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Judgment and decision-making in clinical dentistry

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Abstract

The development of clinical judgment and decision-making skills is complex, requiring clinicians—whether students, novices, or experienced practitioners—to correlate information from their own experience; from discussions with colleagues; from attending professional meetings, conferences and congresses; and from studying the current literature. Feedback from treated cases will consolidate retention in memory of the complexities and management of past cases, and the conversion of this knowledge base into daily clinical practice. The purpose of this narrative review is to discuss factors related to clinical judgment and decision-making in clinical dentistry and how both narrative, intuitive, evidence-based data-driven information and statistical approaches contribute to the global process of gaining clinical expertise.

Keywords

Clinical judgment, dental education, cognitive executive function, decision-making in dentistry, clinical practice, narrative review

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Introduction

Today's dentists face complex challenges; these include dealing not only with younger and healthier patients but also with aging populations who have an increasing number of illnesses, as well as with rapidly evolving biomedical and dental knowledge and technologies. To successfully meet these challenges, clinicians must regularly and continuously update their biomedical understanding and technical skills, which should result in enhanced quality of diagnosis (clinical judgment) and treatment planning (decision-making).[1] Clinical judgment and decision-making both use intuitive (rapid, non-analytical reasoning) and analytical (deliberate reasoning) cognitive processes, which integrate many factors including information obtained in a patient's physical examination and medical history, prior clinical experience, deductive knowledge, and relevant statistical data.[2–5]

In dentistry, as in medicine, clinical judgment and decision-making are complex processes[4,6] dealing with many uncertainties, including patient-specific health factors, treatment-related technical factors, financial constraints, and clinician-related factors such as experience, intelligence, fatigue, and mood. Skills in clinical judgment and decision-making vary substantially among clinicians, such that some are better diagnosticians than others.[7,8]

The way in which information is communicated by the patient to the clinician influences the clinician's clinical judgment and decision-making. Conversely, the way in which treatment choices and decisions are framed and communicated by the clinician may direct patients' attention to particular details, affecting overall understanding and influencing their own process of judgment and decision-making, and ultimately, their choice of treatment.[9,10]

There are different ways to inform patients about the frequency and severity of risks associated with treatment, which substantially vary in their effects. Different presentations of the same problem will bring about different judgments and decisions on the part of the patient. Low-probability events described in terms of relative frequencies (how many) are more heavily weighted than when these are described in more abstract terms, such as probability or chance (how likely). One should be aware of the intuitive human tendency to overestimate the risk of unlikely events, if these are over-weighted.[11]

Although evidenced-based guidelines are important for clinical judgment and clinical decision-making, they cannot be applicable to, or appropriate for, all patients.[12] These guidelines do not take into consideration patient-specific clinical and biopathological data, which are essential to clinical decision-making, and ultimately, to the outcome of treatment. Furthermore, evidence-based treatment does not allow for the use of subjective tacit knowledge and wisdom or intuitive cognitive processes, which are crucial for the process of clinical judgment and for the development of clinical expertise.[2]

Personal clinical experience refers to the clinical knowledge and wisdom assembled and integrated over time in memory, through the experience gained from treating a large number of patients with diverse medical or dental conditions. Personal clinical experience is critical for clinical judgment and decision-making.[2,13] In this context, clinical judgment refers to the cognitive processes of forming diagnoses, making choices of treatment, and conjecturing relevant prognoses.[14]

When encountering the same medical or dental problem, clinical judgment and decision-making sometimes differ among clinicians. This is probably owing to the subjective nature of the cognitive mechanisms used by different clinicians in the process of clinical judgment,[15] as well as the

uncertain and ambiguous nature of relevant clinical data that may be interpreted in several ways.[15]

Compared with a novice, an experienced clinician has a higher knowledge level of the subject matter and is able to focus attention more effectively on the details of a clinical problem, to consciously generate and evaluate a greater number of potential strategies for solving a relevant problem, and to better assess and change the course of treatment on an ongoing basis as new information becomes available. These qualities confer upon the expert clinician effective and efficient analytical and problem-solving skills.[8]

The purpose of this narrative review is to discuss factors related to clinical judgment and decision-making in clinical dentistry and how both narrative, intuitive, evidence-based, and data-driven information, as well as the statistical approach, contribute to the global process of gaining dental clinical expertise. Relevant databases and individual authoritative texts were critically analyzed and the findings integrated, to consider ways of improving clinical problem solving.

Cognitive executive functioning in relation to clinical judgment and decision-making

Executive functions refer to neurocognitive faculties including working memory, that is, the ability to update, integrate, and retain information; cognitive flexibility, which is the ability to shift between rules or modes of thought; inhibition of inappropriate responses; and attentional control. In general, all these permit formulation of higher-order cognitive processes such as reasoning, judgment, and decision-making, regulation of emotional responses, and control over cognition, self-gratification, and behavior patterns. Together, these processes enable execution of goal-directed behaviors and regulation of responses to psychosocial stressors and to noxious stimuli.[16–22] Dysfunctional executive functioning increases the risk of poor stress regulation and of impaired learning, clinical judgment, and decision-making.[18,21,22]

The generation of executive functions resides in the prefrontal cortex, which is functionally connected to the limbic system (amygdala, hippocampus, thalamus, hypothalamus), which is engaged in processing emotion-related information; and to brainstem regions, which have roles in arousal, autonomic control, primitive emotional responses such as aggression and rage, and in predatory and sexual behaviors.[18] Intact neural connections between the prefrontal cortex and the limbic system are critical for cognitive functioning and for adaptive regulation of primitive, emotional, and stress responses.[18] Both behavioral responses and learning capacity are thus the outcome of coordinated interactions between autonomic, neuroendocrine, and psychological processes that require input from both the limbic system and the prefrontal cortex.[23]

High-order cognitive processes that are executive function-driven can generate goal-directed behaviors that are mentally taxing rather than automatic or routine.[17,19] The reserves of mental energy fueling executive functions in the prefrontal cortex are limited. Repeated or continued exposure to psychosocial stressors, to involuntary negative emotions, and to fatigue may deplete these limited resources, leading to impairment of cognitive functioning. Such impairment may result in poor emotional control, judgment, and decision-making, with consequent maladaptive behavior and impaired learning.[16,18,19,24,25]

Clinical judgment and decision-making that are initially cognitively effortful

become routine with practice, such that high-level expert clinicians can solve clinical problems more frequently, more quickly, and with less cognitive effort than novice clinicians. Furthermore, experts perform standard procedures efficiently and effectively, almost automatically, with minimal focused attention. However, complex, difficult or atypical clinical scenarios demand, effortful, time-consuming, and focused analytical cognitive processes, even from clinical experts.[26]

Performing complex clinical procedures demands constant focused attention to pertinent cues in the local environment, and changes in the environmental cues may affect the goals, objectives, and outcome of treatment, to which the clinician must adapt. Focusing concurrently on several clinical variables requires splitting of the limited mental resources for cognitive executive functioning, particularly that of attention, with the risk of maladaptively dealing with one or more variables.[3,26] This may lead to diagnostic errors. With increased experience, the clinician will be able to satisfactorily perform such complex tasks with less focused attention and cognitive effort.

Negative emotions or moods, such as psychological stress, depression, anxiety, anger, burn-out, loss of self-esteem, and loss of motivation; or negative physical sensations, like pain or fatigue, are some factors that may impair cognitive executive functioning, adversely impacting clinical judgment and decision-making.[26] This may result in a reduction in the quality of the clinician's performance.[8,26] In contrast, positive emotions such as compassion, joy, hope, kindness, and goodwill may improve the ability to constructively evaluate clinical problems with consequent appropriate decision-making and enhanced clinical performance, leading to favorable clinical outcomes.[8]

Factors influencing clinical judgment and decision-making in the learner and the inexperienced clinician

In dentistry, as in any other professions, acquisition of knowledge, and communicative and manual skills, require an environment conducive to learning. Continuous third-party assessment, with immediate constructive feedback, is an essential part of the process. Under such circumstances, with time and with repetition, cognitive skills will eventually be developed, such that sound clinical problem-based judgments, choices, and decisions can be made, with the outcome of effective and efficient clinical solutions but with the ability to change course according to changing circumstances.[11,13,27] Novices will then be able to largely take responsibility for their own further learning and development as clinicians and will gain cognitive, affective, and psychomotor capacities for continual dental education and training, at the same time becoming imbued with the moral and ethical responsibility of being lifelong learners.[28]

Assessment should evaluate not only the learner's performance but also the effectiveness of the teaching and training, and it should serve as the basis for meaningful interactions between learners and their academic teachers and clinical instructors. This should lead to thoughtful reflection by the learners, which is essential to self-learning and to the development of moral and ethical values and of empathy, as well as to improvement of the processes of clinical judgment and decision-making. Feedback and reflection reinforce the capacity to recognize patterns of diseases/conditions from previous clinical experience, to promote understanding and to facilitate integration of established and newly acquired knowledge.[4,25,27–29] For the fortunate few, clinical

experience will be crowned by clinical wisdom.

The formulation of a treatment plan should be based on obtaining statistical evidence from a large number of similar cases (evidenced-based treatment) and not based on individual case reports, as is all too often done.[11,27,30] In general, there is a common lack of awareness of the potential adverse effects of decision-making based on a small sample size.[11] The clinician's judgments and decisions regarding the choice of the most appropriate patient-specific dental treatment plan should be guided by personal experience, by evidence-based knowledge, by the expert opinion of colleagues, and in consultation with the patient after presentation of the proposed treatment plan and alternatives. However, the outcome of a successfully executed treatment plan is usually unpredictable, and things may go wrong. Therefore, it is essential to inform the patient of the risks associated with treatment.

Medical and dental professionals may deal with the same patient on different occasions. According to their mood and emotional state, which is determined by any number of personal circumstances, as outlined above, these professionals may come up with different diagnoses and treatment plans.[31] For example, on different occasions, the same oral pathologist may make inconsistent histopathological diagnoses of the same biopsy specimen; even more frequently, diagnoses of the same biopsy specimen may differ when made independently by different oral pathologists.[32]

Factors influencing clinical judgment and decision-making in clinical practice

As mentioned, errors in clinical judgment and inconsistent diagnoses are not uncommon and are usually caused by common cognitive biases. There is an intuitive tendency to search for and to interpret new information that confirms prior beliefs and preferred hypotheses and a tendency to effectively retain and remember new information that supports a pre-existing cognitive position.[33] Cognitive errors can also be attributed to various extrinsic and intrinsic factors, including limited financial resources, time constraints, limited cognitive executive functioning, work overload, overconfidence, deficiency of relevant information, incorrect evaluation and inappropriate prioritization of elements of the clinical information, poor communication skills, or simply to incompetence.[3]

One tends to make decisions based on intuition (rapid, almost automatic and effortless, non-analytical reasoning) rather than on time-consuming, analytical, deliberately attention-demanding reasoning; both are influenced by mood, emotions, and stress, which fluctuate considerably. There is an inherent element of uncertainty in predicting the outcome of any treatment plan because the formulation of a treatment plan relies heavily on the clinician's familiarity with similar cases (heuristic planning) and on the cognitive ease with which relevant information comes to mind. The information retrieved is determined by factors such as characteristics of the event that generated the information, the characteristics of cognitive executive functions, and the quality of the emotional state or mood of the clinician at that time.[13,15,25,29,30,34,35] Intuitive errors of reasoning tend to be recognized by the clinician and corrected by deliberate analytical cognitive and metacognitive processes.[4,6] Both intuitive and analytical reasoning are generally used concurrently in clinical judgment and decision-making.[25,29,36]

Intuitive cognitive processes in diagnosis and treatment planning are prone to bias, and deliberate rational analytical reasoning is time consuming and mentally taxing and

does not always lead to predictably successful or beneficial outcomes. Therefore, the question to be asked is, when and at what stage of the diagnostic process—within the constraints of time and workload in clinical practice—should the systematic analytical approach be used?[26]

In diagnosis and in planning a treatment for a new patient, the clinician retrieves from memory (i.e., from their abstract store of knowledge) the relevant information linked to pattern recognition of similar, previously managed clinical cases. This is how the cognitive process of clinical judgment and decision-making operates. Thus, with the management of each new patient, there is evolution of new knowledge and understanding, generated by integration of new and old clinical experiences. Together with wisdom gained from formal continuing education and evidence-based data, the ability to solve novel and/or complex clinical problems is enhanced.[1,26,27,36] However, diagnostic errors can never be completely eliminated because occasional cognitive biases and mistakes in interpretation of data are unavoidable.[26]

Frequent conscious reflection on daily clinical experience promotes retention of newly acquired knowledge and understanding and its integration with existing knowledge. This, in turn, improves the processes of clinical judgment and decision-making and perfects the technical skills of the clinician.[27,37] Thus, with daily clinical practice and critical reflection upon their own reasoning and decisions, expert clinicians create a bank of pattern-recognition and memory-anchored prototypes.[36,38] Experienced clinicians diagnose and decide on treatment of routine cases intuitively, using automatic pattern recognition and non-analytical reasoning. Deliberate analytical reasoning is activated only by atypical or difficult clinical problems.[27,38]

With clinical experience, newly acquired clinical knowledge is integrated with existing theoretical biomedical knowledge, forming a meaningful concept of the clinical condition in the mental image. Understanding of the pathogenesis of a disease consolidates its features in memory, improves recollection, and enhances the processes of judgment and decision-making.[39]

Ignoring information about the incidence and prevalence of any clinical condition, constructing clinical judgments on the basis of weak evidence or subjective first impressions, underestimating the role of chance, evaluating evidence on the basis of unsubstantiated prior concepts, and focusing on obvious evidence but missing less obvious evidence, are all factors contributing to cognitive biases, predisposing to inconsistent decision-making.[11,13,30,40,41]

If a clinician has elicited an incomplete medical history and does not understand the technical complexities of the proposed treatment, or is simply overconfident, then the treatment may be fraught with unforeseen risks, which would have been avoided had the clinician been more knowledgeable and familiar with the pros and cons of such a treatment plan.[11]

To minimize the random variability in diagnosis and treatment planning, in every case, there must be intense focus of attention and critical deliberation on the details of the medical history, signs and symptoms, and routine consideration of plausible alternatives during the process of diagnosis and formulation of a treatment plan.[4,7,31,34,36]

To avoid the common tendency for cognitive bias, whenever possible (and particularly for complex cases), evidence-based guidelines, algorithms, and statistical methods should be used for diagnosis, prognostication of treatment, and decision-making, rather than relying solely on personal clinical experience.[14,31,41] Evidence-based dentistry requires searching and evaluation of the literature, selecting relevant studies and determining their validity and importance,

and using this scientific information in treatment planning.[42]

Generally, clinicians intuitively choose an unequivocal mode of action (yes versus no, do versus do not do) rather than choose a possibly more statistically informative but equivocal mode of action. The adoption of statistical information into an unequivocal decision is cognitively demanding.[43]

Evidence-based dental clinical practice

Evidenced-based clinical practice refers to the application of current supposedly best available evidence from randomized trials and meta-analytical studies. However, not all evidence-based information is of unquestionable scientific quality because of bias and inconsistency brought about by variabilities in study design and methodology, in methods of statistical analysis, and in criteria for exclusion of selective subgroups from the population investigated.[35,44]

To provide evidence-based care, clinicians must obtain a comprehensive picture of their patient's problem, must have the skills to efficiently search the medical/dental literature and to select relevant studies, to scientifically evaluate the quality of the captured evidence, and to apply the best available evidence whenever possible, to reach a clinical decision. In general, evidence-based practice is likely to improve clinical care and treatment outcomes;[42] however, treatment modalities that have been found in evidence-based research to not be completely effective for the average patient may nevertheless be beneficial for certain patients.[45,46]

Although best available evidence may suffice for the average, randomized patient, others remain who do not fit the characteristics of the "average" patient. For these patients, randomized and meta-analytical studies do not provide guidance for the management of deviations in symptoms, clinical course, and pathobiology of disease, nor do such studies take into account patient-specific risk factors, comorbidities, response to prior treatment, compliance, social support, psychological status, or lifestyle. These are all important factors influencing clinical judgment and decision-making.[44]

Judgment and decision-making in clinical practice should not be determined only by the "best available evidence". Other factors, including those listed above, together with the patient's personal preferences, expert clinical opinions, personal clinical experience, and observational research, must be taken into account.[2,44] Furthermore, because the realm of clinical practice is inherently contingent and ambiguous, strictly evidence-based practice cannot eliminate errors in clinical judgment or therapeutic decisions, which are related to uncertainly.[2]

Framing effects

Clinicians should be aware of the effects of "framing" on patients who are engaged in making decisions about their treatment. There is no doubt that the patient's decision-making and their choice of treatment options can be strongly influenced by a clinician's choice of words in framing the nature of the condition and the proposed treatment plan.[47,48] This framing effect is also influenced by many patient-factors including age, sex, thinking and analytical processes, statistical understanding, mental health, emotional state, lifestyle, cultural background, and whether the patient turns to relatives and friends for advice and discussion.[47,49]

Frank, emphatic, and comprehensive but relaxed discussion with the patient regarding the treatment plan can go a long way toward bringing into perspective a plan of treatment that might initially have been

biased by the framing effect. As a result, the patient may also be more compliant and more likely be satisfied with the outcome of treatment.[47]

Conclusion

Comprehensive patient care is the outcome of complex judgment, decision-making, treatment choices, and the application of a wide range of clinical skills under the uncertainties of everyday clinical practice. Clinical judgment is a complex adaptive cognitive process with unavoidable variations in details among practitioners. Clinical judgment and knowledge-based technical skills are acquired by practice experience, frequent feedback, and reflection.

Well-designed algorithms and guidelines, incorporating principles of statistics and evidence-based data, can be useful adjuncts to personal experience and expert opinion. Neither errors in diagnosis nor in treatment planning nor in execution of the treatment plan can be completely avoided because of individual cognitive biases and mistakes in data interpretation, and because of human factors of uncertainty that so often characterize clinical practice.

Authors' contributions

LF and JL developed the study design. LF and JL wrote the first draft of the manuscript. LF, RAGK, SM, RB, and JL critically revised the second and final draft. RB and RAGK finalized the references. RAGK managed the process of submission.

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References

1. Mylopoulos M, Kulasegaram K and Woods NN. Developing the experts we need: Fostering adaptive expertise through education. *J Eval Clin Pract* 2018; 24: 674–677. DOI: 10.1111/jep.12905.
2. Braude HD. Clinical intuition versus statistics: different modes of tacit knowledge in clinical epidemiology and evidence-based medicine. *Theor Med Bioeth* 2009; 30: 181–198. DOI: 10.1007/s11017-009-9106-4.
3. Lucchiari C and Pravettoni G. Cognitive balanced model: a conceptual scheme of diagnostic decision making. *J Eval Clin Pract* 2012; 18: 82–88. DOI: 10.1111/j.1365-2753.2011.01771.x.
4. Marcum JA. An integrated model of clinical reasoning: dual-process theory of cognition and metacognition. *J Eval Clin Pract* 2012; 18: 954–961. DOI: 10.1111/j.1365-2753.2012.01900.x.
5. Tonelli MR and Upshur RE. A philosophical approach to addressing uncertainty in medical education. *Acad Med* 2019; 94: 507–511.
6. Norman G, Monteiro S and Sherbino J. Is clinical cognition binary or continuous? *Acad Med* 2013; 88: 1058–1060. DOI: 10.1097/ACM.0b013e31829a3c32.
7. Eva KW. What every teacher needs to know about clinical reasoning. *Med Educ* 2005; 39: 98–106. DOI: 10.1111/j.1365-2929.2004.01972.x.
8. Dunphy BC, Cantwell R, Bourke S, et al. Cognitive elements in clinical decision-making: toward a cognitive model for medical education and understanding clinical reasoning. *Adv Health Sci Educ Theory Pract* 2010; 15: 229–250. DOI: 10.1007/s10459-009-9194-y.
9. Entman RM. Framing: Toward clarification of a fractured paradigm. *J Commun* 1993; 43: 51–58.
10. Scheufele DA and Tewksbury D. Framing, agenda setting, and priming: The evolution

of three media effects models. *J Commun* 2007; 57: 9–20.
11. Kahneman D. *Thinking fast and slow*. New York: Farrar, Straus and Giroux; 2011.
12. Elstein AS. Clinical problem solving and decision psychology: comment on "the epistemology of clinical reasoning". *Acad Med* 2000; 75: S134–S136.
13. Elstein AS. Thinking about diagnostic thinking: a 30-year perspective. *Adv Health Sci Educ Theory Pract* 2009; 14: 7–18. DOI: 10.1007/s10459-009-9184-0.
14. Chin-Yee B and Upshur R. Clinical judgement in the era of big data and predictive analytics. *J Eval Clin Pract* 2018; 24: 638–645. DOI: 10.1111/jep.12852.
15. Forde R. Competing conceptions of diagnostic reasoning–is there a way out? *Theor Med Bioeth* 1998; 19: 59–72.
16. Schmeichel BJ. Attention control, memory updating, and emotion regulation temporarily reduce the capacity for executive control. *J Exp Psychol Gen* 2007; 136: 241–255. DOI: 10.1037/0096-3445.136.2.241.
17. Williams PG and Thayer JF. Executive functioning and health: introduction to the special series. *Ann Behav Med* 2009; 37: 101–105. DOI: 10.1007/s12160-009-9091-x.
18. Williams PG, Suchy Y and Rau HK. Individual differences in executive functioning: implications for stress regulation. *Ann Behav Med* 2009; 37: 126–140. DOI: 10.1007/s12160-009-9100-0.
19. Raio CM, Orederu TA, Palazzolo L, et al. Cognitive emotion regulation fails the stress test. *Proc Natl Acad Sci U S A* 2013; 110: 15139–15144. DOI: 10.1073/pnas.1305706110.
20. Shields GS, Kuchenbecker SY, Pressman SD, et al. Better cognitive control of emotional information is associated with reduced pro-inflammatory cytokine reactivity to emotional stress. *Stress* 2016; 19: 63–68. DOI: 10.3109/10253890.2015.1121983.
21. Quinn ME and Joormann J. Control when it counts: Change in executive control under stress predicts depression symptoms. *Emotion* 2015; 15: 522–530. DOI: 10.1037/emo0000089.
22. Quinn ME and Joormann J. Stress-induced changes in executive control are associated with depression symptoms: Examining the role of rumination. *Clin Psychol Sci* 2015; 3: 628–636.
23. McKlveen JM, Myers B and Herman JP. The medial prefrontal cortex: coordinator of autonomic, neuroendocrine and behavioral responses to stress. *J Neuroendocrinol* 2015; 27: 446–456. DOI: 10.1111/jne.12272.
24. Inzlicht M and Gutsell JN. Running on empty: neural signals for self-control failure. *Psychol Sci* 2007; 18: 933–937. DOI: 10.1111/j.1467-9280.2007.02004.x.
25. Croskerry P. A universal model of diagnostic reasoning. *Acad Med* 2009; 84: 1022–1028. DOI: 10.1097/ACM.0b013e3181ace703.
26. Moulton CA, Regehr G, Mylopoulos M, et al. Slowing down when you should: a new model of expert judgment. *Acad Med* 2007; 82: S109–S116. DOI: 10.1097/ACM.0b013e3181405a76.
27. Balla JI, Heneghan C, Glasziou P, et al. A model for reflection for good clinical practice. *J Eval Clin Pract* 2009; 15: 964–969. DOI: 10.1111/j.1365-2753.2009.01243.x.
28. Black P and Wiliam D. Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan* 1998; 80: 139–144.
29. Monteiro S, Norman G and Sherbino J. The 3 faces of clinical reasoning: Epistemological explorations of disparate error reduction strategies. *J Eval Clin Pract* 2018; 24: 666–673. DOI: 10.1111/jep.12907.
30. Tversky A and Kahneman D. Judgment under Uncertainty: Heuristics and Biases. *Science* 1974; 185: 1124–1131. DOI: 10.1126/science.185.4157.1124.
31. Kahneman D, Rosenfield AM, Gandhi L and Blaser T. Noise: How to overcome the high, hidden cost of inconsistent decision making. 2016. https://hbr.org/2016/10/noise.
32. Feller L and Lemmer J. Oral Leukoplakia as It Relates to HPV Infection: A Review. *Int J Dent* 2012; 2012: 540561. DOI: 10.1155/2012/540561.
33. Wagenmakers EJ, Wetzels R, Borsboom D, et al. An Agenda for Purely Confirmatory Research. *Perspect Psychol Sci* 2012; 7: 632–638. DOI: 10.1177/1745691612463078.

34. Kahneman D. A perspective on judgment and choice: mapping bounded rationality. *Am Psychol* 2003; 58: 697–720. DOI: 10.1037/0003-066X.58.9.697.
35. Djulbegovic B, Elqayam S and Dale W. Rational decision making in medicine: Implications for overuse and underuse. *J Eval Clin Pract* 2018; 24: 655–665. DOI: 10.1111/jep.12851.
36. Bowen JL. Educational strategies to promote clinical diagnostic reasoning. *N Engl J Med* 2006; 355: 2217–2225. DOI: 10.1056/NEJMra054782.
37. Mylopoulos M and Regehr G. Putting the expert together again. *Med Educ* 2011; 45: 920–926. DOI: 10.1111/j.1365-2923.2011.04032.x.
38. Mamede S, Schmidt HG, Rikers RM, et al. Breaking down automaticity: case ambiguity and the shift to reflective approaches in clinical reasoning. *Med Educ* 2007; 41: 1185–1192. DOI: 10.1111/j.1365-2923.2007.02921.x.
39. Woods NN. Science is fundamental: the role of biomedical knowledge in clinical reasoning. *Med Educ* 2007; 41: 1173–1177. DOI: 10.1111/j.1365-2923.2007.02911.x.
40. Hambrick DZ and Burgoyne AP. The difference between rationality and intelligence. *The New York Times*. 16 September 2016. https://nyti.ms/2cM5MDU
41. Chin-Yee B and Fuller J. Clinical judgement: Multidisciplinary perspectives. *J Eval Clin Pract* 2018; 24: 635–637. DOI: 10.1111/jep.12931.
42. Evidence-Based Medicine Working Group. Evidence-based medicine. A new approach to teaching the practice of medicine. *JAMA* 1992; 268: 2420–2425.
43. Greenwald AG, Gonzalez R, Harris RJ, et al. Effect sizes and p values: what should be reported and what should be replicated? *Psychophysiology* 1996; 33: 175–183.
44. Feinstein AR and Horwitz RI. Problems in the "evidence" of "evidence-based medicine". *Am J Med* 1997; 103: 529–535.
45. Frieden TR. Evidence for Health Decision Making - Beyond Randomized, Controlled Trials. *N Engl J Med* 2017; 377: 465–475. DOI: 10.1056/NEJMra1614394.
46. Khammissa RAG, Ballyram R, Jadwat Y, et al. Vitamin D Deficiency as It Relates to Oral Immunity and Chronic Periodontitis. *Int J Dent* 2018; 2018: 7315797. DOI: 10.1155/2018/7315797.
47. Almashat S, Ayotte B, Edelstein B, et al. Framing effect debiasing in medical decision making. *Patient Educ Couns* 2008; 71: 102–107. DOI: 10.1016/j.pec.2007.11.004.
48. Gong J, Zhang Y, Feng J, et al. Influence of framing on medical decision making. *EXCLI J* 2013; 12: 20–29.
49. Brick C, McCully SN, Updegraff JA, et al. Impact of Cultural Exposure and Message Framing on Oral Health Behavior: Exploring the Role of Message Memory. *Med Decis Making* 2016; 36: 834–843. DOI: 10.1177/0272989X15570114.