Probabilistic Causation in the Loss of Chance Doctrine: A Comment on Efficiency and Error Mitigation

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In an earlier short Article published in this fine law journal, I argued that the policy underlying the loss of chance is sensible but that the majority rule of damages was erroneous as a matter of mathematics and statistical analysis.¹ The majority rule permits proportional damages calculated as the product of full value of physical loss and the percentage reduction in chance of survival.² This formula is intuitive, but plainly wrong. Errors in mathematics and probabilities are not merely abstractions but have tangible effects on policy. The majority rule systematically undercompensates plaintiffs. In this short Article, I demonstrate that the rule is flawed from the perspective of efficiency. Efficiency here is considered in two ways: (1) appropriate deterrence through the internalization of cost, the standard concept in accident law; and (2) minimization of the total error as measured by errors in liability allocation and overpayments and underpayments in compensation, which is particularly helpful in understanding probabilistic losses. Under both views of efficiency, the majority rule is inefficient.

It is said that half a glass is better than nothing. The loss of chance doctrine with an incorrect damage rule is still better than not recognizing the doctrine at all for reasons of the complexity of factfinding and the uncertainties of knowledge. Such avoidance of complexity and uncertainty comes only with the acceptance of the largest error rates. This Article shows that a rule of no loss of chance produces the least efficient outcome and the greatest error rates as compared to the loss of chance doctrine with or without the correct damage formula. A full glass, however, is better than a glass half empty. Building on the analysis in my prior Article, this Article shows that the loss of chance doctrine with the application of the correct damage formula would produce the most efficient outcome in both its measures. We prefer the rule of law to be the least erroneous.

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² See id. at 40 (explaining majority rule).
This Article demonstrates the correct math and probability analysis that supports a sound public policy.

I. INTRODUCTION

Errors of doctors usually manifest in physical injuries. A slip of the scalpel, a wrong prescription, a poor technique—most medical malpractice cases are no different from other tort cases when causation is immediate and injury is apparent. But there is a class of cases in which plaintiffs may not be able to prove traditional “but for” causation. Misdiagnosis or negligent treatment—the prototypical action for loss of chance—poses a challenge in the special circumstance where the patient entered the doctor’s office with a grave condition that would have more likely than not manifested naturally, and negligence simply reduced a less than probable chance of survival. In this special class of cases, the plaintiff cannot prove that the doctor’s negligence caused any subsequent manifestation of injury, usually death, because in these situations it is always true that the natural illness likely killed the plaintiff.

The facts in Matsuyama v. Birnbaum and McKellips v. Saint Francis Hospital, Inc. illustrate the probabilistic analysis in this Article. In Matsuyama, a doctor failed to detect cancer and the chance of survival decreased from 38% to 0%. In McKellips, a patient had a 40% chance of survival but a negligent misdiagnosis reduced it to a 25% chance of survival. Both patients died. What killed them? The disease itself more likely than not in all such cases, but not in fact in all cases. As a matter of probabilities, the patients always fail the traditional causation test, but negligence always kills a certain portion of them.

The fundamental problem is not really one of factfinding so much as one of epistemology. Problems of epistemology are generally not seen in tort law because causation and injury are often apparent. Even in cases involving drugs or toxins, the inquiry is still one of whether the chemical agent killed the plaintiff, proven or not under the traditional causation standard. The problem of knowledge is one of finding the facts. Proving causal facts may be quite complex and insurmountable with the state of science, but the arrow of time is not called into question. In the context of misdiagnosis or mistreatment, the problem of

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4. 741 P.2d 467 (Okla. 1987).
5. Matsuyama, 890 N.E.2d at 828. The plaintiff had a 37.5% chance of survival and a post-negligence reduction of chance to 0% to 5%. Id. For simplicity and clear comparisons to the facts in McKellips, these probabilities are assumed to be 38% and 0%. The Massachusetts Supreme Judicial Court recently abrogated an aspect of the causation analysis in Matsuyama. See Doull v. Foster, 163 N.E.3d 976, 990-92 (Mass. 2021) (rejecting substantial factor standard of causation adopted in Matsuyama in favor of “but for” standard); Matsuyama, 890 N.E.2d at 842-43. Matsuyama specifically stated: “[t]he substantial contributing factor test is less appropriate, however, as an instruction as to cause in a loss of chance case in which one defendant’s malpractice alone is alleged to have caused the victim’s diminished likelihood of a more favorable outcome.” Matsuyama, 890 N.E.2d at 842.
epistemology is one of counterfactuals. What if there was no negligence? We cannot bend the arrow of time backward to determine “what if.” A reduction in the chance of survival always produces a probability of negligence-induced causation in the individual case and a certainty of negligence-induced physical losses in the aggregate. Because the law and the litigation process work at the individual level, the provable facts in the “loss of chance” actions will always negate causation unless the law creates a solution to this social problem.

Because misdiagnosis or mistreatment on severely ill patients is common in medical practice, we expect that loss of chance is a rather frequent phenomenon. These cases involve a small probabilistic chance attributable to negligence, but traditional liability rules require an all-or-nothing outcome in individual cases. Either negligence or the underlying condition more likely than not caused the injury. For severely ill patients, the likely cause of death is the natural (non-negligence induced) illness in all individual cases. Specifically, whenever a patient enters a doctor’s office with a greater than 50% chance of manifestation of terminal illness, the natural illness more likely than not must have killed the patient. But, as a practical certainty, doctors routinely cause unnecessary injuries in the aggregate. Individual outcomes in total do not approximate the aggregate in whole. Scholars have described these kinds of situations as “recurring misses.”

The problem of “recurring misses” is evident. Suppose as in Matsuyama, a doctor failed to diagnose cancer in a patient who had a 38% chance of surviving an illness (thus a 62% chance of dying), and the negligence reduced this chance to 0%. In 100 such cases, the doctor would escape liability because in each case the natural illness more likely than not killed the patient. Yet as a matter of probabilities, the doctor would have killed 38 patients. Without the loss of chance doctrine, doctors systematically evade liability in a minority of cases in a class of cases with high frequency. It would be bad policy to apply traditional


8. See RESTATEMENT (SECOND) OF TORTS § 431 cmt. b (AM. L. INST. 1965). Causation in fact requires a showing that “the actor’s negligence was in fact the cause of the other’s harm—that is, whether it had any effect in producing it—or whether it was the result of some other cause, the testimony making it clear that it must be one or the other, and that the harm is not due to the combined effects of both.” Id.

9. On the other hand, if a patient had a greater chance of life, then the traditional rule of causation works. Suppose a patient had a 51% chance of survival. The doctor’s negligence reduced this chance to 49%, and the patient later died. The doctor’s negligence did not cause the patient’s death because the patient had a 49% chance of death, which was increased to 51%. The natural illness more likely than not killed the patient. Nevertheless, if negligence reduces the chance of survival to 0%, then negligence more likely than not killed the patient. Of the 100 deaths in such cases, 51 would have been attributable to negligence, thus satisfying “but for” standard of causation.

causation test in these structural situations. Tort law sometimes solves unique problems that do not fit the traditional framework.\textsuperscript{11} Doctors should be held accountable for the proportional injuries they inflict unless the rule of law produces greater error or is not justified based on some other consideration, such as the imposition of other costs.

Several additional prefatory points are necessary before undertaking the analysis. The manifested harm is assumed to be death, though clearly physical injuries come in all forms.\textsuperscript{12} We will consider groups of 100 patients in similar cases. Obviously, no single doctor will confront 100 similar cases and be negligent in all. Thinking in groups of 100 is a heuristic to better intuit the nature of the probabilities. Lastly, loss of chance necessarily requires working through some math problems and conceptualizing the cause of action and damages in probabilistic terms. The math is not the point, but the means to accomplish the policy end. In working through these abstractions, we should not lose focus on the overall tangible problem. The math simply provides the intellectual framework for determining the measure of remedy that best achieves the policy end.

II. MAJORITY RULE OF DAMAGES

To redress the problem of systematic escape from liability, some jurisdictions have recognized the loss of chance doctrine as a theory of action.\textsuperscript{13} The doctrine is a creative solution to a large social problem. It is an exception to the traditional requirement of proving factual causation. The injury is conceptualized as a loss of chance, rather than a physical injury, which can never be proven as a more likely probability. Therefore, the majority rule provides proportional damages. It permits a probabilistic recovery based on the product of the whole value of the physical loss and the percentage reduction of chance:

\textsuperscript{11} See, e.g., Sindell v. Abbott Laboratories, 607 P.2d 924, 937 (Cal. 1980) (holding defendant’s liability calculated by likelihood they supplied defective drug based on their market share); Summers v. Tice, 199 P.2d 1, 7 (Cal. 1948) (holding both defendants joint tortfeasors despite not knowing which defendant’s bullet injured plaintiff).

\textsuperscript{12} The discussion and hypotheticals herein assume death as the ultimate physical injury. Misdiagnosis, however, can relate to any physical illness, loss of body function, or diminished quality of life, such as loss of eyesight or ambulatory capacity.

\[ J = D \times (P - R) \]

Where \( J \) = judgment award of damage

\[ D = \text{whole value for physical harm} \]

\[ P = \text{pre-negligence chance of survival} \]

\[ R = \text{post-negligence residual chance of survival} \]

Consider again the facts in *Matsuyama* and *McKelligs*. Assume that the full value of wrongful death is $1 million:

- *Matsuyama*: $1 \text{ million } (38\% - 0\%) = $380,000
- *McKelligs*: $1 \text{ million } (40\% - 25\%) = $150,000

The law gives us a glass half full. The loss of chance doctrine is good policy, but the majority rule of damage calculation is bad math. It is intrinsically wrong as a point of mathematical logic and probability analysis. It is also wrong as a matter of legal policy based on efficiency and error mitigation. Thus, it is indefensible as a rule of law.

### III. Correct Rule of Damages

The proper formula for damage calculation should consider the fact that some portion of patients exposed to negligence will survive the negligence. They are the lucky ones. If they have not been harmed, they should not be counted. Consider the facts in *McKelligs*. Out of 100 patients, the following are the outcomes: 75 died, out of which 60 died of the natural illness and 15 from negligence, and 25 patients lucked out and survived the natural illness and the negligence. Why should the lucky 25 patients recover at all? They should not. Any recovery by them should be credited in the error column. The denominator of the probability formula for damages should exclude persons who are not harmed. We can generalize the rule for damages when there is a positive residual chance of survival as follows:

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14. *See infra* Part IV (discussing erroneous application of reference class in denominator of loss-of-chance damages equation); Part VII (discussing majority rule’s failure to account for new information by incorporating surviving patients in class).

15. *See infra* Parts V-VI (discussing majority rule error rate and its effects).

\[ J = D \times \frac{P - R}{1 - R} \]

The key difference is the denominator, which is the reference class of the probability calculation. Whereas the majority rule always assumes a denominator of 1 (i.e., 100%, representing the class of all plaintiffs exposed to the negligence), the correct formula excludes from the reference class the percentage of patients who survived the natural illness and the negligence. The application of the correct formula to the facts of Matsuyama and McKellips produces these awards:

- **Matsuyama:** $1 \text{ million } \times \frac{(38\% - 0\%)}{(1 - 0\%)} = $380,000
- **McKellips:** $1 \text{ million } \times \frac{(40\% - 25\%)}{(1 - 25\%)} = $200,000

The McKellips facts result in a higher damage award than the majority rule. Under the majority rule, the damage was calculated as $150,000. Under the correct rule, the damage should be: $150,000 / (1 - 25\%) = $200,000.

In the Matsuyama facts, the damage calculation remains the same because there is no residual chance of survival. Only in the special case where there is no residual chance of survival does the majority rule produce the correct outcome. When (R = 0) the two formulas are the same.\(^\text{17}\)

\[ \text{If } R = 0: \quad D \times (P - R) = D \times \frac{P - R}{1} \Rightarrow D \times P \]

In the normal case of a residual chance of survival, however, the majority rule produces an erroneous damage calculation. The rule systematically undercompensates victims of medical malpractice.

IV. PROBABILITIES AND REFERENCE CLASS

As a matter of mathematical logic and probability analysis, the basic error in the majority rule is an erroneous conceptualization of the reference class. "Statistical probability requires a reference class from which a proportion is derived."\(^\text{18}\) Games of chance often require a clear reference class: e.g., six sides in a die, thirty-eight slots in a roulette wheel, and fifty-two cards in a deck. It is obvious that when the reference class changes, the probability changes as well.

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\(^{17}\) Rhee, supra note 1, at 42-43 (discussing special case of zero chance of survival).

\(^{18}\) Robert J. Rhee, Probability, Policy and the Problem of Reference Class, 11 INT’L J. OF EVID. & PROOF 286, 286 (2007). “By assigning an expectation in reference to the individual, we mean nothing more than to make a statement about the average of his class.” John Maynard Keynes, A Treatise on Probability 104 (1921).
To illustrate, assume that there are 100 other spectators in a concert, and the victim had his wallet picked during the concert. What is the probability that a randomly selected spectator is the pickpocket? The reference class—the denominator—is 100, and the probability is 1%. Suppose, however, that the spectators included a group of 50 handicapped persons who could not have physically performed the theft. The reference class changes, and the probability is now 2%. Thus, the conceptualization of the reference class is important.\(^{19}\)

In a loss of chance action, there are two potential reference classes. The first reference class, call it “exposed victims,” is the number of plaintiffs who have been exposed to the negligent act. The second reference class, call it “harmed victims,” is the number of plaintiffs who have been physically injured. To see the difference in these reference classes, consider the probabilities in McKellips: a 40% chance of survival reduced to a 25% chance. In a group of 100 patients, the “exposed victims” reference class would comprise 100 patients, but the “harmed victims” reference class would comprise 75 patients. If the reference class changes, the probability changes.\(^ {20}\) Two clear implications follow: (1) how we conceptualize the reference class affects the damage calculation because it is the denominator of the probability calculation; (2) a reference class of “harmed victims” will always increase damages because it reduces the denominator whenever patients still retain a positive chance of survival post-negligence.

The majority rule embraces the “exposed victims” reference class, but the correct rule should apply the “harmed victims” reference class. The choice of the “exposed victims” reference class is wrong on two levels.

First, as a point of law, cases for loss of chance should be analyzed from the framework of physical injury cases.\(^{21}\) These cases do not ultimately involve intangible or abstract harms; after all, patients are physically injured. The math is not an end, but simply a policy tool to remedy physical injuries with the least error given epistemological impossibility. The loss of chance is the penultimate step to a physical injury whose causation exists in a Heisenberg-like state of epistemological uncertainty.\(^ {22}\) This perspective of a physical injury is helpful because tort law, while remedying many kinds of injuries, is most comfortable dealing with physical injuries.\(^ {23}\) More pointedly, tort law does not assess liability


\(^{20}\) Rhee, supra note 18, at 286.

\(^{21}\) See Rhee, supra note 1, at 40 (noting loss of chance doctrine applies to medical malpractice cases likely to kill patient).


\(^{23}\) For example, tort law recognizes actions for intangible harms such as defamation, invasion of privacy, and emotional distress. Tort law has special rules when injuries are not physical. See, e.g., Robert J. Rhee, A Production Theory of Pure Economic Loss, 104 NW. U. L. REV. 49, 49-50 (2010) (discussing pure economic loss without physical injuries); Robert J. Rhee, A Principled Solution for Negligent Infliction of Emotional Distress Claims, 36 ARIZ. ST. L.J. 805, 806-08 (2004) (discussing pure emotional harm claims).
just because one was negligent and exposed others to the negligence. Exposing hundreds of drivers on I-95 in a reckless joyride will not result in tort liability absent an accident and a physical injury.

Second, as a point of mathematical probability, the choice of the “harmed victims” reference class produces the most efficient outcomes as measured by deterrence, cost internalization, and error minimization. Good law, policy outcomes, and correct math are linked. In medical malpractice actions, lawsuits should compensate physically injured patients with maximum internalization of cost and minimal error.

V. ANALYSIS OF ERROR RATES

Error should be a prominent consideration of public policy. We prefer rules that maximize the internalization of costs on tortfeasors, and as a corollary, minimize errors in the allocation of costs. This Article formally demonstrates that the majority rule is less efficient and increases error. As discussed above, in cases with zero residual chance of survival, the majority rule is still erroneous as a matter of theory, but it is harmless because it produces the same damage calculation as the correct formula.

Consider the more typical facts in McKellips. Assume negligence reduced a 40% chance of survival to 25%, the plaintiff ultimately dies, and the whole damage for wrongful death is $1 million. We can agree, one assumes, in the ideal world of omniscience, on three incontrovertible propositions: (1) the doctor should internalize $15 million for negligently killing 15 patients; (2) payments will be perfect in that that all patients who died by negligence will be fully paid, and all who died naturally should not recover; and (3) an uninjured plaintiff who lucked out should receive no compensation. This ideal sets the benchmark. Accordingly, there is a formal definition of error attributable to the rule of law:

\[
\text{Total Error} = \text{Under-Deterrence} + \text{Overpayments} + \text{Underpayments}
\]

If an undeserving plaintiff receives compensation per law, it should only be for the purpose of serving a higher policy end. The policy that produces the least sum of these component errors would produce the better rule.

How closely can the rule of law mirror this epistemological ideal? Let us consider the efficiency and error rates of four schemes: (1) rule of no loss of chance doctrine; (2) rule of loss of chance doctrine for pre-death actions with

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25. See supra Part III (explaining how formula reaches correct result in zero-chance scenario).

26. Clearly, in the practical world, it would be impossible to distinguish with precision between natural deaths and negligent deaths. Causation becomes a probabilistic concept. The errors in overpayments and underpayments are simply a function of the probabilities.
majority rule of damages; (3) rule of loss of chance doctrine for post-death actions with majority rule of damages; and (4) rule of loss of chance doctrine for post-death actions with the correct rule of damages.

A. Glass Empty Rule: Rule of No Loss of Chance Doctrine

There are two errors in jurisdictions without the loss of chance doctrine.\textsuperscript{27} First, continuing with the McKellips facts as an example, the doctor is not held liable for $15 million in losses. The liability error is $15 million. Second, there is no overpayment to plaintiffs since none can successfully sue. Third, there is an underpayment error to patients who died by negligence. In the ideal world of omniscience, those patients should recover. In our hypothetical, 15 patients died due to negligence, and thus the underpayment error is $15 million. Without the loss of chance doctrine, the total error is $30 million.

B. Glass Half Empty Rule: Rule of Loss of Chance Doctrine for Pre-Death Actions with Majority Rule of Damages

In jurisdictions that recognize the doctrine and apply the majority rule of damages,\textsuperscript{28} some may grant an action for pre-death (pre-physical injury) claims, i.e., actions for the abstraction of the loss of chance.\textsuperscript{29} Under the majority rule, the damage per patient is:

\begin{align*}
\text{Damages per patient:} & \quad$1 \text{ million} \times (40\% - 25\%) = \$150,000 \\
\text{Total payout:} & \quad$150,000 \times 100 \text{ patients} = \$15 \text{ million}
\end{align*}

Liability is fully imposed against the doctor, a full internalization of the social cost of his negligence. What is the payment error? “Payment error” means, from the view of omniscience, the sum of overpayments and underpayments to patients. With epistemological certainty, that sum would be zero. In “pre-death” actions, all 100 patients can sue and recover under the rule. From the perspective of physical injury, only 15 patients have been harmed by the doctor’s negligence. Therefore, there is both overpayment and underpayment errors.

\begin{align*}
\text{Overpayment:} & \quad 85 \text{ patients} \times \$150,000 = \$12.75 \text{ million} \\
\text{Underpayment:} & \quad 15 \text{ patients} \times (\$1 \text{ million} - \$150,000) = \$12.75 \text{ million}
\end{align*}


\textsuperscript{28} See id. (listing states using loss of chance).

\textsuperscript{29} See, e.g., Mead v. Adrian, 670 N.W.2d 174, 179 (Iowa 2003) (holding pre-death injuries recoverable if proximately caused by defendant’s negligence).
Overpayments are to 85 patients: 60 patients who would have died from the natural illness, plus 25 patients who survived the illness and the negligence. Underpayments are to the 15 patients who were killed by the negligence, but who only received partial damages.

The payment error is $25.5 million (= $12.75 million + $12.75 million). There is no liability error because the doctor is held liable for $15 million. Therefore, the total error is $25.5 million.

C. Glass Half Empty Rule: Rule of Loss of Chance Doctrine for Post-Death Actions with Majority Rule of Damages

In jurisdictions that recognize the doctrine and apply the majority rule of damages,30 most actions are brought in the form of post-physical injury claims. In this situation, only 75 patients can bring an action because 25 patients survived the illness and the negligence. Under the majority rule, the damage per patient is:

\[
\text{Damages per patient: } \quad \$1 \text{ million } \times (40\% - 25\%) = \$150,000
\]

\[
\text{Total payout: } \quad \$150,000 \times 75 \text{ patients } = \$11.25 \text{ million}
\]

There are both overpayment and underpayment errors: 60 patients who died by natural causes are overpaid and 15 patients who died by negligence are underpaid.

\[
\text{Overpayment: } \quad 60 \text{ patients } \times \$150,000 = \$9 \text{ million}
\]

\[
\text{Underpayment: } \quad 15 \text{ patients } \times (\$1 \text{ million } - \$150,000) = \$12.75 \text{ million}
\]

The payment error is $21.75 million (= $9 million + $12.75 million). Additionally, the doctor is held liable for only $11.25 million but has caused losses of $15 million. The liability error is $3.75 million. Therefore, the total error is $25.5 million.

Note that both the “pre-death” and “post-death” approaches produce the same error amount, but in different mixes.

D. Glass Full Rule: Rule of Loss of Chance Doctrine for Post-Death Actions with Correct Rule of Damages

In jurisdictions that recognize the doctrine and apply the correct rule of damages,31 only 75 patients can bring an action upon manifestation of the physical harm. The damage per patient is:

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30. See supra note 27 (listing jurisdictions recognizing doctrine).
31. See supra note 27 (listing jurisdictions recognizing doctrine).
Damages per patient: $1 \text{ million } x (40\% - 25\%) / (1 - 25\%) = \$200,000

Total payout: \$200,000 \times 75 \text{ patients} = \$15 \text{ million}

There are both overpayment and underpayment errors: 60 patients who died by natural cause are overpaid and 15 patients who died by negligence are underpaid.

Overpayment: 60 patients \times \$200,000 = \$12 \text{ million}

Underpayment: 15 patients \times (\$1 \text{ million} - \$200,000) = \$12 \text{ million}

The payment error is \$24 \text{ million} (= \$12 \text{ million} + \$12 \text{ million}). The doctor is held liable \$15 \text{ million}. The liability error is nil. Therefore, the total error is \$24 \text{ million}.

E. Summary of the Four Approaches

The following table summarizes the outcomes of the above four approaches under different rules.

<table>
<thead>
<tr>
<th>Type of Case</th>
<th>Overpayment</th>
<th>Underpayment</th>
<th>Liability to Doctor</th>
<th>Underdeterrence</th>
<th>Total Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No Loss of Chance</td>
<td>0</td>
<td>15,000,000</td>
<td>0</td>
<td>15,000,000</td>
<td>30,000,000</td>
</tr>
<tr>
<td>2. Loss of Chance: Pre-Death Actions</td>
<td>12,750,000</td>
<td>12,750,000</td>
<td>15,000,000</td>
<td>0</td>
<td>25,500,000</td>
</tr>
<tr>
<td>3. Loss of Chance: Post-Death Actions</td>
<td>9,000,000</td>
<td>12,750,000</td>
<td>11,250,000</td>
<td>3,750,000</td>
<td>25,500,000</td>
</tr>
<tr>
<td>4. Loss of Chance: Correct Formula</td>
<td>12,000,000</td>
<td>12,000,000</td>
<td>15,000,000</td>
<td>0</td>
<td>24,000,000</td>
</tr>
</tbody>
</table>

Importantly, while these outcomes are specific to the facts in *McKellips*, the general direction of the numbers and the order of error rates holds in all fact patterns where there is a residual chance of survival. In other words, there is nothing unique in a 40\% antecedent rate of survival and a 25\% post-negligence survival rate that produced the above unique order of error rates. The underlying mathematical concept drives the general direction of the numbers and the order of error rates, which hold true in all combination of antecedent and post-negligence rates of survival.32

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32. For example, assume a modified *Matsuyama* fact pattern: A 38\% antecedent chance of survival reduced by negligence to an 18\% residual chance of survival. A total of 82 patients died, and the doctor killed 20 of them. The total errors under the four approaches are: (1) no loss of chance, \$40 \text{ million}; (2) loss of chance for pre-death actions, \$32 \text{ million}; (3) loss of chance for post-death actions, \$32 \text{ million}; and (4) loss of chance under correct formula, \$30.2 \text{ million} (rounded). Again, loss of chance under the correct formula produced the least error. The damage award under the loss of chance post-death action is \$200,000 (= \$1 \text{ million} \times (38\% - 18\%)), whereas under the correct formula it is \$243,902 (= \$1 \text{ million} \times (38\% - 18\%) / (1 - 18\%)). As explained in
Jurisdictions that do not recognize the loss of chance doctrine produce the greatest error. This should come as no surprise since the total error is the sum of the doctor’s escape from liability, which represents the total underpayment to plaintiffs.

In jurisdictions that recognize the loss of chance doctrine, the “pre-death” actions fully impose the optimal liability on the doctor, but this outcome is seen less often because the typical case involves a “post-death” action. The “pre-death” cases are probably not brought often in the real world because they may be deemed speculative by courts absent a physical injury and may have trouble attracting attorneys.

In the “post-death” actions, the rule minimizes payment error the best compared to the previously discussed rules. This improvement in payments, however, is actually “subsidized” by a reduction in the doctor’s liability. This is not a very good tradeoff. The rule systematically imposes less liability than it should. It is inefficient from the standpoints of deterrence and social cost. Note that both “pre-death” and “post-death” actions under the majority rule of damages produce the same total error of $25.5 million.

The rule that produces the least error is the loss of chance doctrine with the correct formula. There is no underdeterrence of the doctor. Liability error is nil. The total error is the sum of payment errors, which is $24 million. Based on the correct formula as the reference, the majority rule of damage calculation produced a 6.25% increase in total error. Such systemic error is not trivial. Many material consequences in the world are seen at the margin.

VI. GENERALIZATION OF MAJORITY RULE’S ERROR RATE

We get a sense of the range of potential errors in individual cases by assuming the bookends of the extreme facts representing the outer bounds of cases that can be brought under a loss of chance theory. In a loss of chance action, the error range is [1%; 49%] based on the range of maximum and minimum negligence. The magnitude of the error is inversely proportional to the magnitude of the tortfeasor’s negligence. This statement can be demonstrated first with numeric calculations at each pole of the range and then with a generalization and proof through algebra.

the next section, the error rate under these facts is: 1 − 200,000 / 243,902 = 18%. The error rate equals the residual chance of survival. There is a precise mathematical reason why this must hold true. See infra Part VI.


34. For example, a 6% error rate in diagnosis for a disease that is 100% curable upon early diagnosis—but 100% fatal upon late treatment—would result in 6 additional deaths per 100 patients. More generally, any small improvements in the healthcare system would result in substantial aggregate tangible benefits.
Assume two cases in a post-death jurisdiction representing the antipoles of loss of chance actions. Plaintiffs have a 50% chance of living: (1) maximum negligence—the doctor negligently eliminated 49% chance of survival, thus 1% chance of living post-negligence (99 deaths with negligence killing 49 of them); (2) minimum negligence—the doctor negligently eliminated 1% chance of survival, thus 49% chance of living post-negligence (51 deaths with negligence killing 1 of them).

A. Maximum Negligence, Elimination of 49% Chance

*Majority rule* = \( D \times (P - R) = \$1\ million \times (50\% - 1\%) = \$490,000\)

*Correct formula* = \( D \times \frac{P - R}{1 - R} = \frac{50\% - 1\%}{1 - 1\%} = \$494,950\) (rounded)

The majority rule under-deters the doctor because his liability in 99 total cases is \(48,510,000\) (\( = \$490,000 \times 99\)), whereas he should ideally be liable for killing 49 plaintiffs (\( = \$49\ million\)). The amount of under-deterrence is \(\$490,000\). The correct approach optimally deters the doctor by imposing \$49\ million of liability (\( = \$494,950 \times 99\) plaintiffs).

From the perspective of deterrence of the doctor and internalization of social cost of negligence, the majority rule approach has a 1% error rate (\( = 1 - 490,000 / 494,950\)), which is inversely proportional to the magnitude of the doctor’s maximal negligence (49% chance reduction) under a loss of chance theory. This makes sense intuitively because greater negligence kills more patients; thus, the denominator approaches the limit of 1 as negligence kills all patients who could have survived.  

B. Minimum Negligence, Elimination of 1% Chance

*Majority Rule* = \( D \times (P - R) = \$1\ million \times (50\% - 49\%) = \$10,000\)

*Correct Formula* = \( D \times \frac{P - R}{1 - R} = \frac{50\% - 49\%}{1 - 49\%} = \$19,608\) (rounded)

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35. When the post negligence chance of living is 0%, the majority rule approach and the correct approach are the same because the denominator under the alternative approach (\(1 - R\)) where (\(R\) = post-negligence residual chance of survival) is simply 1. Thus, the alternative approach reduces to the majority (\(D \times (P - R)\)).
The majority rule under-deters the doctor because his liability in 51 cases of dead plaintiffs is $510,000 (= $10,000 x 51 plaintiffs), whereas he should ideally be liable for killing 1 plaintiff (= $1 million). The correct approach ideally deters the doctor by imposing $1 million of liability (= $19,608 x 51 plaintiffs). The majority rule has a 49% error rate (= 1 – $10,000 / $19,608). This is a high upper range of the error rate from the perspective of optimal deterrence. The lesser the doctor’s liability, the more the error rate increases.

C. Generalization: Error Rate = R

In summary, the majority rule produces a range of damages [$10,000; $490,000] or [1%; 49%] based on $1 million as the full value of physical harm. The correct formula produces a range of damages [$19,608; $494,950] or [2%; 49.5%] of full value. Based on the correct formula as the denominator (because it imposes 100% liability on the doctor with minimization of total error), the percent difference produced by the majority rule is [49%; 1%]. This is the range of the majority rule’s error rate in individual cases. It is inversely proportional to the magnitude of the doctor’s negligence.

Working out the algebra, based on the different formulas, formally proves this inverse relationship as a mathematical fact:

\[
\text{Error Rate} = 1 - \frac{\text{Majority Rule}}{\text{Correct Rule}}
\]

\[
= 1 - \frac{D(P-R)}{D(P-R)} = 1 - \frac{D(P-R)}{(1-R)} x \frac{(1-R)}{(1-R)} = 1 - (1-R) \Rightarrow R
\]

The majority rule’s error rate is generalized to the post-negligence survival rate. The intuition to understand this error rate is the following: (1) as the number of survivors increase, the error in payments and liability assessments increase; (2) as the number of survivors decrease, the errors decrease until there are no survivors, at which point the majority rule and the correct formula produce the same damage calculation because \( R = 0 \).36

VII. Time, Information, and Probabilities

There is another level of the probability analysis that highlights the error in the majority rule. Probabilities are not static. They change with new

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36. See supra note 35 (explaining majority rule and correct rule when chance of survival equals 0%); supra note 17 and accompanying text (noting when post-negligence chance of survival equals 0%, both approaches produce same result).
information. The majority rule fixes probabilities at the time of the negligence—the exposure to the wrong—thus utilizing the “exposed victims” reference class. At this time, call it \( t = 0 \), the negligence occurred, but there is no manifestation of physical injury. There was a probability \( P_{t=0} \). At the time of the manifestation of physical injury, call it \( t = i \), there is another probability \( P_{t=i} \) because new information is learned, the reference class to which the plaintiff belongs, thus the “harmed victims” reference class. We should appreciate the temporal differences and the effect of new information.

For most things, probabilities change with time because the world is not static, e.g., assets in the financial market or the value of a lottery ticket before and after a drawing. Consider this simple hypothetical. There is a $100,000 lotto drawing. Based on the lottery commission’s electronic record, it can be proven that the Quick Gas store on Lucky Avenue, in a desolate part of town, sold the winning ticket. Surveillance cameras in the store can prove that there were only two purchasers from this gas station on the date of drawing. Each person bought one ticket. At this time, there is a probabilistic value of the ticket. At a party, an hour before the lotto drawing, a drunken tortfeasor negligently destroys both tickets. This is the inverse of the facts in the famous alternative causation case of *Summers v. Tice*: There, two defendants fire identical shotgun blasts simultaneously and independently, and a pellet struck the plaintiff. One plaintiff was harmed by two tortfeasors with 50% causal contribution from each. In this lotto hypothetical, one tortfeasor harmed two people, each with a 50% chance of winning $100,000. At the time of the destruction of the tickets, there is a probabilistic injury. Suppose that a partygoer took a time-stamped picture of plaintiff’s ticket before the destruction. At trial, the picture is admitted into evidence. The new information would change the value of the ticket in fact, and it should change the liability and remedy at law. The ticket had two different values over time: \( V_{t=0} \) and \( V_{t=i} \). The value changed with new information. The rule of law should minimize errors. In this hypothetical, the new information can reduce total error to zero. In the context of loss of chance cases, the new information is the manifestation of physical injury.

There is a fundamental problem with how the majority rule conceives the notion of probability in the context of time and new information. An *ex ante* perspective views the probability of an uncertain future event through the concept of expected value. Expected value is the chance of something occurring in the future given various potential outcomes. Probabilities are assigned to the various outcomes. Mathematically, the calculation is simply the sum of the products of probabilities and outcomes: \( U = \sum_{i=1}^{n} P_i X_i \) where \( P_i \) is the probability of the outcome \( X_i \). The logic of majority rule is apparent. If we consider the potential

37. See supra Part IV (explaining how majority rule embraces “exposed victims” reference class).
38. See supra Part IV (explaining “harmed victims” reference class in greater detail).
future outcomes of medical malpractice and calculate an expected value, that calculation would be: \( U = (P_2 \times 0) + (P_2 \times 0) + (P_3 \times D) \) where \( P_2 \) is the probability of survival, \( P_2 \) is the probability of death from the natural ailment, \( P_3 \) is the probability of death from the negligence, and \( (P_2 + P_3 + P_3 = 1) \). Since a plaintiff can recover nothing from surviving or death from natural causes, the expected value of a doctor’s negligence is \( (U = P_2 \times D) \), which is precisely what courts have adopted as the rule of law on damages \( (J = D \times (P - R)) \).

When a person dies, which should be the precondition to bringing a medical malpractice claim for loss of chance,\(^{40}\) we are no longer concerned with various states of future outcomes including the possibility of survival, but instead we are looking back in time to the past. The reference class is the group of dead plaintiffs and should not include the class of people who survived (this last bit of uncertainty has been resolved). We have a past occurrence of death, and we must assign only two probabilities: \( P_2 \) is the probability that death resulted from the ailment, and \( P_3 \) is the probability that death resulted from negligence where \( (P_2 + P_3 = 1) \). The residual chance of survival must be taken out of the equation to formulate the correct reference class. The causation analysis must answer the question: Given that death occurred, what was the probability that it resulted from the negligence? Damages should follow therefrom.

The majority rule and the correct rule differ in the consideration of time and the incorporation of information. This difference is reflected in the two formulas. The antecedent survival rate \( P \) could be known as early as the exposure to the negligence \( (t = 0) \), perhaps even in the medical consultation process. Immediately after the exposure to the negligence or its discovery, the residual survival rate \( R \) could be discovered, but these facts would not ordinarily be found absent a malpractice action with assistance of an expert witness. There is a more fundamental temporal condition: Whether a plaintiff is a member of the reference class cannot be known until actual manifestation \( (t = i) \). This temporal function is important to policy considerations because we should not give compensation to unharmed persons as this would increase overpayment error.

VIII. CONCLUDING THOUGHTS

The majority rule of proportional damages is indefensible. It is based on an incorrect probability analysis. It does not fully allocate the social cost of negligence to tortfeasors, and it produces more total error than the correct formula. It could be justified based on pragmatic policy if its application was easier than the application of the correct rule. One possibility could be that it is an easier rule to implement, thus a tradeoff occurs between the cost of implementation and accuracy. But the only difference between the two rules is the factor of the residual

\(^{40}\) See Rhee, supra note 1, at 40 (explaining loss of chance constitutes negligence action where plaintiff ultimately dies).
survival rate, which is a required input in both formulas. The correct formula does not require the finding of an additional input.

The majority rule is conceptually flawed along several dimensions. It hinges more on a view of the injury as the abstraction of a probabilistic injury at the specific time of negligence. The correct approach conceives the injury as a physical injury manifested later in a shroud of epistemological uncertainty, thus requiring the instrumental need of probabilistic tools to deliver a proper remedy. There is an internal analytical conflict in the majority rule: although it leans more toward a probabilistic concept, its calculation is affixed to the time of the negligent act even as time may reveal new information that should affect probabilities. This is not how probability analysis works in the real world. The static nature of affixing probability at the time of negligence explains why the majority rule does not vary in terms of total error between pre-death and post-death scenarios, and the only change is the relative proportions among the three components of error. This is a conceptual error, resulting in computational error. The correct approach better links causation between negligence and physical injury, which is the preferred policy end.

41. See supra Part V (providing background on evolution of majority rule).