Rate of false conviction of criminal defendants who are sentenced to death

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The rate of erroneous conviction of innocent criminal defendants is often described as not merely unknown but unknowable. There is no systematic method to determine the accuracy of a criminal conviction; if there were, these errors would not occur in the first place. As a result, very few false convictions are ever discovered, and those that are discovered are not representative of the group as a whole. In the United States, however, a high proportion of false convictions that do come to light and produce exonerations are concentrated among the tiny minority of cases in which defendants are sentenced to death. This makes it possible to use data on death row exonerations to estimate the overall rate of false conviction among death sentences. The high rate of exonerations among death-sentenced defendants appears to be driven by the fact that some of the most death-sentenced defendants are removed from death row and re-sentenced to life imprisonment, after which the likelihood of exoneration drops sharply. We use survival analysis to model this effect, and estimate that if all death-sentenced defendants remained under sentence of death indefinitely, at least 4.1% would be exonerated. We conclude that this is a conservative estimate of the proportion of false conviction among death sentences in the United States.

Significance

The rate of erroneous conviction of innocent criminal defendants is often described as not merely unknown but unknowable. We use survival analysis to model this effect, and estimate that if all death-sentenced defendants remained under sentence of death indefinitely at least 4.1% would be exonerated. We conclude that this is a conservative estimate of the proportion of false conviction among death sentences in the United States.

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The high exoneration rate for death sentences suggests that a substantial proportion of innocent defendants who are sentenced to death are ultimately exonerated, perhaps a majority. If so, we can use capital exonerations as a basis for estimating a lower bound for the false conviction rate among death sentences.

Since 1973, when the first death penalty laws now in effect in the United States were enacted, 1,143 death sentenced defendants have been exonerated, from 1 to 33 y after conviction (mean = 10.1 y) (9). In a previous study we found that 2.3% of all death sentences imposed from 1973 through 1989 resulted in exoneration by the end of 2004 (7). A study by Risinger (10) estimated that had biological samples been available for testing in all cases, 3.3% of defendants sentenced to death between 1982 and 1989 for murders that included rape would have been exonerated by DNA evidence through February 2006. That estimate, however, is based on a small number of exonerations (n = 11) (10). Both studies were limited to convictions that occurred 15 y or more before the study date, and so include a high proportion of all exonerations that will ever occur in the relevant groups. Nonetheless both studies underestimate the false conviction rate for death sentenced defendants because they do not reflect exonerations that occur after the study period, and do not include false convictions that are never detected at all.

Capital defendants who are removed from death row but not exonerated typically because their sentences are reduced to life imprisonment no longer receive the extraordinary level of attention that is devoted to death row inmates. (This applies as well to those who are executed or die on death row from other causes.) If they are in fact innocent, they are much less likely to be exonerated than if they had remained on death row. As a result, the proportion of death sentenced inmates who are exonerated understates the rate of false convictions among death sentences because the majority of death row defendants who were in fact innocent are largely abandoned once the threat of execution is removed.

In other words, the engine that produces an exoneration rate that is a plausible proxy for the rate of false conviction among death sentenced prisoners is the process of reinvestigation and reconsideration under threat of execution. Over time, most death sentenced inmates are removed from death row and resentenced to life in prison at which point their chances of exoneration appear to drop back to the background rate for all murders, or close to it. Thus, we will get a better estimate of the rate of false capital convictions if we are able to estimate "what the rate of capital exonerations would be if all death sentences were subject for an indefinite period to the level of scrutiny that applies to those facing the prospect of execution" (7). This study does just that.

### Current Study

#### Data

We examine exonerations among defendants sentenced to death from the beginning of the "modern" death penalty in the United States in 1973, after the Supreme Court invalidated all prior death sentencing laws (11), through the end of 2004. Our data come from two sources. (i) Death sentences since 1973 are tracked by the Bureau of Justice Statistics (BJS) of the Department of Justice, which maintains data on the current status of all death sentenced defendants in that period (12). We know that 7,482 defendants were sentenced to death in the United States from January 1973 through December 2004, and we know when (if ever) each defendant was removed from death row by execution, death by other means, or legal action by courts or executive officials. (ii) The Death Penalty Information Center maintains a list of defendants who were sentenced to death in the United States and exonerated since the beginning of 1973 (13), including 117 who were sentenced to death after January 1, 1973 and exonerated by legal proceedings that began before the end of 2004. We collected additional data on these cases from public records and media sources, expanding on the dataset used by Gross and O'Brien (7). We were able to match on several key variables 108 of the 117 death sentence exonerations in this period to specific cases in the BJS database to produce the database we analyzed.

Table 1 displays the status of the 7,482 death sentenced defendants we studied as of December 31, 2004, the final day of our study period. On that date, 12.6% of these defendants had been executed, 1.6% were exonerated, 4% died of suicide or natural causes while on death row, 46.1% remained on death row, and 34.8% were removed from death row but remained in prison after their capital sentences or the underlying convictions were reversed or modified.

Table 1 is a snapshot of the status of these defendants at the end of the study period. (It would look quite different if it dis played the status of death sentenced defendants at the end of 1985, for example, or 2000.) It cannot be used directly to estimate the rate of exoneration because exonerations are a function of time. Many of the defendants on death row at the end of 2004 had only been there for a year or two, far less than the mean of 10.1 y from conviction to exoneration for all capital exonerations since 1973.

Over time, many of those who remained on death row at the end of 2004 will be removed (or already have been); most will end up with sentences of life imprisonment. If the pattern for death sentences from 1973 through 1995 holds, over two thirds of prisoners sentenced to death will have the judgments against them overturned. The majority will remain in prison for life (14, 15), but some will be exonerated and released.

### Threat of Execution

A central variable of interest is whether an exoneration took place while the defendant was still under threat of execution (for detailed information, see SI Materials and...
We define an exoneration under threat of execution as an exoneration that is the result of legal proceedings that were initiated while the defendant was on death row. The date we assign to an exoneration is the date of removal from death row, the last date on which the exoneration can be initiated and still count as under threat, not the date on which the process was completed. Using these criteria, we determined that 107 of the 117 exonerations that occurred before the end of 2004 were under threat of execution, and 10 exonerations were not under that threat. The significance of this classification is apparent from Table 1. Of defendants sentenced to death since 1973, 35.8% had been resentenced to a prison term by the end of 2004. However, only 8.5% of capital exonerations (10 of 117) came from this group even though these prisoners were, by definition, at a later stage of their imprisonment than those who remained on death row. (Except for those who are exonerated and a very small group who are resentenced to lesser penalties and eventually released, all prisoners who are sentenced to death do ultimately die in prison. They all start out on death row, some stay there until death by execution by other means, and the rest eventually are moved to the general prison population where they remain until they die.)

Our estimate of the rate of false convictions among death sentenced defendants is based on the hypothesis that death sentenced prisoners who remain under threat of execution are far more likely to be exonerated than those who remain in prison but no longer face that threat. We use a Cox proportional hazards model with a time dependent covariate to test that hypothesis. We find, consistent with expectations, that death sentenced defendants who are no longer under threat of execution had a rate of exoneration approximately one eighth of that for defendants who remained on death row, 0.131 (P < 0.0001) (with 95% confidence interval of 0.064–0.266) (SI Materials and Methods, section 3).

Analysis. Our task is to estimate the cumulative probability over time of the event of interest, exoneration, in the population of death sentenced defendants who remain under threat of execution. The temporal measure (t) is time from conviction. Estimating this probability is complicated by the structure of the
population for two reasons. (i) Individual defendants joined this population across a 32 y period. Their duration in the study period varied from 1 to 32 y. (ii) All death sentenced defendants began, at conviction, under threat of execution, but for most that threat, and their membership in the population of interest, ended with execution. Usually, the defendants who remained under threat of execution were exonerated at some later point if the study period varied from 1 to 32 y.

To estimate this cumulative probability, we use survival analysis. This technique has been used in a related context, to estimate the rate of all reversals of death sentences in the United States (15). It is most commonly used, however, to evaluate the efficacy of medical treatments when not all patients experience the outcome of interest. The issue we address is analogous, but the analogy is counterintuitive.

We use survival analysis to assess the prospects of members of a population that is subject to a special risk. In the usual medical context, the condition that defines the population is a pathology such as Lyme disease or diabetes; for our study the defining condition is “death sentence.” As a result of this condition, every member of this population is subject to the risk of a terminal event that might remove him from the group that has survived this condition. In biomedical survival studies, that terminal event that is studied & death from the pathology in question; for our study, it is exonerations. This is a counterintuitive equivalence: For our purposes, remaining in prison following a death sentence counts as “survival;” and exonerations, which removes the subject from prison, is analogous to “death” in the common context in which survival analysis is used.

Survival analysis is often used to evaluate the efficacy of a medical treatment that may reduce mortality from a pathology. In this study the “treatment” that lowers the probability of the terminal event of interest (exoneration) is removal of the threat of execution (by execution, suicide, or natural causes). Exonerating an innocent defendant is, of course, a good thing for that defendant, but removal from death row is equivalent to a treatment that reduces the “risk” of exonerations. Our focus, however, is not on the treated group (those removed from death row) but on those who remain untreated (defendants who remain under threat of execution and therefore at high risk of execution).

In this study, as in medical research, subjects may be removed from the population of interest by means other than the terminal event at issue. In survival analysis of a disease, the usual means of exit by other means are death from a different cause or discontinuation of participation in the study. In our study, all deaths after capital sentencing (by execution, suicide, or natural causes) remove the person from the population that is subject to the risk of execution. However, most removals from the population by means other than exonerations are by legal action that reduces the defendant’s sentence to life in prison and thereby eliminates the threat of execution.

A primary difficulty in estimating the cumulative probability of exonerations is that some defendants were censored, i.e., they did not have an opportunity to be exonerated under threat of execution during the study period. Some defendants were removed from that threat during the study period but would have been exonerated had they remained under threat; others, who were sentenced to death relatively recently, remained under threat and had not been exonerated at the end of the study period but would have been exonerated at some later point if the study period were extended. As a result, a simple proportion of exonerated defendants to all defendants is a biased estimate of the cumulative probability of exonerations.

We therefore use the Kaplan Meier estimator to calculate the cumulative probability of exoneration under threat of execution for death sentenced defendants, by time from conviction through 2004. This estimator takes account of the censoring of observa-

As Fig. 2 shows, the cumulative probability of exonerations for death sentenced defendants who remained under threat of execution for 21.4 y was 4.1% (with a 95% confidence interval of 2.8% 5.2%). We replicated the Kaplan Meier estimate of the cumulative probability of exonerations under threat of execution using the Fleming Harrington estimator (9). Both results are virtually indistinguishable (SI Materials and Methods, section 3).

This 4.1% estimate may approach the underlying rate of false convictions because it reflects the cumulative effect of a process that is uniquely efficient at detecting such errors. To rely on this estimate, however, two additional steps are necessary. Sensitivity analysis. An important assumption for the validity of the Kaplan Meier estimator is that censoring events that remove subjects from consideration are statistically independent of the time to the event of interest if the subjects had not been removed. In this context, that assumption is plausible with respect to censoring by recency of conviction and by death from suicide or natural causes while under threat of execution. On the other hand, there are strong reasons to believe that both execution and removal from death row by legal procedures without exonerations are not independent of time to exonerations. Because the assumption of independence may be violated, sensitivity analysis is necessary.

Specifically, (i) 13% of death sentenced inmates were removed from death row by execution (943 of 7,482). Some exonerated defendants may have been innocent, and, although none has been exonerated after execution (9), both might have been exonerated if they had remained alive and on death row. However, we expect that the proportion of innocent defendants is
lower among those who are executed than among those who remain on death row (7) (SI Materials and Methods, section 4).

The threat of execution is the engine that drives the process of exonerating innocent death row prisoners, and it is likely that this process becomes more painstaking as inmates approach their execution dates. This concern about executing innocent defendants also drives a second bias: (ii) It increases the proportion of innocent defendants among the 36% of death row inmates who were removed from death row and resentenced to prison but not exonerated (2,675 or 7,482). Courts and executive officials explicitly recognize that it is appropriate to take the possibility of innocence into account in deciding whether to reverse a conviction for procedural error or commute a death sentence to life imprisonment, and a wealth of anecdotal evidence suggests that this practice is widespread (SI Materials and Methods, section 4).

As a result, those who are resentenced to punishments less than death are more likely to be innocent than those who remain on death row.

In short, we believe that (i) executed defendants are less likely to have been exonerated if they had remained on death row than those who in fact remained on death row, and (ii) defendants who were removed from death row but remained in prison are more likely to have been exonerated if they had remained under threat of execution.

These two biases are not equivalent in magnitude. Nearly three times as many innocent death row prisoners were resentenced to prison (2,675) as were executed (943). Even a modest increase in the proportion of innocent defendants among death sentenced prisoners resentenced to life imprisonment, compared with those who remain on death row, would more than offset a complete absence of innocent defendants among those who are executed.

We use competing risks methodology (18), along with explicit assumptions about the counterfactual probability of exoneration for those who were executed or resentenced to prison, to develop a sensitivity analysis for the Kaplan Meier estimate of the cumulative exonerate rate. First, we estimate the cumulative incidence of exonerate subject to the competing risks of execution and resentencing by 21.4 y after conviction, on the assumption that censoring by recency, suicide, or natural death was independent of these three event processes. The estimates of the probabilities of removal from risk of exonerate by exonerate under threat of execution, by execution itself, or by resentencing, are 2.2% (1.7%, 2.7%), 23.8% (22.3%, 25.3%), and 48.3% (46.7%, 50.0%), respectively. Thus, a defendant sentenced to death who had an equal 22% chance of being exonerated while under threat of execution by 21.4 y after conviction, assuming those executed or resentenced had zero chance of being exonerated (i.e., allowing for the competing risks of execution and resentencing) (SI Materials and Methods, section 3).

Consider instead the assumption that, had they remained on death row, (i) those who were executed would have had zero chance of exonerate, and (ii) those who were resentenced would have had twice the chance of exonerate as the entire population of defendants sentenced to death. This yields the following estimate of the cumulative probability of exonerate from execution:

\[
\text{Probability of exonerate} = 0 + (2.2\% + 0 (23.8\%) + 2 (2.2\%) (48.3\%) = 4.4\%
\]

Using the Delta method, the confidence interval for this estimate is 3.41 5.28%, assuming that the cumulative incidences of exonerate and resentencing have zero covariance.

A zero probability of exonerate for executed defendants had they remained on death row is, for the purposes of this estimate, a conservative assumption. We believe that the assumed probability of exonerate for those who were removed from death row and resentenced to prison, twice the mean for the population, is reasonable. We conclude that the Kaplan Meier estimate we obtained is conservative. Indeed the same result we would obtain if we assume that the probability of exonerate for those resentenced to prison, had they remained on death row, is equal to or greater than 1.77 times the population average [2.2% + 0 (23.8%) + 1.77 (2.2%) (48.3%) = 4.1%].

Estimating false convictions from exonerations. Because there is no general method to accurately determine innocence in a criminal case, we use a proxy, exonerate: an official determination that a convicted defendant is no longer legally culpable for the crime for which he was condemned. There will be misclassifications. Some exonerated defendants are guilty of the crimes for which they were sentenced to death. We expect that such errors are rare, given the high barriers the American legal system imposes on convicted defendants in persuading authorities to reconsider their guilt (1, 3, 7) (SI Materials and Methods, section 4). To date, one such case has come to light, and has been reclassified (19). Monte Carlo simulations reveal that the effect of such misclassifications on the cumulative rate of exonerate is linear: If 10% of exonerated defendants were in fact guilty, the mean cumulative rate of innocence for death sentenced defendants would be 3.7% rather than 4.1% (95% confidence interval of 3.3 4.0%); if 20% were guilty, the mean rate would be 3.3% (95% confidence interval of 2.8 3.7%) (SI Materials and Methods, section 3).

On the other side, some innocent defendants who remained on death row for more than 21.4 y but were not exonerated are misclassified as guilty. Some may still be exonerate; some may be executed; and most will likely die in prison, on death row or off, of natural causes or suicide. In the absence of better data we assume that the probability of a legal campaign to exonerate any prisoner under threat of death who has a plausible innocence claim is 1, and we assume that the probability of success for an innocent prisoner who remains under such threat for at least 21.4 y is also 1. These are necessarily conservative assumptions. To the extent that these probabilities are in fact less than 1, our estimate will underestimate the actual rate of false convictions.

The distribution of possible misclassifications is asymmetrical: 216 defendants remained on death row longer than 21.4 y, whereas only 107 were exonerate under threat of execution. Unless the process of death row exonerate is assumed to be unrealistically thorough, it is likely that the number of innocent death sentenced defendants misclassified as guilty exceeds the number of guilty defendants exonerate under threat of execution and misclassified as innocent. [The proxy we use (the exonerate rate) is also import in its own right: It is a direct measure of the rate of death sentencing of defendants later determined to be legally not guilty.]

Taken together, the sensitivity analysis and the likely net effects of misclassification both point in the same direction and suggest that our 4.1% estimate of the rate of false conviction among death sentenced defendants is conservative.

Discussion

We present a conservative estimate of the proportion of erroneous convictions of defendants sentenced to death in the United States from 1973 through 2004, 4.1%. This is a unique finding; there are no other reliable estimates of the rate of false conviction in any context. The main source of potential bias is the accuracy of our classification of cases as true or false convictions. On that issue it is likely that we have an undercount, that there are more innocent death row defendants who have not been identified and exonerate than guilty ones who have been exonerate in error.

The most charged question in this area is different: How many innocent defendants have been put to death (6)? We cannot estimate that number directly but we believe it is comparatively

* A reviewer of an earlier draft suggested an alternative analytic approach. The suggested approach postulates a campaign process that gives some but not all death-sentenced defendants the opportunity to be exonerate. Identification of the false conviction rate is then based on independence assumptions between innocence and removal from death row. With more complete data of the sort required for the best realization of this analytic approach, we believe that it would offer a particularly valuable supplement, and test of the robustness of our findings and conclusions.
If the rate were the same as our estimate for false death sentences, the number of innocents executed in the United States in the past 35 y would be more than 50 (20). We do not believe that has happened. Our data and the experience of practitioners in the field both indicate that the criminal justice system goes to far greater lengths to avoid executing innocent defendants than to prevent them from remaining in prison indefinitely. One way to do so is to disproportionate reverse death sentences in capital cases in which the accuracy of the defendants’ convictions is in doubt and to resentence them to life imprisonment, a practice that makes our estimate of the rate of error conservative. However, no process of removing potentially innocent defendants from the execution queue can be foolproof. With an error rate at trial over 4%, it is all but certain that some of those who are sentenced to death sentences to the rate of false convictions in any broader category of capital cases. There are theoretical reasons to believe that the conviction testing will have at most a modest effect on that rate. It is possible that the death sentencing rate of innocent defendants has changed over time. No specific evidence points in that direction, but the number and the distribution of death sentences have changed dramatically in the past 15 y (22). One change, however, is unlikely to have much impact: the advent of DNA identification technology. DNA evidence is useful primarily in rape rather than homicide investigations. Only 13% of death row exonerations since 1975 (18 of 142) resulted from postconviction DNA testing (13), so the availability of preconviction testing will have at most a modest effect on that rate.

Unfortunately, we cannot generalize from our findings on death sentences to the rate of false convictions in any broader category of crime. Capital prosecutions, and in a lesser extent murder cases in general, are handled very differently from other criminal cases. There are theoretical reasons to believe that the rate of false conviction may be higher for murders in general, and for capital murders in particular, than for other felony convictions, primarily because the authorities are more likely to pursue difficult cases with weak evidence of guilt if one or more people have been killed (23). However, there are no data that confirm or refute this hypothesis.

We do know that the rate of error among death sentences is far greater than Justice Scalia’s reassuring 0.027% (6). That much is apparent directly from the number of death row exonerations that have already occurred. Our research adds the disturbing news that most innocent defendants who have been sentenced to death have not been exonerated, and many including the great majority of those who have been sentenced to life in prison probably never will be.

This is only part of a disturbing picture. Fewer than half of all defendants who are convicted of capital murder are ever sentenced to death in the first place (e.g., 49.1% in Missouri as in ref. 24, 29% in Philadelphia as in ref. 25, and 31% in New Jersey as in ref. 26). Sentencing juries, like other participants in the process, worry about the execution of innocent defendants. Interviews with jurors who participated in capital sentencing proceedings indicate that lingering doubts about the defendant’s guilt is the strongest available predictor of a sentence of life imprisonment rather than death (27). It follows that the rate of innocence must be higher for convicted capital defendants who are not sentenced to death than for those who are. The net result is that the great majority of innocent defendants who are convicted of capital murder in the United States are neither executed nor exonerated. They are sentenced, or resentenced to prison for life, and then forgotten.

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5. United States v Garrison, 291 F 646, 649 (SD NY 1923) (Judge Learned Hand).