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Models of clinical reasoning with a focus on general practice: a critical review

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Abstract

Introduction: Diagnosis lies at the heart of general practice. Every day general practitioners (GPs) visit patients with a wide variety of complaints and concerns, with often minor but sometimes serious symptoms. General practice has many features which differentiate it from specialty care setting, but during the last four decades little attention was paid to clinical reasoning in general practice. Therefore, we aimed to critically review the clinical reasoning models with a focus on the clinical reasoning in general practice or clinical reasoning of general practitioners to find out to what extent the existing models explain the clinical reasoning specially in primary care and also identity the gaps of the model for use in primary care settings

Methods: A systematic search to find models of clinical reasoning were performed. To have more precision, we excluded the studies that focused on neurobiological aspects of reasoning, reasoning in disciplines other than medicine decision making or decision analysis on treatment or management plan. All the articles and documents were first scanned to see whether they include important relevant contents or any models. The selected studies which described a model of clinical reasoning in general practitioners or with a focus on general practice were then reviewed and appraisal or critics of other authors on these models were included. The reviewed documents on the model were synthesized

Results: Six models of clinical reasoning were identified including hypothetic-deductive model, pattern recognition, a dual process diagnostic reasoning model, pathway for clinical reasoning, an integrative model of clinical reasoning, and model of diagnostic reasoning strategies in primary care. Only one model had specifically focused on general practitioners reasoning.

Conclusion: A Model of clinical reasoning that included specific features of general practice to better help the general practitioners with the difficulties of clinical reasoning in this setting is needed.

Keywords: Problem solving, General practitioners, Diagnosis

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Introduction

Diagnosis lies at the heart of general practice (1-3). Every day general practitioners (GPs) visit patients with a wide variety of complaints and concerns, with often minor but sometimes serious symptoms. For every patient, GPs try to translate the patients' narration of their problem into a possible diagnosis. They select symptoms and put them together with what they find as they observe the patient, take history and do physical

examinations (4). Over 70% of all diagnoses in general practice are based on history taking (5); and diagnostics is estimated to be the largest part of all GPs' work (80%-85%) (6).

As diagnosis is a central component of the physicians' tasks, the teaching and learning of diagnostic reasoning should have a critical position for medical education system. In fact, medical educators believe that clinical reasoning is a central component of physicians' competence and during the last 3 decades, an increasing number of medical education bodies and medical schools recognize this competence in their recommendations and documentations. All agree that clinical reasoning or one of its equivalent terms, such as problem solving diagnostic reasoning and clinical judgement, should be taught and examined. However, when it comes to action, to plan relevant learning experiences and assess the level of achievement by the medical students, we see that the whole story grows more complicated (7).

During the last four decades, studies on the nature of clinical reasoning have advanced our knowledge on the subject and different models have been developed for describing the factors contributing to clinical reasoning. In most of these studies, the main focus was to study the difference between novices and experts in terms of clinical reasoning skills (7), and little attention has been paid to clinical reasoning in general practice.

General practice has many features which differentiate it from specialty care setting. Since many patients are visited at the early stages of disease progression, the cues to decide on are fewer and sometimes different. The GPs have to be particularly responsive to behavioral clues. Since the probability of diseases seen in general practice is different from that in selected patients referred to specialties, the initial diagnostic hypothesis will be different; in other words, at least the list at differential ranking order is not similar. Since the GPs encounter the disease in its early stages, diagnosis has to be made with higher level of uncertainty compared with more differentiated presentation of later stages of diseases observed in hospital practice (8).

Since GPs' goals are often different from those of specialties (where a definitive diagnosis is the typical goal), the end point of clinical reasoning process may be different. For example, in a patient with moderate abdominal pain, the end point decision of GPs may be achieved when there is enough evidence to refer the patient for surgical evaluation although the definitive diagnosis is not known (9, 10).

This article aimed to critically review those clinical reasoning models with a focus on the clinical reasoning in general practice or clinical reasoning of general practitioner to find out to what extent the existing models explain the clinical reasoning, specially in primary care, and also identity the gaps of the model for use in primary care settings. This contributes to the design of a new model that fills the gap between our understanding of the complex strategies used in clinical reasoning and their application in real setting of general practice.

Methods

As in this study our main goal was to find models of clinical reasoning with a focus on general practice to see their strength and weaknesses, critical review was an appropriate method, as Carnwell and Daly state the main purpose of critical review is appraising and synthesizing the current state of knowledge related to a topic of interest in order to identify the gaps in that area (11).

The topic of interest in this study was clinical reasoning models with a focus on general practice. The next step was a systematic search with the following keywords in pubmed and google scholar:

"clinical reasoning, clinical problem solving. diagnostic strategies, diagnostic reasoning model, clinical judgment, clinical reasoning model, problem solving model" AND, OR "primary care, general practice, family physicians, generalist, general practitioner".

To be more precise, we excluded the studies that focused on neurobiological aspects of reasoning, reasoning in disciplines other than medicine, decision making or decision analysis on treatment or management plan.

All the articles and documents were first scanned to see whether they include important relevant contents or any models. The selected studies which described a model of clinical reasoning in general or with a focus on general practice were then reviewed. The refrences of the main articles describing a model were also hand searched to include all important topics related to the model.The articles which provided the use of these models in general practice or appraised and criticised these models were also included. In order to ensure the inclusion of all important criticisms on these models, the main articles descibing the models were tracked for citation through pubmed and google scholar.

As Carnwell and Daly (10) emphasized, care was taken to avoid mere description of the model.

Results

The search results were initially screened

by reviewing the titles and abstracts for relevance. In the initial search, 132 articles were extracted; 43 articles were identified irrelevant (teaching reasoning, decision making for management,etc.) and the rest were reviewed for identifying important and relevant models or criticisms on models or their use in general practice. Further search of refrences and citations identified 26 relevant articles which resulted in 115 final articles.

Six models of clinical reasoning were identified. Only one (Model of diagnostic strategies used in primary care) was directly focused on general practice. For each model, first the elements of the model were described; second, the critics' views (if any) were reviewed, and at the end our views are explained.

1. Hypothetico – deductive model

A study by Elshtine et al. (12) showed that in a clinical encounter after a few minutes clinicians generated several diagnostic hypotheses based on the cues they found and subsequently they gathered data to rule in or rule out these hypotheses. Elstein explained four components in the diagnostic reasoning process: cue acquisition hypothesis generation, cue interpretation and hypothesis evaluation which all work in a cycle (Figure 1).

What this model adds to the previous knowledge was that in contrast to the traditional understanding that recommended we should first gather extensive information of the patients though a complete history and physical exam, and generate a list of differential diagnosis (13), hypothesis generation is an early event in the diagnostic reasoning process. The problems with this model was that it did not respond to the researchers' expectation of explaining the difference in the experts' better performance in diagnostic reasoning in comparison to novices since all practitioners at all levels were following a similar process (14). Elstein noted that solving one clinical problem is not a strong predictor of solving the second problem; he called this as "content specificity" which was in contrast with the general long-held belief that problem solving was an independent ability associated with expertise. Later Barrows et al. showed that the quality or accuracy of the early generated hypotheses were more strongly associated with final success compared with the number of hypotheses generated or the time of hypotheses generation in the course of diagnostic reasoning course (15). Given the fact that hypotheses generation is a synthetic cognitive activity, and the fact that based on Bloom's taxonomy of cognitive objectives working on this level is time consuming (16), we believe this model is not capable of explaining the diagnostic process in these instances that the physician diagnoses the patient's problem quickly. However, Elshtine later accepted that this model explained only one kind of diagnostic reasoning (17).

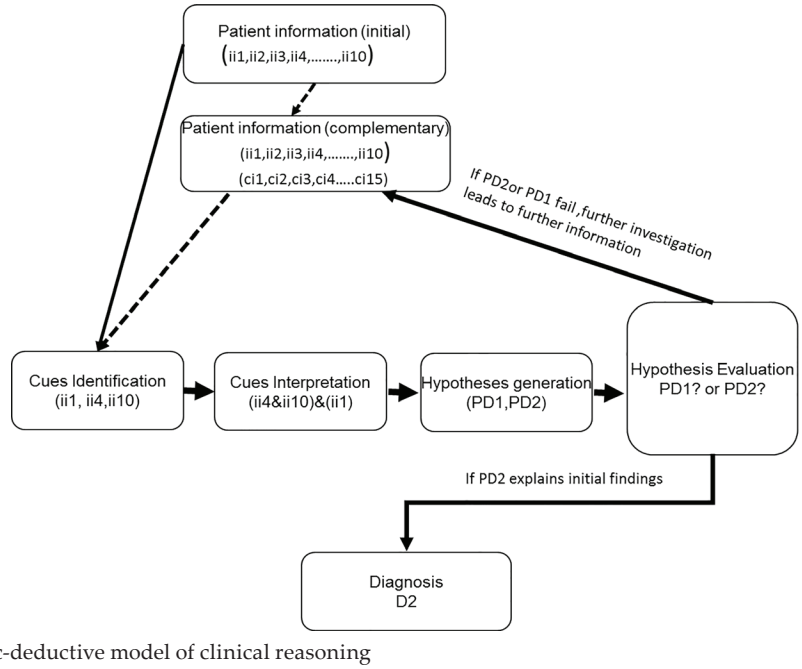

Figure 1: hypothetic-deductive model of clinical reasoning

At first patient physician visit few initial information initiated (ii). The practitioner identifies some information(ii1,4,10) as important cues. They interpret the cues to form hypotheses PD1 and PD2. If in evaluation one hypothesis(PD2) explains the findings then the diagnosis is confirmed. If all hypotheses fail to explain the findings further investigation (from more detailed history to lab tests) generate complementary information (ci) and the process is repeated(dashed lines shows the beginning of a new attempt for making the diagnosis)

2. Pattern recognition model

Arocha suggested that diagnosis occurs through rapid non-analytical matching of clinical presentation with a pattern previously formed of constructs of clinical signs and symptoms (or pattern) in memory (18-20). He believes that the retrieval of these pattern is triggered by recognition of key features within the case (18). New cases are classified according to their resemblance to clinical patterns (19, 20). The idea of pattern recognition was further strengthened with the observation that the clinical reasoning of medical experts in familiar situations does not frequently include hypotheses testing (19-22). A question may be raised as to the nature of the pattern stored in the memory against which new cases are categorized. Two answers to this question were supported by research evidence. A new case is matched against a specific instance or "exemplar" or to a more abstract construct or "prototype". In an exemplar-based recognition, a new case is matched by its resemblance to memories of specific instances previously encountered (19, 22). The observation that diagnosis is strongly influenced by the context even when the context is irrelevant (for example the age and occupation of a patient with a left bundle branch block on an ECG) supported the notion of exemplar (20). In the prototype-based recognition, a new case is matched to a prototype (23, 24). The basis of prototype model is that an abstraction process is used to construct a common memory trace of two or more patients, seen with the same disease or set of signs and symptoms (25).

Barrows and Feltovich (26) questioned the pattern recognition asking how the patient's pattern is obtained by the doctor to make a comparison. They also pointed out that the patient's problem required a temporal unfolding, so the pattern of patient's problem was not available instantly. They claimed that those working on pattern recognition might have presented their physician participants with complete or near complete cases and ignored the complex process that occurs during the actual reading of the cases presented. They believed that pattern recognition was a form of very fast hypothetic-deductive inquiry and because it happened at an incredible speed, this processes could not be traced and this should not suggest that their reasoning process must be a simple pattern recognition.

Groves et al. (27) who studied the pattern of clinical reasoning of a group of general practitioners found that most GPs were able to reach the correct diagnosis despite frequent failures to identity a problem's most critical features, suggesting that their diagnosis process shortcuts the hypothesis generation necessary for hypothetic-deductive model. This finding answers the Barrow's questioning the existence of pattern recognition.

We believed that most clinical experts used pattern recognition for many familiar patients' problem encountered in every day clinical visits, but when the patient's problem is not a routine one and more ambiguous, pattern recognition could not be used.

As pattern recognition is a form of non-analytical reasoning, it is warranted to suppose that error in the process is more likely.

3. A dual process diagnostic reasoning model

Two fundamental approaches to clinical reasoning, non-analytical (intuitive) and analytical, have been identified. Croskery (28) provided a model of clinical reasoning that linked the two approaches. The patient's presentation starts the process. If key features of the presentation are recognized at this stage, the non-analytical mode (system 1) gets automatically active. This initial feature or pattern can be visual presentation of the illness or injury, such as dermatological conditions, fractures, endocrine disorders, etc. or combination of such symptoms or findings (syndromes), illness scripts, etc.). If the presentation is not recognized, or if there are ambiguities on the presentation, the analytical reasoning mode of reasoning (system 2) is engaged. In this system, the data are systematically examined and logically decided on. As the cycle of cues identification, cues interpretation, hypothesis generation, and hypothesis testing are in place in this system (28, 29), it is slower than system 1 and is more resource intensive in terms of cognitive work it needs, but it is considered less prone to error (28).

System 1 and system 2 may interact (28, 30, 31). Pattern recognition provides clinicians with hypotheses more rapidly and then the analytical process is confirmed, ruling out other possibilities (32). System 2 also monitors system 1 and might apply a rational override (28). For example, a rash which looks like shingles at first sight (system1) might be further worked up (system) if there are atypical features (for example if it crosses the midline). At times, system 1 may override the sound reasoning developed by system 2 (28). For example, think of a physician that has recently read a guideline on radiography for low back pain, stating that the routine radiography in non-complicated low back pain is useless, but he or she still orders radiography for the patients with low back pain following his intuitive approach.

The repetitive processing in system 2 leads to recognition of the process by system 1 (28). In other words, repetition moves the relevant illness presentation from system 2 to the pattern reservoir of system 1.

As this model is derived from cognitive psychology (33), further evidence is needed to investigate if the physicians actually perform their reasoning within this model.

Balla et al. studied GPs reasoning and found that GPs first automatically make a quick working diagnosis based on key features of the clinical presentation (system 1), and then they activity confirm the diagnosis by deliberately collecting further information (system 2) (34).

The interaction of the two systems and particularly the conditions of system 1 override (dysrationalia) should also be investigated because system 1 is more prone to error.

4. Pathway for clinical reasoning model

Ferreria et al. (35) examined clinical reasoning of 16 physicians during patients visit and through clinical discussion between these physicians, and individual interviews with them. The resulting model description is as follows:

Physicians begin with a set of exploratory questions about the patient's current complaint and past and family history. Physicians use these general questions as a way to find one or more signs and symptoms that trigger a clue to a diagnosis. When this initial diagnostic hypothesis is reached, the physician stops exploring and starts on a confirmatory path, rather than examining the alternatives.

One important source of information from the very beginning of the encounter is environmental sources such as previous health record, previous lab test results, and referral letters from other health care professionals. This environmental or contextual information usually ledds to a cautionary sense resulting in a more rigorous investigation.

After the initial hypothesis is reached, physicians continue to gather hypothesis specific information to confirm the diagnosis. When information contradicting the initial hypothesis emerged, its sources are usually the patients or unexpected findings on lab tests, not the physician. The first attempt at the encounter of contradictory findings is trying to refute the contradicting information rather than immediately moving to alternative hypotheses. Only, when physicians cannot refute the contradictions, they explore alternative hypothesis. If no contradictory information is found (or if found, refuted) the physician goes to saturation point where the diagnosis is deemed final.

We believe that this model is an elaboration of hypothetic- deductive model, adding more detail to what happens at the evaluation stage and more insight into how evaluation leads to diagnosis with introduction of saturation concept. Assigning a role to environmental or contextual factors, and the attempt to explain them as distinct effective factors are valuable, but further studies are recommended to better define it. The model is rather too general and does not recognize specific strategies the physicians might use at different stages of generating hypothesis and its confirmation.

5. An integrative model of clinical reasoning

Gruppen and Fohna (36) state that the reasoning process starts with the information taken from the patients. The physician's prior knowledge helps to form an initial representation of the patient problem. The quality of this initial problem representation is critical for fruitful result of the reasoning process.

The next step is evaluation of this problem representation; the evaluation here is not the last stage but a repetitive step in the reasoning cycle. At the initial cycles, the evaluation might be largely non-analytical, roughly comparing the problem representation with archived knowledge structure of the physician to identify the lacking feature. This, in turn, directs the information gathering as the next step. These new pieces of information lead to a new problem representation and evaluation. This cycle continues until the evaluation confirms the goodness of fit of the problem representation with a diagnosis.

This cycle is affected by factors in the environment or the context. Physicians' prior relationship with the patient, prior experience with similar problems, the availability of clinical resources, and the patients' general expectation of care process are some examples of contextual factors that influence the physicians' clinical reasoning. Although context is neglected in a significant proportion of clinical reasoning research, a study showed that experts are more sensitive to contextual cues than novices (37).

In this model, problem representation is used rather the same as hypothesis concept in other models. In this model, the perception of the physician based on his prior knowledge and contextual or environmental factors were emphasized. The hypothesis or problem representation is repetitively developed based on gathering new information and evaluation, while in previous models the rejection or confirmation of a single hypothesis at each stage were proposed.

This model does not explain analytical vs. non-analytical modes of reasoning . Further studies are needed to clarify different kinds of contextual factors' effect on information gathering problem representation and evaluation. The concept of evaluation and its different stages with advancement of the cycle should be defined.

6. Model of diagnostic reasoning strategies in primary care

Hereghan et al. (38) provided a three-stage model of initiation of diagnostic hypothese, refinement of the diagnostic hypotheses, and defining the final diagnosis. In each stage, several strategies are recognized. The strategies in each step may be used together or alone and in some instances, the diagnosis may be reached at the first or second stage without reaching the final stage (for example, diagnosing simple acne and initial stage).

Four strategies were recognized at the first stage. Spot diagnosis (39) - self labeling – presents the complaint and pattern recognition trigger. Spot diagnosis arises from a non-analytical recognition of a particular non-verbal pattern. It does not require further history from the patient to reach possible diagnosis (like acne). Many consider spot diagnosis as the basic pattern recognition (40, 41). Spot diagnosis was used in 20% of cases and for 63% of these, no further diagnostic strategy was used.

Self-labeling is the diagnosis that patient may tell you. This may or may not be correct and is based on the patient's experience with the same problem.A study on women with recurrent urinary tract infection showed that their self-diagnosis was correct most of the time (38, 42). Presenting complaints is the first step proposed by traditional textbooks on diagnosis (38, 43). Pattern recognition triggers the findings in history or physical examination that may trigger a hypothesis (38, 44).

Five strategies were used in refinement stages of this model, restricted rule outs (38, 45) stepwise refinement of the diagnostic hypothesis, probabilistic reasoning (38, 46, 47), pattern recognition fit (38), and clinical prediction rule. These strategies are used to direct the information gathering and refinement of the diagnostic hypotheses.

By the end of this stage, less than half of the cases result in the certainty of a known diagnosis (38) or, as Ferreira et al. said, reach a saturation point (22). The GPs use other strategies in the final stage of diagnosis, including ordering further tests, test of treatment (25, 48) and test of time (38, 49). In some cases, the final diagnosis could not be given a label (38, 50). This model focused on the diagnostic strategies used for hypotheses generation and evaluation. These strategies, which are close to real practice, are lacking in other models we have already described.

We believe this model highlights the analytical mode strategies (Restricted rule out, stepwise refinement probabilistic reasoning, clinical prediction rule) and non-analytic reasoning strategies (Pattern recognition trigger-pattern recognition fit, snap diagnosis). But in contrast with other models that attempted to show a general view of the reasoning process, it does not further provide where and when the strategies of the second and third stages in the process of reasoning for diagnosis are used.

Discussion

General practitioners' reasoning ability is central to reaching a correct diagnosis and prescribing effective treatments, but models of clinical reasoning, specially in general practice, form only a small proportion of the current research and medical curriculum (51).

Six models of clinical reasoning were identified,including hypothetic-deductive model, pattern recognition, a dual process diagnostic reasoning model, pathway for clinical reasoning, an integrative model of clinical reasoning, and model of diagnostic reasoning strategies in primary care (Table 1).

It has been a long tradition in medicine that to diagnose a patient (case) first the physician should take complete history, do a thorough physical exam, and then based on the acquired information develop a differential diagnosis list (16). Elshtein et al. showed that hypothesis development is an early event in the process of diagnosis (1). The model clarified what is going on in the analytical mode of reasoning but provided no explanation of non-analytical reasoning. The pattern recognition model based on theories of knowledge organization in experts explained the rapid non-analytical mode of reasoning.

The dual process model was an attempt to explain the two mode of reasoning relation and interaction. It also explains that the repetition of the same clinical problem in system 2 contributes to the formation of knowledge structures about that problem so that the reasoning on that problem moves to system1 (non-analytical reasoning), clarifying the role of experience in development of non-analytical pathway.

Pathway for clinical reasoning by Ferreria et al. (35) as well as the integrative model of clinical reasoning by Gruppen and Frohna (36) both added the concept of environmental or contextual factors, besides the clinical

Table 1: Description of six clinical reasoning model

Models of clinical reasoning	A brief description of the component
1. Hypothetic-deductive	Elshtein explained four components in the diagnostic reasoning process: cue acquisition hypothesis generation, cue interpretation and hypothesis evaluation which all working in a cycle. The hypothesis generation is an early event in the diagnostic reasoning process.
2. Pattern recognition	The diagnosis occurs through rapid non-analytical matching of clinical presentation with a pattern previously formed of constructs of clinical signs and symptoms (or pattern) in memory. the retrieval of these pattern is triggered by recognition of key features within the case.
3.A dual process diagnostic reasoning model	The model builds on both analytical and non-analytical modes of reasoning. The initial presentation, if familiar to let any pattern recognized, will be dealt with system1. If the patient problem is complicated, system 2 which is analytical will be activated. The system 2 also monitors system1 and if detects any problem(rational override) but at times system 1 overrides system 2 (dysrationalia).
4. Pathway for clinical reasoning	The initial patient presentation is searched for cues. The identified cues as well as environmental factors interacts to form an initial hypothesis. The physician actively searched for information to confirm this hypothesis unless unwanted contradictory evidence emerges. The physician first tries to refute the contradictions. If refutation fails the physician then revise the hypothesis in light of new evidence. The new hypothesis should be confirmed again.
5. An integrative model of clinical reasoning	The features of patients complaint, physicians' prior knowledge leads to an initial patient problem representation(PR) which was immediately evaluated and if this initial PR does not lead to diagnosis more information is gathered, PR is revised and evaluated again. This cycle is influenced by contextual elements and repeated until a diagnosis made.
6. Model of diagnostic reasoning strategies in primary care	Explain strategies physicians used in three stage of initiation of diagnostic hypotheses, refinement of the diagnostic hypotheses, and defining the final diagnosis. It covers both analytical and non-analytical strategies.

information, in hypothesis development. Ferreia et al. highlights the importance of the initial hypothesis as the primary force driving the physician attempt to confirm it and refuting contradictory clues or evidence. In contrast, Gruppen and Frohna see a developmental cycle of information gathering, problem representation (hypothesis development) and evaluation which could change the initial problem representation for several times until a good fit with a diagnosis happened through evaluation.

Model of diagnostic strategies introduces stages for clinical reasoning and specific strategies used in general practice. It does not classify the strategies based on analytical vs. non-analytical modes of reasoning, but it covers strategies of both modes. Although it classifies the strategies into three different stages, it does not provide any further clue on how these strategies within a stage and among stages are related.

The models of clinical reasoning each shed light on different parts of the process of clinical reasoning, but as the setting of general practice has specific features and general practitioners encounter higher degrees of uncertainty, a model of clinical reasoning which could contribute to diagnosis in general practice is still needed.

Conclusion

The review of models in clinical reasoning reveals that much improvement has happened during more than 40 years of works on clinical reasoning and our understanding of this phenomenon has been constantly improved. Each model attempts to explain a part of the process that was not represented in other models. However, we still need models of clinical reasoning that include specific features of general practice to help the general practitioners with difficulties of clinical reasoning in this setting.

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