

Five decades of research and theorization on clinical reasoning: a critical review

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Abstract: Clinical reasoning is a complex cognitive process that is essential to evaluate and manage a patient's medical problem. The aim of this paper was to provide a critical review of the research literature on clinical reasoning theories and models. To conduct our study, we applied the process of conducting a literature review in four stages in accordance with the approach of Carnwell and Daly. First, we defined the scope of the review as being limited to clinical reasoning theories and models in medical education. In the second stage, we conducted a search based on related words in PubMed, Google Scholar, PsycINFO, ERIC, ScienceDirect and Web of Science databases. In the third stage, we classified the results of the review into three categories, and in the fourth stage, we concluded and informed further studies. Based on the inclusion and exclusion criteria, 31 articles were eligible to be reviewed. Three theories and two models were recognized and classified into three categories. Several theories and models have been proposed in relation to clinical reasoning, but it seems that these theories and models could only explain part of this complex process and not the whole process. Therefore, to fulfill this gap, it may be helpful to build a Meta-model or Meta-theory, which unified all the models, and theories of clinical reasoning.

Keywords: clinical reasoning, medical education, review

Introduction

Clinical reasoning is a complex cognitive process that is essential to evaluate and manage a patient's medical problem.¹ It includes the diagnosis of the patient problem, making a therapeutic decision and estimating the prognosis for the patient.² In describing the importance of clinical reasoning, it has been acknowledged that clinical reasoning is the central part of physician competence,³ and stands at the heart of the clinical practice,⁴ it has an important role in physicians' abilities to make diagnoses and decisions.¹ Clinical reasoning has been the subject of academic and scientific research for decades;⁵ and its theoretical underpinning has been studied from different perspectives.⁶ Clinical reasoning is a challenging, promising, complex, multidimensional, mostly invisible,⁷ and poorly understood process.⁸ Researchers have explored its nature since 1980,⁹ but due to the lack of theoretical models, it remains vague. Most used theoretical models have limited explanatory power, and are based on certain assumptions about what constitutes clinical reasoning.¹⁰ In the literature of clinical reasoning, several competing theories and models have been raised.^{1,11-13} Although most of the theoretical contributions on clinical reasoning belong to the 20th century, proposing new models are well continued into the 21st century, for example, Haring and her

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colleagues proposed a conceptual model for expert judgment of clinical reasoning of medical students.¹⁴ However, there is no general agreement as to which of these is the best.¹⁵ The purpose of this paper is to provide a critical review of the research literature on clinical reasoning theories and models and present a comprehensive view of main models and theories of clinical reasoning in medical education. A clearer understanding of clinical reasoning models and theories help medical teachers for teaching, planning, and assessment of clinical reasoning. This paper tries to clarify the current knowledge regarding the clinical reasoning models and theories and present a classification of the main theories and models.

Materials and methods

Grant noted, “A critical review aims to demonstrate that the writer has extensively researched the literature and critically evaluated its quality.”¹⁶ It included a degree of analysis and conceptual innovation.¹⁶ In this study, we applied the process of conducting a literature review according to Carnwell and Daly.¹⁷ They proposed a “four-stage” method that included: 1) “Defining the scope of the review,” 2) “Identifying and selecting the sources of relevant information,” 3) “Organizing the results of the review into categories,” and 4) “Concluding and informing further studies.”¹⁷

Step 1: defining the scope of the review

The scope of this review was limited to the main clinical reasoning theories and models proposed in medical education literature. We concentrated our review on published works in scholarly journals between the years 1970 and 2018.

Step 2: identifying and selecting the sources of relevant information

At this stage, each of the two reviewers conducted a separate search based on keywords – “clinical reasoning,” “diagnostic reasoning,” “clinical reasoning theory,” “clinical reasoning model,” “script theory,” “hypothetico–deductive model,” “cognitive continuum theory,” and “dual processing theory” – in PubMed, Google Scholar, PsycINFO, ERIC, ScienceDirect and Web of Science databases. The results were pooled and extensive literature were found (n=305) which was from 1970 to 2018, but due to lack of access to the full text of some articles, and after removing duplicated studies, the title and abstract of

articles from 1974 up to 2018 have been reviewed by researchers (n=170) (Table 1).

Then, the articles that presented theories or models of clinical reasoning in medicine or provided evidence in relation to them were selected to full-text study. Studies were eligible for this critical review if they presented a model or a theory of clinical reasoning, or related critiqued models and theories or the studies that add some features to the theories and models of clinical reasoning (n=47). The inclusion criteria of selecting studies were: 1) published articles in English and Persian and 2) published articles in the field of medicine. Studies were excluded if they provided clinical reasoning models or theories in other fields (like nursing and optometry), examined the clinical reasoning in the field of artificial intelligence (like clinical decision support systems), and/or examined brain biology and brain functions (like fMRI studies).

Step 3: organizing the results of the review into categories

After excluding irrelevant studies, a total of 31 documents were initially selected for review which is shown in PRISMA flowchart below (Figure 1).

Models and theories which were extracted from studies, classified to three categories and each category, based on Carnwell and Daly approach, reviewed in three steps: first, we present a summary of the models and theories, and then reflect other author’s views and finally, we present our view (Table 2).¹⁷ If a model or theory explains about the process of clinical reasoning our first category owns it while models and theories which clarified the formation of knowledge structures and their application during the clinical reasoning process belongs to the second category, and our third category consisted models and theories which consider more than one processing modes of clinical reasoning.

Results

First category: theories and models based on the process of clinical reasoning

This category includes the models and theories that explain the clinical reasoning process, between models and theories that we reviewed, only hypothetico-deductive model was eligible to get placed in the first category as the most reputed model that explains the clinical reasoning process. This model was proposed by Elstein (1978), and, according to this model, the physicians primarily generate

Table 1 Scientific studies about clinical reasoning that has been title and abstract reviewed

| First decade | Second decade | Third decade | Fourth decade | Fifth decade |
|--|---|---|---|---|
| Feinstein (1974) ⁴¹ Rubin (1975) ⁴² Elstein et al (1978) ⁴³ Elstein & Bordage (1979) ⁴⁴ | Kraytman et al (1981) ⁴⁵ Feltovich et al (1984) ⁴⁶ Kuipers & Kassirer (1984) ⁴⁷ Schmidt & de Volder (1984) ²³ McGuire (1985) ⁴⁸ Patel et al (1986) ¹⁹ Barrows et al (1987) ³¹ Case et al (1988) ³² Hamm (1988) ³⁹ Groen & Patel et al (1988) ⁴⁹ Girotto & Legrenzi (1989) ⁵⁰ | Elstein et al (1990) ¹⁸ Joseph & Patel (1990) ⁵¹ Patel et al (1990) ⁵² Norman et al (1990) ⁵³ Schmidt et al (1990) ²⁵ Ericsson (1991) ⁵⁴ Kaufman (1991) ⁵⁵ Mattingly (1991) ⁵⁶ Custers et al (1992) ⁵⁷ Evans & Patel (1992) ⁵⁸ Florance (1992) ⁵⁹ Henny Boshuizen et al (1992) ⁶⁰ Higgs (1992) ²⁰ Arocha et al (1993) ⁶¹ Hassebrock et al (1993) ⁶² Patel et al (1993) ⁶³ Schmidt et al (1993) ⁶⁴ Higgs (1993) ⁶⁵ Joseph Arocha et al (1993) ⁶⁶ Bordage (1994) ⁶⁷ Elstein (1994) ²² Patel et al (1994) ⁶⁸ Jones (1995) ⁶⁹ Joseph Arocha & Patel (1995) ⁷⁰ Custers (1995) ⁷¹ Custers et al (1996) ^{26,28} Hammond (1996) ³⁸ Mandin et al (1997) ³⁰ Van de Wiel (1997) ⁷² Allen et al (1998) ⁷³ Chang & Bordage (1998) ⁷⁴ Charlin et al (1998) ⁷⁵ Custers et al (1998) ²⁴ Cuthbert (1999) ⁷⁶ Kaufman et al (1999) ⁷⁷ Round (1999) ⁷⁸ | Charlin et al (2000) ¹² Carter & Robinson (2001) ⁷⁹ Harries & Harries (2001) ⁸⁰ Round (2001) ⁶ Elstein & Schwarz (2002) ⁸¹ Nendaz (2002) ⁸² Patel et al (2002) ⁸³ Bleakley et al (2003) ⁸⁴ Coderre et al (2003) ⁸⁵ Norman & Eva (2003) ⁸⁶ Eshach & Bitterman (2003) ⁸⁷ Groves et al (2003) ⁸⁸ Hardin (2003) ⁸⁹ Charlin & Van der Vleuten (2004) ⁹⁰ Eva (2004) ⁹¹ Rikers et al (2004) ⁹² Verkoijen et al (2004) ⁹³ Holyoak & Morrison (2005) ²¹ Norman (2005) ³ Tamayo-Sarver (2005) ⁹⁴ Anderson (2006) ⁹⁵ Bowen (2006) ⁹⁶ Eva & Cunningham (2006) ⁹⁷ Lofus (2006) ⁵ Montgomery (2006) ⁹⁸ Novak et al (2006) ⁹⁹ Thornton (2006) ¹⁰⁰ Auclair (2007) ¹⁰¹ Schmidt & Rikers (2007) ¹⁰² Norman et al (2007) ¹¹ Banning (2008) ¹⁰³ Evans (2008) ¹³ Harasym et al (2008) ²⁹ Heiberg (2008) ¹⁰⁴ Higgs (2008) ⁷ Humbert (2008) ¹⁰⁵ | Aleluia et al (2010) ¹¹³ Corcoran (2010) ¹¹⁴ Mariasin (2010) ¹¹⁵ Lee et al (2010) ¹¹⁶ Omana et al (2010) ¹¹⁷ Wilhelmsson (2010) ¹¹⁸ Thomson et al (2010) ⁸ Amini et al (2011) ¹¹⁹ Durning (2011) ¹²⁰ Franklin et al (2011) ¹²¹ Pelaccia et al (2011) ¹ Thomson et al (2011) ⁸ Adams (2012) ¹²² Ashoorion et al (2012) ¹²³ Van Bruggen (2012) ¹²⁴ Charlin et al (2012) ¹²⁵ Demirören & Palaoglu (2012) ¹²⁶ Braude (2012) ¹²⁷ Braude (2012) ¹²⁸ Khatami et al (2012) ¹²⁹ Lucchiari & Pravettoni (2012) ¹⁰ Lofus (2012) ⁴ Marcum (2012) ³⁴ Nouh et al (2012) ¹³⁰ Shaban (2012) ¹³¹ Adams (2013) ⁹ Custers (2013) ⁴⁰ Audétat et al (2013) ¹³² Da Silva (2013) ¹³³ Evans & Stanovich (2013) ³⁶ Gigante (2013) ¹³⁴ Kriewaldt (2013) ¹³⁵ Lubarsky et al (2013) ¹³⁶ Munshi et al (2013) ¹³⁷ Smith (2013) ¹³⁸ Weiss et al (2013) ¹³⁹ Ilgen et al (2013) ¹⁴⁰ |

(Continued)

Table 1 (Continued).

| First decade | Second decade | Third decade | Fourth decade | Fifth decade |
|--------------|---------------|--------------|--|---|
| | | | <p>Noreen et al (2008)¹⁰⁶ Vertue & Haig (2008)¹⁰⁷ Braude(2009)¹⁰⁸ Bissessur et al (2009)¹⁰⁹ Carrière et al (2009)¹¹⁰ Croskerry (2009)^{35,37} Elstein (2009)³³ Stempsey (2009)¹⁵ Rehder & Woo Kim (2009)¹¹¹ Vosniadou (2009)¹¹²</p> | <p>Bowen & Ilgen (2014)¹⁴¹ Delany & Golding (2014)¹⁴² Freiwald et al (2014)¹⁴³ Geisler et al (2014)¹⁴⁴ Gordon (2014)⁴⁵ Holmboe & Durning (2014)¹⁴⁶ Hrynchak et al (2014)¹⁴⁷ Hochberg et al (2014)^{148,149} Monajemi (2014)⁵⁰ Roots (2014)¹⁵¹ Salkeld (2014)¹⁵² Smith et al (2014)¹⁵³ Capaldi (2015)¹⁵⁴ Custers (2015)²⁷ Gaba (2015)¹⁵⁵ Islam et al (2015)¹⁵⁶ Lafleur & Leppink (2015)¹⁵⁷ Lubarsky et al (2015)¹⁵⁸ Park et al (2015)¹⁵⁹ Lisk (2016)¹⁶⁰ McBee et al (2016)¹⁶¹ Gruppen (2017)¹⁶² Haring et al (2017)¹⁴ Jarodzka et al (2017)¹⁶³ Norman et.al (2017)¹⁶⁴ Ten Cate et.al (2017)¹⁶⁵ Zamani et al (2017)¹⁶⁶ Bowen & ten Cate (2018)¹⁶⁷ Custers (2018)¹⁶⁸ Daly (2018)² King et al (2018)¹⁶⁹ Keemink et al (2018)¹⁷⁰ Lopes et al (2018)¹⁷¹ Yazdani & Hoseini (2017)¹⁷² Yazdani et al (2018)¹⁷³ Higgs et al (2018)¹⁷⁴</p> |

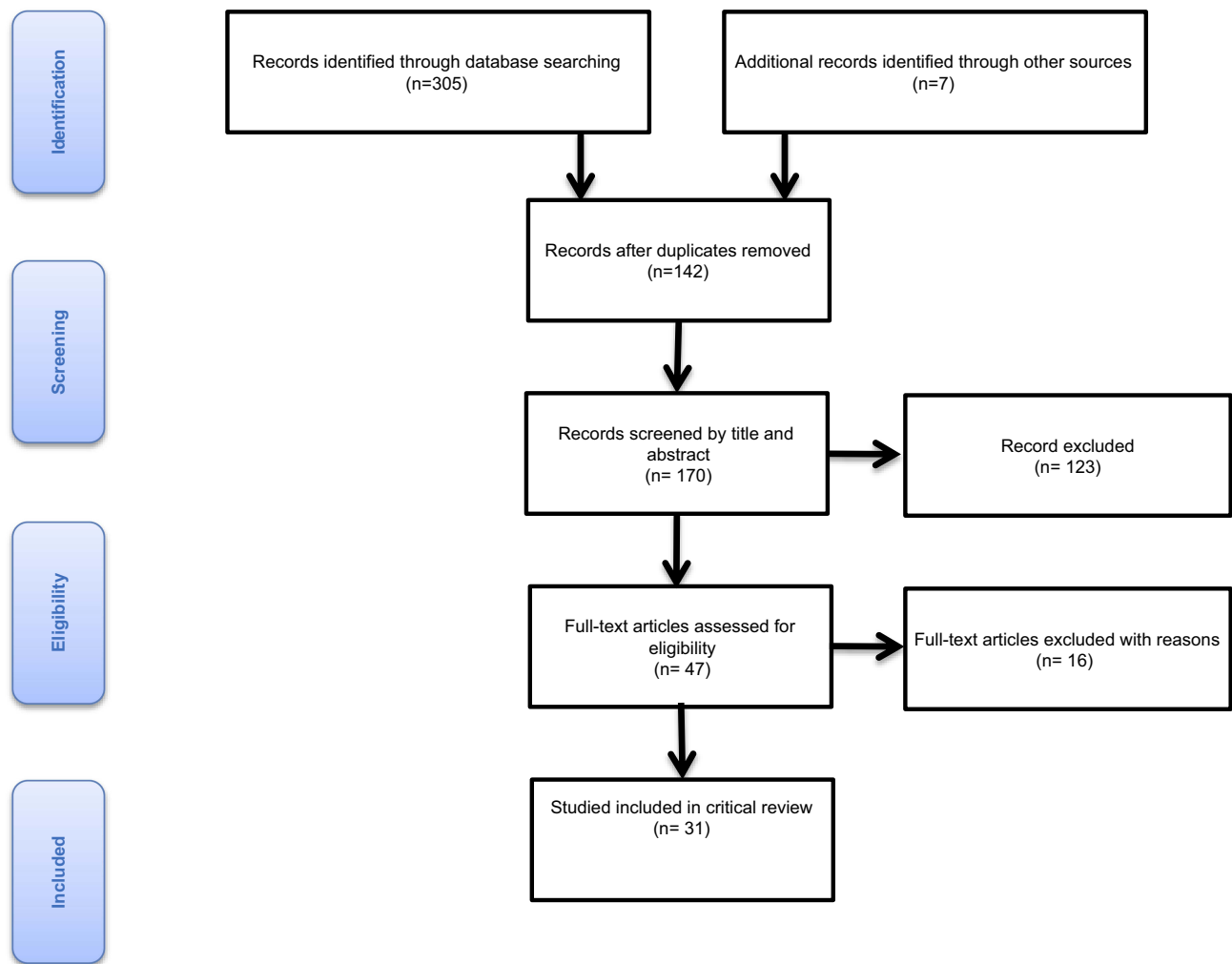


Figure 1 PRISMA flowchart.

a limited number of diagnostic hypotheses or problem formulations in the process of solving a diagnostic problem and then testing them. These hypotheses guide further patient information.^{18,19} Unlike the findings of hypothetico-deductive model that claim: “primarily generated and tested hypotheses by expert and novice are the same,” Patel believed that it is not consistent in other domains, like physics.¹⁹

Higgs argued that this model posits the idea that the process of clinical reasoning is largely a sequential process.²⁰ Charlin pointed out that the psychological mechanisms involved in the generation and testing of relevant hypotheses are unfamiliar,¹² and Holyoak argued that this model does not distinguish between novice and expert clinical reasoning strategies.²¹ Loftus believed that the collected information and the way they interpreted, distorted by the used hypothesis.⁵ This model as an

adequate description of the process of clinical reasoning has challenged by the case specificity findings.⁷

Nevertheless, some researchers defend hypothetico-deductive model, Elstein argued that the small set of solutions that generated in this model transformed an unstructured problem to structured one and it is an effective way to solve diagnostic problems.¹⁸ This model is recommended by medical experts as a useful reasoning strategy for medical students.²² Hypothetico-deductive model is applicable when data are vague or reveal over time,²² and is a representation of clinical reasoning.²⁰ This model represents a description of the mental processes used by physicians and has repeatedly been validated by empirical studies and is the basis for modern clinical education.¹²

Hypothetico-deductive model assumes the physician starts hypothesizing after collecting patient information

Table 2 The list of 31 related literatures that included in the review

| Category no. | Theory/model | Author | Year | Aspects related to supporting/criticizing the model |
|--|-----------------------------|---|--------------------|---|
| First category: theories and models based on the process of clinical reasoning | Hypothetico-deductive model | Elstein | 1990 ¹⁸ | The description of the hypothetico-deductive model The advantages of hypothetico-deductive model |
| | | Patel | 1986 ¹⁹ | Lack of consistency of hypothetico-deductive model with other domains |
| | | Higgs | 1992 ²⁰ | Clinical reasoning process is not sequential |
| | | Charlin | 2000 ¹² | Unfamiliarity of psychological mechanisms involved in this model |
| | | Holyoak | 2005 ²¹ | No differentiation between novice and expert clinical reasoning |
| | | Lofus | 2006 ⁵ | Clarification of the role of hypothesis in clinical reasoning process |
| | | Higgs | 2008 ⁷ | Adequate description of the process of clinical reasoning |
| | | Elstein | 1994 ²² | Application of hypotheses for framing of clinical problems |
| | | Schmidt | 1984 ²³ | The description of the illness script theory Formation and development of the illness script |
| | | Custers | 1998 ²⁴ | The description of the illness script theory |
| Second category: theories and models based on the knowledge structure | Illness script theory | Schmidt | 1990 ²⁵ | The structure of illness script Formation and development of the illness script |
| | | Custers | 1996 ²⁶ | The structure of illness script |
| | | Custers | 2015 ²⁷ | Script concordance test Formation and development of the illness script |
| | | Custers | 1996 ²⁸ | The structure of illness script |
| | | Harasym | 2008 ²⁹ | Formation and development of the illness script |
| | | Mandin | 1997 ³⁰ | Distinction between the concept of the script and the schema |
| | | Barrows | 1987 ³¹ | The description of the model |
| | | Case S | 1987 ³² | It used by experienced practitioners |
| | | Norman | 2007 ¹¹ | The most usual form of nonanalytic processes |
| | | Elstein | 2009 ³³ | Unanswered questions about pattern recognition model |
| | | Marcum | 2012 ³⁴ | The complexity of cognitive processes involved in clinical reasoning to be ignored. |
| Higgs | 2008 ⁷ | Pattern recognition model examined in limited field of expertise. | | |

(Continued)

Table 2 (Continued).

| Category no. | Theory/model | Author | Year | Aspects related to supporting/criticizing the model |
|---|------------------------|---------------------|--------------------|---|
| Third category: compilation theories and mode | Dual processing theory | Evans | 2008 ³⁶ | The description of the theory |
| | | Croskerry | 2009 ³⁵ | Advantages of this theory |
| | | Croskerry | 2009 ³⁷ | Proposing a model based on dual processing theory |
| | Pelaccia | 2011 ¹ | | Clarification of the place of pattern recognition and hypothetico-deductive models in dual processing theory. |
| | Evans | 2013 ³⁶ | | Criticized this theory in five major themes |
| | Lucchiari | 2012 ¹⁰ | | Models based on dual processing theory |
| | Hammond | 1996 ³⁸ | | The description of the theory |
| | Hamm | 1988 ³⁹ | | The description of the theory |
| | Custers | 2013 ⁴⁰ | | Advantages of this theory |
| | | Cognitive continuum | | |

and then tests hypotheses, while we believe the physician starts hypothesizing initially from his/her clinical encounter. The initial hypotheses can be strong or weak, depending on whether the physician is an expert or novice, the difference between the novice and the expert lies in the quality of the hypotheses they made. Therefore, since the initial hypothesis of an expert has good quality, hypothesis testing will be fast and efficient. The simplicity of this model in describing the process of clinical reasoning is both strength and the weakness of it, as a strength, because it simply portrays the start point of the process of clinical reasoning so it can be used to design the teaching plan and evaluate clinical reasoning. As a weakness, because it considers the process of diagnostic reasoning very simple, while even for a novice, this process does not occur so easily, and other factors (such as the individual’s knowledge structure, the context, the health system, etc.) affect the process of clinical reasoning, but this model does not consider these factors.

Second category: theories and models based on the knowledge structure

For this category, we considered theories and models that explain the formation of knowledge structures in the clinical reasoning process, by this description and the inclusion criteria just one theory and one model of clinical reasoning gain eligibility to include, the “illness script theory” and the “pattern recognition model.”

The illness script theory proposed by Barrows and Feltovich consists of three components: 1) enabling conditions, 2) fault, and 3) consequences.²³ The first component is the factors such as age, sex, current medication, previous medical history, occupation, risk behavior, hereditary, and environment affect the probability of someone gets a disease, are the patient’s contextual and background factors that refer to “Enabling conditions.” These “Enabling conditions” can cause the latter pathophysiological malfunctioning that called “fault” which is the second component of illness script. Consequences of this fault are complaints, signs, and symptoms that consist of the third component.²⁴ Illness scripts are the list-like structures,²⁵ which conceptualized as a specific representation of clinical knowledge.²⁶ Script concordance test designed according to this theory.²⁷

While we were studying about Illness script theory, we realized that we could categorize studies into two broad groups. The first group is the studies that deal with the concept of the script, the schema, and the illness script, and their features, distinctions, and components (Table 3).^{24,26-28}

Table 3 The studies that deal with the concept of “script,” “schema,” and “illness script,” and their features, distinctions, and components

| Author | year |
|----------------|----------------------|
| Custers et al. | (1996) ²⁶ |
| Custers et al. | (1996) ²⁸ |
| Custers et al. | (1998) ²⁴ |
| Custers et al. | (2015) ²⁷ |
| Loftus | (2006) ⁵ |
| Charlin | (2000) ¹² |

The second group deals with the formation and development of the illness script during the acquisition of expertise and changes in the physician’s knowledge structure (Table 4).^{23,25,26,29}

The first group of studies also looked at the distinction between the concept of the script and the schema, but this distinction was not clear in the literature. The schemas and scripts are stored in long-term memory.³⁰

Table 4 The studies that deal with the formation and development of “illness script” during the acquisition of expertise and changes in the physician’s knowledge structure

| Author | year |
|----------------|----------------------|
| Schmidt et al. | (1990) ²⁵ |
| Schmidt et al. | (1984) ²³ |
| Harasym et al. | (2008) ²⁹ |

Schema as a knowledge structure has an “if/then” formatting and occurs sequentially, in the sense that this sequence divided into two branches: “if” and “then,” so we can claim out that its format is algorithmic. This algorithm starts with a hypothesis in a person’s mind or something that a person thinks about and then continues with inquiries and searches that a physician has performed and then with the findings that a physician has reached, and finish with the decisions that he/she has finally taken (Figure 2).

In terms of the structure of the script, we also agree with Schmidt’s view that the scripts are list-like structures, but unlike Charlin, who believed that “the script describes the structure of clinical knowledge,” we believe that the script is not necessarily the structure of clinical knowledge, but a knowledge structure that has clinical applications. The script is schemas for common situations, which include a packet or a list of expectations of what people see or do at a given location. The schemas and scripts are stored in long-term memory, and if physicians encounter a clinical case that matches with them, they will retrieve it from long-term memory and move it to short-term memory (Figure 3).

Pattern recognition model

In the pattern recognition model, a physician directly compares the pattern of the patient’s problem with disease patterns and if found them similar to each other, then select the pattern that matches it.³¹ Experienced

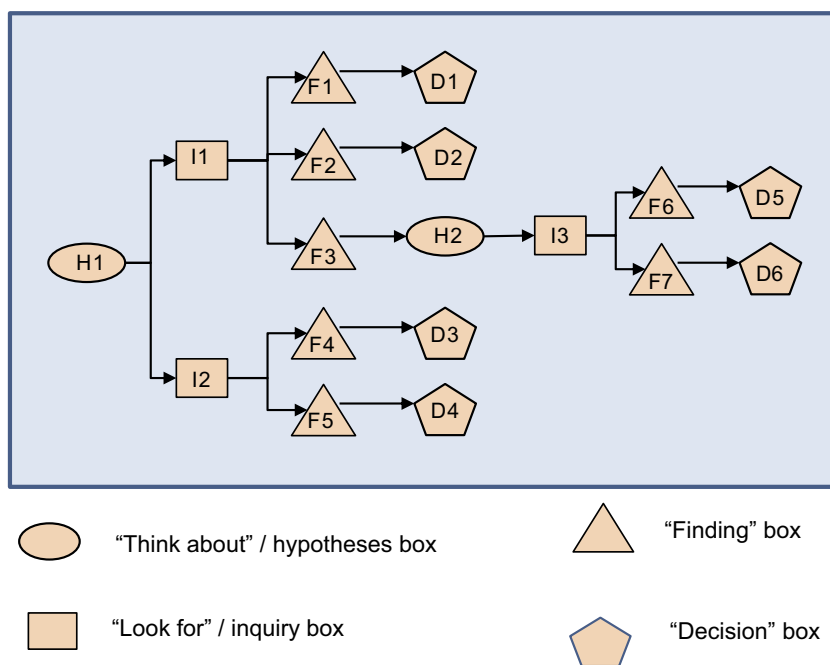


Figure 2 Generic flow of events in a typical schema. D1: Decision No 1; D5: Decision No 6; F1: Finding No 1; F5: Finding No 5; H1: Hypothesis No 1; H2: Hypothesis No 2; I1: Inquiry No 1; I3: Inquiry No 3.

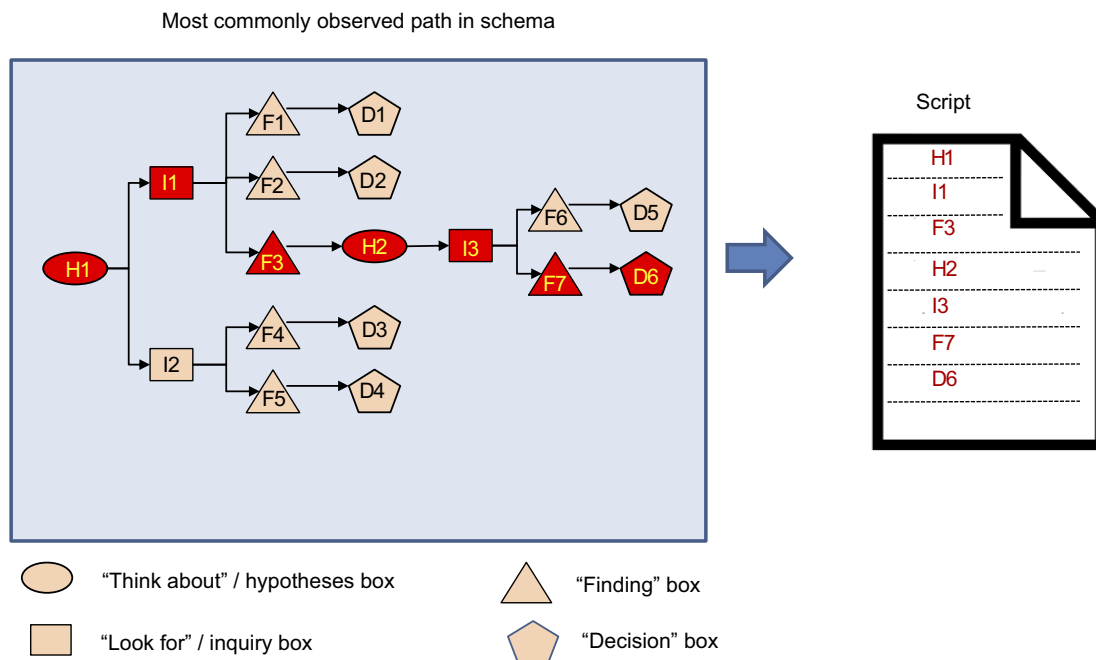


Figure 3 Script as a routinized pathway of previously used schema. D1: Decision No 1; D5: Decision No 6; F1: Finding No 1; F5: Finding No 5; H1: Hypothesis No 1; H2: Hypothesis No 2; I1: Inquiry No 1; I3: Inquiry No 3.

practitioners often use pattern recognition to achieve a medical diagnosis.³² Norman and his colleagues argue that pattern recognition is the most usual form of nonanalytic processes.¹¹ However, Elstein proposed some questions about this model, as followed:

- When dose a person use a pattern recognition model?
- When is this method preferable to the hypothetico-deductive method?
- What guarantees that the choice of a pattern or an illness script is correct?
- What happens if the pattern or script stored in the knowledge base is wrong?³³

This model considers the complexity of cognitive processes involved in clinical reasoning to be insignificant.³⁴

Based on the definition of the pattern recognition model, it only mentions the existence of patterns in mind, but does not explain how the construction of these patterns occurred. The studies which designed to prove that the pattern recognition model happens in reality are in a limited field of expertise, like radiology, dermatology, and pathology.⁷ So the pattern recognition model is not extendable to all medical specialties.

Third category: compilation theories and model

Some of the included documents were about “dual processing” and “cognitive continuum” theories that explain two

modes of reasoning – “analytical” and “non-analytical,” these modes are the characteristics of both first and second category, so we cannot involve them in one of them, therefore they form our third category.

The dual-processing theories commonly have two different processing modes in which they refer to: System 1 and System 2.¹³ System 1 described as a fast, automatic and intuitive mode, which shares similarities through perception, while System 2 is slow and analytic mode that applies rules without inferring emotions.⁷

Croskerry believed that dual-processing theory is an applicable model in multiple domains of health care like decision-making and it can be useful in teaching decision theory or in making a platform to future research.³⁵ Pelaccia et al noted that in the framework of this theory, the pattern recognition and hypothetico-deductive models are the basis of the intuitive system and the analytic system, respectively.¹

Evans and Stanovich criticized this theory in five major themes: 1) various theorists have proposed multiple and vague definitions for this theory, 2) there is no consistency in associated attribute clusters with dual systems, 3) distinctions are referred to the continuum of processing and not to discrete processing; 4) the apparent dual-process phenomenon can present by single-process accounts; and 5) the evidence base for the dual-processing theory is ambiguous or unconvincing.³⁶

In the reviewing of the literature, we found out that some of the researchers established their models based on dual-processing theory like Marcum,³⁴ Croskerry,^{35,37} and Lucchiari and Pravettoni.¹⁰

Dual-processing theory employs many of the seemingly contradictory features that have been proposed for clinical reasoning in the literature (such as fast, slow, reflective, etc.). It seems that, in reality, a physician does not use just intuitive or analytic systems and the mind of physician operates in the space between them, while the dual-processing theory ignores this.

The theories and models that have been proposed following this theory have led to the introduction of cognitive concepts such as metacognition and perception and their role in the process of clinical reasoning. This theory has relatively clarified the role of emotions and their place of influence in the process of clinical reasoning, and has also contributed to clarifying the concept of intuition in clinical reasoning.

The second theory that has placed in third categories is cognitive continuum, as Hammond claimed, this theory considered two poles, an intuitive cognition and an analytical cognition, in which various modes or forms of cognition have relational order on a continuum, and this assumption rejected the dual-processing approach.³⁸ Hamm believed, this theory does not explain the information processing that is the basis of analysis and intuition, but based on analytical and intuitive cognitive attributes it gives us various techniques in describing cognitive modes. Also, he believed that this theory did not offer an instruction about thinking analytically or intuitively, and it just presented a general framework. Cognitive continuum theory described the features of cognition and their correlation with the characteristics of the task.³⁹ Custers noted that this theory illustrates the cognitive processes and the cognitive tasks on a continuum, and this theory can be used to provide advice on how to structure clinical tasks in an educational setting.⁴⁰ In criticizing cognitive continuum theory, we did totally agree with Hamm and Custers.

Conclusion

The present study was conducted to critically review theories and models of clinical reasoning that have often been raised in the medical education literature within five decades (1970–2018). Several theories and models presented in relation to clinical reasoning and it seems that they can explain only part of the complex process, but not the whole process. For example, the models and theories of

the first category in our study just address the process of clinical reasoning and do not pay attention to knowledge structures and cognition; in the second category, they just focused on knowledge structures and their formations during clinical reasoning process and do not clarify the process of clinical reasoning. In addition, the dual processing and cognitive continuum theories that form the third category just covered the cognition part of the clinical reasoning. Therefore, to fulfill this gap, it may be helpful to build a Meta-model or Meta-theory, which unified all the models, and theories of clinical reasoning. Although our focus was on the main models and theories of clinical reasoning in the field of medical education, but we acknowledge that there are other models and theories of clinical reasoning in the literature and their absence can be the bias of this study.

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Disclosure

The authors report no conflicts of interest in this work.

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