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## **Loss of Chance, Probabilistic Cause, and Damage Calculations: The Error in *Matsuyama v. Birnbaum* and the Majority Rule of Damages in Many Jurisdictions More Generally**

Robert J. Rhee\*

This short commentary corrects an erroneous understanding of probabilistic causation in the loss-of-chance doctrine and the damage calculation method adopted in *Matsuyama v. Birnbaum*.<sup>1</sup> The Supreme Judicial Court of Massachusetts is not alone. Many other common law courts have made the same error, including Indiana, Nevada, New Mexico, Ohio, and Oklahoma.<sup>2</sup> The consistency in the mistake suggests that the error is the majority rule of damages. I demonstrate here that this majority rule is based on erroneous mathematical reasoning and the fallacy of probabilistic logic.

To be clear, I do not contest the propriety of the loss-of-chance doctrine because the underlying policy sensibly addresses the social problem of medical malpractice inflicted on severely ill patients.<sup>3</sup> Without the doctrine, there would be no such thing as medical malpractice for patients who were more likely to not survive the ailment. I only comment on the conceptual understanding of probabilistic causation and the nature of probability-based damage calculation. The essential error in *Matsuyama* and other courts' decisions is a misconception of the reference class from which probabilistic

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1. 890 N.E.2d 819 (Mass. 2008).

2. See, e.g., *Cahoon v. Cummings*, 734 N.E.2d 535, 540-41 (Ind. 2000); *Perez v. Las Vegas Med. Ctr.*, 805 P.2d 589, 592 (Nev. 1991); *Alberts v. Schultz*, 975 P.2d 1279, 1282-83 (N.M. 1999); *Roberts v. Ohio Permanente Med. Grp., Inc.*, 668 N.E.2d 480, 484-85 (Ohio 1996); *McKellips v. Saint Francis Hosp., Inc.*, 741 P.2d 467, 476-77 (Okla. 1987).

3. See Robert J. Rhee, *The Application of Finance Theory to Increased Risk Harms in Toxic Tort Litigation*, 23 VA. ENVTL. L.J. 111, 146-47 (2004). See generally Joseph H. King, Jr., *Causation, Valuation, and Chance in Personal Injury Torts Involving Preexisting Conditions and Future Consequences*, 90 YALE L.J. 1353 (1981). The loss-of-chance doctrine has been adopted by many jurisdictions. See *Matsuyama*, 890 N.E.2d at 828 n.23 (citing jurisdictions that have adopted loss of chance doctrine). Some jurisdictions have rejected the loss-of-chance doctrine. See *Fennell v. S. Md. Hosp. Ctr., Inc.*, 580 A.2d 206, 215 (Md. 1990); see also *id.* at 209 n.3 (citing jurisdictions that have rejected loss-of-chance doctrine); *Matsuyama*, 890 N.E.2d at 828-29 n.23 (same).

causation is calculated. This error undervalues damages in certain types of cases where even after the medical malpractice, the plaintiff still had some residual chance of survival, though she ultimately died, thus begetting the cause of action.

#### LOSS-OF-CHANCE DOCTRINE AND DAMAGE CALCULATION

The loss-of-chance doctrine applies in medical malpractice actions in which the plaintiff cannot prove traditional “but for” causation because she was likely to die from her ailment even before the negligence. The doctor’s negligence is typically the failure to diagnose the condition or to treat the condition, and as a result the plaintiff suffers the loss of a chance to survive. Under a traditional analysis, as a matter of probability it is more likely than not that the natural ailment killed the plaintiff in each instance, and the doctor would escape liability no matter how egregious the negligence. This situation leads to what scholars have called “recurring misses,” when doctors systematically escape liability for negligent treatment in cases involving severely ill patients.<sup>4</sup>

*Matsuyama* presents a typical fact pattern.<sup>5</sup> The plaintiff had cancer at the time he was examined by the defendant. The examination failed to detect the cancer. The jury found that at the time of the initial examination, the plaintiff had only a 37.5% chance of survival.<sup>6</sup> The defendant’s negligence destroyed that small chance to survive.<sup>7</sup> As a matter of probability, he would have succumbed to his natural health condition irrespective of the negligence. Of course, if we had three such plaintiffs in exactly the same condition, the odds suggest that negligence would have killed one of them.<sup>8</sup>

Common law courts have adopted the loss-of-chance doctrine to provide plaintiffs a remedy in medical malpractice cases.<sup>9</sup> Loss of chance is an

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4. See Daniel A. Farber, *Recurring Misses*, 19 J. LEGAL STUD. 727, 727-28 (1990); Saul Levmore, *Probabilistic Recoveries, Restitution, and Recurring Wrongs*, 19 J. LEGAL STUD. 691, 705-10 (1990).

5. *Matsuyama*, 890 N.E.2d at 824-25.

6. *Id.* at 828.

7. The plaintiff had a post-negligence chance of survival of 0% to 5%. *Matsuyama v. Birnbaum*, 890 N.E.2d 819, 845 (Mass. 2008).

8. The precise probability that at least one of the deaths would have been caused by negligence is:  $[1 - \text{Probability}(\text{No Negligence})]$  where  $\text{Probability}(\text{No Negligence}) = 0.625 \times 0.625 \times 0.625$ . This means that based on the law of multiplication the chances of all three independent events resulting in death from ailments is the product of the probabilities. See M.G. BULMER, *PRINCIPLES OF STATISTICS* 15-22 (1979). The probability that in all three cases the natural ailment would kill the plaintiff is 0.244. Accordingly, the probability of at least one death having resulted from negligence is:  $1 - 0.244 = 75.6\%$ . This simply means that on a repeating basis, negligence causes harms even if the individual probability is small because the small chance of a bad thing, if repeated, eventually catches up. This is also the reason why the loss-of-chance doctrine is a sensible rule of law addressing the problem of medical malpractice in cases where patients are severely ill in the first place.

9. The loss-of-chance doctrine extends only to medical malpractice actions. See *Matsuyama*, 890 N.E.2d at 834 (“We emphasize that our decision today is limited to loss of chance in medical malpractice actions.”).

exception to the traditional causation analysis, and provides an alternative theory of liability for medical malpractice. The doctrine recognizes that a plaintiff's loss of probabilistic chance to survive should be a cognizable injury.<sup>10</sup> Courts provide an award of damages based on this probabilistic loss of chance.

The Supreme Judicial Court of Massachusetts in *Matsuyama* provides a five-step process for calculating damages.<sup>11</sup> The jury must find these facts:

- (1) "the full amount of damages allowable for the injury," without any probabilistic offset;
- (2) the probability of survival before the medical malpractice;
- (3) the probability of survival after the medical malpractice;
- (4) the difference in probabilities between steps (2) and (3); and
- (5) the product of the difference in probabilities (4) and the full amount of damages (1).

We can generalize this rule of law with this formula:

$$J = D \times (P - R)$$

where  $J$  = award of damages

$D$  = full damages

$P$  = pre-negligence chance of survival

$R$  = post-negligence residual chance of survival

The court provides the following numeric example to illustrate the damage calculation: The full value of a wrongful death is \$600,000. The patient had a 45% chance of survival before the medical practice. The patient had a 15% chance of survival after the medical malpractice. Based on the reduction of 30% chance of survival, the court suggests that the damage for loss of chance is: 30% (reduction in chance) x \$600,000 (full loss) = \$180,000 (damages).<sup>12</sup>

A number of other courts have adopted the same approach toward damage calculations.<sup>13</sup> For example, in *McKellips v. Saint Francis Hospital, Inc.*, the Supreme Court of Oklahoma gave this example: The full value of a wrongful death is \$500,000. The patient had a 40% chance of survival before the medical malpractice. The patient had a 25% chance of survival after the medical malpractice. Based on the 15% reduction of chance of survival, the court suggested that the damage for loss of chance is \$75,000 (= 15% x

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10. See generally King, *supra* note 3 (defining loss-of-chance cause of action).

11. See *Matsuyama*, 890 N.E.2d at 840.

12. *Id.*

13. See *supra* note 2 (listing courts adopting loss-of-chance approach).

\$500,000).<sup>14</sup> Indeed, this method in *McKellips* has influenced a number of subsequent decisions, including *Matsuyama*.<sup>15</sup>

The above damage calculation method is a common approach taken by courts in conceptualizing causation analysis and damage calculation. This approach is wrong. In fact, for reasons explained below, the damages in the above hypotheticals should be \$211,765 in the *Matsuyama* hypothetical<sup>16</sup> and \$100,000 in the *McKellips* hypothetical.<sup>17</sup>

The *Matsuyama* court and other courts have incorrectly calculated probabilistic causation and the damage calculations derived therefrom. The method of calculation endorsed in these cases is correct only in the special case when malpractice reduced the chance of survival to zero. If the malpractice still left a residual chance of survival (as seen in the hypotheticals above), then as a matter of mathematics and probability, the method of damage calculation adopted by the courts is incorrect.

#### THE SPECIAL CASE OF ZERO CHANCE OF SURVIVAL

When medical malpractice reduces a less-than-probable chance of survival to zero chance of survival, the proper damage amount is the reduction in the chance of survival multiplied by the full value of the loss. In these cases, the *Matsuyama* and *McKellips* method produces the correct result. For example, assume the following: (1) full value of loss is \$600,000; (2) the chance of survival before the negligence is 30%; and (3) the chance of survival after the negligence is 0%. The damage calculation is: 30% (reduction in chance) x \$600,000 (full loss) = \$180,000 (damages).

In calculating the percentage decrease in the probability of survival due to negligence, we first need the reference class (the denominator in the fraction). Logically, the denominator is the number of people who died: The reference class is based on the number of people who died from either the natural ailment condition or the malpractice. This constitutes the 100%—another way to say this is that all deaths are explained as having been caused by a natural condition or by negligence. The numerator is the number of people who died from the negligence, and this fraction calculates the damages based on probabilistic causation.

An easier way to think about this situation in probabilistic terms is to imagine 100 people in the identical position. Irrespective of any negligence,

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14. *McKellips v. Saint Francis Hosp., Inc.*, 741 P.2d 467, 476-77 (Okla. 1987).

15. See *Matsuyama v. Birnbaum*, 890 N.E.2d 819, 840 (Mass. 2008) (citing *McKellips*); see also *Cahoon v. Cummings*, 734 N.E.2d 535, 540-41 (Ind. 2000) (same); *Perez v. Las Vegas Med. Ctr.*, 805 P.2d 589, 592 (Nev. 1991) (same); *Alberts v. Schultz*, 975 P.2d 1279, 1287 (N.M. 1999) (same); *Roberts v. Ohio Permanente Med. Grp., Inc.*, 668 N.E.2d 480, 484-85 (Ohio 1996) (same).

16. This value is calculated as:  $\$211,765 = (30\% \div 85\%) \times \$600,000$ .

17. This value is calculated as:  $\$100,000 = (15\% \div 75\%) \times \$500,000$ .

how many of these people would have died naturally from the ailment? Seventy people. How many died from the malpractice? Thirty people. What is the probabilistic causation attributable to the negligent doctor? The answer must be 30%, calculated as 30/100. Thus, the damage calculation based on \$600,000 full loss must be \$180,000 (= 30% x \$600,000).

We can generalize the special case where the negligence reduces the pre-negligence chance of survival to zero (death is certain after the negligence) as the following:

$$J = D \times P$$

where  $J$  = award of damages

$D$  = full damages

$P$  = pre-negligence chance of survival

This method is seen in *Matsuyama* and other cases. In *Matsuyama*, the damage calculation formula was:  $J = D \times (P - R)$ , but since  $R = 0$  in the special case, the formula reduces to:  $J = D \times P$ . This method applies only when there is no residual chance of survival. Otherwise, the application of this method is an error as a matter of probability analysis.

#### THE NORMAL CASE OF RESIDUAL CHANCE OF SURVIVAL

When malpractice reduces a less-than-probable chance of survival but there still remains a residual chance of survival after the negligence,<sup>18</sup> the proper damage amount *cannot* be the product of the reduction in the chance of survival and the full value of the loss. For example, assume the exact hypothetical provided in *Matsuyama*: (1) full value of loss is \$600,000; (2) the chance of survival before the negligence is 45%; and (3) the chance of survival after the negligence is 15%, which is the residual chance of survival after the negligence. The damage cannot be \$180,000 (= 30% x \$600,000) as *Matsuyama* suggests.

To see why, again imagine 100 people in the plaintiff's exact situation. How many of these people would have died naturally from the ailment? Fifty-five people, because the plaintiff had a 45% chance of survival before the malpractice. How many would have died from the malpractice? Thirty people, because the doctor reduced the chance of survival from 45% to 15%. How many people would have survived despite the negligence? Fifteen people, because there is still a 15% residual chance of survival after the negligence. Because these 15 people would have survived the natural ailment *and* the

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18. See, e.g., *Herskovits v. Grp. Health Coop.*, 664 P.2d 474, 475 (Wash. 1983) (en banc) (negligence reduced chance of survival from 39% to 25%, and plaintiff subsequently died). I call this the "normal" case because my intuition is that most patients still have some residual chance of survival even after the negligence.

malpractice, they would have no injury and thus no legal claim. How many people would have died in total? Eighty-five people.

The reference class from which probability is calculated must be all injured people, which is 85 people and *not* 100 people. Of these unfortunate 85 people, 55 died from the natural ailment, and 30 died from the malpractice.

What, then, is the probabilistic causation attributable to the negligent doctor? The answer clearly cannot be 30%. The probabilistic causation attributable to the doctor's negligence must be:  $30/85 = 35.3\%$ . Thus, the damage calculation must be:  $35.3\%$  (reduction in chance)  $\times$  \$600,000 (full loss) = \$211,765 (damages). The error in the hypothetical resulted in an undervaluation of damages of \$31,765.

The *Matsuyama* decision confirms its error in discussing the specific facts of the case. The plaintiff had a pre-negligence chance of survival of 37.5% and \$875,000 full value of damages.<sup>19</sup> The plaintiff had a 0% to 5% post-negligence chance of survival.<sup>20</sup> The court suggested that the actual post-negligence chance of survival was an important fact that the trial court should have considered, which is correct as a general application of the rule, but the court used an incorrect statistical reasoning to explain why the datum is important. The court opined that a 5% residual chance of survival would cause a 32.5% loss of chance, rather than 37.5%, decreasing damages from \$328,125 ( $= 37.5\% \times \$875,000$ ) to \$284,375 ( $= 32.5\% \times \$875,000$ ).<sup>21</sup> As explained above, this is the wrong analysis of the plaintiff's actual damages. If there is a finding that the plaintiff had a 5% residual chance of survival, the probabilistic causation attributable to the defendant's negligence would be:  $32.5\% \div 95\% = 34.2\%$ . Thus, the damages are:  $34.2\% \times \$875,000 = \$299,342$ .

The error in *Matsuyama* produces only a small difference between the erroneous damages and correct damages because the residual chance was so small. In other cases where the residual chance is large, the difference in damage amounts can be large. Consider this hypothetical: The plaintiff's pre-negligence chance of survival was 50%, and full damages are \$600,000. The defendant's negligence reduces the chance of survival to only 10%. The damages are \$266,667 ( $= 40\% \div 90\% \times \$600,000$ ). However, if the defendant's negligence reduces the chance of survival to only 40%, the damages are \$100,000 ( $= 10\% \div 60\% \times \$600,000$ ). Thus, the residual chance of survival—which is an indicator of how the negligence took away the chance of survival—matters greatly in the damage calculation.<sup>22</sup>

19. *Matsuyama*, 890 N.E.2d at 827-28.

20. *Id.* at 845.

21. *Matsuyama v. Birnbaum*, 890 N.E.2d 819, 845 n.55 (Mass. 2008).

22. My colleague Andrew Blair-Stanek provided this additional analysis in a conversation. Suppose a doctor misdiagnoses 100 identical patients: Each patient had a life worth \$1 million, a 50% chance of survival without the malpractice, and a residual post-negligence 15% chance of survival. The doctor causes 35 unnecessary deaths due to negligence. The formula used by courts should result in the doctor paying a total of

We can generalize the rule of law for damage calculation when there is a post-negligence residual chance of survival:

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

where  $J$  = award of damages

$D$  = full damages

$P$  = pre-negligence chance of survival

$R$  = post-negligence residual chance of survival

This formulation takes into account that a percentage of patients survive both the ailment and the negligence, and as a result they are not injured and cannot be plaintiffs. These people must be excluded from the calculation of probabilistic causation.

Note also that the above formula produces the same outcome as the formula used in the special case where there is no residual chance of survival (recall that the formula in the special case is  $J = D \times P$ ). If  $R = 0$ , then the following must be true:

$$D \times P = D \times \frac{P - R}{1 - R}$$

Thus, my corrected formula should be the general rule of law applicable to both the special and normal cases.

Lastly, I note that my formula requires no more additional factfinding or exceptional application of mathematical analysis by juries. The math is basic elementary school arithmetic, and in any loss-of-chance case, juries are still required to find the pre- and post-negligence chance of survival: The variables are still only  $D$ ,  $P$ , and  $R$ . As a matter of judicial administration, the only adjustment required is the application of a correctly stated and conceived formula to calculate probabilistic causation and damages.

#### CONCLUDING THOUGHTS

If courts adopt the loss-of-chance doctrine, and many do, they must award damages based on the probabilistic causal contribution of the defendant's negligence to the plaintiff's death. Indeed, courts embrace this concept of

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\$35 million, which is the harm to society. The *Matsuyama* formula results in each dead patient getting  $\$1M \times (50\% - 15\%) = \$350,000$ . Because there are 85 dead patients, the doctor pays only  $85 \times \$350,000 = \$29.75$  million in total damages, instead of the \$35 million. Under the correct formula, each patient gets:  $\$1M \times (50\% - 15\%) \div (100\% - 15\%) = \$411,764$ . If we multiply this amount by the 85 dead patients who can sue, it is \$35 million, which is the amount of damage the doctor caused to society.

probabilistic causation and damages.<sup>23</sup> How, then, did the courts err in the analysis? The error in the mathematical logic arises from the choice of perspective on uncertainty. Courts have conceptualized probabilistic causation from an ex ante perspective when in theory they should consider probabilities from an ex post perspective.<sup>24</sup>

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:  $E(x) = P_1 X_1 + P_2 X_2 + \dots + P_n X_n$  where  $P_i$  is the probability given an outcome  $X_i$ .

The logic of *Matsuyama* and other cases is apparent. If we consider the potential future outcomes of medical malpractice and calculate an expected value, that calculation would be:  $E(x) = P_1 0 + P_2 0 + P_3 D$  where  $P_1$  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  $P_1 + P_2 + P_3 = 1$ . Since a plaintiff can recover nothing from surviving or death from natural causes, the expected value of a doctor's negligence is  $E(x) = P_3 D$ , which is what courts have adopted as the rule of law on damages.

However, when a person dies, which is a precondition to bringing a medical malpractice claim for loss of chance, 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:  $P(d_1)$  the probability that death resulted from the ailment, and  $P(d_2)$  the probability that death resulted from negligence where  $P(d_1) + P(d_2) = 1$ . The residual chance of survival must be taken out of the equation. 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.

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23. See *Matsuyama*, 890 N.E.2d at 839 ("The formula aims to ensure that a defendant is liable in damages only for the monetary value of the *portion* of the decedent's prospects that the defendant's negligence destroyed."); see also *Cahoon v. Cummings*, 734 N.E.2d 535, 541 (Ind. 2000) (holding damage calculation should not hold doctors liable beyond their own negligence); King, *supra* note 3, at 1382 ("A better method of valuation would measure a compensable chance as the percentage probability by which the defendant's tortious conduct diminished the likelihood of achieving some more favorable outcome.")

24. Cf. Chris Guthrie et al., *Inside the Judicial Mind*, 86 CORNELL L. REV. 777, 784 (2001) (suggesting judges subject to heuristics and biases that result in incorrect legal decisions).