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Cognitive bias: how understanding its impact on antibiotic prescribing decisions can help advance antimicrobial stewardship

Bradley J. Langford[1,2]*, Nick Daneman[1,3,4,5], Valerie Leung[1,6] and Dale J. Langford[7]

[1]Public Health Ontario, Toronto, Ontario, Canada; [2]Hotel Dieu Shaver Health and Rehabilitation Centre, St Catharines, Ontario, Canada; [3]University of Toronto, Toronto, Ontario, Canada; [4]Sunnybrook Research Institute, Toronto, Ontario, Canada; [5]ICES (formerly Institute for Clinical Evaluative Sciences), Toronto, Ontario, Canada; [6]Toronto East Health Network, Michael Garron Hospital, Toronto, Ontario, Canada; [7]Department of Anesthesiology and Pain Medicine, School of Medicine, University of Washington, Seattle, WA, USA

*Corresponding author. E-mail: bradley.langford@oahpp.ca

The way clinicians think about decision-making is evolving. Human decision-making shifts between two modes of thinking, either fast/intuitive (Type 1) or slow/deliberate (Type 2). In the healthcare setting where thousands of decisions are made daily, Type 1 thinking can reduce cognitive load and help ensure decision making is efficient and timely, but it can come at the expense of accuracy, leading to systematic errors, also called cognitive biases. This review provides an introduction to cognitive bias and provides explanation through patient vignettes of how cognitive biases contribute to suboptimal antibiotic prescribing. We describe common cognitive biases in antibiotic prescribing both from the clinician and the patient perspective, including hyperbolic discounting (the tendency to favour small immediate benefits over larger more distant benefits) and commission bias (the tendency towards action over inaction). Management of cognitive bias includes encouraging more mindful decision making (e.g., time-outs, checklists), improving awareness of one's own biases (i.e., meta-cognition), and designing an environment that facilitates safe and accurate decision making (e.g., decision support tools, nudges). A basic understanding of cognitive biases can help explain why certain stewardship interventions are more effective than others and may inspire more creative strategies to ensure antibiotics are used more safely and more effectively in our patients.

Introduction

The way clinicians think about decision-making is evolving. Psychologist and economist, Dr Daniel Kahneman proposed the Dual Process Theory, which is an example of a framework that categorizes human decision-making as either fast and intuitive (Type 1) or slow and deliberate (Type 2).[1] While these dual processes are complex (e.g., types of thinking interact and variability exists within each type), the broad concept of a distinction between types or systems of thought is well-established and central to various psychological and physiological theories.[2] Probably as a result of conferring a survival advantage, humans spend 95% of their time in the intuitive Type 1 mode.[3] In busy healthcare settings, where the volume of decisions required is often as many as thousands per shift, Type 1 thinking can reduce cognitive load, and help ensure decision making is efficient and timely.[4] However, the subconscious, hard-wired, habitual, and often emotional nature of this mode can lead to imperfect results.[5] The speed and efficiency of Type 1, though at times beneficial, may in some scenarios come at the expense of accuracy, leading to systematic errors, also called cognitive biases.[6]

Over 100 cognitive biases have been described, many of which apply to decisions made in healthcare.[7] These cognitive biases may explain common diagnostic and medical errors,[8] but they may also help us understand insufficiencies in the process of antibiotic prescribing. There are at least four 'moments' of antibiotic prescribing decision-making: (1) initiation (deciding whether antibiotics are required); (2) empirical (sending appropriate cultures and selecting initial antibiotic therapy); (3) re-assessment (de-escalating, changing route); and (4) selecting an appropriate duration of treatment.[9] The impact of cognitive bias at each of these moments may contribute to the high incidence of suboptimal antibiotic prescribing across healthcare settings.[10–12]

Recent studies evaluating antimicrobial prescribing have called for a more behavioural approach to addressing antibiotic overuse by considering the emotional, cognitive and social factors associated with this complex decision.[13,14] Antimicrobial stewardship interventions designed using an implementation science approach emphasize identifying and addressing barriers and facilitators to behaviour change, which can include numerous factors including knowledge and skills, environmental context and resources, and social influences such as family pressure.[15] Although our experience is that successfully addressing the more complex barriers to behaviour change related to antimicrobial prescribing takes a thoughtful, coordinated and multifaceted approach,[16] understanding mental shortcuts (also known as heuristics) may be an underused tool to help us better design and implement effective antimicrobial stewardship interventions. In this review, we use patient vignettes to illustrate cognitive biases as barriers to appropriate antibiotic use and suggest incorporating de-biasing approaches as a novel way to further support antimicrobial stewardship endeavours.

Patient vignettes that demonstrate cognitive biases

Ms G.H. is a 79-year-old long-term care resident with mild cognitive impairment who is admitted to the hospital with reduced urinary output, confusion and lethargy but no acute dysuria or abdominal or flank pain. In the emergency department (ED), the provider orders a urine culture, urinalysis, and initiates empirical antibiotics and intravenous (IV) fluids. A preliminary diagnosis of dehydration and query urinary tract infection (UTI) are made. After 24 h the patient is transferred to the ward and appears much better. Her urine culture comes back positive for *Escherichia coli* and her urinalysis shows positive leucocyte esterase and nitrites. Ms G.H. is continued on antibiotics for a 7 day course and is discharged back to long-term care on day 4.

Antimicrobial stewards may recognize this case to be a classic episode of asymptomatic bacteriuria, where antibiotics in non-pregnant adults provide no benefit and could in fact lead to harm.[17] So what went wrong? Is more education needed for the providers, family members and patients on the appropriate use of antibiotics for asymptomatic bacteriuria or are there more complex cognitive-behavioural factors at play? In fact, several potential cognitive biases may be driving suboptimal prescribing in this scenario.

When the ED provider receives the patient from the nursing home, she receives a note from the medical director of the home with the past medical history, history of presenting illness and an indication that this is a suspected UTI given the foul-smelling urine and altered mental status. Although the ED prescriber recognizes that true UTI is unlikely, the assertion of UTI by the medical director provides initial suspicion that is reinforced by concerns from family members (***diagnostic momentum*** – *initial incorrect suspicion gathers momentum as it passes between individuals*). The ED provider also feels that the optics of sending the patient back to long-term care without significant medical management could be perceived by the family and the medical director as negligent, and feels that something should be done for this patient (***commission bias*** – *tendency towards action over inaction).* Although the ED prescriber is aware of the potential harms of antibiotic use such as antibiotic resistance and *Clostridioides difficile* infection, those outcomes are both less tangible and more distant temporally (***hyperbolic discounting*** – *tendency to favour small immediate benefits over larger more distant benefits or reduced harms*). The patient's family members believe that antibiotics will drastically improve the situation and have minimal risks (***optimism bias*** – *overestimate of benefits, with underestimate of risks*). The hospitalist receiving the patient on the ward notes their improvement on the combination of antibiotics and IV fluids and indicates that the rapid response and the results of urine culture and urinalysis confirm the diagnosis (***confirmation bias*** – *tendency to seek out evidence that confirms an initial hypothesis*), hence he continues the patient on antibiotics for a week of therapy.

Another scenario reveals additional cognitive biases. A 42-year-old patient, Mr A.I. is admitted to hospital with sepsis caused by methicillin-susceptible *Staphylococcus aureus*. Mr A.I. reports a penicillin allergy based on a mild rash to amoxicillin when he was 5 years old. The triage nurse documents this reaction in the chart. While awaiting an infectious diseases consultation, Dr D.U., the internist, initiates IV vancomycin, avoiding the preferred β-lactam due to Mr A.I.'s reported penicillin allergy. While Dr D.U. knows that a β-lactam, such as cefazolin or cloxacillin, would be preferred therapy with a substantial survival benefit over vancomycin, and that the reaction A.I. reported as a child is likely not a true IgE-mediated allergy, Dr D.U. remembers a very severe case of anaphylaxis he had to manage 2 months ago and worries this could happen again (***negativity effect*** – *negative outcomes make a greater impression than equally positive outcomes and increase the perceived frequency of the outcome* and ***availability bias*** – *tendency to overestimate the likelihood of an event that is easily recalled*). Seeing the reaction documented by the nurse as an allergy in the chart and repeated by the patient solidifies Dr D.U.'s concerns (***diagnostic momentum*** – *initial incorrect suspicion gathers momentum as it passes between individuals*). The ID physician decides that this patient is at low risk for reaction to β-lactams and Mr A.I. is switched safely to IV cefazolin. The ID physician later invites Dr D.U. to participate in a quality improvement initiative to improve appropriate documentation of penicillin allergy labels and optimize treatment in patients with reported allergies. Dr D.U. becomes a key opinion leader and informal champion of reducing inappropriate penicillin allergy labels (***IKEA effect*** – *the tendency of a person to place higher value on, and satisfaction with, a product if they made it themselves*).[18]

Scenarios such as these undoubtedly occur across health systems on a regular basis. Understanding the myriad cognitive biases that occur in decision-making may provide some insight into how we can bridge the gap between evidence and practice in order to steward our antimicrobials more effectively.

Addressing cognitive biases through antimicrobial stewardship initiatives

Management of cognitive biases involves slowing down to activate Type 2 decision-making, reflecting on one's own biases, reducing cognitive load associated with decision-making, and taking cognitive bias into account when designing interventions.[19] Table 1 explains several common cognitive biases associated with inappropriate antibiotic use and describes approaches that may be used to address them. The following are some evidence-based de-biasing strategies to managing or mitigate cognitive bias in antimicrobial usage.

Slow down

Clinician decision making includes both intuitive and reflective components, both of which play an important role in providing patient care. There is evidence that a balanced approach to Type 1 and Type 2 thinking may optimize medical decision making.[20,21] A 'slow down' strategy aims to improve this balance by supporting

Table 1. Selected cognitive biases associated with antibiotic use

Bias	Definition	Example	Managing the bias
Anchoring	Fixating on certain diagnostic features early in the process. Initial impression can be powerful and a challenge to deviate from, even once new information becomes available. Anchoring can lead to 'premature diagnostic closure' where other diagnoses may not be considered.	Altered mental status in an elderly nursing home resident may often be considered to be caused by UTI before other causes are ruled out. Antibiotics are often initiated in these patients even though antibiotics do not confer any survival benefit.[43]	Decision support and algorithms to trigger assessment of other causes for non-specific symptoms (e.g., dehydration in the older patient with altered mental status). Re-evaluation of antibiotic therapy once further information is available (e.g., antibiotic time-out).
Availability bias	Overestimating the likelihood of events that are more memorable. See *Negativity effect*.	There may be a tendency to select an antibiotic that has had recent perceived success and avoid antibiotics with recent perceived failure.[33] Physicians who recalled that they had frequently cared for bacteraemic patients were more likely to over-estimate bacteraemia in a current patient.[44]	Estimate and re-evaluate confidence in predictions. Provide and reflect upon statistical data showing the risks and benefits of each option and its alternatives.
Commission bias	Tendency towards action over inaction. This may be influenced by the perception that doing something is better than nothing; the regret associated with an omission error outweighs that of a commission error, and may be augmented by patient and family demand.	Antimicrobial stewardship recommendations are more likely to be accepted if they expand antibiotic spectrum compared with reducing spectrum,[45] and are more likely to be accepted if they increase antibiotic exposure rather than decrease exposure.[46] Concerns about missing an infection outweigh concerns about serious antibiotic harms such as *Clostridioides difficile* infection.[47]	Sharing narratives and stories of harm associated with antibiotic commission or overuse (e.g., *C. difficile* infection or antibiotic-resistant infections).[48] Thorough evaluation of risks and benefits of antibiotic therapy and withholding antibiotic therapy, ideally at the point of care.
Confirmation bias	The tendency to seek out evidence that confirms an initial hypothesis and reject information that refutes it. This is an especially powerful bias as it helps to reduce cognitive overload associated with evaluating other alternative hypotheses.	An initial suspicion of UTI in a patient with non-specific symptoms is often 'confirmed' by a positive urine culture or dipstick result, leading to unnecessary antibiotic treatment.[49] Clinicians and patients may justify antibiotics retrospectively based on symptom resolution, for example, for upper respiratory tract infection, where the natural course of illness is self-resolution with or without antibiotics.	Seek out disconfirming evidence, e.g. use of mnemonics to remind clinicians of alternative diagnoses.[4] Provide statistical data on the likelihood of infection (and spontaneous resolution), colonization, and contamination in specific patient populations.
Diagnostic momentum	An initial suspicion can gather momentum and quickly become solidified as a diagnosis as it passes from the patient to health care provider and then across disciplines during the course of illness.	Antibiotics initiated unnecessarily in the ED for suspected UTI are often continued once the patient is hospitalized.[50] Although β-lactam allergy labels are common, <10% represent true IgE-mediated hypersensitivity. Penicillin allergy labels reported by the patient and accepted at face value can lead to selection of suboptimal therapy.[51] Once reported, a penicillin allergy is often difficult to remove.	Re-evaluation of antibiotic therapy upon healthcare transitions (e.g., ED to ward, upon discharge). Structured communication tools to assist nurses in transferring adequate information regarding long-term care residents with suspected infection to prescribers.[52] Use of checklists and frameworks to re-evaluate β-lactam allergies.[53]
IKEA effect		At the individual-patient level, physicians may be more likely to support a	Engage end users and prescribers early in process of antibiotic

Continued

Table 1. *Continued*

Bias	Definition	Example	Managing the bias
	The tendency of a person to place higher value on, and satisfaction with, a product if they made it themselves.	given antibiotic regimen if they were the initial prescriber. At the programmatic level, clinician involvement in antibiotic stewardship strategy selection is associated with increased appropriateness of antibiotic use.[54]	stewardship strategy and guideline development.
Negativity effect	Experienced negative outcomes make a greater impression than equally positive outcomes and as a result may be deemed to be more frequent than their actual occurrence.[55]	Adverse outcomes (side effects, relapse) may be more easily recalled and alter decision making to less judicious therapy (e.g., broader spectrum agents, longer duration).	Reassurance through face-to-face discussion. Provide and reflect upon statistical data showing the risks and benefits of each option and its alternatives.
Optimism or Impact bias	Clinicians and patients have a tendency to overestimate benefits and/or underestimate risks of a specific test or treatment.[6,56]	Parents of patients vastly underestimate the benefits of antibiotic therapy on symptom duration for upper respiratory tract infections.[57] Physicians tend to perceive antibiotic resistance as a problem, but that it tends to be driven by other prescribers in different practice settings.[28]	Participating in shared decision making with patients, discussing both the benefits and risks of each option can help manage patient expectations and reduce unnecessary antibiotic use.[58]
Present bias (hyperbolic discounting)	Tendency to favour smaller more immediate benefits over larger benefits in the future.	The immediate benefit of antibiotics that increase patient satisfaction and potentially improve symptoms is weighed more heavily than later outcomes such as antibiotic resistance or *C. difficile* infection.	Providing cues to prescribers about potential antibiotic risks at the time of prescribing to re-calibrate benefits-versus-risk assessment.

Type 2 (slow and deliberate) thinking to re-evaluate the appropriateness of antibiotic therapy. Such approaches include ‘antibiotic time-outs’ where prescribers are prompted to re-assess therapy and decide whether discontinuation or de-escalation is reasonable.[22] Typically in hospital settings, antibiotic time-outs are a supplemental strategy that can be applied for selected patient populations (e.g., receiving targeted antibiotics) and involves a formal re-assessment of antibiotic use by the provider most responsible, usually occurring at 48 to 72 h after initiation of antibiotic treatment, in an effort to decide if antibiotics are no longer needed or can be de-escalated. This time-out strategy is generally associated with improved antibiotic utilization and guideline concordance.[23] Antibiotic time-outs can be combined with a structured tool such as a checklist to ensure a comprehensive re-assessment occurs. Despite low uptake, the use of a checklist with quality indicators for antibiotic therapy at the point of prescribing and again at 72 h has been associated with improved quality of care, such as appropriate culturing, documentation and guideline concordant prescribing.[24] A more personable face-to-face alternative to checklists also appears to be an effective approach. Physician-led[25] and nurse-led[26] prompting of the prescriber to re-evaluate antibiotic therapy in the ICU is associated with reduced antibiotic utilization. Providing additional information at the time of prescribing, particularly in a visual format, can help re-calibrate the prescriber’s understanding of risks versus benefits.[27] This latter tactic requires further evaluation in antimicrobial stewardship strategies.

Reflect

Clinicians are often able to identify bias in others, but they tend to lack insight into their own biases. This phenomenon itself is a common bias referred to as *blind spot bias*.[8] For example, although physicians generally recognize that antibiotic over-prescribing is a problem, there is a sense of *externalized responsibility*, in that many believe antibiotic over-prescribing is driven by physicians other than themselves.[28] De-biasing requires clinicians to become aware of their own cognitive biases, how often they occur, and how they differ from accurate estimates. Cognitive interventions, such as those that prompt providers to ‘consider-the-opposite’ of an initial judgement, may be helpful de-biasing strategies, particularly for biases that lead to over- or under-estimating the likelihood of an event (such as anchoring bias, optimism bias, and confirmation bias).[29,30] Considering-the-opposite can be done in real time by seeking evidence to refute an initial assumption (e.g., the use of mnemonics to consider a broader range of diagnoses aside from infection that may lead to delirium in older patients).[31] Similarly, asking learners to estimate their confidence in their performance and then compare this with their actual performance can help to recalibrate overconfidence and improve accuracy.[32] Such meta-cognitive de-biasing approaches have yet to be evaluated in antimicrobial stewardship initiatives, and therefore provide an opportunity for future research (e.g., the impact of de-biasing training on management of asymptomatic bacteriuria or upper respiratory tract infections).

It should be acknowledged that infectious disease and antimicrobial stewardship experts are equally susceptible to cognitive bias and may also benefit from de-biasing strategies. The ***curse of knowledge*** is the tendency to be unaware of the challenges faced by non-infectious diseases colleagues,[33] such as the difficulties in selecting an antibiotic with optimal spectrum of activity or interpreting microbiology reports. The specialized expertise in antimicrobial stewardship can also lead to the ***law of the instrument*** bias, an over-reliance on familiar strategies (e.g., if all you have is a hammer, everything looks like a nail),[33] such as the tendency to focus solely on antimicrobial stewardship opportunities in each patient rather than the bigger picture of the patient scenario. ***Omission bias*** (a tendency toward inaction over action) may be a greater concern in antimicrobial stewardship teams where antibiotic harms may be over-valued compared with the immediate benefits to patients. Formalized interactions between prescribers and antimicrobial stewards including face-to-face antimicrobial stewardship rounds[34] and bringing together clinical teams and infectious disease and antimicrobial stewardship experts in the development of guidelines and pathways[35] can help ensure a more-balanced approach is taken.

Make it easy

A key approach to improving clinical decision-making is to design an environment that makes it easier for clinicians to make optimal decisions despite existing cognitive biases. This strategy mainly involves reducing the cognitive load associated with decision-making, primarily through clinical decision support and presentation of information and options in a format that guides optimal decision making (e.g. forcing functions and optimal choice architecture). Clinical decision support systems including information technology to improve antibiotic prescribing (e.g., clinical pathways, order sets, alerts, or reminders) are generally associated with improved antibiotic utilization and quality of prescribing.[36] However, despite their widespread use, these decision support tools tend to lack sophistication, and primarily focus on antibiotic selection rather than initiation, reassessment, and discontinuation.[37] Structured allergy assessments have been used as an accessible tool to help safely de-label patients with reported β-lactam allergies and can help mitigate the ***diagnostic momentum*** of penicillin allergy labels in patients who do not have true penicillin allergies. This systematic approach to pharmacist-led allergy history assessment was associated with increased use of first-line antibiotics peri-operatively, which are generally safer and more effective than second-line alternatives.[38] Another promising strategy, employed largely through microbiology reporting, is nudging, whereby the architecture of the report is modified to gently encourage more evidence-based antibiotic prescribing.[39] For example, non-reporting of ciprofloxacin susceptibility results on microbiology laboratory reports when there was susceptibility to narrower-spectrum agents was associated with reduced use of ciprofloxacin and improved Gram-negative susceptibility to this agent in an interrupted time series analysis.[40] Similarly, non-reporting of mid-stream urine culture results for hospital inpatients was associated with reduced treatment of asymptomatic bacteriuria, with no adverse patient outcomes.[41,42]

Considerations for future research

The application of behavioural insights to antimicrobial stewardship is in its infancy, so there are lessons to be learned from behaviour change experts in economics, sociology and psychology. Partnership with these experts, in addition to implementation science practitioners, is likely to yield more-refined, well-designed, and optimally adopted antimicrobial stewardship strategies. Recognizing cognitive biases as an additional perspective for identifying and addressing complicated barriers to practice change may help antimicrobial stewards ensure antibiotics are used more appropriately in a range of healthcare settings. The following are some examples of key antimicrobial stewardship research, education, and policy opportunities that address or incorporate an understanding of the impact of cognitive biases on prescribing patterns:

1. Mapping cognitive biases across the four moments of antibiotic prescribing using experimental studies, naturalistic observation, and qualitative interviews
2. Incorporating an understanding of provider cognitive biases in the design of antibiotic prescribing clinical decision support tools and audit and feedback interventions
3. Devising public policy and communication strategies to engage the general public in antimicrobial stewardship by countering optimism bias and re-calibrating an understanding of the risks and benefits of antibiotics
4. Developing a framework that incorporates dual process theory into implementation science, knowledge translation and quality improvement to support the development of theory-informed antibiotic stewardship initiatives
5. Evaluating the impact of meta-cognitive de-biasing approaches to minimize antibiotic prescribing for common conditions that do not require antibiotic therapy

Conclusions

Cognitive bias is a common aspect of daily decision-making that may play an underappreciated role in antibiotic prescribing decisions. Behavioural science represents a largely untapped field of knowledge to help improve the design and implementation of antibiotic stewardship interventions. Management of cognitive bias includes encouraging more mindful decision making (e.g., time-outs, checklists), improving awareness of one's own biases (i.e., meta-cognition), and designing an environment that facilitates safe and accurate decision making (e.g., decision support tools, nudges). A basic understanding of cognitive biases can help explain why certain stewardship interventions are more effective than others and may inspire more creative strategies to ensure antibiotics are used more safely and more effectively in our patients.

Transparency declarations

None to declare.

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