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On the Existence of Fundamental Theorems of Medical Diagnosis and Practice

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Abstract

In this article, the authors discuss their previous treatment of the fundamental theorems of medical diagnosis and practice to a wider class of situations in which Koch postulates and Fredericks & Relman extended version theorem could be used to prove the second theorem. A new approach is introduced involving the importance of Koch's famous postulates to disease transmission.

Keywords: Koch Postulates, Fredericks & Relman Extended Version Theorem, Diagnosis, Zero-Point Condition, Equilibrium Point Condition, Disease Transmission

Introduction

Despite the well-developed field of diagnostic medicine, the practice of medical diagnosis has no theorems of its own. Recently, the results of a diligent study in medicine furnished us with an idea that medical theorems could be derived from diagnostic principles to help champion the usefulness of the field of diagnosis, which has for many years already gained tremendous illumination from Bayesian theorem. The latter theorem, which is borrowed from mathematics, is commonly used to help discussions involving medical diagnosis because of its probabilistic nature.

This short inquiry could later lead to collaborations from competent professionals who will make their contemplations concerning this important phenomenon in renowned journals around the world. These theorems, if scholars agree, could then be scrutinized further to commence the gradual development which theories and its theorems go through before they are accepted in the academic domain and later elaborated upon for them to fulfill their academic functions.

Statement of the Problem

For some time, the Bayesian theorem from mathematics has been utilized to explain the dynamics of what goes on in medical diagnosis without making a concrete analysis of what the contents of medical diagnosis as a whole entail. These implicit advantages which physicians gain by employing this useful theorem worldwide have made them neglected the fact that the procedure of diagnosis itself has its fundamental theorems which could be used

to help diagnosticians to comprehend disorder-symptom relation, disorder-transmission relation, and finally, practitioner-patient relation in medicine.

Statement of Purpose

This paper is intended to analyze the fundamental theorems of medical diagnosis, which have been deduced from a well-known theory of medicine that postulates the existence of several conditions that ultimately lurk behind etiology of illnesses/diseases whether it is physical, psychological or mental disorders. In particular, the article points out that Koch (1876) postulates and its reformulation by Fredericks and Relman (1996), could be adequately employed to prove the existence of the second fundamental theorem of medical diagnosis which states that 'A disorder can be transmitted from one individual to one another.'

Methodological Issues in the Inquiry

Employing the method of deductive, the investigation provides some essential principles and definitions by which other propositions or theorems are deduced from for further analyses and considerations. The method of deductive as a scientific procedure leads to scientific knowledge that is more superior which could then be tested by empirical scientists. The design offers premises in the form of definitions and then uses observation, empirical materials, and reason to prove them. Let us, therefore, premise this investigation with definitions, for as Aristotle and some later scientists saw this clearly, the basic premises of demonstrations are definitions. With these definitions and the premises, one can then move further to deduce the theorems for the field of diagnostic medicine.

The Bayesian Theorem in Brief and its Importance to Medical Diagnosis

Bayes theorem is by far one of the most important probability theorem set forth by an English mathematician called Thomas Bayes who lived between the years 1702-1761 (Bayes & Price 1763). In medical decision making and some of the biomedical sciences, his theorem has become essential and significant. It is utilized to make accurate measurements in guiding physicians' decision making. Bayes' theorem is employed in clinical epidemiology to establish the probability of a particular disorder in a group of persons with a specific characteristic based on the overall rate of which disorders and its likelihood of that specific characteristic in healthy and disordered individuals occur. The theorem is also applied in clinical decision making where it is employed to calculate the probability of a particular conclusion given at the onset of specific indicators, signs, or outcomes of some tests that have been made.

One example which scholars employ often is in the use of Coronary Artery Disease known as CAD. Here, the accuracy of the exercise cardiac stress test in predicting significant coronary artery disease (CAD) depends in part on the "pre-test likelihood" of CAD: the "prior probability" in Bayes' theorem (Lukeprog 2011). This theorem, therefore, makes it possible in order to permit the influence of new information on the merit of competing for scientific hypotheses to be compared, by computing for each hypothesis the product of the antecedent plausibility and the likelihood of the current data given that particular hypothesis and rescaling them so that their total is unity. In the terminology of mathematics, in Bayes' theorem, the antecedent plausibility is termed "the prior probability;" the likelihood of the current data given that particular hypothesis is called the "conditional probability;" and finally, the rescaled values are the "posterior probabilities"(Lukeprog 2011). Presently, Rev. Bayes theorem remains the normative standard for medical diagnosis, but as some have noted, unfortunately, it is commonly debased in clinical practice (Lukeprog 2011). An attempt to simplify its application with diagnostic computer programs, nomograms, rulers or internet calculators have not helped to enhance its application and use in research (Lukeprog 2011).

Criticisms against Bayes Theorem

According to Norton, "while Bayesian analysis has enjoyed notable success with any particular problems of inductive inference," he does not see it conforming true to universal logic of induction. To him, the Bayesian

approach fails to provide a universal logic of induction. He makes more arguments in support of his thesis in his article (Norton n.d.).

Lukeprog, on the other hand, finds two enduring criticisms to Bayes' system which unfortunately affect its credibility. He says that in the first place, mathematicians were extremely dismayed to discover something as whimsical as a guess play role in rigorous mathematics. Second, Bayes said that if he did not know what guess to make, he would just assign all possibilities equal probability to start. For most mathematicians, Lukeprog indicates that this problem of priors was insurmountable.

To Lukeprog the fact that Bayes never published his much-acclaimed discovery, but left it to his friend Richard Price to do it later makes it all the more insecure and untrustworthy. Price found it in Bayes' notes after Bayes' death in 1761, worked with it, and found publishers for it. It is therefore assumed that his theory was not read by several people until the arrival of Laplace's disputations on this very theory concerning chance (Lukeprog 2011).

A question like "Is Bayes' theorem the most robust mathematical theorem for developing medical diagnosis algorithms?" in our opinion would be answered by many scholars who have followed the literature in research reviews as indeed "Yes." This is because it uses conditional relationships and identifies the magnitude of the joint probabilities of multiple events when using small sample sizes. It can therefore be argued that the theorem is after all significant in medicine despite the criticisms leveled against it by some philosophers of logic and mathematics.

The current notion is that it is useful and could be applied in the medical domain such as diagnosis. A scholar of applied mathematics at Columbia University called Chris Wiggins (2019) gave an illustration with a posed question like this in an article in *Scientific American* to stress its usefulness in modern-day diagnosis: Let us take for instance that a patient goes to consult a doctor in his practice. Then this doctor conducts a test with 99 percent reliability–that is, 99 percent of people who are sick test positive and 99 percent of the healthy people test negative. Still, imagine that the doctor is aware that only 1 percent of the people in the country are currently sick. The question then is put forward: "if the patient tests positive, what are the chances the patient is sick?" The spontaneous response by many people would be 99 percent, but Wiggins indicates the precise answer should be indeed 50 percent. Why should it be so?

According to Wiggins, whose work has been adopted by many scholars for similar illustrations, the solution to this posed question can easily be computed by employing the theorem of Bayes. Bayes stated that the probability a patient tests positive and is sick is the product of the likelihood that one test positive given that one is sick and the "prior" probability that he is sick– the prevalence in the population. Put simply, his rationalization is that Bayes's theorem permits one to compute a conditional probability based on the information that is provided.

The formula for Bayes's Theorem goes like this:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

P (A) is the probability of event A; P (B) is the probability of event B; P (A|B) is the probability of observing event A if B is true; P (B|A) is the probability of observing event B if A is true. Wiggins's rationalization can be recapitulated with the aid of the below-mentioned table that gives the setting in a conjectural resident of 10,000 inhabitants:

Table 1: Conditional and unconditional probability table on medical diagnosis (Adapted from Wayne 2016)

	Those having disease	Those without disease	Total
Testing positive (+)	99	99	198
Testing negative (-)	1	9,801	9,802
Total	100	9,900	10,000

In this setting P (A) is the unconditional probability of disease; that is 100/10,000 = 0.01. P (B) is the unconditional probability of a positive test; that is 198/10,000 = 0.0198.

But what we want to find out is P (A | B), that is, the probability of disease (A), provided that the patient has a positive test (B). We are given that the prevalence of disease (the unconditional probability of disease) is 1% or 0.01; this is denoted by P (A). In a population of 10,000, therefore, there will be 100 diseased people and 9,900 non-diseased people. We also know the sensitivity of the test is 99%, i.e., P (B | A) = 0.99; therefore, among the 100 diseased people, 99 will test positive. We also know that the specificity is also 99%, or that there is a 1% error rate in non-diseased people. Therefore, among the 9,900 non-diseased people, 99 will have a positive test. And from these numbers, it follows that the unconditional probability of a positive test is 198/10,000 = 0.0198; this is P (B). Thus, P (A | B) = (0.99 x 0.01) / 0.0198 = 0.50 = 50%. From the above illustration, one can also see that given a positive test (subjects in the Test + row), the probability of disease is 99/198 = 0.05 = 50%.

The theorems to be discussed below will add more knowledge to Bayes theorem to make it rich in its application to medical diagnosis in that they provide more information concerning the context in which medical diagnosis could take place, as well as postulate that certain conditions exist in the background which must be taken seriously.

Formal Presentation of Fundamental Theorems of Medical Diagnosis

General Definitions

Fundamental theorems originate from theorems of war and mental disorders that describe human unhealthiness which triggers the precipitation of distressed conditions (Ayim-Aboagye et al. 2018). The disease stricken person voluntarily seeks help from a competent practitioner (i.e., trained through several years of apprenticeship in medicine). Here, the inequality which steers the fruitful relationship is described and portrayed vividly. With (<), the patient is portrayed as being in a subservient position in the distressed condition in relation to the practitioner S who is strong and healthy, and with (>), the latter is shown to be possessing exceeding knowledge encompassing the patient providing us the inequality of conditions $Q_{\vartheta} < S > Q$. This is synonymous to professional security that is guaranteed and ultimately given to Q_{ϑ} in his distressed condition. Zero-point condition (Z_{ς}) signifies the state of being in absolute distressed, petrified, and non-equilibrium. This state is closer to the death state (t_{ς}) which is equal to the state of negation (N_{ς}). So ($t_{\varsigma} = N_{\varsigma}$) in the phenomenon of medical diagnosis. A patient's restoration to 'health–generated–wellness' by the practitioner is called equilibrium–point condition (E_{ς}). Thus zero-point (Z_{ς}) is defined as "Q_{ϑ} is in a subservient condition of S if $Q_{\vartheta} < S$ for all $Q_{\vartheta} \, \varepsilon \, N$." The equilibrium-point condition (E_{ς}) thus becomes "S is more knowledgeable over Q_{ϑ} if $S > Q_{\vartheta}$ for all $S \, \varepsilon \, N$." With this, we can also add the concept of time (t) in the rationalization accompanying the onset of any disease/illness.

Fundamental theorems, furthermore, establish the existence of common fundamental grounds upon which all medical diagnoses rest among a collection of abnormalities defined on certain arranged disorders that are subject to diagnostic procedures. The theorems are relevant both because of its interdependent theoretical significance and also because other results can be deduced from them that can be regarded as corollaries (Ayim-Aboagye 2008).

The following are the theorems of medical diagnosis:

Theorem 1:
No disorder is without a symptom; vice versa no symptom is without a disorder.
Theorem 2:
A disorder can be transmitted from one individual to one another.
Theorem 3:
An Individual patient disorder cannot be treated in isolation by the patient; it must be attended to by experts through voluntary consultation that has been made by the patient.

Alternative Statements of the Theorems can also be written as:

1. If a patient is diagnosed as possessing a specific disorder, then there is a corresponding symptom(s) on which the practitioner has based his competent decisions/predictions.
[If an individual Q is diagnosed as having a disorder D, then there is a corresponding symptom C which is known as lurking behind D; then $Q_ə = C \cong D$ and the vice versa is also true $Q_ə = D \cong C$.
Where $_ə$ represents the condition of Q.]

2. In cases where a disorder is judged to be an infectious disease or violent personality disorder, then there is the greater likelihood that a patient can transmit this disorder to other individuals irrespective of who comes into contact with him/her.
[Suppose that $Q_ə$ were to be the distressed patient in a zero-point condition (Zç) who is distressed, petrified, and disequilibrium, then the following (could result) patients can contract the illness from $\{Q_ə \rightarrow Q_ə1 \rightarrow Q_ə 2 \rightarrow Q_ə 3 \rightarrow \ldots Q_ə N\}$]. The formula then becomes $Zç = Q_ə \rightarrow Q_ə1 \rightarrow Q_ə 2 \rightarrow Q_ə 3 \rightarrow \ldots Q_ə N$.

3. A diagnostic procedure involving a disorder is not handled in isolation by a patient; it is attended to and steered by a competent practitioner who confronts a distressed patient that has voluntarily sought help.
[Let Q be in the zero-point condition (Zç) of illness $Q_ə$ that is distressed, petrified, and disequilibrium. For every zero-point condition $Q_ə < S > Q$. Then, the following inequalities hold at any zero-point condition: $Zç = Q_ə < S > Q$. This means $Q_ə$ is subservient to S, the practitioner that is more knowledgeable than Q in the encompassing powerful context of medical diagnosis.]

These theorems can help physicians to comprehend: Firstly, disorder- symptom relation; secondly, disorder-transmission relation (Here, Koch postulates and its reformulation by Fredericks and Relman (1996) could be used to prove this theorem); and thirdly, practitioner-patient relation.

Proof of First Fundamental Theorem

If an individual Q is diagnosed as having a disorder D, then there is a corresponding symptom C which is known as lurking behind D; then $Q_ə = C \cong D$ and the vice versa is also true $Q_ə = D \cong C$.
Where $_ə$ represents the condition of Q.]

Proof
Referring to theorem one, since it is acknowledged that every disorder has a symptom upon which it could lead the competent practitioner to the root cause of the patient's dire situation, and vice versa every symptom has a lurking disorder/points to a disorder at every zero-point condition (Zç), the theorem is said to be obvious. Thus it says that $Q_ə = C \cong D$ and the vice versa is also true $Q_ə = D \cong C$. Furthermore, the zero-point condition is the originating point of all true conditions of disease /illness when patients need cure/treatment.

Remarks
The nature of the theorem as an obvious one is not to be disputed. It can, therefore, be remarked that when we discuss or engage in the commencement of every diagnosis, we most often focus on the fundamental theorem.

Proof of Existence of Second Fundamental Theorem

Preamble
Let us now introduce the second fundamental theorem again:
A disorder can be transmitted from one individual to one another.
Alternative propositions:
In cases where a disorder is judged to be an infectious disease or violent personality disorder, then there is the greater likelihood that a patient can transmit this disorder to other individuals irrespective of who comes into contact with him/her.

[*Suppose that $Q_э$ were to be the distressed patient in a zero-point condition ($Z_ç$) who is distressed, petrified, and disequilibrium, then the following (could result) patients can contract the illness from $\{Q_э \rightarrow Q_э 1 \rightarrow Q_э 2 \rightarrow Q_э 3 \rightarrow ... Q_э N\}$*]. The formula then becomes $Z_ç = Q_э \rightarrow Q_э 1 \rightarrow Q_э 2 \rightarrow Q_э 3 \rightarrow ... Q_э N$.

Remarks

While the first theorem is obvious and needs no proof, because it is agreed that every disorder has a symptom and also that every symptom portrays the signal of a major or minor lurking disorder, according to our understanding, the second fundamental theorem could easily be proved with Koch postulates (Koch, 1893:319-38). Yet, additional illumination could also be gained from the use of the Fredericks and Relman (1996: 18-33) extension theorem of Koch postulates.

Robert Hermann Koch and his Famous Postulates

Proof Using Koch's Postulates

Koch postulates guarantee the existence of disorders' transmission as they satisfy the conditions in which these are experienced be it in the laboratory or research field. Koch's postulates are four criteria designed to establish a causative relationship between a microbe and a disease that can later be transmitted to humans. The postulates were originally formulated by Robert Koch and Friedrich Loeffler in 1884(Koch 1893), based on earlier concepts labeled by Jacob Henle and perfected and published by Koch in 1890 (Evans 1978). Koch used the postulates to picture the etiology of cholera and tuberculosis which he generalized to other diseases. It must be emphasized that Koch postulates were generated before the understanding of modern concepts in microbial pathogenesis that cannot be examined using Koch's postulates, including viruses– which are obligate cellular parasites– or asymptomatic carriers. Currently, they have largely been ousted by other well-known principles such as the Bradford Hill Criteria for infectious disease causality in modern literature of public health.

The following are Koch's postulates which have been disseminated widely in the literature both academic and popular science: The microorganism must be found in abundance in all organisms suffering from the disease, but should not be found in healthy organisms; The microorganism must be isolated from a diseased organism and grown in pure culture; The cultured microorganism should cause disease when introduced into a healthy organism; The microorganism must be isolated again from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent (Koch, 1876: 277–310).

Alternative Proof Using Fredericks and Relman Extended Version Theorem

Fredricks and Relman have also suggested an extended version theorem of Koch's postulates for the present century and they also guarantee the existence of transmission of disease/disorders. The following conditions also satisfy the fundamental theorems:

(a) A nucleic acid sequence belonging to a putative pathogen should be present in most cases of an infectious disease. Microbial nucleic acids should be found preferentially in those organs or gross anatomic sites known to be diseased, and not in those organs that lack pathology.

(b) Fewer or no copies of pathogen-associated nucleic acid sequences should occur in hosts or tissues without the disease.

(c) With the resolution of disease, the copy number of pathogen-associated nucleic acid sequences should decrease or become undetectable. With clinical relapse, the opposite should occur.

(d) When sequence detection predates disease or sequence copy number correlates with the severity of disease or pathology, the sequence-disease association is more likely to be a causal relationship.

(e) The nature of the microorganism inferred from the available sequence should be consistent with the known biological characteristics of that group of organisms.

(f) Tissue-sequence correlates should be sought at the cellular level: efforts should be made to demonstrate specific in situ hybridization of microbial sequence to areas of tissue pathology and visible microorganisms or to areas where microorganisms are presumed to be located.

(g) These sequence-based forms of evidence for microbial causation should be reproducible.

These adaptions by Fredericks and Relman (1996:18-33), according to some scholars, are still debatable in that they are not successful in accounting well for established disease associations, such as papillomavirus and cervical cancer nor do they take into account prion diseases, which have no nucleic acid sequences of their own. All the same, these could be employed to explain how diseases could be transmitted from individuals to individuals [organism to another organism].

Since the second theorem of the fundamental theorems of medical diagnosis states that a disorder can be transmitted from an individual to another individual and this is well exemplified in hospital environments as well as general environment through research, we infer from Koch postulates and Fredericks and Relman's extended version theorem that a disorder is transmittable to individuals in all conditions as explained (whether it is in the laboratory or the field). Hence there is an illness or disease transmission that is enshrined in the fundamental concepts of medical diagnosis. Moreover, there exists a disorder transmission principle which the second theorem postulates.

Concluding Remarks

Fundamental theorems of medical diagnosis are the results in a medical theory involving disorders which establish the existence of a common genesis of zero-point condition illness or disease etiology. The theorems are ingredients in several other important results, notable among which are proofs that a disorder can be transmitted from one person to another person. Therefore, it signifies that there exists a disorder transmission that the second theorem in particular postulates on. Finally, the theorems are to be represented by the following formulas:

T1: $Q_\vartheta = C \cong D$ and the vice versa is also true $Q_\vartheta = D \cong C$.

T2: $Z_\varsigma = Q_\vartheta \rightarrow Q_\vartheta 1 \rightarrow Q_\vartheta 2 \rightarrow Q_\vartheta 3 \rightarrow \ldots Q_\vartheta N$.

T3: $Z_\varsigma = Q_\vartheta < S > Q$.

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