (1970).

\textsuperscript{37} For an explanation of the logical connective of disjunction, see \textit{supra} note 36. A truth-functional negation, symbolized "\(\sim x\)," is true only when the argument proposition \(x\) is false, and false only when \(x\) is true. Logical conjunction, symbolized "\(x \& y\)," is true only when both \(x\) and \(y\) are true.

\textsuperscript{38} See \textit{supra} text accompanying note 23.

\textsuperscript{39} This notation can be introduced as a definition:
\[
\text{Pr}(x | y) = \frac{\text{Pr}(x \& y)}{\text{Pr}(y)}.
\]

E.g., \textsc{David Kaye, Probability Theory Meets Res Ipsa Loquitur, 77 Mich. L. Rev. 1456, 1470 (1979); see Howson \& Urbach, supra} note 36, at 16.

\textsuperscript{40} The definition given in note 39 provides the basis for Bayes' Theorem by algebraic transformation, as follows:
\[
\text{Pr}(x | y) \text{Pr}(y) = \text{Pr}(x \& y);
\]
since \(\text{Pr}(x \& y) = \text{Pr}(y \& x)\),
\[
\text{Pr}(x | y) \text{Pr}(y) = \text{Pr}(y | x) \text{Pr}(x),
\]
and
\[
\text{Pr}(x | y) = (\text{Pr}(y | x) \text{Pr}(x)) / \text{Pr}(y).
\]
Bayes' Theorem can then be stated as:
For \(\text{Pr}(x), \text{Pr}(y) > 0\),
\[
\text{Pr}(x | y) = (\text{Pr}(y | x) \text{Pr}(x)) / \text{Pr}(y).
\]
See, e.g., \textsc{Michael O. Finkelstein, Quantitative Methods in Law} 87-89 (1978); \textsc{Howson \& Urbach, supra} note 36, at 16; \textsc{Kyburg, supra} note 36, at 19-20.

When we are interested in defining the probability of one proposition as a function of the probability of its negation, a more useful formulation of Bayes' Theorem is the following:
For \(\text{Pr}(x), \text{Pr}(y) > 0\),
When these axioms, definitions and theorems are added to the calculus of truth-functional logic,\textsuperscript{41} this expanded calculus can be used to model the formal structure of both the probabilities of statements' being true and the probabilities within the content of statements. The reason is that the same formal calculus can be interpreted either as referring to propositions (probabilities take propositions as arguments) or to types of events (probabilities are predicated of events).\textsuperscript{42} For example, a generic proposition "a" that an event of type E has a probability of occurrence of 0.8 might be symbolized \( P_{R}(E)=0.8 \). This particular proposition might itself have only a 0.2 probability of being true \( (P_{R}(a)=0.2) \). Writing out the full symbolism displays the distinction between the probability of the statement and the embedded statement about probability: "\( P_{R}("P_{R}(E)=0.8") = 0.2. " \) I will assume, however, that both probabilities in this expression are probabilities precisely because they both satisfy the same formal calculus.

2. Objectivist Interpretations of Probability Statements

It is one thing to acknowledge the formal syntactical requirement that in order for a set of values to be probabilities, at least in a full quantitative sense, the values must satisfy the axioms of the probability calculus. It is yet another thing to interpret or give meaning to statements about probabilities concretely in terms of human experience. The question is what we mean when we make assertions about unconditional or conditional probabilities. The primary contending theories today are "objectivist" ("realist" or "physicalist") interpreta-

\[
P_{R}(x|y) = \frac{P_{R}(y|x) P_{R}(x)}{(P_{R}(y|x) P_{R}(x)) + (P_{R}(y|\neg x) P_{R}(\neg x))}.
\]

This formulation follows from the axioms since \( x \) and \( \neg x \) are logically inconsistent and yet one of them must be true. \textit{See, e.g., Finkelstein, supra at 88-89; Howson & Urbach, supra note 36, at 26 (stating general form); Brilmayer & Kornhauser, supra note 36, at 137; Richard O. Lempert, Modeling Relevance, 75 Mich. L. Rev. 1021, 1022-23 & n.12 (1977).}

In the lost chance cases, \( x \) might be the proposition that the plaintiff's injury is a defendant-caused injury and \( \neg x \) the proposition that the plaintiff's injury is a baseline injury. Evidence presented in the litigation might be represented by the proposition \( y \). Then one might characterize the task of the factfinder as determining \( P_{R}(x|y) \). An excursion into the usefulness of using Bayes' Theorem to model (either descriptively or normatively) the probabilistic inference in lost chance cases is not the topic of this Article, although Bayes' Theorem might play a role in a substantive theory of evidence. \textit{See discussion supra part II.A.4}

\textsuperscript{41} For a general discussion of such a unified system, see, for example, Sainsbury, supra note 31, at 103-32.

\textsuperscript{42} See supra note 36.
tions and "subjectivist" ("idealistic" or "personalist") interpretations of probability statements. The distinction being made is between theories that claim that statements about probabilities refer to "objective" features, characteristics, or laws of observable events themselves, and theories that such statements refer to "subjective" states of mind, such as degrees of belief or degrees of uncertainty. A leading example of an objectivist interpretation is the theory offered by von Mises. In that theory, a probability is the limit of the frequency of occurrence of a specified type of outcome event (such as throwing a "6" on a die) relative to the total number of repeated trials of a repeatable event (such as throwing the die), as the number of such repeated trials goes to infinity. On this analysis, observed relative frequencies are not themselves probabilities, nor are they always good estimates of probabilities. In one series of throws of a die, the relative frequency of throwing a "6" might be 93 out of 600, in another series 109 out of 600, or even 134 out of 600. If relative frequencies were themselves probabilities, each finite sequence of trials would have its own set of probabilities and not the repeatable event as such. But if the causal factors influencing the outcome of the throw remain the same, an objectivist expects the probability (that is, the limit value of the relative frequency) to remain the same over many finite trial sequences. If the repeatable event itself does not change in character, its probability characteristics should not change either.

It is entirely possible, of course, that the relative frequencies calculated for a number of observed sequences of trials will not converge toward a single limit, and therefore will not yield a stable probability. In von Mises' terminology, a repeatable event can have associated probabilities only if the sequences of observed trials from the repeatable event is a "collective." A "collective" is an infinite


45. Howson & Urbach, supra note 36, at 203-08; von Mises, supra note 44, at 24-25. Probabilities necessarily refer to some collective, and the unqualified term "probability" was always intended by von Mises to mean "the probability of that attribute [type of possible outcome] within the given collective." Von Mises, supra note 44, at 29.
series of potential outcomes\(^6\) that satisfies two conditions or axioms: the Axioms of Convergence and Randomness. The Axiom of Convergence requires that some definite limiting value actually exists for the relative frequency of interest in the series.\(^7\) The Axiom of Randomness requires that limiting value to be the same for any infinite subsequence selected from the infinite series by some method executable in advance.\(^8\) Therefore, on von Mises' analysis, a statement about probabilities does not merely describe the relative frequencies of events observed to date, but asserts something beyond the observable—namely, that the reference event (used to specify the denominator) and the outcome event (used to specify the numerator) must be sufficiently identified, repeatable and predictable that they can be regarded as generating a collective.

Such objectivist interpretations based on relative frequency (which I will refer to simply as "frequentist" interpretations) do seem to capture one of our main intuitions about the meaning of generic probabilistic propositions about observable and repeatable events, such as statements about the probability of throwing a "6" with a die. A fundamental feature of lost chance cases, however, is that the jury must determine not only whether some incidence of defendant-caused injuries would be expected for persons similarly situated to the plaintiff ("generic causation"), but also the probability that the particular plaintiff's injury was defendant-caused ("specific causation"). But if probability statements are interpreted only as referring to limits of relative frequencies in an indefinite number of trials of a repeatable experiment, then in what sense could probabilities be predicated about single, unique events, such as the plaintiff's injury?

Some frequency theorists like von Mises have held that probability statements are never meaningful with reference to particular events or occurrences.\(^9\) The only possible meaning in such cases is the

\(^6\) The series has been described by von Mises either as an infinite sequence of potential outcomes or as a finite sequence of actual outcomes which would satisfy the Axiom of Convergence if indefinitely extended. Howson & Urbach, supra note 36, at 204-06.

\(^7\) Howson & Urbach, supra note 36, at 204-05; Von Mises, supra note 44, at 12-15, 24. In "[a] collective appropriate for the application of the theory of probability," the relative frequencies must "become more and more stable as the number of observations is increased" and they must possess "limiting values." Von Mises, supra note 44, at 12, 24.

\(^8\) Howson & Urbach, supra note 36, at 205-08; Von Mises, supra note 44, at 23-29 (calling this requirement "the Principle of the Impossibility of a Gambling System": the limit of the relative frequency of throwing a "double 6" with two dice, for example, remains the same even if we bet on only every second throw).

\(^9\) Von Mises was very careful and clear on this point:  

https://scholarlycommons.law.hofstra.edu/hlr/vol23/iss2/1
indirect and vague one that if the particular occurrence were repeated a large number of times and if the series of outcomes were to be a subsequence of a von Mises collective, then the probability would be the limit of the relative frequency of occurrence in that collective.\footnote{50}

By contrast, "propensity" interpretations of probability statements have attempted to address this problem of unique events.\footnote{51} On a propensity theory, a statement of probability asserts that there is a repeatable experiment under consideration that has some set of objective physical characteristics or features ("propensities") which in the long run would produce stable, limiting relative frequencies of possible outcomes, provided the experiment were continued indefinitely under similar conditions.\footnote{52} Part of the meaning of a probability statement on this interpretation is that some causal system is at work that would produce a series of outcomes that would be a "collective" (in von Mises' sense) if continued indefinitely. Propensity theorists would seem to have the advantage of proposing that specific probability statements do make sense after all, because they are really assertions about the underlying propensities physically in the specific individual or situation.\footnote{53}

There are several major problems with using either of these frequentist theories in lost chance cases to interpret probabilities about the plaintiff's particular situation. First, either explanation of meaning depends necessarily on the notion of repeating the reference situation (the circumstances leading to the plaintiff's injury event) a large number of times. Both the von Mises theory and the propensity theory assume that we can make sense of the notion of repeating the

\footnote{When we speak of 'the probability of death,' the exact meaning of this expression can be defined in the following way only. We must not think of an individual, but of a certain class as a whole, e.g., 'all insured men forty-one years old living in a given country and not engaged in certain dangerous occupations.' A probability of death is attached to this class of men or to another class that can be defined in a similar way. We can say nothing about the probability of death of an individual even if we know his condition of life and health in detail. The phrase 'probability of death' when it refers to a single person, has no meaning at all for us.

VON MISES, supra note 44, at 11.

50. See, e.g., Ball, supra note 32, at 811-13.

51. HOWSON & URBACH, supra note 36, at 221-25 (discussing Popper's theory). On propensity theories generally, see COHEN, supra note 43, at 53-58; KYBURG, supra note 36, at 46-50; JOHN L. POLLOCK, NOMIC PROBABILITY AND THE FOUNDATIONS OF INDUCTION 23-32 (1990); cf. POLLOCK, supra note 26, at 96-97, 105 (considering "propensities" as "physical probabilities").

52. HOWSON & URBACH, supra note 36, at 221.

53. COHEN, supra note 43, at 55-56; HOWSON & URBACH, supra note 36, at 221-22.
injury-causing situation. However, this seems contrary to our intended meaning in making the probability statement. When we make the probability statement, we are not making any claim about a hypothetical “thought experiment,” nor do we intend that anyone “run” such a thought experiment in order to assess the truth of any probability statement. When the jury is told to determine whether the plaintiff’s injury was probably defendant-caused, as opposed to baseline, they are not being invited to sit back, close their eyes, imaginatively run an indefinitely long sequence of similar reference situations, and (mentally) “observe” the relative frequency of outcomes. In fact, running such a thought experiment in one’s head would be a sign that he or she did not understand the intended meaning of the probability statement. In short, this theory of meaning does not square with our experience, and any hypothetical thought experiment is probably a fiction invented merely to save the frequentist theory of probability when it is applied to statements describing particular events.\(^\text{54}\)

A second set of objections is based on the premise that the idea of repeating a unique event is itself flawed. The theory cannot mean repeating exactly or precisely the same unique event with all of its causal determinants. If this were the event to be repeated, and if the world in which the law works is even roughly deterministic, then each repetition would have the same outcome as the original event, and the relative frequency of the original outcome would always approach 1.\(^\text{55}\) Instead, what would have to be meant is that the repetitions would be of the “same” event in the sense that certain (probably unspecified) causal factors are identical throughout the series of repetitions, but not so many causal factors as to predetermine the outcome of each trial.\(^\text{56}\) However, this criterion of “sameness” used to define the repeatable or reference event must not be an objective characteristic of the event, but a subset of causal factors chosen for the purpose of determining the probability. This choice of defining factors for “sameness” introduces a subjective feature of probabilities that many objectivist theorists would want to avoid, because the value of the associated probability is no longer a function merely of objective features of the events themselves, but must vary with each choice.

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54. See Kaplan, supra note 35, at 1066 ("It is meaningless to speak of the probability of the defendant’s guilt in terms of the number of times he would be guilty in an infinite number of exactly similar cases . . . .").

55. Id.

56. For a similar argument addressed to Popper’s theory of propensities, see HOWSON & URBACH, supra note 36, at 223.
of descriptors used to identify the "same" event.57

Of course, frequency theorists such as von Mises might not be troubled by either of these objections, if they consider probability statements simply inapplicable to unique or particular events. However, if they so limit the scope of meaningful probability statements, their theory leaves many normal uses in a legal context without any interpretation. Legal theorists, concerned with evaluating the probabilities of many statements about particular, unique events, are understandably skeptical about the usefulness of an interpretation that either distorts the normal meaning of probability statements or leaves essential uses undefined.58 Moreover, there is no reason to accept such distortions in meaning if, as I argue below, there is no compensating conceptual gain in dealing with legal problems.

In my theory of warranted direct inference, there is an important place for generic probability statements with a frequentist interpretation, when they are properly placed in harness with other probability statements and interpretations. The strength of a frequentist theory is that it addresses our intuition that the best way to infer probabilities is from observed frequencies of occurrence. By using a frequentist interpretation for precisely those evidentiary statements for which the theory is appropriate, I intend to take advantage of this strength, even though such a theory will not account for all of the types of probability statements used in the law.

57. This objection might be made to any frequentist interpretation, even of generic statements, because a criterion of "sameness" is essential for describing any "repeatable event," which is necessary for defining any limit value of relative frequency. This would not be an objection to the frequentist analysis as such, however, but to characterizing it as entirely "objective." A frequentist might well concede that probability values are inherently a function of how we choose to define classes of events, but insist that once the reference or repeatable event is defined by some specification of "similarity" or "sameness," the relative frequency of occurrence of a possible outcome is still an objectively determinable characteristic of the sequence of outcomes. See, e.g., VON MISSES, supra note 44, at 17-18. The "subjectivity" introduced by the need to define the reference event is quite different from a subjectivist theory that probability statements merely refer to an individual's degree of belief.

58. See, e.g., Neil B. Cohen, Confidence in Probability: Burdens of Persuasion in a World of Imperfect Knowledge, 60 N.Y.U. L. Rev. 383, 391-92 (1985); Kaye, The Paradox of the Gatecrasher and Other Stories, supra note 35, at 105; Kaye, supra note 36, at 41-47; Tribe, supra note 35, at 1346-49. But see Ball, supra note 32, at 810-13 (arguing that although probabilities are about frequencies and not directly about individuals, "there is no question that behind every relevancy statement is a proposition which casts human experience into frequency form").
3. Subjectivist Interpretations of Probability Statements

Subjectivist interpretations of probability statements often take such statements as referring not to observable events, but to a "degree of belief" or "degree of confidence" in the truth of the statement. On such an interpretation, even probabilities that seem to be about events are really indicators of our strength of belief about those events.

An immediate difficulty for subjectivist theories is explaining how an individual's degrees of belief would necessarily satisfy the axioms of the probability calculus. A person's degrees of belief in the truth of propositions considered one at a time are not necessarily going to (or perhaps even likely to) have the logical properties required of probabilities. In other words, subjective degrees of belief might not satisfy the probability calculus. One approach to this problem has been to eschew actual subjective beliefs of individuals, and to turn instead to the "degree of belief" that a "rational person" would hold. If criteria for rationality can be formulated such that the degrees of belief of this ideal "rational person" would necessarily satisfy the probability calculus, then "rational degrees of belief" would be probabilities. Probability statements could be interpreted as referring to the degrees of belief that such a "rational person" would have.

A recent variation on this approach has been presented by Howson and Urbach. They suggest that probabilities can be interpreted as a reasonable person's estimate of a "fair betting quotient" for a proposition. A "betting quotient" is an algebraic transform of the "betting odds" that could be placed on the truth of a proposition. The betting odds on the truth of a proposition is the ratio of

59. See generally sources cited supra note 43.
60. E.g., LEONARD J. SAVAGE, THE FOUNDATIONS OF STATISTICS 7-8, 19-21 (2d ed. 1972) (discussing that probability postulates "can be regarded as a logic-like criterion of consistency," and behavior at variance with the theory is handled as one would a "slip in logic," to be explained in psychological terms).
61. HOWSON & URBACH, supra note 36.
62. The betting odds on a proposition do not satisfy the probability calculus because they do not range from 0 to 1, but rather from 0 to infinity. Probabilities can be derived from odds, however, by the function \( PR = \Omega / (1 + \Omega) \), where \( PR \) is the probability and \( \Omega \) is the odds. Id. at 58.

This formula provides a one-to-one mapping of odds onto probabilities, with odds of zero being equal to a probability of zero, odds of 1:1 (equal odds) being equal to a probability of 1/2 (since 1/2 = (1/1) / (1 + (1/1))), and odds of infinity being equal to a probability
the amount the bettor would lose if the proposition proves to be false, divided by the amount the bettor would win if the proposition is true. A "fair" betting quotient is one for which it could not be determined, in advance of learning whether the proposition is in fact true or false, whether any bettor at those betting odds would necessarily enjoy an advantage at winning or losing money. A "fair" betting quotient eliminates any a priori or necessary advantage to betting either for or against the truth of the proposition.

The claim is that betting quotients that are "fair" in this sense are in fact probabilities—that is, they satisfy the axioms of the probability calculus. Any set of betting quotients assigned by an individual, in order to be fair betting quotients, must satisfy the probability calculus, because if the axioms are violated, then a net advantage will follow necessarily for some bettor, independently of whether the betting quotients are correctly set and independently of the truth or falsehood of the propositions involved. If someone were to con-

<table>
<thead>
<tr>
<th>Odds (Ω)</th>
<th>Probability (Ω / (1 + Ω))</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3:1000</td>
<td>3/1003</td>
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<tr>
<td>1:2</td>
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<tr>
<td>1000:3</td>
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</tr>
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<td>∞</td>
<td>1</td>
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The quantity "Ω / (1 + Ω)" is referred to as the "betting quotient."

If someone judges the proposition to be very probable, she should set the odds on the proposition so that a proportionately small payoff would follow if the proposition proves in fact to be true. Thus, we commonly say, when commenting on a highly probable proposition, that "odds are that . . . ," meaning that the odds are in favor of the proposition being true. If the individual judges the proposition to be improbable, then the odds on the proposition should produce a high payoff should the proposition (contrary to expectations) prove to be true. Thus, the odds set by an individual on the truth of a proposition would be related to her assessment of the probability of truth. The appropriate betting odds would ideally balance out the risk taken in wagering, so that a reasonable person wishing to place a bet should be indifferent to wagering for or against the proposition.


63. It is not important whether or not an individual asserting a probability is at all interested in actually wagering on the truth of the proposition, for the individual functions in this context as a fairness judge or regulator, not as a bettor.

64. Details of the argument can be found at HOWSON & URBACH, supra note 36, at 59-63. Given a betting quotient associated with odds Ω, on proposition x, it can be deduced that the fair betting quotient on its negation ¬x must be 1 minus the betting quotient for x,
struct such an "unfair" set of betting quotients and somehow require two persons to place bets on opposite sides of the entire set, the betting proposal would be "biased" because it would be certain in advance that one bettor or the other must stand to lose money. It is possible, therefore, to interpret a set of subjective betting quotients as probabilities provided that they are in fact fair in this particular sense. To avoid confusion with other concepts of fairness, I will refer to such betting quotients as being "minimally fair." 65 In this Article, I will adopt the Howson and Urbach account for a subjectivist interpretation of probability statements, and will use the phrase "subjective probability" to mean a betting quotient that is minimally fair.

The sense in which a fair betting quotient is "subjective" has now taken on a distinctly intersubjective meaning. An individual's subjective betting quotations are fair only if they adhere to the probability axioms, and they cannot be set merely by the subjective whim

in order for the betting quotients on both x and \( \neg x \) to be fair. In terms of probabilities, if PR is the probability of x, then 1 minus PR must be the probability of \( \neg x \). If any probability other than 1-PR were to be assigned to \( \neg x \), say PR', then we can be certain that the set of betting quotients PR and PR' is not fair, for betting on or against the set will necessarily produce a net advantage or disadvantage regardless of the truth of x. For example, if PR = 2/3 (with odds of 2:1) and PR' = 1/4 (odds of 1:3), then a reasonable person would conclude that a bet on the pair of propositions x and \( \neg x \) at those odds will necessarily have an advantage regardless of whether it is x or \( \neg x \) that is true. If x is true and \( \neg x \) false, the bettor will gain 1 unit bet on x and lose 1 unit bet on \( \neg x \). But if \( \neg x \) is true, the bettor will gain 3 units on \( \neg x \) and lose only 2 units on x. Thus, the bettor cannot lose money and can only gain money on the bet. The betting quotients on the pair are a priori favorable to a bet on the pair. Therefore, in order for the betting quotients on both a proposition and its negation to be fair, they must be set in accord with the probability calculus.

Similarly, for any second betting quotient associated with odds \( \Omega \) on a second proposition y, it can be deduced that, if x and y are mutually inconsistent, the subjectively fair odd odds on "x v y" must be the sum of the betting quotients for x and y. It can be demonstrated, although I do not reproduce the proof here, that if the third axiom of the probability calculus is not satisfied, then the subjective odds for x, y and "x v y" cannot all be fair. A wager on or against all of these three propositions must necessarily produce a net advantage for some bettor, regardless of whether x and y prove to be true or false.

65. By "minimally fair," I mean fair only in the sense that the set of betting quotients is unbiased, and the probability calculus is satisfied. Other notions of fairness are not intended. Also, a set of betting quotients can be minimally fair without being the correct betting quotients or probabilities, see supra notes 62-63.

A somewhat analogous but psychological argument for why bettors themselves should prudently adhere to the probability calculus is based on their presumed desire to avoid having a "Dutch book" made against them. See generally COHEN, supra note 43, at 59-60; HOWSON & URBACH, supra note 36, at 71-73; POLLOCK, supra note 26, at 99-100; BRIAN SKYRMS, CHOICE AND CHANCE: AN INTRODUCTION TO INDUCTIVE LOGIC 168-98 (2d ed. 1975). The argument made here for holding jurors to a standard of minimal fairness is not based on such a psychological argument. It is based on the fairness argument that jurors should not be allowed to make a Dutch book against any party.
of the individual. Presumably, if the individual were reasonable, this
collection that betting quotients must be probabilities in order to be
fair could be demonstrated to her satisfaction. However, whether or
not she is in fact reasonable, and whether or not she considers those
axioms to express minimal conditions of fairness, is beside the
point. Rather, reasonable persons should be able to agree that her
subjective betting quotients must satisfy the probability calculus or
they are not all fair. Assuming, that is, that we are reasonable per-
sons, we should reach this conclusion about her subjective betting
quotients.

This situation is no different than that encountered with the
axioms of deductive logic. An individual may or may not draw logi-
cally valid inferences from her premises, but reasonable persons
should be able to agree about which of those inferences are to be
regarded as valid and which are not. An individual’s efforts to draw
valid inferences do not guarantee that she will do so. Deductive logic
provides a theory of valid inferences, not a psychological prediction
about a given individual’s actual reasoning patterns. Likewise, the
probability calculus provides a theory of minimal conditions for the
fairness of betting quotients, and thus for subjective probabilities,
regardless of its merit as a descriptive theory of a given individual’s
actual patterns of reasoning.

This comparison of the probability calculus to deductive logic
suggests a further analogy. Deductive logic provides a theory about
which inferences from premises are valid, but not about which con-
clusions are sound or which premises are true. For example, if
someone believes that there are exactly four aces in a certain deck of
playing cards, and that only one of them is drawn out and not re-
placed, then a valid inference deduced from these premises is that
three of the remaining cards must be aces. But deductive logic does
not tell us whether these premises and this conclusion are true. The
theory of deductive logic, in other words, does not tell us that there
were in fact four aces originally in that particular deck. Similarly, if
someone’s subjective probability (fair subjective betting quotient) for
a proposition is 0.8, then the probability calculus allows us to deduce
that, if her betting quotients are to be in fact fair, then her subjective
probability for the negation of that proposition must be 0.2 (that is, 1
minus the probability of the original proposition). This conclusion fol-

66. SeeHOWSON & URBACH, supra note 36, at 273-74.
67. See, e.g., SAINSBURY, supra note 31, at 23-25.
lows simply from our decision to require the person's betting quotients to be minimally fair. However, our determination to maintain minimal fairness (in the form of the probability calculus) does not ensure that 0.8 is in fact the correct betting quotient, setting the appropriate fair odds that adequately balance the risk in betting on the particular proposition. The correctness of a betting quotient (as opposed to its minimal fairness) depends on the content of the proposition, the substantive evidence, and the true state of affairs, not just on satisfaction of the probability calculus.

I will argue that the principle of fairness to all parties requires that jury determinations of the likelihood of truth of factual propositions must satisfy the probability calculus. Unless the subjective betting quotients for a set of logically related factual propositions satisfy the axioms of the probability calculus, we can be certain—in advance and independently of the truth or falsehood of any of the particular propositions themselves—that the set produces a net bias for or against some party. Put another way, if the set of betting quotients for the factual determinations needed in order to reach a general verdict does not satisfy the probability calculus, then that set of determinations must be biased against some party. All parties to the litigation, however, should be entitled to have the jury reach a set of conclusions that is minimally fair in the sense that no one party will be automatically and systematically disadvantaged, regardless of the truth of the allegations at issue.

A set of factual determinations with biased odds, if wagered upon indifferently, would necessarily produce a net advantage or disadvantage for some wagerer. The opposing parties in a litigation are necessarily in the position of the "wagerers," in the sense that one of them will "win" the lawsuit and the other will bear the cost of the injury at issue in the suit. If one were to decide whether the jury had found the facts correctly, such a decision might be based on intuitions or on the evidence presented at trial or on information not available to the jury. Such a decision is very different from deciding that the findings are minimally fair. Minimal fairness is a matter of satisfying the probability calculus. The set of betting quotients assigned to the findings should be minimally fair in the sense that one

68. There is no need here to delve into the complexities of comparative fault, partial damages, and other ways a jury can effect a compromise judgment. For simplicity of analysis, I will assume that either one side or the other "wins" the case and that the other side bears the cost of the injury.
can decide, independently of deciding the truth or falsehood of the findings, that a wager in favor of one party or another will not have a necessary advantage or disadvantage. If there is an inspection of only the betting quotients themselves, the reasonable bettor should be indifferent about betting on either side in the case.

The judicial system routinely places minimal constraints of logical consistency on jury determinations of fact. When judges do not allow logically inconsistent verdicts to stand, they are in fact requiring jury determinations to comply with the requirements for valid deductive inference. I argue that judges should go further and should require the factual determinations of a jury to be internally coherent as well, in the limited sense of satisfying the additional axioms of probability theory. In so doing, judges would be increasing only modestly the formal requirements of reasonableness for factfinders.

A number of objections have been raised against any subjectivist interpretation of probability that draws upon betting concepts. First, it has been argued that this approach confuses "rationality" with "prudence." It might not be prudent to bet on a set of propositions whose odds are "loaded" against you, but it does not follow that doing so is irrational in any epistemological sense. If my goal here were to analyze an epistemological concept of "justified belief" I might agree with this objection, but the lost chance cases in law present a different situation. I have argued above that it is important for the law to require jurors to be minimally fair to the litigating parties. This approach merely requires jurors to be fair setters of betting quotients, not to be bettors themselves, and this makes this objection irrelevant. The law imposes minimal fairness constraints on jurors not because it demands that verdicts be epistemologically rational, but for distinct policy reasons of its own. When the law requires juries to be minimally fair to the litigating parties, this in fact imposes the requirement that the jury's subjectively assigned betting quotients (degrees of belief) satisfy the probability calculus (be probabilities). Juries do not

69. It may be that judges intuitively enforce the constraints of the probability calculus in any event. See supra note 23.

70. POLLOCK, supra note 26, at 99-100.

71. A similar response is appropriate to the objection that, when faced with a complicated set of propositions or bets, a reasonable person may in fact bet into a Dutch book. See POLLOCK, supra note 26, at 100. Subjective probabilities need not be descriptive about how people actually set betting quotients: the claim is not that they always do so fairly. My argument is simply that the judicial system should hold jurors to minimal standards of fairness whenever it comes to the judge's attention that the jury has in fact made a Dutch book against some party to the litigation.
have to be bettors; they simply have to be minimally fair factfinders.

A second objection to subjective probabilities is that there is no reason to think that, for any specific case, there is a unique degree of belief that is rational. It does seem likely, this objection continues, that there would be such a unique degree of rational belief "in any fixed epistemic setting," given a fixed body of evidence.\(^2\) If a factual proposition has a probability of being true, then that probability cannot be interpreted subjectively.

There are a couple of responses to such an objection. One is to point out once again that, while uniqueness might be a sensible requirement for an interpretation or theory of rationality, epistemological rationality is not the task before us in the lost chance cases. When we are required to adjudicate a case in the face of residual baseline risk, perhaps the least we can hope to achieve is minimal fairness, and, in addition, coming as close as the evidence and human reasoning will allow to the "correct" determinations of fact. It would be neither surprising nor of great legal concern if being minimally fair would not itself guarantee that there exists a unique probability for every proposition in a given evidentiary situation.\(^3\)

Another response to this objection is that the subjective interpretation of probability statements that I will use here is an analysis based on minimal fairness, and does not guarantee the correctness of the betting quotients set or the factual determinations made. Satisfaction of the probability calculus does not generate a probability of truth for an isolated proposition. It merely imposes constraints on assignments of probability to groups of logically related propositions.\(^4\) Thus, requiring minimal fairness of a jury will not constrain the jury to arrive at any unique determinations about probabilities. The jury is still free to set the probabilities (the fair betting quotients) as the jurors believe warranted. The requirement of fairness is just the minimal one that the jury must not bias the set of determinations a

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72. POLLOCK, supra note 26, at 101.

73. It may be that the desire to know that a unique probability is warranted in any given situation is one aspect of "objectivity" that a subjective interpretation relinquishes, even when the "subject" is a hypothetical "rational person." It might be unsettling to an epistemologist that a theory of rationality would not guarantee a unique line of reasoning from a given set of evidentiary premises to a unique probability for a conclusion, but this is unlikely to be unsettling to jurists, for whom rationality constraints are generally minimalist and do not determine a unique solution. To jurists, a "rational determination" is usually one over which "reasonable minds may differ."

74. See supra notes 64-65. For example, if \(P(x)\) is 0.8, then \(P(-x)\) must be 0.2. However, the theory of probability itself does not entail that \(P(x)\) must be 0.8.
priori against any party.\textsuperscript{75}

A major advantage of this subjectivist interpretation should be emphasized. Subjectivist theories, unlike some objectivist theories, have no difficulty giving an interpretation to probability statements about unique events. A probability statement stating a fair betting quotient reflects the factfinder's degree of belief in the truth of the proposition presented, not an estimate of the relative frequency of outcomes in hypothetical thought experiments. Therefore the difficulties encountered by a frequentist interpretation are avoided altogether.

The requirement of minimal fairness does place certain constraints on sets of logically connected probability assignments, thus imposing some "intersubjective" criteria on factfinders. But one might be inclined to think, at this point in the analysis, that requiring jury determinations to be subjective \textit{probabilities} (minimally fair betting quotients) is itself a minimally fruitful development. How does this conceptual move help us resolve the paradox of baseline risk presented in the lost chance cases? In the next part, I develop the perhaps surprising result that in certain situations involving residual baseline risk, such as the lost chance cases, the requirement of minimal fairness alone \textit{can compel} some fairly concrete assignments of subjective probability to factual determinations. When certain requirements of warranted direct inference are satisfied, minimal fairness compels a specific assignment of subjective probability to the individual case.

\section*{III. Warranted Direct Inference in the Lost Chance Cases}

In the lost chance cases, most courts agree that, unless there is a rethinking of traditional concepts of causation or compensable injury, or an overriding social policy established, they should decide cases against the plaintiff as a matter of law whenever the percentage of baseline cases relative to reference situation cases is greater than

\textsuperscript{75} The conception of avoiding a priori bias against any party with a set of probabilities assigned to propositions, \textit{see supra} notes 64-65, allows me to present an analysis about verdict outcomes without first having an adequate theory for how to arrive at single probabilities for propositions on the basis of evidence, or for combining probabilities from subsidiary propositions into a single probability for the conclusion. In other words, the argument here is not predicated on having a complete theory of probabilistic inference, such as Bayesian theorists are trying to construct, or a complete theory of substantive evidence. \textit{See supra} part II.A.4 and note 35. The minimal requirement here is that, whatever the set of propositions and probabilities adopted by the jury on the basis of the evidence presented, arriving at a verdict must not be accomplished on the basis of a set that is, as a set, a Dutch book against some party.
50%.\textsuperscript{76} They also agree that when defendant-caused injuries are a greater percentage than baseline injuries in the reference situation, a verdict for plaintiffs can be readily defended. Implicit in all of this reasoning is the assumption that the \textit{ratio} of defendant-caused cases to baseline cases is a direct determinant of the \textit{probability} that the defendant caused the plaintiff’s injury.

I argue in this part that this underlying assumption must be analyzed more carefully, and that in its simplest form it is incorrect. I present an analysis of exactly how the generic statistical evidence is logically related to, and capable of supporting, the ultimate statement of probability about specific causation. Specifically, the problem is deciding when it is warranted to conclude proposition “C”:

There is a probability of S/100 that this specific plaintiff’s injury of type I is a defendant-caused injury, \textsuperscript{(C)}
on the basis of the propositions “A” and “B”:

This specific plaintiff is characterized by risk factors \{C_1, C_2, \ldots, C_n\}; and \textsuperscript{(A)}

Out of the class of persons characterized by risk factors \{C_1, C_2, \ldots, C_n\}, an estimated S% would suffer injury I as a result of the defendant’s negligence (i.e., S% would suffer defendant-caused injuries).\textsuperscript{77} \textsuperscript{(B)}

In propositions A and B, the circumstances referred to as “C_1, C_2, \ldots, C_n” are those \textit{known} characteristics of the plaintiff (e.g., genetic predisposition, pre-existing colon cancer) that are also \textit{known} risk factors for an injury of type I (e.g., death from colon cancer). That set also includes the defendant’s negligent act, which is an established risk factor. The “reference situation” is, by definition, those known risk factors \{C_1, C_2, \ldots, C_n\} plus any other risk factors for injury I that are in fact present in the plaintiff’s case, whether those risk factors are known or not. Thus, \{C_1, C_2, \ldots, C_n\} is usually a subset of a larger set of risk factors (known and unknown) that char-

\textsuperscript{76} See supra text accompanying notes 19-25.

\textsuperscript{77} As discussed above, see supra text accompanying notes 12-14, the premise B is derivable in the typical lost chance case from statistics available for those diagnosed correctly at time t_1 and for those diagnosed correctly at time t_2, with the delay from t_1 to t_2 being attributed to the misdiagnosis of the plaintiff’s condition by the defendant at t_1. In the more general case involving residual baseline risk, such as a toxic tort case, there may be more uncertainty associated with estimating the percentage of defendant-caused injuries in the reference situation.
characterizes the entire reference situation.

The problem of "direct inference" addressed in this part of the Article is this: under what conditions is the specific, categorical proposition C justifiably inferred from propositions A and B? Such direct inference is central to the judicial reasoning in the lost chance cases in that courts assume that whenever the S% in proposition B is greater than 50%, C is inferable with a probability greater than 0.5. They also usually assume that whenever S% is equal to or less than 50%, inferring C is not justified. In other words, they assume that proposition C is generally or always inferable from A and B alone. I will argue that this simple reasoning is invalid. Before setting out my affirmative account of direct inference, however, I will examine and reject several theories of warrant for direct inference.

A. Reasoning Based on Random Selection of Plaintiffs

One might think that using the relative frequency of defendant-caused cases to baseline cases to derive proposition C can be justified because the plaintiff can be treated as though she were a case chosen at random from the population of reference situation cases. This rationale conceptualizes the direct inference problem as though one were drawing a ball from an urn containing known percentages of red balls (defendant-caused cases) and blue balls (baseline cases). Recasting proposition C along these lines, we have the question: "What is the probability that the plaintiff we have in court has been drawn from the defendant-caused class of cases?"

Adopting this model, the reasoning is as follows. If a ball is drawn from the urn using a simple random procedure, then, by definition, every ball in the urn has an equal chance of being drawn.

78. The problem addressed in this Article is not the difficult one of how to identify or characterize the "narrowest reference class about which one has adequate statistics," Henry E. Kyburg, Jr., The Reference Class, 50 PHIL. OF SCI. 374, 377 (1983) (paraphrasing Reichenbach's famous formulation), but rather how to justify using any such reference class in the lost chance cases, assuming that some acceptable reference class can be identified through the litigation process.

79. The need for additional assumptions to make a valid inference has been recognized before. George James argued that the reasoning "[n]ine-tenths of all A's are X, B is an A, therefore the chances are nine to one that B is X" is not logically valid "except upon the assumption that A's may be treated as a uniform class with respect to the probability of their being X." George F. James, Relevancy, Probability and the Law, 29 CAL. L. REV. 689, 697 (1941). While it is uncertain what precise meaning to give to James' additional assumption, he clearly recognized that there is a logical gap to be closed.

Using such a selection procedure, the probability of drawing a red ball is identical to the proportion of red balls in the urn.\textsuperscript{81} This thinking might be transferred to the lost chance cases, by reasoning that because S\% of the reference situation cases are defendant-caused cases and because this plaintiff was drawn in a simple random fashion from the reference situation cases, the probability of the plaintiff being a defendant-caused case is S/100.\textsuperscript{82} This reasoning is appealing because it allows a direct translation of generic statistics (e.g., S\% = 61\%) into probabilities for specific causation (0.61). The reasoning is of interest to judges because it seems to sanction a direct and compelling inference ("as a matter of law") from a high baseline risk (e.g., 80\%) to a high probability that the plaintiff’s injury was not defendant-caused (0.8).

This “simple random draw” model, therefore, leads to the thesis that C is derivable from A and B on the basis of the additional premise “R”:

The specific plaintiff was selected from the set of all those persons in the relevant reference situation by means of some simple random process.

(R)

The central importance of this premise should be clear. The information about the selection process becomes the critical basis for warranting the inference. If I neither know nor assume anything about the process by which a ball is selected from the urn, I would have no rational basis for translating the percentage of red balls in the urn into a probability that the one actually drawn is red. For example, a selection process that involved inspecting the color of the ball before drawing it and purposely drawing two blue balls for every red one would defeat any such inference.

As a theory to explain legal reasoning in the lost chance cases,

\textsuperscript{81} This reasoning typically favors an objectivist interpretation of probability statements, in which the drawing and replacing of balls is the repeatable experiment. See supra part II.B.2.

\textsuperscript{82} This reasoning is somewhat related in its strategy to the “principle of indifference” in the classical theory of probability. That principle was a default rule for assigning probabilities to mutually exclusive but exhaustive types of events. See Cohen, supra note 43, at 43-47; Howson & Urbach, supra note 36, at 40-42; Kristin S. Shrader-Frechette, Risk and Rationality: Philosophical Foundations for Populist Reforms 112-16 (1991). Even if that principle is extended to assigning probabilities to groups, however, that is not the problem of direct inference. Direct inference assumes that statistics can somehow be derived for groups (usually empirically), and addresses the inference from those group statistics to the individual case.
however, an analysis based on a simple random plaintiff-selection model is suspect for several reasons. First, it represents a conceptual shift away from the specific causation problem of how the particular plaintiff's injury was caused, toward the selection issue of how this particular plaintiff emerged as a plaintiff from those in the reference situation. These are generally assumed to be very different issues: the first has traditional causal significance, while the second is much more tangential to the litigation. It is at least surprising to be told that when we inquire about the likelihood of specific causation, we really are inquiring about any bias inherent in the selection process (usually a self-selection process) by which an injured patient decided to bring a lawsuit. We thought we were inquiring about how the plaintiff became injured, not about how an injured person became a plaintiff.

Second, by focusing on the process of selecting persons from the reference situation to be plaintiffs in lawsuits, this model is probably conceptualizing the process by which this plaintiff was selected as a repeatable event, with the probability of drawing an instance of a defendant-caused injury being understood on a frequentist interpretation. This conceptualization is subtly inherent in the model of drawing a ball from the urn: when we imagine this activity we imagine a repeatable event, with probabilities interpreted in terms of relative frequency of "success." However, the objections to applying frequentist interpretations of probability statements to unique events, discussed above, are just as applicable to any attempt to conceptualize the particular plaintiff's selection as a "random draw" from the pool of persons in the reference situation.83

A third reason for rejecting a random plaintiff-selection theory as inadequate is that if it is true, then a relevant issue in the lawsuit should be whether the plaintiff-selection process over-selects or under-selects defendant-caused cases. On such a theory, an important factual element of the plaintiff's prima facie case should be the proposition that the process leading to the plaintiff's decision to sue was an unbiased one with respect to any risk factors for the injury I, whether known or unknown.84 Whether the decision by a particular plaintiff

83. See supra text accompanying notes 49-58. We intuitively object that we are not interested in a hypothetical plaintiff drawn at random but in the actual status of this particular plaintiff. And we think that this particular plaintiff's injury either was caused by this defendant's negligence or was not.

84. Any known risk factors would be included in \{C_1, C_2, \ldots, C_n\}, would presumably be the subject of evidence presented in the case, and should be taken into account in deter-
to sue was unbiased with respect to the injury outcome would become an issue of fact in the case. Psychological factors, for example, might influence the decision to bring a lawsuit and might also correlate with survival prospects from the underlying disease: an aggressive, combative attitude toward life might correlate both with willingness to sue and the ability to survive cancer. Economic factors such as significant wealth might also correlate both with suing and with survival (through financial ability to afford better medical care).

The point I wish to make is not that a trial in a lost chance case should include consideration of such psychological, economic or other factors. My point is rather that a plaintiff-selection theory requires a determination that the selection process was in fact random and unbiased. It is not sufficient that we are merely ignorant of any bias. What the model requires in order to warrant direct inference from A and B to C is knowledge of lack of bias in selection, not lack of knowledge of selection bias. In fact, I reject the plaintiff-selection theory in part because I do not think that establishing such unbiased self-selection should be an element of the plaintiff's prima facie case.

A fourth objection to the random plaintiff-selection model is that it obscures the true relevance of the percentage of defendant-caused cases. On the random selection model, it is irrelevant what process led to the proportion of red and blue balls in the urn: the entire force of the reasoning derives from the process of selection from the urn, not any process of coloration or of being placed into the urn. This model counterintuitively eliminates even the relevance of the very underlying causation that we thought was crucial. However, I believe that the causal system at work in the reference situation is surely relevant to adjudicating the particular plaintiff's case. It seems utterly peculiar that such relevance would be entirely replaced by an inquiry into whether the plaintiff's self-selection to be a plaintiff approximated a random draw.

A final concern with the random-draw model is that it relies for its persuasive force upon a mental image that is especially misleading with respect to the lost chance cases. The random plaintiff-selection model is dependent upon a mental image of drawing balls from an urn, a picture with typically the following features: (1) we can determin-
mine the color of any ball by means of a perceptual process that is epistemologically independent of the selection process (that is, a ball’s color can be determined regardless of how the ball was drawn); (2) we can determine the true percentage of red balls in the urn, at least in principle, by complete enumeration (without sampling); and (3) we can compare the results of any sampling process (the sample) with the true value of the population in the urn, so that any bias in the selection or sampling process can be determined. If these are typical features associated with our mental picture of drawing balls from an urn, it is important to appreciate that none of these features applies in a lost chance case (let alone in the more general case involving residual baseline risk).

In a lost chance case, there is usually no alternative factfinding process other than that used in the litigation by which we can determine whether a given person’s injury is defendant-caused or baseline. If there were such a method, we would use it as evidence in the litigation, and we would not have the problem posed by the lost chance cases. The problem of what to do in the face of residual baseline risk is a problem precisely because there is no known independent method for deciding how to classify any particular case. Moreover, the population in a lost chance case (“those in the reference situation”) is hypothetical and not finite, and we can usually observe only occasional actual cases. Finally, we can never independently assess the accuracy or bias of the plaintiff-selection process. We will never be able to prove, even in principle, that the selection process by which this plaintiff came to the court is an unbiased one, relative to the type of injury. Therefore, with so many features not in common between ball-drawing and plaintiff-selecting, the mental picture of drawing balls from an urn is a misleading abstraction that is of limited relevance to the lost chance cases.

Taken together, these considerations constitute persuasive reasons for not adopting a plaintiff-selection rationale for direct inference in the lost chance cases.85 We must look elsewhere for the logical

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85. If one were to pursue the ball-from-urn analogy, in a lost chance case it is as though we are handed a single ball concealed in a box (so its color cannot be independently determined); we are told that the ball is chosen from an urn in which approximately 5% of the balls were red, but we are not told how this particular ball was chosen from that urn; and we are instructed to award damages if, but only if, the ball is red. Most people would consider it unwarranted, I believe, simply to assume that the ball-selection process was a truly random one. Moreover, we do not really care about how the ball was drawn, but rather about the process leading to this particular ball having the color it has.
bridge needed to conclude proposition C from propositions A and B.

B. Pollock’s Theory of Direct Inference Based on Nomic Probabilities

An alternative approach to warranting direct inference is to find the basic rationale in the objective world, using an objective interpretation of probability. Such a theory has been put forward by John Pollock, who rejects at least certain versions of subjective probability. Pollock distinguishes between “indefinite probabilities,” which are probabilities about classes or properties of individuals, and “definite” or “single case probabilities,” which are probabilities that particular states of affairs obtain. Examples of indefinite probabilities are the probability of a smoker getting lung cancer or the probability of its raining “when we are confronted with a low pressure system of a certain sort,” while examples of definite probabilities are “the probability that Jones will get cancer” or “the probability that it will rain tomorrow.” Direct inference involves the logical movement from indefinite probabilities to definite probabilities.

Pollock’s account of justified direct inference posits two principal preconditions. The first is that the indefinite probability from which the definite probability is derived must be a “nomic probability”—not merely a statistical generalization, but a “law” about “physically possible objects” that supports counterfactual assertions about what would be the case in alternative possible worlds. Thus, the foundation for the direct inference must be a statistical law that holds

86. Pollock, supra note 26, at 97-103. “I regard the entire theory of subjective probability as being pervasively confused, turning upon a conflation of epistemic and prudential rationality.” Id. at 102. Pollock was not, however, considering the fairness formulation presented here, and I do not consider the reasons for his rejection compelling as against the Howson and Urbach formulation. Moreover, I consider his “objectivist” explanation of the meaning of probability statements in terms of proportions in physically possible worlds to carry unnecessary ontological baggage. Pollock, supra note 51, at 45-48. Pollock himself seems to regard his ontology as dispensable in some sense. Id. at 74. Regardless of the ontology adopted, it is noteworthy that his account of our intuitions about direct inference reinforces the analysis I propose in this Article.

88. Id. at 21-22.
89. Pollock, supra note 26, at 103-05; Pollock, supra note 51, at 109.
90. Pollock’s analysis arrives not at the truth of the definite probability, but at a “prima facie reason” for believing the truth of the definite probability. Pollock, supra note 51, at 77-79. The inference is a reasonable one in the absence of conflicting information, but it is possible to later obtain conflicting information that will render the inference unreasonable.
91. See id. at 32-38, 42-43, 81-86, 132-40.
across all possible worlds. Moreover, the definite probability that is the conclusion of the direct inference must also be lawlike. A definite probability about the proportion of times that a certain die would roll a four might be a nomic probability because of our extensive knowledge of the relevant physical structure of that die.92 The nomic probability expresses an "average" of events for that die across all possible worlds, and we might state our conclusions in terms of the propensities of the particular die involved.93 A direct inference to a conclusion about a particular thing is warranted in part by the lawlike nature of the statistical evidence.

The second logical condition for direct inference is that it must take into account all of the warranted beliefs about the specific individual that are relevant to determining the probability.94 Pollock refers to this as the "total evidence" requirement.95 Our direct inference to the probability in the specific individual's case is justified only if we intend to take into account, and do in fact take into account, everything relevant about that specific individual that we are warranted in believing.96 A warranted proposition is one that we "would become justified in believing" if we were "ideal reasoners."

Pollock's objectivist theory of direct inference is best understood as applying to the probabilistic laws of modern physics or to the kind of chance setup exemplified by a fixed game of chance. We can lay out the theory in terms familiar from our direct inference problem. If the generic probability in proposition B expresses a statistical law true across all physically possible worlds, and if the identifying characteristics \{C_1, C_2, \ldots, C_n\} have taken into account all of the properties

92. See id. at 33, 45-46, 115-23. Pollock would apparently deal with the problems with probability statements about unique and specific individuals by interpreting the statements to be about proportions obtaining in all "possible worlds" in which the specific individual occurs. See id. at 133-34. I am not here adopting any semantics of possible worlds.

93. See id. at 23-32, 267-78.

94. POLLOCK, supra note 26, at 104; POLLOCK, supra note 51, at 133-34. When we simply assert the definite probability statement (my proposition C), we are in effect asserting a "mixed physical/epistemic probability reflecting both the relevant nomic probabilities and our warranted beliefs about the object" of the probability statement. POLLOCK, supra note 51, at 132.

95. See POLLOCK, supra note 51, at 133.

96. Pollock precisely defines the concept of a "warranted" proposition. A proposition is warranted for someone if he could, "through reasoning proceeding exclusively from the propositions he is objectively justified in believing," (1) become justified in believing the proposition, and (2) his justification could not be defeated in the long run by reasoning proceeding exclusively from other propositions he is justified in believing. See id. at 87.

97. Id.
of the specific individual relevant to affecting that generic probability, then we are warranted in making the direct inference to proposition C. If new information subsequently arises that leads us to revise our estimate S%, then the conclusion of the direct inference can be revised accordingly.

Although Pollock’s theory of direct inference may be useful when dealing with relatively simple closed physical systems and gambling devices, there are serious drawbacks to using it in the lost chance cases. The requirement that the indefinite probability on which the inference is based (the generic statistic S% in proposition B) must be “nomic” and a “statistical law” will hardly ever be met in lost chance cases. Our knowledge of risk factors for most diseases is primitive at best, and few would venture to consider our provisional estimates of risk to be statistical laws. Even for the few diseases and risk factors for which our confidence in our risk estimates is fairly high, we have very little confidence in our estimates of integrated risks due to combinations of risk factors. This is true in general, let alone for the particular values for those risk factors possessed by the particular plaintiff. Even the combined risk of lung cancer from cigarette smoking and asbestos inhalation is difficult to assess, let alone integrated risks for diseases less well studied. Our knowledge of the risk factors at work in the particular reference situation is hardly ever going to approach the level of being lawlike.98

Pollock’s second requirement of “total evidence” also poses severe difficulties. It is a heavy burden to require that we take into account in the direct inference all information about the particular plaintiff that we are warranted in believing, in Pollock’s strong sense of “warrant.”99 We typically know or could find out a great deal of information about the plaintiff, but our problem is not knowing which information is relevant to the disease or injury. If we cannot decide what of what we know is relevant, why should we profess to take “total evidence” into account? In fact, our usual conviction in lost

98. Pollock acknowledges that two direct inferences based on two independent risk factors might lead to inconsistent probability estimates. Id. at 130, 132-33. In such a case, without additional information, “we are left without an undefeated direct inference to make,” since each risk factor’s probability undercuts the other. Id. However, the inability to make any direct inference in such cases is a major problem for lost chance reasoning, since we may well have independent and different probabilities of injury given different risk factors, and no information about the interplay of those factors that will let us decide a single probability and will warrant a single direct inference.

99. See supra note 96.
chance cases is that we have not taken all our information into account. But Pollock's theory suggests to us that unless we can make this claim to using total evidence, then we would be unreasonable in making the direct inference.

I think that Pollock's theory of direct inference captures more of the logic of that reasoning than does the plaintiff-selection theory. Pollock's chief advantage is that he re-orient our attention to the underlying causal system that produced the injury, and deemphasizes the process of plaintiff selection. However, he demands too much of that causal system and of our knowledge of it. In the theory I propose below, I retain reference to this underlying causation, while cutting back on the demands on our knowledge. The move in the next part is to harness objective probabilities about such causal systems to a subjective probability conclusion about the particular plaintiff.

C. Howson and Urbach's Minimal Fairness Analysis of Direct Inference

Howson and Urbach have proposed their own theory of direct inference, based on the "Principal Principle" formulated (although somewhat differently) by David Lewis.\(^\text{100}\) The core rationale is based on what I call minimal fairness, as follows. If someone believes that a causal system would, if repeated, generate a series of outcomes that can be characterized by an objective or frequentist probability, and this were all the information believed by that person to be relevant and true about the next outcome from that system, then the only fair betting quotient that can be subjectively assigned to that next outcome must be equal to the value of the objective probability. If that person were to assign some other probability, and believed it to be minimally fair, then she would be asserting that, in her view, there is no a priori advantage to betting for or against that outcome on those odds. But by hypothesis she in fact believes that repeated trials will generate a different frequency of outcome, so she should believe that setting different odds would be to disadvantage some better a priori.

This is of course a subjective unfairness. She might be mistaken

about the causal system or about the correct value for the objective probability. However, given the factfinder's subjective beliefs about that causal system and about the probabilities thought to describe its outcomes, minimal fairness requires that person to assign to the next outcome a subjective probability identical to the value believed to be the objective frequentist probability. Thus, under the Principal Principle, a subjectively assigned definite probability should sometimes be governed by beliefs about objective indefinite probabilities, if the subjective betting quotient is to be minimally fair.

In a lost chance case, a juror might conclude that the causal system at work in the plaintiff's case (in the reference situation) would produce defendant-caused injuries with a certain objective probability. Given this belief, and given no additional information about the particular plaintiff other than that she was an outcome from this causal system, then minimal fairness requires the juror to assign that same probability value to the proposition that the specific plaintiff is a defendant-caused case. This subjective probability assignment to the particular case is not only warranted but compelled, provided the juror has the requisite beliefs about the underlying causal system and that is all the relevant information the juror possesses about the particular plaintiff. These two preconditions for warranted direct inference must be examined further.

The first condition is that the juror must believe that the causal system generating the outcomes (injuries) must be random and relatively stable, so that the outcomes can be correctly characterized by a probability. The juror must believe, therefore, that there are risk factors that produce baseline and defendant-caused injuries in a proportion that is sufficiently stable so that it can be characterized as a probability. Moreover, enough must be known about that system so that a particular value can be assigned to that probability.

The second condition, which I will refer to as the "sole evidence" requirement, is that all that the juror believes to be relevant about the specific plaintiff is that the plaintiff is an outcome from that causal system. This condition is essential for compelling the inference required by the Principal Principle. If a juror believes that some characteristic of the particular plaintiff renders that plaintiff more than merely an outcome of the causal system characterized by

101. Howson and Urbach specify that the outcomes must be a von Mises collective. HOWSON & URBACH, supra note 36, at 202-20, 227-30. For a discussion of von Mises' notion of a collective, see supra part II.B.2.
the objective probability, the juror could (and perhaps should) refuse to assign that generic probability to the particular case, and would not be unfair in refusing to do so. For example, if the juror concluded that the particular plaintiff was not "representative" of the patient outcomes from the causal process, the juror might assign a different probability to the particular plaintiff. The Principal Principle sometimes allows us to decide that a betting quotient is not minimally fair, but if the Principle does not apply, then the fairness of the subjective probability assignment is simply unresolved.

As applied to lost chance reasoning, this rationale sometimes allows us to infer a subjectively assigned probability in proposition C (describing a specific unique event) from a generic objective probability in premise B. Moreover, this result is achieved on the basis of the same principle of minimal fairness that we used to require subjective odds assignments to satisfy the probability calculus. This is a powerful yet economical result.

On the other hand, the rationale might be too subjective for legal purposes. It is not important under this analysis that the factfinder actually be correct about the causal system, the value of the objectively interpreted probability in proposition B, or the representativeness of the particular plaintiff as an outcome from that system. The Principal Principle only assumes that the finder of fact has certain beliefs about the causal system and the plaintiff. But the law is interested in more than internally consistent factual findings. The lost chance cases would not be problematic if we were willing to settle for mere subjective consistency. The goals of substantive and distributive justice, optimal deterrent effect, and optimal allocation of societal resources all require sufficiently accurate factfinding.102

A second weakness of the fairness account is that it applies in only a narrow subset of cases. The "sole evidence" requirement creates difficulties similar to those raised against Pollock's total evidence requirement. Jurors typically have a great deal of additional particularistic information about a specific plaintiff. They do not think of the plaintiff as merely another outcome of the causal system for which generic statistics are available. They have additional informa-

102. An inference bridge from objective chances to subjective beliefs is also an epistemological goal. See HOWSON & URBACH, supra note 36, at 228; 2 LEWIS, PHILOSOPHICAL PAPERS, supra note 100, at 86-87, 90-92. Additional information undercuts the compulsion of the Principal Principle, and leaves the factfinder free to assign the subjective probability on other (so far indeterminate) grounds.
tion about family history, life experiences, and symptoms that goes beyond the risk factors addressed in the available studies. The causal relevance of this additional evidence may be suspected by the jury, or even thought probable, yet the additional factors were not taken into account in the scientific study generating the estimated S%. If the "sole information" requirement is taken seriously, it may be a stumbling block to any widespread use of direct inference in lost chance cases.

In the next part of this Article, I will weld the objective causal focus of Pollock's theory to the inference of subjective probability required by the Principal Principle. With the addition of a more permissive notion of sufficient knowledge about the causal system, the resulting theory of warranted direct inference will prove useful in analyzing the lost chance cases.

D. A Proposed Theory of Warrant for Lost Chance Inferences

The logical conditions for "warrant" in law might be different from those applicable in the sciences. The courts are bound to adjudicate cases, and they in fact always affect the interests and rights of the parties in the sense that parties must win or lose. In deciding cases, courts must employ a notion of justification that balances procedural fairness, substantive social policy, morality, and judicial administration, as well as epistemic adequacy. Nevertheless, the legal interest in epistemic adequacy is strong, for unless factfinding gets the facts roughly right, there may result a failure to achieve such tort goals as optimal deterrence and distributive justice. In this Article, I cannot attempt to articulate a theory of how this balancing of objectives should be made. I likewise leave for another time the general question of the extent to which a theory of warrant should incorporate, at least implicitly, the competing policy goals at work in the context in which the inference occurs. Although these tasks are bypassed here, it is important to recognize that the account of direct inference in which the law is interested probably need not attain a level of epistemic validity desirable in the sciences.

The lost chance cases are an important species of direct inferences in part because they present situations in which an estimate of the true percentage of defendant-caused cases in the reference situation can be made with considerable confidence. We are often confident

103. See supra text accompanying notes 12-14.
that there was some increase in risk due to the defendant's negligence, and that our estimate of the magnitude of that increased risk is reliable. Thus, we often have considerable confidence in accepting propositions A and B as true.\textsuperscript{104} Our confidence in the truth of A and B can also make the desire to warrant a direct inference even more compelling. Even if we were to assume in a particular case, however, that A and B are true, the direct inference problem would remain: What more should be true or warranted, before the inference to proposition C is warranted?\textsuperscript{105} I suggest that the above review of Pollock, Howson and Urbach leads to the following conclusions.

First, the reasoning from "minimal fairness" drawn from Howson and Urbach provides an adequate rationale for inferring a plaintiff-specific probability (in proposition C) from a generic probability (based on proposition B). The random plaintiff-selection theory is inadequate because it relies entirely on only one feature of the inference problem (plaintiff selection), and in so doing renders irrelevant the underlying causal process in which the law is interested. Pollock's account is unhelpful in its requirements for "total evidence" and "statistical laws"—requirements that are not only imposed on proposition B, but that impose on the probability assertion in proposition C the "physical" interpretation of being an estimate of a true proportion of defendant-caused injures "averaged" across physically possible worlds. The "subjectivist" interpretation of minimal fairness allows us to sidestep these disadvantages, and to ground the move from generic ("objectivist") probability to plaintiff-specific ("subjectivist") probability on the Principal Principle and on a policy of minimal fairness to the parties.

Second, the legal interest in the objective validity of a generic probability estimate based on proposition B can be addressed by placing certain requirements on that proposition. The central goal is to have the generic percentage S% adequately describe the expected out-

\textsuperscript{104} Premises A and B are:
This specific plaintiff is characterized by risk factors \(\{C_1, C_2, \ldots, C_n\}\);
and
Out of the class of persons characterized by risk factors \(\{C_1, C_2, \ldots, C_n\}\), an estimated S% would suffer injury I as a result of the defendant's negligence (i.e., S% would suffer defendant-caused injuries).

\textsuperscript{105} Conclusion C is as follows:
There is a probability of S/100 that this specific plaintiff's injury of type I is a defendant-caused injury.

See supra text accompanying note 77.

See supra text accompanying note 77.
comes of an underlying causal process. This can be achieved by three sub-requirements on the set of risk factors \( \{C_1, C_2, \ldots, C_n\} \) in proposition B.

The first sub-requirement is that those risk factors that are used in generating the generic estimate \( S\% \) of the true percentage of defendant-caused cases in the reference situation (premise B) must be causal factors relative to the injury complained of. The law is not interested in basing the direct inference on an estimated percentage that reflects mere statistical association. Pollock is correct in thinking that the direct inference is warranted only if an objective causal system underlies the estimate of defendant-caused cases. In the lost chance cases, we should try to understand why the delay in diagnosis would ordinarily lead to an increase in objective risk. The evidence presented should therefore include sufficient data and theory about causal mechanisms so that the finder of fact can rule out of consideration any predicates not causally related to the injury (such as red-headedness). If the probability estimate is based on causal and not coincidental factors, then proposition B will also warrant counterfactual claims about the reference situation, and the inferred proposition C will also (in fairness) warrant counterfactual claims about the particular plaintiff.

The second sub-requirement is that the members of the set of risk factors \( \{C_1, C_2, \ldots, C_n\} \) used to identify the reference situation and to generate the generic statistics in proposition B should be significant risk factors for that injury. Mere causal relevance is not sufficient to ensure that a factor is directly and non-spuriously related to the injury.\(^{106}\) Including a significant risk factor in the causal model adds to the predictive power of the model as a whole, and eliminating any significant factor can be expected to alter the estimate \( S\% \) itself. Put another way, the set of variables used to estimate the expected percentage of defendant-caused cases in the reference situation should not contain variables that are merely of marginal or indirect causal relevance. The set \( \{C_1, C_2, \ldots, C_n\} \) should contain only those factors that make a direct, significant predictive contribution to the causal model as a whole.

Third, we know that in practice the set \( \{C_1, C_2, \ldots, C_n\} \) is usually incomplete. If \( \{C_1, C_2, \ldots, C_n\} \) is the set of risk factors known to be significant for the plaintiff's type of injury, and whose

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106. See, for example, my discussion of "causally spurious correlations" in Walker, supra note 21, at 613-14, and sources cited therein.
values are known in the plaintiff's case, there are probably other risk factors that are unknown but causally significant for the injury, but which are not included in \( \{ C_1, C_2, \ldots, C_n \} \). Medical research is seldom so advanced that we know all the significant risk factors for a medical condition. To that extent, the set \( \{ C_1, C_2, \ldots, C_n \} \) does not completely specify the true causal model for the injury. The normative ideal toward which we strive, however, is to have a causal model that precisely covers the significant variables and their values in the plaintiff's case. This is the point of having the reference situation defined in terms of the actual risk factors present in the plaintiff's particular case—not in terms of what studies scientists happen to have performed. But there are almost certainly causally significant factors in the particular plaintiff's case that medical science has not studied and may never study. Moreover, there may be interactive effects of the specific combinations and levels of significant causal factors in the plaintiff's case that, if the interactive effects were adequately studied, would lead to a somewhat different estimate than \( S\% \). So in the lost chance cases, we must face the fact that the causal models are almost always going to be incomplete.

The law and many human affairs (including, I suspect, even the medical sciences) need not wait until the best possible estimate of the true percentage is in hand, before a direct inference is warranted. On the other hand, the estimate \( S\% \) has to be "good enough" for the purpose at hand. How good the estimate needs to be in tort cases is necessarily a function of balancing competing objectives such as distributive justice, economic efficiency, and administrative effectiveness. However, we may be able to capture the appropriate level of confidence in a general fashion by requiring that \( \{ C_1, C_2, \ldots, C_n \} \) must be a reasonably complete set of the significant causal factors for the injury. By this I mean that a reasonable person would conclude, based on all the evidence produced in the litigation, that the estimate of \( S\% \) is unlikely to change substantially as new information about risk factors arises in the foreseeable future.

This third subrequirement is of course a pragmatic counterpart to the "total evidence" requirement of Pollock. I have argued above that Pollock's requirement of "total evidence" is unnecessary as part of the meaning of proposition \( C \), as well as impractical as a condition for its warrant. On the other hand, with respect to Howson and Urbach, I have argued that a purely subjective evidentiary basis for direct inference would be unsatisfactory to the law. It is not sufficient—given the legal objectives competing with fairness—that the
juror merely believes that \( S\% \) generates the correct probability estimate. In order for the direct inference to be legally useful, \( S\% \) must substantially approximate the true percentage of defendant-caused cases in the reference situation. My proposal attempts to stake out a middle ground for proposition B. The law’s requirement for permitting the direct inference should be that the factfinder must reasonably conclude, given the evidence, that the set \( \{C_1, C_2, \ldots, C_n\} \) probably contains all of the significant and causally relevant risk factors for the particular plaintiff’s injury, such that the estimate \( S\% \) is expected to be regarded as substantially accurate for the reasonably foreseeable future. When the evidence warrants such a conclusion, and the juror in fact reaches that conclusion, then the juror should draw the conclusion \( C \), if she is being reasonable and minimally fair.

This proposal refocuses the evidentiary core of the direct inference back on the particular plaintiff. It forces the finder of facts to evaluate the descriptive and explanatory adequacy of the generic statistics in proposition B with reference to the risk factors actually at work in the plaintiff’s case. It recognizes, however, that a “science of specific individuals” is inherently unattainable, and that even decent approximations are often hard to come by. It is the jury’s task, in the face of this problem, to evaluate the validity of the generic causal model that is actually available, to decide whether it is a “reasonably good approximation” as a model of the plaintiff’s case, and to deal with the parties on the basis of minimal fairness. One requirement of minimal fairness is that if that generic model is “good enough,” then the direct inference to proposition C is not only warranted but compelled.

In conclusion, judges faced with lost chance cases have not adequately analyzed the evidentiary requirements needed to make the direct inference a reasonable one. I believe that the random plaintiff-selection rationale is their intuitive and predominant line of reasoning—although I have argued above that this line of reasoning is clearly inappropriate. What judges need is an epistemologically adequate yet practically useful theory about when the available evidence justifies a direct inference of proposition C from premises A and B. My proposal is that such an inference is warranted and compelled whenever the set \( \{C_1, C_2, \ldots, C_n\} \) is a reasonably complete set of the significant and causally relevant risk factors for the plaintiff’s injury. Such a theory, of course, does not resolve all of the evidentiary and
epistemological problems encountered in lost chance cases, let alone the broader policy questions of fairness, justice, and efficiency. But the theory does lead to some very interesting solutions to some issues of law routinely faced by courts in lost chance cases. In the next part of this Article, I use this theory of warranted direct inference to explore those solutions.

IV. RESOLVING ISSUES OF LAW IN THE LOST CHANCE CASES

The task in this part is to use the proposed theory of warranted direct inference to resolve some practical legal problems that arise in the lost chance cases. These problems center on the substantive determinations that the finder of fact should make before making the direct inference, but also include such questions as how a jury should be instructed, who should bear the burdens of persuasion and production on various sub-issues, and what constitutes sufficient evidence to permit a jury determination. The proper answers to these questions can be appreciated only within the context of the proposed theory of inference based on minimal fairness.

A. The Principle of Minimal Fairness

We are now in a position to step back and consider the fundamental underlying problem presented by the baseline risk paradox, and in particular by the lost chance cases. The problem of direct inference is the problem of how to warrant an inferential move from the generic to the specific, from statistics about groups to probabilities about individuals, when the predicates being considered are not defined in terms of directly observable properties. That is, when we cannot warrant the conclusion by directly inspecting the specific individual, how does the generic information create the needed warrant?

The approach that I propose to adopt is the one developed by Howson and Urbach, using Lewis's "Principal Principle." This approach is to interpret the probability assertion about the individual in "subjectivist" terms, by requiring it to be a fair betting quotient. This principle of minimal fairness to the litigating parties also warrants

107. This theory does not suggest, for example, how particularistic information about the plaintiff that is thought to be causally relevant, but which is not taken into account in the generic statistics, should be incorporated into the definite probability in conclusion C. See supra part II.A.4 and note 75.
108. See supra part III.C.
(and under certain conditions compels) that the numeric value of the
generic probability be adopted as the fair betting quotient for the
individual case. Therefore, the basis for warranted direct inference is
the principle of fair and equal treatment to the parties. 109 The
factfinder is warranted in drawing a conclusion about the probability
that the individual plaintiff is a defendant-caused case because, if
certain conditions on premise B are met, to do otherwise would be to
treat one or another party unfairly.

For the lost chance cases, this fairness rationale constitutes a
fundamental shift. Once courts understand that the specific factfinding
is itself warranted by the fundamental policy of fairness to the parties,
they should feel freer to incorporate additional policy concerns into
their decision making. Some courts have pointed out that the uncertain-
ty about what would have happened in the plaintiff’s case was
itself caused by the defendant’s negligence. 110 They also point out
that in many cases the defendant owed a special duty of care to the
plaintiff due to the physician-patient relationship. 111 However, once
we realize that the direct inference itself is based on a policy of
minimal fairness to the parties, then it is easier to understand why
this policy of even-handedness might well be modified by additional
considerations of the defendant’s role and responsibilities. If my pro-
posed theory of warrant is adopted, it should make more sense that
some defendants relinquish part of their claim to equal treatment
through their actions or a special relationship to the plaintiff.

Of course, the proposed theory is not confined to lost chance
cases. It applies to any case involving residual baseline risk, and any
case involving direct inference. In many such cases outside the typical
lost chance context, there will be no physician-patient relationship or
other special relationship creating a special duty. Nevertheless, there
may be other policy considerations that can come into play in deci-
ding how tenaciously to hold to the principle of minimal fairness. My
intent here is not to foretell the outcomes of those policy debates, but
to identify them as policy debates, once we understand that direct
inferences are in fact warranted by a policy of fairness.

109. I have also addressed the concern that this subjective approach might render the
entire inference unconstrained by any objective criteria. I have argued that the direct inference
should proceed only if certain conditions on the generic objective statistics have been met.
See supra text accompanying notes 105-07.
111. E.g., id. at 51-52; see RESTATEMENT (SECOND) OF TORTS § 323 (1965).
B. Required Findings and the Burden of Persuasion

According to the theory I am proposing here, direct inferences in the lost chance cases are inferences to a conclusion about the subjective probability that the particular plaintiff's injury was defendant-caused. Such an inference, with a subjective probability equal to S/100, is not only warranted, but compelled whenever the finder of fact concludes that S% is an accurate estimate of the true percentage of defendant-caused injuries that would be caused to groups of patients similarly situated to the plaintiff (that is, to groups of patients in the reference situation).\footnote{112} This conclusion, however, depends upon the proposition that the causal model used to derive that statistical estimate in fact adequately describes the reference situation, which will be true provided the set of risk factors \( \{C_1, C_2, \ldots, C_n\} \) is a reasonably complete set of the significant and causally relevant risk factors that were in fact at work in the plaintiff's specific case.

Although the underlying rationale for this conclusion has been given in a theoretical framework in part III above, there is also an intuitive basis. Unless the factfinder is satisfied that the causal model used to generate the group statistics is also an adequate model for the plaintiff's own case, those statistics should not be applied to the plaintiff's case. Further, if the causal model does in fact adequately describe the plaintiff's situation, the factfinder is not at liberty to disregard it. In fairness, the only option open to the factfinder is to conform her subjective probability (fair betting quotient) to the generic statistics. Thus, the direct inference, under these circumstances, is not only warranted but compelled.\footnote{113}

This is not to suggest, of course, that making the required findings needed to warrant the direct inference is an easy matter. It will not generally be easy to determine that the statistics are based on a causal model that takes into account all of the significant and causally relevant risk factors. Nor will it generally be a simple matter to make appropriate adjustments in the estimate S% to reflect factors whose

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\footnote{112}{Some of the uncertainty surrounding the value S/100 will be due to the types of uncertainty inherent in any scientific information, much of which is quantifiable. \textit{See supra} part II.A.4. Additional uncertainty, however, will be due to the possibility that the model used to generate the generic statistics in Premise B does not adequately describe the plaintiff's reference situation.}

\footnote{113}{It should be emphasized that this analysis applies to any direct inference in the face of residual baseline risk, and not merely to lost chance cases.}
relevance has not been scientifically studied. These are difficult tasks involving treatment of available data, evaluation of study design, and professional judgment concerning missing data and variables. The implications of the difficulty of this task for judicial decisions on motions challenging the sufficiency of the evidence will be discussed in the following subsection of the Article.

I suggest that the traditional requirement that the jury must find specific causation has been the normal means of communicating to the jury a rough surrogate for the logical conditions required by my theory of direct inference. The traditional requirement of specific causation is that the jury must determine that the defendant’s negligent act probably caused the specific injury of the particular plaintiff. Whether the rationale for this requirement has been fairness to the defendant or an expectation of effective deterrence, it has seemed reasonable to require that the defendant’s negligent act was in fact a cause of the plaintiff’s injury.

If under traditional instructions the jury has determined in a lost chance case that the defendant’s negligent act was a “but for” condition in bringing about the plaintiff’s injury, or at least a “substantial factor” in the set of jointly sufficient causal factors, then the jury probably found evidence sufficient to satisfy the logical conditions under my theory of direct inference. If there is convincing evidence of traditional specific causation, then there is probably also convincing evidence that the conclusion was based on a causal model that adequately took into account all the significant causal factors in the plaintiff’s case. I suggest that if the jury can in fact make a finding of traditional specific causation, then it is probably warranted in making the direct inference necessary to the case. The conclusion is that the traditional judicial position is consistent with my theory: if there is specific causation, then there is also warrant for direct inference.

The problem in the lost chance cases has been, of course, precisely this specific causation requirement. The presence of residual baseline risk means that even after all the available information has been taken into account, we are left with generic statistics about groups. This is probably a common situation in toxic tort cases, and we often face an obvious leap from generic group statistics to the specific plaintiff. The traditional concept of specific causation provides no conceptual bridge for the chasm, leaving the factfinder to her intuition that if the statistical estimate of defendant-caused injuries is “big enough,” she should make the leap, and not worry about the fact that she is guessing. The lost chance cases are so difficult be-
cause it seems that, although the statistical estimate of defendant-caused injuries is "too low," we should sometimes make the leap to specific causation, or ignore the traditional requirement of specific causation.

My analysis provides a conceptual bridge for all cases, regardless of the size of the statistic. My analysis shows that the inferential leap is indeed warranted in certain specified circumstances. It also shows that determining when those circumstances obtain is not an easy matter in many toxic tort and lost chance cases. Moreover, it leads to the conclusion that the traditional instruction on specific causation provides a sufficient but not necessary criterion for when those specified conditions obtain. An inference based on a finding of specific causation is probably warranted, but it does not follow that the inference is never warranted unless such a finding is possible.

My analysis of direct inference leads to the conclusion that the traditional instruction on specific causation, while normally a sufficient guarantor of correct results, is unnecessarily strong and unfortunately vague when the factfinder confronts the residual baseline risk of the lost chance cases. It is unnecessarily strong in multiple factor cases, when there are significant but non-essential factors contributing to the total risk. While direct inference may be warranted with respect to "but for" factors, that does not mean it is never warranted with respect to factors with less critical contributions. On the other hand, the traditional specific causation instruction couched in terms of "substantial factor" is unnecessarily vague, in that it provides too little guidance to a serious factfinder. The substantial factor instruction's "heart" might be in the right place, but its mind is elsewhere.

My theory provides a clear elaboration of what must be found to be the case before a direct inference to the specific case is warranted. It might be more beneficial, at least in such cases, to instruct the jury more informatively, by telling them that they must find for the plaintiff if they determine that the statistical evidence adequately takes into account all of the significant causal factors likely to have played a role in bringing about the plaintiff's injury, and that such evidence convinces them that "probably" the defendant's negligence was also a cause of that injury.\textsuperscript{114}

\textsuperscript{114}. I do not wish to argue here that jury instructions should necessarily be revised to incorporate my theory on warrant, for far more is involved in the design of jury instructions than I am able to take into account here. Moreover, I have indicated my belief that the "substantial factor" instruction, while vague and lacking in guidance, might convey sufficient
There is, however, an extremely important disadvantage to the traditional conception and instruction on specific causation. With a single issue of specific causation, it is too easy to continue the traditional approach of placing the entire burden of persuasion on the plaintiff. One reason for this is that specific causation appears to be a single, unified determination, without the potential for allocating the burden of persuasion to more than one party. Another reason is that specific causation appears to judges to be an issue of stubborn scientific fact. This perception changes dramatically when specific causation is replaced by the set of determinations or sub-issues proposed by my theory of inference, and the principal policy underwriting the warrant for direct inference is no longer science but fairness.

One could, of course, adopt my theory of warrant and continue the traditional allocation of persuasion entirely to the plaintiff. However, there is no longer a clear necessity to do so. The policy of holding defendants responsible for the uncertainty their negligence has caused, as well as the policy of holding physicians responsible for the unreasonable additional risk imposed upon their patients, may lead to other approaches. One approach would be that once the plaintiff establishes that the defendant’s negligence was a significant risk factor for the plaintiff’s injury, the defendant must bear the burden of per-

information to be adequate. It may be that the usefulness of my theory is best confined to judicial findings of fact, judicial rulings on motions, and judicial thinking when devising new legal concepts and doctrines. Some courts have explicitly rejected converting judicial reasoning into a jury instruction. See Thompson v. Sun City Community Hosp., Inc., 688 P.2d 605, 615-16 (Ariz. 1984) (adopting RESTATEMENT (SECOND) OF TORTS § 323 as rule of law for judge but not jury, and allowing plaintiff’s case to go to the jury on expert opinions that did not quantify plaintiff’s lost chance of complete recovery and that characterized plaintiff’s chance absent negligence as one “substantially better” than plaintiff’s actual chance; court refused to instruct jury on § 323, but authorized instructions on only “general principles of probability and causation” and required the jury to find for defendant unless it found “a probability that defendant’s negligence was a cause of plaintiff’s injury”).

I do believe, however, that more informative and precise jury instructions are possible, if the courts wish to create them. I suggest, for example, the following language, which manifests a split allocation of the burden of persuasion between plaintiff and defendant that will be discussed in the text:

Even if you find that the defendant acted negligently, the defendant is still not liable unless that negligence proximately caused this plaintiff’s injury. If the plaintiff proves, by a preponderance of the evidence, that the defendant’s negligence significantly increased the risk of the plaintiff’s injury, then you should find that the plaintiff’s injury was in fact proximately caused by that negligence, unless the defendant proves that most people in the plaintiff’s situation who suffered the same injury would have done so in any case, whether the defendant had acted negligent-ly or not.
suaision that the plaintiff was not in the defendant-caused category. In other words, the defendant would have the burden of persuasion on the existence of an adequate causal model that would warrant and compel a direct inference to a low subjective probability. The defendant would be entitled to an instruction, however, that if the defendant proves that the true percentage of defendant-caused cases is less than 50%, based on a causal model that takes into account a reasonably complete set of the significant causal risk factors present in the plaintiff's case, then the jury must find a (subjective) probability for the plaintiff less than 0.5 (that is, the jury must find for the defendant). For example, any biasing effects due to plaintiff self-selection might be introduced into the case in this manner, with the burden of persuasion on the defendant.

Other approaches are possible. For example, the plaintiff might be given some burden of persuasion on generic causation, with the burden of showing, on the basis of relevant statistics, that the defendant created a "substantial" increased risk for persons in the reference situation—a risk perhaps in excess of some threshold amount, ranging up to 50%. If such a substantial risk were shown, then the defendant would have the burden of showing that additional risk factors present in the plaintiff's case in fact compelled a lower subjective probability that is not "substantial."

This last approach illustrates the distinction between my theory of direct inference and judicial policies about compensation for increased risk. Whether or not society should compensate victims of increased risk through judicial action is a pressing contemporary issue of tremendous importance. The theory that I am putting forward here does not itself lead to any particular conclusion in that debate. My

115. I assume in this Article that 0.5 is the appropriate decision threshold, and the proper quantitative interpretation of the legal term "probable." That is, if a subjective probability is less than 0.5, the conclusion is possibly true but not probably true, while subjective probabilities over 0.5 indicate that the proposition is probable. This is intended to interpret quantitatively the preponderance of the evidence standard of proof. I wish to emphasize, however, that I am merely accepting this, at this point, as a convenient and conventional assumption about the appropriate meaning of preponderance, and about the appropriate legal significance of the subjective probability found by the factfinder.

Given this assumption of 0.5 as the quantitative interpretation of preponderance, my theory gives the same result as the usual judicial ruling in cases in which the plaintiff is able to prove, on the basis of an adequate causal model, that the true percentage of defendant-caused cases is over 50% (with a resulting subjective probability over 0.5). See supra text accompanying notes 22-25.

116. For a discussion of plaintiff self-selection, see supra part III.A.
theory of warrant for direct inference is compatible with traditional rejection of such compensation, as well as with adoption of compensation for mere increased risk.

Similarly, I do not here analyze any of the proposed schemes to introduce concepts of “proportional causation” or “proportional damages,” and do not discuss the various substantive policies that might lead to such introduction. However, a word of caution deriving from my theory is appropriate. To the extent that such proposals effectively eliminate the requirement of specific causation in the lost chance cases (perhaps on the argument that proof of negligence and generic causation should be sufficient to impose liability), care should be taken to ensure that liability is imposed only if the logical conditions of direct inference are met. If I am correct that the requirement of traditional specific causation has acted as a surrogate tending to ensure that those logical conditions are met before liability is imposed, elimination of that surrogate without an adequate substitute simply invites unfair conclusions of subjective probability. Of course, this caveat is of little concern if what one wishes to achieve is a radical revamping of the very basis of tort liability.

While I do not argue here that there are no compelling reasons for introducing new concepts of compensable injury or causation, I do suggest that the adverse collateral effects of such conceptual innovations might be unnecessary in many lost chance cases, if only the courts were to proceed with clearer notions of probability and direct inference. I do urge that if the courts are tempted to revise such foundational concepts merely in an effort to address the lost chance cases, they should do so only upon an adequate understanding of the direct inference at the heart of those cases, and only after considering whether less drastic measures would satisfy their concerns.

C. Sufficiency of Evidence on the Findings

Given my analysis of the logical requirements for warranted direct inference, some comments should be made about resolving certain evidentiary problems in the lost chance cases. Jury determinations should be minimally fair, in the sense of satisfying the probability calculus. When all of the logical conditions for direct inference have been satisfied and an estimate of the true percentage of defendant-caused cases is obtained that takes into account a reasonably complete set of the significant causal factors present in the plaintiff’s case, then minimal fairness requires that the subjective probability for the specific plaintiff be set equal to that same proportion. Any other subjective probability is unwarranted. In order to make such a direct inference, a reasonable factfinder must have sufficient evidence from which to determine that the logical requirements for direct inference are met. Hence, it is reasonable for a trial court judge to review the evidence to determine whether such evidence has been produced by the party urging a direct inference. 118 If a party relying on direct inference has produced insufficient evidence, 119 or if there is compelling or uncontested evidence that all the conditions have been met and the required subjective probability is too low (e.g., 0.1), then that party should suffer a directed verdict on causation.

The findings required to warrant the direct inference, however, are not simple determinations. They require the application of considerable expertise and judgment on statistical analyses of data and on the adequacy of study design, as well as medical judgment about particular features of the plaintiff’s personal situation. In many lost chance cases, a judicial determination that a party’s evidence is insufficient as a matter of law is unwarranted. For example, a plaintiff

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118. In the lost chance cases, this has generally been the plaintiff. There is no reason in principle, however, why the defendant might not argue a direct inference from statistical evidence as part of a rebuttal argument or an affirmative defense. In addition, there may be policy reasons to shift the burden of persuasion to the defendant. See supra text accompanying notes 114-17.

119. Although a plaintiff may rely on direct inference, and if choosing to do so should be required to produce quantitative evidence of the quality needed to support such an inference, I do not here argue that direct inference is the only acceptable method of proof in a lost chance case. Therefore, I do not take a position on whether quantitative evidence of the magnitude of defendant-caused risk is required in all cases before a plaintiff can reach the jury. For the controversy over whether quantitative evidence is required, see cases cited supra note 8.
who has the entire burden of production on direct inference and who has produced statistical evidence showing that only 30% of injuries in the reference situation are defendant-caused, might also present evidence that there is considerable uncertainty around the 30% statistic. She might also produce testimony that there is reason to conclude that the true proportion in her reference situation is probably higher than 30%, because several significant risk factors present in her case were left out of account in the available scientific studies. Judges may have become too enchanted with the statistics, and may be too quick to translate "49%" (an objective statistic) into "improbable" (a subjective probability), when that inference can only be warranted by qualitative judgments about the descriptive adequacy of the causal model underlying the statistics.

Although courts have recognized that qualitative and "particularistic" information about the plaintiff's situation is somehow relevant to the lost chance case, they have been unclear about how the presence of such information relates to the sufficiency of the evidence. My analysis of the baseline risk paradox leads to the conclusion that the relevance of qualitative information is probably to adjust the baseline risk statistics, not to remove the uncertainty altogether.120 My theory of warranted direct inference suggests that particularistic information is relevant only if it is about a significant causal risk factor that is present in the plaintiff's case. If that risk factor has not been taken into account in deriving the statistical estimate of 5%, then perhaps a reasonable conclusion would be to begin with that statistical estimate but to adjust it in one direction or the other in arriving at a subjective probability for the particular plaintiff.121

These suggestions about sufficiency of evidence are based solely on my proposed theory of warranted direct inference. Other policy considerations, of course, might well lead a court to influence the jury decision in other ways as a matter of substantive law.122 I have

120. See supra text accompanying note 15.

121. Such an inference must be based on sufficient evidence, not merely on the baseless speculation of a willing expert witness. While I do not address the implications of my theory for judging the admissibility of expert testimony, and for evaluating the factual and theoretical bases for expert testimony, those are obviously important issues under my theory.

122. The issue of sufficiency of the evidence involves a range of policy considerations, including the constitutional right to jury trial in civil cases. This Article does not attempt such a complete analysis of sufficiency, but has the modest goal of listing the evidentiary requirements in lost chance cases that could be justified solely with respect to the warrant for direct inference.
already suggested that the policy of creating some deterrent effect against negligence in recurring situations with high baseline risk, or the importance attached to the right of patients to competent medical services, might be compelling reasons to assist the plaintiff through judicial evidentiary presumptions or through shifting to the defendant certain burdens of persuasion or production. By shifting the burdens of persuasion and production on certain issues to the defendant, it would be far more likely that the plaintiff would reach the jury. Such burden shifting would have to be justified on substantive policy grounds, however, and does not seem derivable from the theory of direct inference itself.\textsuperscript{123}

\section*{V. CONCLUSION}

My theory of warrant for direct inference identifies the logical conditions for inferring subjective probabilities about specific plaintiffs from objective generic statistics about groups. At the core of that theory is the thesis that it is fairness to the parties, not science, that warrants that inference. This central premise has general implications for legal concepts and doctrines closely associated with direct inferences. Although the need for careful analysis has been prompted by the lost chance problem, the theory I have proposed applies generally to any situations involving residual baseline risk or direct inference. Such reasoning from the generic to the specific is a recurring feature of the law, and direct inference may well play a much wider role in legal factfinding than I have examined here.

The jurisprudential intuition about the lost chance problem has rightly been that something at the root of the cases is deeply confused, but the nature of that confusion has been uncertain. Also, the judicial handling of the lost chance cases may provide an important study of how forced legal solutions to inappropriately conceived problems can themselves create far more conceptual problems than they solve. My theory of warranted direct inference returns to the root problem in those cases by analyzing the foundations of our legal reasoning and the meaning of the legal concept of probability. I believe that by clarifying our reasoning, at least a few of our conceptual knots will unravel of their own accord, and that we might be able to see better solutions to whatever tangles remain.

\textsuperscript{123} The case for a burden shift has been argued, for example, by Delgado, \textit{supra} note 117, at 899-900.