Diagnosis – a logical consideration of the Science of Medicine

Greig Russell

Correspondence to: Greig.Russell@xtra.co.nz

ABSTRACT

This paper will introduce academic logic in a medical setting by discussing medicine from the perspective of Kuhn's paradigm model of science. Kuhn proposed that each science is organised around a central paradigm by which all study occurs and all results are interpreted. This paper will argue that the central unifying paradigm for medicine is the diagnostic paradigm. Accurate diagnosis is the only common component of the patient care common to all of the various branches of medicine so fulfilling Kuhn's paradigm model. The current limitations of clinical medicine, but not the social organisation of medicine, will be seen as inherent in this paradigm model. Indeed the social organisation of medicine represents another manifestation of this paradigm. Hence the belief that social engineering of medical organisations will address the core limitations of medicine will be seen as futile and 'a priori' diagnostic errors will continue unchecked.

Key words

Logic, philosophy, Kuhn's model of science.

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Greig Russell *is a Medical Director of City Doctors in Palmerston North. After completing degrees in biochemistry, behavioural sciences and medicine, his postgraduate training was in psychiatry before switching to general practice. After working for 15 years in rural medicine, including one fascinating year as a rural locum, he moved into an urban A&M clinic. This has allowed time to study Philosophy on an extramural basis while commencing the FAMPA.*

Introduction

Philosophy is the study of ideas—a study often seen as esoteric and of little practical importance, especially in applied sciences such as medicine. Equally, the philosophical study of the structure of science has led to a greater understanding of the processes of science itself. This paper will use one branch of philosophy—logic—to investigate what insights from the philosophy of science, namely Kuhn's paradigm model, reveals about medicine, its current difficulties and the proposed solutions in the New Zealand context. It will conclude that the strengths of status quo are underestimated, as is the inherent difficulty of the challenge confronting medical practitioners. The effectiveness of proposed solutions such as nurse practitioners to resolve these inherent difficulties will be shown to be indeterminate, while legal prescriptivism could exacerbate inherent difficulties.

Logic and logical notation

Logic is to philosophy as mathematics is to physics. It enables the description and study of the form of an argument independent of the content. For if the form itself is not valid then the argument itself cannot be valid regardless of the contents. To introduce logic and logical notation, consider the historical model of medicine in which an apprenticeship model guides both medical tuition and diagnosis.

Example:
According to my Master
Premise 1) As my patient describes hearing voices.
Premise 2) and given patients who hear voices have schizophrenia.
Conclusion) Therefore my patient has schizophrenia.

In logical notation this is expressed as:

P1) $A \supset B$ (where A=is a patient, then, B=hears voices)
P2) $B \supset C$ (where B=hears voices, then, C=has schizophrenia)
hence
P3) $A \supset C$ (where A=is a patient, then, has C=has schizophrenia)
Or more usually written as:
$\{(A \supset B) \wedge (B \supset C)\} \supset (A \supset C)$

This example is a hypothetical syllogism and is one of the historic tautologies of academic logic. A truth-value can be assigned to each variable (each variable can be either true or false) and, given standard rules for each operator ("$\supset$" in this example), a truth-value for a whole equation can be derived. A tautology is where, if the premises are true, so must the conclusion also be true and this applies to this equation.[1]

Apprenticeship-based medicine is organised to implement this paradigm and so diagnosis is learnt from a Master (in the sense of a Master of a particular trade as defined by a trade guild). The limitation, of course, is that the Master may be totally wrong, as this model has no inherent need for any empirical knowledge as its basis. Rightness reflects a social or political process either within a guild or college or between Masters. Outcomes will be confounded by the charisma (or lack of it) of the Master and any consequent placebo effect. Cooper[2] described exactly this diagnostic model with these exact limitations in the USA/UK diagnostic project. During the 1960s the project demonstrated that American psychiatrists were more likely to diagnose a given patient as having schizophrenia compared to their British counterparts.

Kuhn's Central Diagnostic Paradigm

Kuhn, in his philosophical theory of science, stated that each branch of science is organised around a central paradigm. This central belief is the basis for all study within the branch.[3] The core role of the physician, and hence medicine, has always been to heal the sick. The rise of modern scientific medicine stems, in part, from Hume's influential philosophical work on 'cause and effect'.[4] So by understanding and resolving the underlying cause for any given clinical effect, the patient will be healed.

The accurate diagnosis as to the causation of any given illness has become the central paradigm of all medicine. It is the one step that is common to all branches of medicine even if the diagnostic and curative paradigms are unique to each sub-specialty. In logical notation this is expressed as:

$$\exists t \forall p((Atp \vee Btp) \wedge Atp \wedge \sim Btp) \supset Atp)$$

(Equation 1)

Equation 1 reads that at some point in time for every patient, that patient could have either diagnosis A or diagnosis B. They do have diagnosis A and do not have diagnosis B so they must have diagnosis A. A clinical example is that a child who presents crying could have a viral illness (diagnosis A) or have a teething syndrome (diagnosis B). The child does have a temperature, plus clinical signs of a viral illness (namely the child does have diagnosis A). There are no apparently erupting teeth on examination (so the child does not have diagnosis B). Hence the child must have a viral illness (diagnosis A).

This formula is a tautology because it must always be true if both the premises are true. It does not matter if "A" and "B" are two independent diagnostic options or if "A" is a state of pathology and "B" is the state of normality. The two most significant terms in equation 1 are those that state 'at some point in time for every patient, they do have diagnosis *"A"*' $(\exists t \forall pAtp)$ and 'at some point in time for every patient they do not have diagnosis *"B"*' $(\exists t \forall p \sim Btp)$. These two terms describe clinical medicine as experienced by physicians. They also delineate the source of clinical errors that bewilder and frustrate patients.

$$\exists t \forall p(Atp)$$

Meaning that at some point in time for every patient they do have a diagnosis of A. This term of the diagnostic equation is most familiar to clinicians and appears self-evident. It is an expression containing the consideration of the leading clinical diagnostic option and the associated non-independent diagnostic options. More correctly it should be expressed so as to describe the interplay between the various dependent diagnostic options:

$$\exists t \forall p((Atp \vee Atp') \wedge \sim(Atp \wedge Atp'))$$

(Equation 2)

Equation 2 outlines that the patient can have diagnosis A or dependent diagnosis A' but not both. Consider a patient who presents with acute arthritis. At this point in time, this patient could have acute osteoarthritis (diagnosis A) or acute gout (diagnosis A') as the cause for presentation, but not both. Medicine is organised primarily around this term, with each sub-specialty having a specific diagnostic process to answer this question. Most sub-specialty research is focused on the attributes and treatment of the various dependent diagnoses.

It is also one source of limitation in the diagnostic paradigm and hence generates diagnostic errors. The formula reads *'in at least one point in time, for every patient'*. Sadly it need not be the current point in time or any time before the patient's death, considering some rapid onset illnesses such as bacterial meningitis. This limitation is especially pertinent to general practice and emergency medicine where accurate diagnosis at a single point of time is socially expected but not always possible. This term will remain a constant source of bewilderment for patients with inevitable diagnostic failures and ongoing anxiety for clinicians. Its origin as a term is that medicine is not intrinsically about social issues (although there are social dimensions), rather it is primarily about the diagnosis and treatment of extrinsic adverse biological processes. The sigmoid curve of symptom development describes the impact of this extrinsic biological process on the human organism.

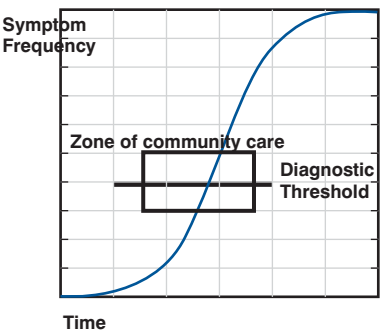

Figure 1. The accumulation of symptoms as an illness develops from normality to the classic clinical description.

The symptoms have to pass a diagnostic threshold before the diagnosis can be made even though the patient will experience symptoms for a period of time prior to this threshold. The diagnosis is easier, to the point of becoming self-evident, as time progresses, but this does not imply that a diagnosis can be made earlier. Presentations at or before the diagnostic threshold are common in general practice or emergency medicine so that accurate diagnosis is difficult, if not actually impossible. Consequently delayed diagnosis is inevitable in these disciplines.

$$\exists t \forall p(\sim B_{tp})$$

Meaning at some point in time for every patient the diagnosis is not B. This is a frequently forgotten term and is also the major cause for serious error in diagnosis. This term considers all of the independent diagnostic options. More correctly it should be expressed as the disjunctive series:

$$\exists t \forall p(\sim Btp(1) \vee \sim Btp(2) \vee \sim Btp(3) \vee \ldots \vee \sim Btp(n) \vee \sim Btp(n+1))$$

(Equation 3)

This states that at a given point in time for every patient the clinician needs to exclude each and every independent diagnosis B1 to Bn. As an example, consider the patient who presents with an inflamed joint following a fall. To exclude inflammatory arthritis as a cause of this current presentation in this particular patient the physician must exclude gout (**Btp(1)**) and osteoarthritis (**Btp(2)**) and rheumatic fever (**Btp(3)**) and so on for every other item in the differential diagnosis of acute arthritis. The final term (or 'n-th' term) in the list of differential diagnostic options that has been considered being term (**Btp(n)**).

This series is usually an empty set, namely there are no independent diagnostic options or it has a membership of only one item 'Normality'. Usually is not equivalent to always. Clinicians may not consider, or they may be unaware of, the (rare and often very rare) independent diagnostic options. This is the first source of diagnostic error this term creates. Physicians attempt to address this issue by the social process of long and exhaustive training, currently in the region of 15 years for a vocationally registered practitioner in New Zealand, with the addition of extensive ongoing maintenance of skills programmes run by each College.

The other error is the impossibility of excluding the negative. It is impossible to know if there is yet another diagnostic option (a **Btp(n+1)** diagnostic term) that requires exclusion even if **Btp(1)** to **Btp(n)** has been successfully excluded. Such a term may be a new cause of illness not previously described. This impossibility is made worse by the time parameter, so that even if the clinician somehow (magically) knows of the existence of a Bn+1 term, its exclusion may not be possible at the given point in time. Hence an absolute diagnosis can never be made for any given patient.

Clinicians solve this dilemma empirically by making a presumptive diagnosis and treatment is implemented on this diagnostic assumption. The patient is then monitored for illness resolution and for unexpected developments suggesting the revelation of a **Btp(n+1)** alternate diagnostic possibility.

There are inevitable financial implications generated by this term. The cost of diagnostic medicine will never be finite, as each test has a financial cost and each patient potentially needs infinite numbers of tests, so the cost must be infinite for each patient. Practically clinicians stop investigating as the law of diminishing returns becomes significant. Yet medico-legal fears, community expectations and clinicians' predominately type A personalities conspire to drive the diagnostic process beyond the reasonable with secondary budgetary consequences. Hence the apparently insatiable requirement for greater financial investment in health is logically inherent to the core diagnostic paradigm beyond the Lamarckian growth in medical knowledge itself.

The empirical solution of a working diagnosis with ongoing monitoring has its own associated limitations. The current funding models, in which the patient partially or wholly funds the monitoring phase, must lead to over-representation in poor outcome statistics for those who cannot afford, or fear they cannot afford, the proposed care. Capitation funding models, logically, will further exacerbate the limitations by the capping of state co-payments, either limiting a physician's ability to provide follow-up or increasing the financial burden on the patient, thereby undermining the effectiveness of the current medical model and potentially increasing the risks to the patient.

Medicine in crisis?

Kuhn, in his paradigm model of science, proposed a cycle in which science has an existing paradigm as the basis for all work. An existing paradigm begins to fail and a sense of crisis develops as increasing internal dissatisfaction develops. A new paradigm begins to emerge as a social process with the move by individuals from the old to the new paradigm.

Medicine can be seen to be in such a crisis. Despite apparently endless financial investment to solve existing problems, diagnostic errors continue as does the call for still more financial investment. Patients' expectations are not met and diagnostic tragedies continue seemingly unchecked.

What is unusual at this time is that there is little internal sense of crisis. Clinicians perceive dramatic advances in diagnostic processes providing new understandings of the underlying basic sciences being reflected in clinical practice. In effect, a relative golden era exists where society is enjoying the benefits accrued from the tremendous investment in medical science and

implementation systems to date. A relative utopia, which is hampered only by staff shortages and the lack of further financial investment, to allow the full benefit of the existing knowledge gains.

Any sense of a Kuhnian crisis is external. Medicine is perceived as failing to meet the needs of society by the society itself as judged by the Cartwright inquiry[5] and the ministerial inquiry into the under reporting of cervical smear abnormalities in Gisborne.[6] Society commonly perceives physicians' faith in the current medical model as about maintaining social status with its associated financial rewards rather than the delivery of clinical benefit. Society is equally intolerant of the missed or delayed diagnosis and feels that, for their financial investment, there should be a better return by now. The explanation that this is inevitable within the diagnostic paradigm and biological systems on which the paradigm operates generates new layers of skepticism and suspicion of endemic self-interest within the profession. Various social solutions have been proposed to the limitations inherent in Equation (1).

The Ottawa rules for the investigation of potential ankle fractures represents one such social solution. It seeks to limit the costs of investigation by confining it to the reasonable. Associated with this is a social/legal process stating that false negative results within these rules are unlikely but also acceptable, as the benefit to the whole of society from the money saved, both outweighs and pays for the cost to these unfortunate individuals.[7]

Recently the nurse practitioner has been proposed as another social solution in New Zealand. Nurses are more prevalent than physicians (and cheaper), while nursing paradigms are perceived as underutilised and undervalued in the health system.[8] Studies show that nurse practitioners and their associated nursing paradigms provide added benefit to patient care.[9] The case seems compelling. What the studies do not show is how the nursing paradigms will solve the inherent difficulties in Equation (1) any better than the medical paradigm. Moller[10] outlines physicians' fear of a growth in diagnostic errors and consequent worsening patient outcomes. This fear is based on the different emphasis of nursing training and the shorter duration of training leaving nurse practitioners less equipped to deal with the realities of diagnosis as expressed in Equation (1).

Conclusion

This paper has introduced the use of formal academic logic as a research tool to help understand medicine and its social structure and limitations by understanding the structure of the underlying beliefs. The equations, although complicated at first appearance, are only a nomenclature to describe the relationships between ideas. In this paper it has been shown a priori (by reason alone) that the endless need for financial injection is inevitable, as are delayed or incorrect diagnoses, with the current core diagnostic paradigm. In this paper logic has also been used to consider some of the current social solutions to these inherent limitations. Logic could also be used as a tool to describe and consider alternative solutions to Equation (1) and the delivery of health care in general. In reality, such an alternative solution would actually describe a major shift in belief and perception by all the stakeholders involved (physicians, nurses, other allied health providers, the state and the public) about health as a total concept. At this time, although the dialogue has started, much more research is needed. Logic provides a tool for that research effort, allowing for the focus to remain on the issues that confront society rather than on the political/social processes that co-exist.

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Competing interests

None declared.

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