Theory of scientific investigation by Hempel and a case of Semmelweis

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ABSTRACT

Carl Gustav Hempel brought our attention to 19th century Hungarian physician Ignaz Semmelweis and his investigations in “systematic discovery” of solution to a “scientific problem.” The historical account of Semmelweis provided an impetus for Hempel to ponder upon the role of “induction” in “scientific inquiry.” By considering various conjectures, Hempel examined through this case, how a hypothesis once proposed is tested and rejected on the basis of test implication. Somewhere around this account lies the lesson for family practitioners of modern age in how to fight age-old-dogmatic beliefs with simple answers, but the ones that require appreciation from larger academia.

Keywords: Causal inference, hypotheses, theory

Theory of Scientific Investigation by Hempel and a Case of Semmelweis

In 1966, Carl Gustav Hempel, a German philosopher who developed influential theories of scientific explanations, highlighted a historical case from the field of medicine in his book titled, “Philosophy of Natural Science.”[1] The simple illustration of Ignaz Semmelweis’s work by Hempel on childbed fever (puerperal sepsis as it is known today) provided an excellent example and a very influential text for elucidating “basic steps in testing a hypothesis” and “role of induction” in scientific inquiry. Hempel introduced a 19th-century Hungarian physician who worked at the first Maternity Division of Vienna General Hospital from 1844 to 1848. Hempel brought our attention to Semmelweis’s investigations in a scientific problem” and his approach to “systematic discovery” of solution.

Semmelweis observed a strange phenomenon in mortality statistics of the “First Maternity Division” where the number of deaths from childbed fever was much higher than the “Second Maternity Division” of the same hospital where almost same numbers of women were admitted for deliveries. He embarked on solving this mystery by considering various explanations that were prevailing at the time, by rejecting some of them outright because of their incompatibility with well-established “facts” while for others, he did specific “tests” to confirm his “hypothesis” that he intuitively developed. The prevailing view at the time was attributed to “epidemic influences” that was generically described as “atmospheric-cosmic-telluric changes.” Furthermore, it was noted that death rate among street births was lower than the First Division. He rejected the conjectures regarding overcrowding of patients as cause of mortality. Even when the number of medical students was halved (who were thought to be handling patients in First Division), it did not reduce the mortality. Semmelweis also tried the “psychological” explanation by changing the route of priest without ringing of bell (that was thought to have a terrifying effect on patients of fever). He even tested by changing the position of deliveries from “supine” to “lateral” position. Finally with the death of his colleague, Jakob Kolletschka, Semmelweis realized that his physician colleagues and medical students were in fact carriers of disease.
of some infectious material, when after performing dissections in autopsy room, they in fact were infecting women in maternity room with their insufficiently clean hands. By testing his idea of “infection from cadaveric material” through mandatory cleaning of hands of medical students with chlorinated lime, mortality was brought down to less than the level of Second Division.

The historical account of Semmelweis provided an impetus for Hempel to ponder upon the role of “induction” in “scientific inquiry.” By considering various conjectures, he examined through this case, how a hypothesis once proposed is tested and rejected on the basis of test implication. Here, he brought the attention to an interesting mode of reasoning “modus tollens,” i.e., if hypothesis H implies test implication I and I is not true, then H cannot be true (deductively valid argument). Alternatively, if I is true, the conclusion that H is true is deductively invalid. Hempel called it “fallacy of affirming the consequent,” i.e., favorable outcome do not conclusively prove the hypothesis to be true (as was the case for final hypothesis of Semmelweis that was broadened from cadaver to possible microorganism). He also highlighted the “scientific inquiry” through examples of observations, test, hypothesis, and implications by Galileo, Torricelli, Pascal, and others. This led him to an account of “narrow inductivism” and its four stages of scientific inquiry: (1) observations of and (2) analysis and classification of “facts” and (3) inductive derivation of and (4) further testing of “generalization.” He also discussed relevant facts and classification of facts. Finally, he stated that scientific knowledge does not come from inductive inference and generalization of facts but by inventing hypothesis as tentative answers to a problem under study and then subjecting them to empirical test (hypothetico-deductive method).

To understand Semmelweis’s dilemma, we need to go back in time when the role of infectious microorganisms was not realized and Pasteur’s germ theory was not even conceived whereas much of the proposition about “casual” origin of “puerperal sepsis” was endorsed by “miasma theory” as pointed out by Hempel in chapter 2 of his book.[1] Even though “childbed fever” was identified from the times of ancient Greeks as well as from the texts of Avicenna, its epidemic nature was realized in the last century and was brought to light much later after Semmelweis’s death because his observations unfortunately conflicted with the established medical opinions of the time, and therefore, his ideas were rejected by the medical community.[2] There was, however, a difference in the nature of maternal mortality in one specific division of Vienna General Hospital versus the epidemics of cholera or smallpox in general population (that were also attributed to miasma or atmospheric-cosmic-telluric changes) that Semmelweis realized was “nonselective” nature of deaths. By discarding the miasma theory, he realized that causal origin of childbed fever lies in the differences between the two divisions. One of the initial observations was that the deliveries in his division were conducted by doctors and medical students while midwives conducted deliveries in the other division. From here onward, by conducting series of minitests, he started ruling out possible causal differences between the two divisions, for example, position of delivery, ringing of bell by priest, and finally cleaning of hands of doctors with chlorinated lime provided Semmelweis a completely new and original theory about the cause of childbed fever. His new theory that childbed fever is caused by introduction of putrid matter from cadaver and his test-implication produced stunning results. In fact, later on, this opened up door to another explanation of certain strains of bacteria entering the bloodstream of women conveyed through unclean hands.

Even though with exceptionally smart approach taken by Semmelweis in solving a problem, if we closely examine Hempel’s text, it seems that he did not adequately describe how Semmelweis could have offered a “causal mechanism” that could give a logical explanation that washing hands with chlorinated lime can prevent maternal deaths. This could not only hold true for doctors performing autopsies but also to midwives in other division who were not performing autopsies (as shown later by Semmelweis himself when even after cleaning hands for the first woman examined, the other women can get infected with the same pair of hand). It would not be surprising that without clear causal explanation to support his hypothesis, the scientific community would be cautious in accepting his results (this might also have been partly because of racial bias towards him). It is also not clear how much is “causal mechanism” important in explaining the observed phenomenon. Can the demand for causal mechanism by the scientists lead to “infinite regress” is not clear (series of propositions arising if the truth of proposition number “1” requires the support of proposition number “2,” the truth of proposition number “2” requires the support of proposition number “3,” and the truth of proposition number “n − 1” requires the support of proposition number “n” and “n” approaches infinity).

Finally, the “hypothetico-deductive method” coined by Hempel does not clearly account for the initial observation by Semmelweis about overcrowding and diet. Even if they are not the cause of high number of deaths in the second division, this does not mean that overcrowding or diet cannot be the cause of childbed fever. This point is interesting because the physicians in those days probably considered “single necessary cause” of death or disease instead of more “complex process of causation.” Although Semmelweis used a higher level of intuition in solving a problem that saved lot of lives, he might have thought in the same way when he rejected “overcrowding” as a cause of childbed fever.

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