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Editorial

# Forensic Epidemiology: An Evidence-Based System for Analyzing Individual Causation in a Medicolegal Setting

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## Editorial

In the Sign of Four, Sherlock Holmes famously commented to Dr. Watson that, “Once you have eliminated the impossible, whatever remains, no matter how improbable, must be the truth.” He was determined to communicate the concept, repeating it two more times in the same story, and then again in The Adventure of the Bruce-Parrington Plans and The Adventure of the Blanched Soldier. Arthur Conan Doyle wrote the Sign of Four in 1890, 42 years after John Snow first employed epidemiologic methods to investigate the cause of a cholera outbreak in London in1848, noting the fact that the disease was distributed in the same pattern as the common water supply to the homes made it likely that the source of the disease was the water. Snow was criticized at the time for suggesting that the cause of the outbreak was contaminated water, as there was no evidence that there was anything in the water that was producing the disease (such evidence was discovered only 6 years later, in 1854 by FilipoPacini). Snow’s theory regarding the cause of the cholera outbreak was based on an inference drawn from an observed association, rather than a direct observation; no one could “see” that the water was the cause of the disease [1].

More than 100 years after Snow’s discovery, Austin Bradford Hill gave a lecture to the Royal Society of Medicine in 1965 in which he outlined nine viewpoints by which an observed association could be evaluated for causality. In this famous lecture, immortalized now as the “Hill criteria” (a characterization that has persisted to the present day despite Hill’s protestations that he did not want his viewpoints turned into a checklist) he made it clear that, despite advances in science and medicine, we are still vexed by questions of how best to approach investigations of causality. But he also noted that a strong association is most commonly the best evidence of a causal relationship. He illustrated this concept with the observation that chimneysweeps sustain scrotal cancer 200 times more often than other occupations, and this fact alone stands as powerful evidence of a causal relationship between sweeping chimneys and cancer of the scrotum.

Holmes, Snow, and Hill were all describing the same fundamental truth; that a cause cannot be seen, and for this reason it must be inferred.

It is widely accepted that unreliable evidence is a significant problem in the forensic sciences generally and in forensic medicine specifically. One of the explanations for this phenomenon is the lack of validated and reliable standards and methods for common tasks performed in a forensic setting. Determination of the cause of injury or disease is a pivotal issue in virtually all criminal and civil actions, and one that is often vigorously contested. Despite this fact, there are no published standards regarding what constitutes scientifically valid evidence of causation, nor a systematic means of quantifying and weighing evidence of causation. The single largest explanation for this state of affairs, as noted above, is the fact that causation cannot be observed, and thus conclusions of causation are not observations but rather inferences, based on a presumed degree of association between an exposure and injury [2].

The lack of a generally accepted systematic approach to what is essentially an exercise in probabilistic reasoning results in the reliance by lay fact finders (i.e. judge and/or jury) on what is often speculative and unreliable evidence regarding causation. Outside of a forensic or legal setting, causal evaluations are most commonly performed in a medical setting by physicians. This is because the determination of the diagnosis of the condition for which the cause is sought is the responsibility of the physician, rather than because clinicians are routinely trained in causal methodology (they are not). Courts expect clinicians to be able to “see” a cause as readily as they can “see” a diagnosis, despite the fact that the process of arriving at a diagnosis is entirely different than the determination of cause. As an example, a child can see a broken femur on an X-ray and make the diagnosis of a fracture, a fact that anyone who sees the X-ray would have to agree with. We do not qualify the diagnosis of a fracture as being present on a “more likely than not basis,” the standard for most expert testimony, because the abnormal state of the femur is undeniable. If, however, we are informed that the individual with the broken leg was involved in two car crashes that happened one right after the other; the first one involving a far side crash and the second a frontal impact, how do we determine which crash was the cause of the fracture? Such a determination is not based on observation, nor is it based on diagnosis. The clinician might claim sufficient experience to opine that femur fractures are more common in frontal crashes than side impacts or vice versa, but this is an untestable inference rather than an observation that can be scrutinized by others and thus reliably duplicated.

Determination of causality is an important part of the practice of forensic pathology, where the primary purpose of the postmortem examination is to determine the manner and cause of death. In this setting, when there is a high degree of association between the diagnosis and the cause of the death (for example, a gunshot wound to the head), the determination of causation is easily made as a matter of common sense. This is because the large strength of the association, like Hill’s example of scrotal cancer among chimney sweeps, tends




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to rule out competing causes. In the example of a gunshot wound to the head, causation is obvious because such injuries are nearly always fatal, and the probability of an alternative cause of death coinciding with the time of the gunshot wound is exceedingly low in most circumstances. In contrast, the cause of death in a hospitalized patient with pneumonia, an 80% blockage of the left coronary artery, and who received an intravenous injection of a narcotic 30 minutes before going into respiratory arrest, cannot be determined as a matter of common sense. In such a circumstance the only causal analysis that can yield valid and repeatable results is the assessment and comparison of the risk of death associated with each of the plausible causes. Risk is a population-based metric defined as the probability or chance that an event will occur in the future, based on what has happened in the past. The field of study from which risk is estimated is epidemiology. Epidemiology is broadly described as the branch of medicine dedicated to the study of the cause of disease and injury in populations. Epidemiologic study examines the relationships between exposures and outcomes (and vice versa) and describes the results in terms of frequencies, rates, and probabilities. Epidemiologist's use standardized methods to describe disease and injury occurrence in specified populations in order to identify populations that are at higher risk than others and to evaluate factors that may account for the risk differences. In assessing causes, epidemiologists consider components of cause both individually and collectively, as well as which components are necessary (required) for causation, and the components that are sufficient for causation.

Although a primary function of epidemiology is to investigate and describe the causes of disease and injury in populations (general causation), epidemiology is largely silent about methods for investigating the cause of disease and injury in individuals (specific causation). Despite this fact, when there is a low degree of association between an injury observed in an individual and a suspected cause, or there are multiple competing causes, an evidence-based causal assessment requires the quantification and comparison of risks acting on the individual at the time of the injury.

The discipline of Forensic Epidemiology (FE), essentially a hybrid of principles and practices common to both forensic medicine and epidemiology, is directed at filling the gap between clinical judgment and epidemiologic data and methods in the evaluation of both general and specific causation in civil and criminal matters. The purpose of an FE causal analysis is to provide an evidence-based foundation for an opinion regarding the probability of causation, suitable for presentation in a medicolegal setting. As questions pertaining to risk and causality are pervasive in virtually all aspects of civil and criminal litigation, the applications of FE methods are potentially quite broad.

In the Elsevier text Forensic Epidemiology: Principles and Practice, we have endeavored to give the reader an overview of concepts and methods of FE and provide illustrations of the methods with case studies and examples. While the text is the most comprehensive publication on the topic to date (with 23 chapter authors from a variety of legal, medical, and scientific disciplines), it does not cover all applications of FE, as the methods have potential application to any medicolegal question of causality. Neither is the text intended as a comprehensive primer on epidemiologic or biostatistical methods, as there are many well-written texts that do this already. The goal of the book is to introduce the reader to FE, rather than make the novice an expert in the field [3].

This text is organized into three major sections; in the first section is a description of the principles of FE practice, including a historical perspective on how epidemiologic evidence has been used in courts and the methods used in FE investigations. In the second section are introductory chapters to non-epidemiologic forensic disciplines that in some cases are incorporated inan FE investigation. In the last section are examples of how FE methods have been applied to a wide variety of circumstances as a means of assessing causal relationships.

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