E26 The Error Odds Method of Objectively Assessing Bioengineering Based Claims of Causation: A Bayesian Approach to Test Validity Quantification

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The goal of this presentation is to demonstrate the Error Odds test, a method of objectively assessing the validity of forensic applications of bioengineering methods and conclusions

Bioengineering has seen increasing use in civil and criminal forensic settings in recent years as a means of objectively assessing injury risk. A lack of a validating gold standard for the method makes the technique highly susceptible to evidentiary challenges such as *Daubert*, et al. This presentation will impact the forensic science community by demonstrating how the ability to quantify the probability that a positive bioengineering test result is a true rather than false positive can have a substantial impact in guiding fact finders with regard to the admissibility and weight assigned to such testimony.

The National Research Council of the National Academy report on forensic science included a list of 13 recommendations.[1] The third recommendation addressed the lack of research pertaining to accuracy, reliability, and validity in forensic sciences, and recommended the development of quantifiable measures of the uncertainty in the conclusion of forensic analyses as a form of quality control. Uncertainty is quantified by probability, as the one is the complement of the other; *i.e.,* [1-probability] = uncertainty, and [1-uncertainty] = probability.[2] In compliance with the NRC recommendations, the present abstract is a description of a measure of test validity for the application of forensic bioengineering analyses and conclusions.

A relatively recent trend in civil and criminal litigation is the investigation of injury causation using a biomechanical or engineering reconstruction of the forces of an injury mechanism, which are then compared with human injury tolerance levels as a means of quantifying injury risk. The results of such analyses are typically presented as probabilities that either support or refute medical observations of injury, or that assign a probability to an alternative hypothetical explanation; e.g., the effect of seat belt use on the risk of a traffic crash injury in an unbelted occupant. Courts have been reluctant to accept such testimony in some cases, in part because it is difficult to assess the validity of the opinions and in part because outside of the forensic arena (e.g., academic, industry, or government applications) bioengineering is exclusively used to explain how medically observed injuries occur, and never to cast doubt on such observations. There are other problems associated particularly with the bioengineering approach to refuting injury causation, most notably the fact that the opinions are rendered in terms of injury *risk*, a prospective rather than retrospective forensic tool. Regardless of how small of a risk a particular injury mechanism may present, low risk cannot serve as a basis for concluding that an event did not occur; when assessing an individual outcome of traumatic event an injury is either present or it is not. Another problem with the bioengineering approach to injury causation is the fact that risk assessment arises from observational or historical data, and not experimentally derived theory. As an example, the biomechanical literature on femur fractures in traffic crashes indicates a minimal to absent risk of fracture in frontal collisions of less than 25 mph speed change, yet real world observations demonstrate femur fractures occur in collisions with a delta V of as little as 10 mph delta V and a fracture risk of 0%.[3]

A means of objectively assessing the validity of a bioengineering assessment of injury risk is the Error Odds test, a "Bayesian" method of conditioning probability.[4] Bayes' Law is means of conditioning probability given specific circumstances surrounding the probability. Conditioning of probability simply refers to how a probability is modified when certain conditions are accounted for. For example, given no information beyond the fact that a crime has been committed, the probability that it was committed by a man is approximately 80%. If the probability that a crime has been committed is conditioned by the knowledge that the crime took place in a women's prison then the probability it was committed by a man is substantially less than 80%. The Error Odds application of Bayes' Law is designed to be applied to positive forensic test results, and it incorporates three metrics associated with the test; the true positive rate of the test (the rate at which the test detects the condition of interest when it is present), the false positive rate of the test (the rate at which the test erroneously identifies the condition of interest as present when it is not), and the base rate of the condition (the prevalence of the condition among relevant test subjects). The Error Odds is calculated using the simple formula below:

$$\frac{\text{Test True Positive Rate}}{\text{Test False Positive Rate}} \times \frac{\text{Prevalence of positive outcome of interest in relevant population}}{[1 - \text{prevalence of positive outcome of interest in relevant population}]}$$

The result of the calculation is the ratio of true positive tests to false positive tests given the base rate of the condition in a population like the test subject. It has been postulated that an Error Odds result of more than 10 (indicating that for every 11 positive test results 1 will be a false positive) is a minimum threshold for a test to be considered valid.[5] Several examples of the application of the Error Odds test as a means of validity assessment will be presented.

References:

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Bayes' Law, Forensic Epidemiology, Error Odds test