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Clinical reasoning and diagnostic error

UPDATE

Razonamiento clínico y el error diagnóstico

Raciocíneo clínico e erro diagnóstico

Abstract

The diagnostic process in healthcare is complex, context-dependent, interactive, and non-linear. It can involve patients, families, individual clinicians, and healthcare teams. Reducing diagnostic errors is a key objective in the health professions due to their associated morbidity and potential preventability. Diagnostic errors are typically multifactorial in origin, involving both system-related factors and cognitive components. The mechanisms for addressing cognitive errors have been studied less extensively than those related to system factors. Scientific literature suggests that both Type 1 (intuitive) and Type 2 (analytical) reasoning contribute to diagnostic errors. This study examines different types of errors based on various authors' perspectives and the reasoning processes that can lead to error.

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Resumen

El proceso de diagnóstico en el área salud es complejo, dependiente del contexto, interactivo y no lineal y puede involucrar a pacientes, familias, clínicos individuales y equipos de salud. La reducción del error diagnóstico es un objetivo importante en las profesiones de la salud debido a su morbilidad asociada y a su posible prevención. Los errores diagnósticos suelen ser de origen multifactorial, e implica tanto factores relacionados con el sistema como componentes cognitivos. Los mecanismos para solucionar los errores cognitivos han sido menos estudiados que los relacionados al sistema. La literatura científica sugiere que el razonamiento Tipo 1 (intuitivo) y el Tipo 2 (analítico) contribuyen a errores diagnósticos. Se analiza algunos tipos de errores de acuerdo a la visión de diferentes autores y los procesos en el razonamiento que pueden inducir a error.

Palabras clave: Razonamiento clínico, diagnóstico, errores diagnósticos, sesgos.

Resumo

O processo diagnóstico em saúde é complexo, contexto-dependente, interativo e não linear e pode envolver pacientes, familiares, clínicos individuais e equipes de saúde. A redução do erro diagnóstico é uma meta importante nas profissões de saúde devido à morbidade associada e possível prevenção. O erro diagnóstico é geralmente de origem multifatorial, envolvendo tanto fatores relacionados ao sistema quanto componentes cognitivos. Os mecanismos de resolução de erros cognitivos têm sido menos estudados do que aqueles relacionados ao sistema. A literatura científica sugere que o raciocínio Tipo 1 (intuitivo) e Tipo 2 (analítico) contribuem para erros diagnósticos. Alguns tipos de erros são analisados de acordo com a visão de diferentes autores e os processos de raciocínio que podem levar ao erro.

Palavras-chave: Raciocínio clínico, diagnóstico, erros diagnósticos, vieses.

Introduction

Clinical Reasoning (CR) refers to a cognitive process, necessary to evaluate and manage people's health problems.[1] It allows health professionals to establish diagnoses, make decisions, and define treatment plans, thus it is considered one of the determining factors of the clinician's abilities.[2]

Traditionally, clinical reasoning methods have been classified as analytical or hypothetico-deductive and non-analytical or patterned. Currently, it is accepted that analytical and non-analytical methods of reasoning are not mutually exclusive and that, on the contrary, their combination is synergistic.[3]

Hypothetico-deductive model. The traditional model that health educators have focused their studies on is the analytical one. Clinical expertise involves reaching a diagnosis through careful analysis of the relationship between symptoms, signs, and data from complementary examinations. It uses analytical thinking, which is slower than non-analytical thinking and is performed more consciously. It involves the following steps:

1) observation, **2)** gathering information, **3)** physical examination, **4)** hypothesis generation, **5)** correlation of the data obtained with the hypothesis(es) made, **6)** confirmation or not of the hypothesis defined through diagnostic tests.

According to Loayssa and Fuentes,[4] this type of reasoning is based on the fact that the characteristic features of the diseases are clearly evident and that diagnostic reasoning involves understanding the relationship between the detected features and the underlying diseases, generating a list of presumptive diagnoses weighted in terms of relative probability.

Non-analytic or pattern recognition model. According to Loayssa and Fuentes,[4] in this reasoning mode, which has gained significant support in recent years, the clinician does not analyze the diagnostic "weight" of each data point. Instead, they look for similarities between the current case and others encountered in the past, drawing on their stored experience of diagnoses in the form of prototypes, examples, or scripts. According to the aforementioned authors,[4] CR involves understanding and quantifying the relationship between the encountered data and potential diagnoses. It requires formulating a list of relevant diagnoses and weighing them in terms of their relative likelihood based on the available data. Each case is processed by comparing it with previous ones, and similarities with those are sought. The clinician does not need a detailed analysis of the relationship between each available piece of data and the possible diagnoses, and

often does not even need to think explicitly. This process is usually automatic, implicit, and intuitive, and thus not conscious.

The non-analytical model relies primarily on the clinician's experience, who quickly and without careful analysis establishes a diagnosis through a "pattern recognition" process, using past experiences to form a judgment based on the likelihood that the current clinical problem resembles a previously encountered case. This form of reasoning is automatic, rapid, and does not require full awareness, which can increase the risk of error.[4] All healthcare professionals engage in this process because these fields involve a strong component of images and patterns in real life, so the process of assigning value or weight to the data is done unconsciously.

Eva K. (2015)[5] acknowledges that the two processing forms are not mutually exclusive and that both likely contribute to the final decisions made by both novices and experts. In some cases, similarity triggers an analytical evaluation of the current case, analogous to analyses previously performed on similar cases. The optimal form of CR should be viewed as a synergistic model in which both analytical and non-analytical processes play a role.[5]

Diagnostic error. The National Academy of Sciences, Engineering, and Medicine (2015)[6] defines diagnostic error as "the failure to establish an accurate and timely explanation for a patient's health problems or to communicate that explanation to the patient." This definition considers the outcomes of the diagnostic process, highlighting that any issue arising within it can lead to errors. The diagnostic process itself is complex, context-dependent, interactive, and non-linear, and may involve patients, families, individual clinicians, and healthcare teams.

This study presents a literature review on diagnostic errors in the health professions, aiming to integrate evidence into clinical practice and emphasize the importance of research in healthcare. The search aimed to identify studies that analyzed the clinical diagnostic process and the potential for errors in its definition.

Methodology

This study presents a literature review of research on diagnostic errors related to clinical reasoning. Scientific articles were retrieved from written and/or electronic sources to provide a new contribution with a comprehensive perspective on complex concepts, theories, or health problems. The databases and portals consulted included PubMed, Timbó, SciELO, and the Cochrane Library, with no restrictions on year, study type, country, or population. The following descriptors were used: clinical reasoning, diagnosis, diagnostic errors, and biases, which were combined in different ways to ensure a thorough search for relevant studies. Additionally, the exploration was expanded by reviewing and tracing the references cited in these articles. The inclusion criteria were:

1) original articles forming the theoretical-conceptual framework,
2) indexed, peer-reviewed journals.

Results

A total of 30 articles were reviewed, of which 15 were selected as part of the theoretical-conceptual framework, methodology analysis, or integrated into the discussion. The remaining 15 were excluded as they did not specifically address diagnostic error or were not original sources suitable for citation in the conceptual framework or discussion. The 15 included records varied in type: 7 reviews (narrative and systematic), 5 original investigations (inquiry and experimental), and 3 case studies. The reviewed articles are listed in Table 1, ordered by year of publication.

Reducing diagnostic errors is a key objective in the health professions due to their associated morbidity and potential for prevention. These errors can arise from various causes.[7]

In his book "Diagnosis", Croskerry P. (2014)[8] affirms that diagnosis is the central skill in a health professional's clinical performance. The book addresses the main challenges in this area, particularly where the diagnostic process fails and how it can be improved. In recent years, there has been considerable interest and significant progress in various fields. Although medicine has made important advances in knowledge and technology in recent decades, there is consensus that the diagnostic failure rate remains around 10–15%.[8]

According to the author, diagnostic errors are largely due to flaws in the reasoning process (knowing how to think) rather than a lack of knowledge. Common diagnoses are more prone to errors than rare ones. It is widely accepted that while many useful decisions are made intuitively, most reasoning failures occur in this intuitive mode. Finding ways to enhance critical thinking, particularly intuitive performance, is imperative.[8]

Mamede S. (2004, 2010)[9, 10] conducted two studies in which physicians were first shown a series of cases or a disease description and asked to conduct a detailed examination. They were then presented with new cases, some resembling the previous ones but with different diagnoses. Physicians were more likely to misidentify similar cases by assigning the same diagnosis as in the initial set, but incorrectly in the second round. However,

TABLE 1
Selected and Reviewed Articles

AUTHOR	ARTICLE TITLE	YEAR
Allen SW, Brooks LR, Rosenthal D.	Effect of prior examples on rule-based diagnostic performance	1988
Brooks LR, Norman GR, Allen SW.	Role of specific similarity in a medical diagnostic task	1991
Nolan TW.	System changes to improve patient safety	2000
Croskerry P.	The importance of cognitive errors in diagnosis and strategies to minimize them	2003
Mamede S. Schmidt H.	The structure of reflective practice in medicine	2004
Graber ML, Franklin N, Gordon R.	Diagnostic Error in Internal Medicine	2005
Mamede S, Van Gog T, Van den Berge K, et al.	Effect of availability bias and reflective reasoning on diagnostic accuracy among internal medicine residents	2010
Graber ML, Kissam S, Payne VL, et al.	Cognitive interventions to reduce diagnostic error: A narrative review	2012
Croskerry P.	Bias: a normal operating characteristic of the diagnosing brain	2014
Norman GR, Monteiro SD, Sherbino J, Ilgen JS, Schmidt HG, Mamede S.	The Causes of Errors in Clinical Reasoning: Cognitive Biases, Knowledge Deficits, and Dual Process Thinking	2017
Croskerry P.	Becoming Less Wrong (and More Rational) in Clinical Decision making	2020
Croskerry P, Campbell SG.	Autopsy Approach Towards Explaining Diagnostic Failure	2021
Staal, J, Alsma, J, Mamede S. et al.	The relationship between time to diagnose and diagnostic accuracy among internal medicine residents: a randomized experiment	2021
Croskerry P, Campbell SG, Petrie DA	The challenge of cognitive science for medical diagnosis	2023
Vally Z.I, Khammissa R, Feller G, Ballyram R, Beetge M, Feller L.	Errors in clinical diagnosis: a narrative review	2023

cognitive bias (prior data) appears to work both ways. Two previous dermatology studies[11, 12] found that prior exposure to a similar case within the same category can improve diagnostic accuracy in new cases.

Graber et al. (2005)[13] took a different approach, examining cognitive bias in diagnostic reasoning through retrospective reviews of real errors.[13] The authors analyzed 100 diagnostic errors in the emergency department, evaluating each case for system-related and/or cognitive factors by reviewing records and, when possible, conducting interviews. Errors were classified into three categories based on etiology:

a) errors without medical fault or responsibility (silent or masked disease, atypical or rare presentation, patient noncompliance), **b)** system-related errors (technical failures, equipment issues, organizational defects), and **c)** cognitive errors (poor knowledge, lack of data, faulty synthesis)[13].

Results showed that 7% of cases involved errors without professional fault, while 93% were linked to professional activity.

Graber et al. (2012)[14] also found a higher risk of diagnostic errors in patients with negative reactions ("affective risk"), as this led professionals to pay less attention.

Norman et al. (2017)[15] confirmed that contemporary theories of clinical reasoning support a dual-processing model, consisting of a fast, intuitive component (Type 1) and a slower, logical, analytical component (Type 2). While

there is general consensus that this model accurately represents clinical reasoning, the causes of diagnostic errors remain unclear. Cognitive theories of human memory suggest that errors can arise from both Type 1 and Type 2 reasoning. Scientific literature indicates that with greater experience and knowledge, error rates decline. Norman et al. aimed to answer two key questions: "To what extent do diagnostic errors stem from Type 1 (intuitive) or Type 2 (analytical) processes? Are errors due to cognitive biases or knowledge deficits?" The authors concluded that strategies focused on knowledge reorganization provide small but consistent benefits. Group decision-making has also shown success in reducing errors.[15]

Croskerry (2020) (16) states that all human decision-making inevitably involves both intuitive (Type 1) and analytical (Type 2) decisions. Achieving an accurate diagnosis depends on knowing how and when to use each. Current perspectives on CR do not advocate relying solely on System 2, as this would be impractical and potentially harmful to patients. Instead, they emphasize a balanced approach—using a combination of strategies when risk is low and favoring analytical reasoning when possible. Most decisions are made intuitively, as they are routine and straightforward, requiring no deliberate intervention. However, and this is key, all brain-generated decisions must be monitored by rationality, with analytical reasoning serving as the corrective mechanism. Monitoring our thinking must become a habit, as sustained vigilance is essential. The importance of rational clinical decision-making cannot be overstated. A recurring message in cognitive science is the need to address biases and logical fallacies, which are considered the primary threats to rationality. Therefore, cognitive bias mitigation strategies tailored to emergency medicine require further development.

Croskerry and Campbell (2021)[17] conducted an in-depth analysis of 30 anonymized emergency medical service cases, evaluating error-producing conditions, knowledge-based errors, and physicians' decision-making processes. The cases spanned various disciplines and diagnoses. They identified 24 cognitive and affective biases contributing to misdiagnosis, while knowledge-based errors were rare, reinforcing the effectiveness of medical training. In sum, this study provides a foundation for investigating the critical role of biases in clinical decision-making and offers a plausible explanation for diagnostic failures.[17]

In line with this Croskerry et al. (2023)[18] emphasize that understanding the complexity of clinical decision-making and judgment is essential for reducing diagnostic errors. They highlight the importance of recognizing cognitive biases, implementing mitigation strategies, and equipping future professionals with heuristic management skills. During the diagnostic process, the physician analyzes a series of steps leading to a probable diagnosis. One potential issue at this stage is "premature closure," where a decision is made without fully "unpacking" all available data. Therefore, it is important to consider that, in heuristic models, a bias (anchoring) may be associated, leading to premature closure in decision-making. This can be partially reversed, for example, by making decisions as a team rather than individually.

Croskerry et al.[18] describe multiple dependent and interdependent variables involved in this complex process, which does not occur in isolation but within a specific, and located context, interacting with the patient and their environment—both of which may influence judgment and decision-making.

Discussion

In general, scientific literature advocates identifying and addressing failures in the healthcare system as a more effective approach to improving safety, suggesting that this would also reduce diagnostic errors. Measures aimed at improving the system include professional training and guidance, the quality and availability of diagnostic tests, and factors that contribute to suboptimal reasoning, such as stress, fatigue, excessive workload, and inefficient processes that lead to diagnostic delays. However, efforts to reduce cognitive errors have been limited. Currently, some authors highlight the substantial potential for improving the cognitive component of diagnosis, emphasizing training to enhance metacognition, diagnostic reasoning, problem-based learning approaches, and differential diagnosis.[18] Increased cognitive monitoring may lead to delays in establishing a diagnosis, as additional tests and treatments are requested to enhance certainty. It has been argued that second opinions before certain types of elective surgery reduce the number of unnecessary procedures.[18] The potential to reduce or eliminate diagnostic errors across the three major categories (no-fault errors, system-related errors, and cognitive errors) is real and achievable. This is supported by advancements in detecting diseases at preclinical stages and an increasing understanding of atypical disease presentations. However, while the potential for reducing diagnostic errors is real and significant, achieving this goal remains challenging due to the need to overcome multiple factors, including resource constraints, procedural inefficiencies, and administrative and organizational barriers.[18] Key target areas for intervention to reduce system-related errors include the supervision of students, access to specialized expertise, care coordination, communication procedures, professional training and guidance, the quality

and availability of diagnostic tests, environmental factors (such as undue stress, fatigue, distractions, and excessive workload), and inefficient processes that contribute to diagnostic delays.[18]

Mechanisms targeting cognitive interventions have been less explored. Nolan (2000)[19] states, "Although we cannot change the aspects of human cognition that lead us to make mistakes, we can design systems that reduce errors and make diagnoses safer for patients." These include training to improve metacognition, courses on reasoning, diagnosis, and biases, as well as problem-based learning approaches. Seeking greater diagnostic certainty may result in higher costs due to the need for additional studies or tests, as well as increased effort and time spent conducting a broader search for possibilities to enhance diagnostic accuracy and precision.

Vally et al. (2023)[20] estimate that the occurrence rate of diagnostic errors associated with adverse outcomes ranges from 10% to 15%, with approximately 75% of these errors linked to cognitive mistakes made by clinicians. The authors align with those who argue that while most diagnostic errors stem from complex interactions between healthcare system factors and intrinsic cognitive factors, many are primarily caused by prevalent cognitive biases. To avoid diagnostic errors, physicians must have a specific domain of clinical knowledge and expertise, possess the cognitive tools necessary to recognize and counteract relevant biases and reasoning flaws, and master both analytical reasoning and intuitive cognitive processes that support effective clinical judgment and decision-making. Vally et al.[20] highlight that clinicians and healthcare system administrators should acknowledge the prevalence of this phenomenon across all clinical domains and its adverse effects. Raising awareness may enhance the motivation of all stakeholders and facilitate the implementation of preventive and corrective measures. Therefore, they recommend integrating certain elements of cognitive science and critical thinking, as well as foundational knowledge about the phenomenon of error, into health sciences curricula. Additionally, determining the best ways to manage clinical uncertainties is crucial to avoid diagnostic errors.

Staal et al. (2023)[21] state that diagnostic errors have been attributed to cognitive biases (reasoning shortcuts) resulting from rapid reasoning, leading to suggestions that slowing down the reasoning process may help. However, the authors argue that slower reasoning is not necessarily more accurate than faster reasoning. Their study analyzed the relationship between time to diagnosis and diagnostic accuracy, concluding that correct diagnoses are generally reached more quickly than incorrect ones. However, this does not imply that professionals who arrive at a diagnosis more rapidly are superior. Instead, they indicate that rapid diagnostic reasoning often underlies correct diagnoses and does not necessarily lead to diagnostic errors.

Conclusions

Scientific literature suggests that Type 1 (intuitive) and Type 2 (analytical) reasoning can influence the occurrence of errors. Diagnostic errors typically have a multifactorial origin, involving both system-related factors and cognitive components. Strategies focused on reorganizing knowledge to reduce errors have shown small but consistent benefits. Mechanisms for addressing cognitive errors have been less studied than those related to system factors. It is important to recognize the value of expert versus novice experience when seeking a second opinion. No universally agreed-upon and binding criteria for diagnostic errors exist; instead, the criteria used are often variable, vague, and clinically challenging to apply. This makes it difficult to measure and assess the occurrence of diagnostic errors accurately or consistently, and consequently, to determine the true epidemiological characteristics of this phenomenon.

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