The utility of measuring behavioral variability as a marker of provider uncertainty in clinical scenarios

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Abstract

Among the countless decisions healthcare providers make daily, many clinical scenarios do not have clear guidelines, despite a recent shift towards the practice of evidence-based medicine. Even in clinical scenarios where guidelines do exist, these guidelines do not universally recommend one treatment option over others. As a result, the limitations of existing guidelines presumably create an inherent variability in provider decision-making and the corresponding distribution of provider behavioral variability in a clinical scenario, and such variability differs across clinical scenarios. We define this variability as a marker of provider uncertainty, where scenarios with a wide distribution of provider behaviors have more uncertainty than scenarios with a narrower provider behavior distribution. We propose four exploratory analyses of provider uncertainty: (1) field-wide overview; (2) subgroup analysis; (3) provider guideline adherence; and (4) pre-/post-intervention evaluation. We also propose that uncertainty analysis can also be used to help guide interventions in focusing on clinical decisions with the highest amounts of provider uncertainty and therefore the greatest opportunity to improve care.

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Abstract

Among the countless decisions healthcare providers make daily, many clinical scenarios do not have clear guidelines, despite a recent shift towards the practice of evidence-based medicine. Even in clinical scenarios where guidelines do exist, these guidelines do not universally recommend one treatment option over others. As a result, the limitations of existing guidelines presumably create an inherent variability in provider decision-making and the corresponding distribution of provider behavioral variability in a clinical scenario, and such variability differs across clinical scenarios. We define this variability as a marker of provider uncertainty, where scenarios with a wide distribution of provider behaviors have more uncertainty than scenarios with a narrower provider behavior distribution. We propose four exploratory analyses of provider uncertainty: (1) field-wide overview; (2) subgroup analysis; (3) provider guideline adherence; and (4) pre-/post-intervention evaluation. We also propose that uncertainty analysis can also be used to help guide interventions in focusing on clinical decisions with the highest amounts of provider uncertainty and therefore the greatest opportunity to improve care.

Introduction

Physician-level variations in treatment behaviors have been described across different countries, regions, and institutions. [1,2] Such variations cannot be attributed to physicians, patients, or systems alone and persist even in carefully designed clinical scenarios where explicit guidelines are in place. [1,3] Nonetheless, there are many scenarios in medicine where multiple acceptable provider decisions exist. The variability becomes more pronounced, particularly in scenarios with no clear evidence-based guidelines.

This variability may exist for several reasons. To name a few, clinical scenarios are inherently variable and don't always fit with guidelines. The training, experiences, biases, heuristics, and judgment of providers influence treatment decisions. Patient characteristics and preferences influence providers' treatment decisions as well. Lastly, the divergence in priorities for patients and providers can drive variation. In acute care scenarios, patients and providers are typically aligned on preserving the patient's life as the top priority. In chronic disease management, more opportunities for shared decision-making exist.

A clinical scenario of certainty has a limited number of acceptable treatment decisions. In the case of acute hypoxic respiratory failure, immediate ventilation with noninvasive or invasive modalities is warranted. [4] On the other hand, a clinical scenario of uncertainty could be considered one where there is relatively more behavioral variability across populations of physicians. For example, in the case of moderate-to-severe ulcerative colitis, a variety of pharmacological agents, such as biologics, biosimilars, and small molecules, are available in the treatment arsenal, in addition to surgical referral. [5] This behavioral variability is documented in many fields: given an identical clinical scenario, providers of the same specialty exhibit considerable heterogeneity in diagnostic and treatment decision-making, subsequently resulting in heterogeneous behavioral outcomes. [6–8]

The presence of provider uncertainty is not unambiguously bad, but it should be understood and characterized. To this end, we propose that provider uncertainty in a clinical scenario can be quantified by measuring population-level provider variability in that scenario. Furthermore, we argue that measuring uncertainty has clinical value: measurement of uncertainty is a tool that can be used to determine which clinical scenarios would benefit most from interventions.

The Utility of Measuring Provider Uncertainty

Many tools exist for studying the association of patient-specific characteristics - such as variation in genomic, transcriptomic, or environmental factors - with certain conditions and outcomes.[9,10] While provider behavior influences clinical trajectory as much as patient physiology, there is no similar method for systematically examining behavioral variability in relation to outcomes. Such analysis would provide a versatile method of examining different aspects of clinical practice in scenarios with multiple acceptable behaviors with several major clinical applications that can be combined or utilized independently.

1. Field-wide Overview

Measuring provider uncertainty represents an unexplored opportunity to examine where individual provider behaviors fall in the context of other providers in terms of frequency, outcomes, and cost. To start, one should define what constitutes the repertoire of provider behavior outcomes in a given clinical scenario with each scenario presumably exhibiting its own signature distribution of behaviors in a provider uncertainty analysis. In some clinical scenarios, such analysis might be cumbersome to interpret if a myriad of possible behaviors exist. For example, when working up a patient presenting with acute abdominal pain to the emergency department, physicians can decide whether or not to admit the patient, to order diagnostic tests, or to administer medications, among many other clinical decisions. Possibilities quickly expand within each category of behaviors, given the vast number of laboratory or imaging tests or medications available. As such, one should exercise caution when comparing patient outcomes if provider behavior options included in the clinical scenario of interest are not comprehensive. Therefore, a field-wide overview of provider uncertainty characterizes the current state of provider behavioral variation, serving as the foundation for further detailed investigation.

2. Subgroup Analysis for Disparity Detection

We offer a more nuanced analytical approach to provider uncertainty with the option to further stratify by patient and provider characteristics. Provider treatment behaviors are determined by both clinically-relevant (e.g., physiology, clinical presentation) and non-clinical (e.g., demographics) patient characteristics. However, some of these factors are not apparent. Within a clinical scenario, provider uncertainty can carve out patient subpopulations according to provider behavior and permits examining patient characteristics and outcomes associated with each treatment selection. As illustrated in Figure 1, greater disease severity is more likely to prompt providers to alter treatment plans. Current guidelines are shaped by evidence gleaned from randomized controlled trials (RCTs), which are designed in homogeneous populations with limited variability in patient characteristics. In contrast, provider uncertainty analysis may aid in the individualization of treatment guidelines, an undertaking that has been associated with significant cost savings and care quality improvement. [11] Similar stratifications can be applied to provider characteristics. For example, providers may exhibit different levels of comfort with or encounter varying degrees of access barriers for newly approved therapeutics depending on length of practice, volume, and specialty status. [12,13]

3. Provider Guideline Adherence

Treatment guidelines frequently undergo updates given the emergence of real-world evidence

and new therapeutics, necessitating continuous monitoring of providers' practice patterns. Field-wide overview of provider uncertainty can distinguish the early adopters, delays in the uptake of, or persistence in deviation from evidence-based recommendations. These patterns of uncertainty over time, especially when segmented by provider attributes, may reveal select provider subgroups' initial inertia or hesitation in response to guideline shifts. This analysis can shed light on insights into provider uptake barriers and opportunities for improving guideline adherence.

4. Pre-/Post Intervention Evaluation

The temporal sensitivity of provider uncertainty allows researchers to conduct observational pre-/post- studies to assess the impact of interventions aiming to reduce provider variation. For instance, clinical decision support systems (CDSS) are intended to improve the processes for providers to deliver high-quality healthcare. [14] However, meta-analyses showed mixed effects of CDSS on provider behaviors. [15,16] Provider uncertainty analysis may reveal variability in provider adoption and effectiveness of these systems at institutional, regional, or national levels. By analyzing pre- and post-intervention data, a successful intervention is reflected in a more concentrated or narrow distribution of provider behaviors for a given clinical scenario, suggesting a move towards more uniform clinical practice. Conversely, minimal changes in the width of a provider uncertainty distribution may suggest that an intervention was ineffective, pointing to the need for modification. Therefore, tailoring interventions targeting provider behavior change based on provider uncertainty analyses can enhance the efficiency of resource utilization and intervention efforts.

5. *Development of clinical decision support tools*

One additional value in provider uncertainty analysis is to identify scenarios of uncertainty that would benefit the most from interventions such as the use of clinical decision-support systems (CDSS). The effectiveness of interventions in reducing provider uncertainty would be more easily measured in clinical scenarios with wide provider behavior distributions at baseline. Conversely, low value in scenarios where a limited number of provider behaviors is established from conventional clinical decision-making pathways (e.g., immediate ventilation for acute respiratory failure). Therefore, measurement of provider uncertainty should serve as a framework for academic research labs, hospital systems, and health IT vendors seeking to develop interventions with the greatest clinical impact.

Sample Clinical Scenario

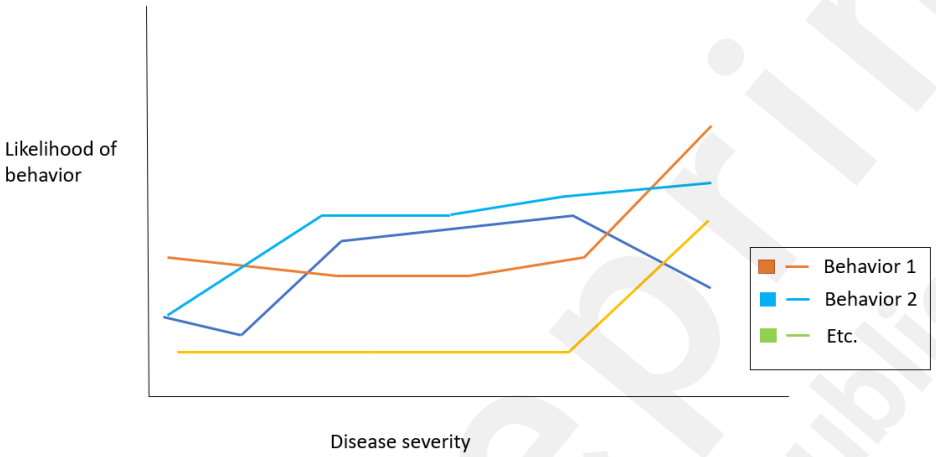
There are many uncertain clinical scenarios that would benefit from such an analysis. For example, a common scenario with multiple acceptable decisions lies in patients with type 2 diabetes (T2DM) with suboptimal blood glucose control despite metformin monotherapy treatment. Metformin is the first-line oral agent of choice in treating this disease, but nearly half of the patients worsen despite metformin monotherapy and require treatment escalation. [17] These patients are faced with several possible options for the stepwise addition of a second agent. The American Diabetes Association (ADA) guidelines proposed several acceptable options for providers to individualize therapy based on specific patient factors, such as patient comorbidities, preferences, self-management, and social determinants of health in selecting the appropriate therapy. [18] A provider uncertainty analysis may help answer descriptive questions such as: which drug classes are most commonly prescribed for a patient with a certain set of comorbidities, or does one prescribing behavior stand out among others? More importantly, this analytical framework may help provide insights into personalizing treatment in this patient population, given that the exact distribution of provider behaviors around this scenario is unknown. [19,20]

Conclusion

Behavioral variation provides a useful conceptual framework to quantify uncertainty among providers in clinical scenarios where there is no clear guideline or gold standard to recommend one behavior over the other. Provider uncertainty analysis can inform intervention opportunities and uncover insights into broader treatment landscapes and health disparities and aid in the reduction of provider deviation from evidence-based recommendations, ultimately improving patient outcomes.

Figures

Figure 1. The likelihood of physician behaviors in a given clinical scenario changes with disease severity.



References

1. Song Z, Kannan S, Gambrel RJ, Marino M, Vaduganathan M, Clapp MA, Seiglie JA, Bloom PP, Malik AN, Resnick MJ. Physician practice pattern variations in common clinical scenarios within 5 US metropolitan areas. JAMA Health Forum American Medical Association (AMA); 2022 Jan 28;3(1):e214698.

2. Corallo AN, Croxford R, Goodman DC, Bryan EL, Srivastava D, Stukel TA. A systematic review of medical practice variation in OECD countries. Health Policy 2014 Jan;114(1):5–14. PMID:24054709

3. Schwartz AL, Jena AB, Zaslavsky AM, McWilliams JM. Analysis of Physician Variation in Provision of Low-Value Services. JAMA Intern Med 2019 Jan 1;179(1):16–25. PMID:30508010

4. Davidson AC, Banham S, Elliott M, Kennedy D, Gelder C, Glossop A, Church AC, Creagh-Brown B, Dodd JW, Felton T, Foëx B, Mansfield L, McDonnell L, Parker R, Patterson CM, Sovani M, Thomas L, BTS Standards of Care Committee Member, British Thoracic Society/Intensive Care Society Acute Hypercapnic Respiratory Failure Guideline Development Group, On behalf of the British Thoracic Society Standards of Care Committee. BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults. Thorax 2016 Apr;71 Suppl 2:ii1–35. PMID:26976648

5. Feuerstein JD, Isaacs KL, Schneider Y, Siddique SM, Falck-Ytter Y, Singh S, AGA Institute Clinical Guidelines Committee. AGA Clinical Practice Guidelines on the Management of Moderate to Severe Ulcerative Colitis. Gastroenterology 2020 Apr;158(5):1450–1461. PMID:31945371

6. Smulowitz PB, James O'Malley A, Zaborski L, Michael McWilliams J, Landon BE. Variation In Emergency Department Admission Rates Among Medicare Patients: Does The Physician Matter? Health Aff Health Affairs; 2021 Feb 1; doi: 10.1377/hlthaff.2020.00670

7. Verma AA, Guo Y, Jung HY, Laupacis A, Mamdani M, Detsky AS, Weinerman A, Tang T, Rawal S, Lapointe-Shaw L, Kwan JL, Razak F. Physician-level variation in clinical outcomes and resource use in inpatient general internal medicine: an observational study. BMJ Qual Saf BMJ Publishing Group Ltd; 2021 Feb 1;30(2):123–132. PMID:32220936

8. Barnett ML, Boddupalli D, Nundy S, Bates DW. Comparative Accuracy of Diagnosis by Collective Intelligence of Multiple Physicians vs Individual Physicians. JAMA Netw Open American Medical Association; 2019 Mar 1;2(3):e190096–e190096.

9. Manolio TA. Genomewide association studies and assessment of the risk of disease. N Engl J Med 2010 Jul 8;363(2):166–176. PMID:20647212

10. Patel CJ, Bhattacharya J, Butte AJ. An Environment-Wide Association Study (EWAS) on Type 2 Diabetes Mellitus. PLoS One Public Library of Science; 2010 May 20;5(5):e10746.

11. Eddy DM, Adler J, Patterson B, Lucas D, Smith KA, Morris M. Individualized guidelines: the potential for increasing quality and reducing costs. Ann Intern Med 2011 May 3;154(9):627–634. PMID:21536939

12. Hoorn CJGM, Crijns HJGM, Dierick-van Daele ATM, Dekker LRC. Review on Factors Influencing Physician Guideline Adherence in Cardiology. Cardiol Rev 2019 Mar/Apr;27(2):80–86. PMID:29634492

13. McKinlay JB, Link CL, Freund KM, Marceau LD, O'Donnell AB, Lutfey KL. Sources of variation in physician adherence with clinical guidelines: results from a factorial experiment. J Gen Intern Med 2007 Mar;22(3):289–296. PMID:17356957

14. Sutton RT, Pincock D, Baumgart DC, Sadowski DC, Fedorak RN, Kroeker KI. An overview of clinical decision support systems: benefits, risks, and strategies for success. NPJ Digit Med 2020 Feb 6;3:17. PMID:32047862

15. Ronan CE, Crable EL, Drainoni M-L, Walkey AJ. The impact of clinical decision support systems on provider behavior in the inpatient setting: A systematic review and meta-analysis. J Hosp Med 2022 May;17(5):368–383. PMID:35514024

16. Kwan JL, Lo L, Ferguson J, Goldberg H, Diaz-Martinez JP, Tomlinson G, Grimshaw JM, Shojania KG. Computerised clinical decision support systems and absolute improvements in care: meta-analysis of controlled clinical trials. BMJ 2020 Sep 17;370:m3216. PMID:32943437

17. Brown JB, Conner C, Nichols GA. Secondary Failure of Metformin Monotherapy in Clinical Practice. Diabetes Care American Diabetes Association; 2010 Mar 1;33(3):501–506. PMID:20040656

18. ElSayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, Collins BS, Hilliard ME, Isaacs D, Johnson EL, Kahan S, Khunti K, Leon J, Lyons SK, Perry ML, Prahalad P, Pratley RE, Seley JJ, Stanton RC, Gabbay RA, on behalf of the American Diabetes Association. 9. Pharmacologic Approaches to Glycemic Treatment: Standards of Care in Diabetes-2023. Diabetes Care 2023 Jan 1;46(Suppl 1):S140–S157. PMID:36507650

19. American Diabetes Association. 9. Pharmacologic Approaches to Glycemic Treatment: Standards of Medical Care in Diabetes—2020. Diabetes Care American Diabetes Association; 2020 Jan 1;43(Supplement 1):S98–S110. PMID:31862752

20. Davies MJ, D'Alessio DA, Fradkin J, Kernan WN, Mathieu C, Mingrone G, Rossing P, Tsapas A, Wexler DJ, Buse JB. Management of Hyperglycemia in Type 2 Diabetes, 2018. A Consensus Report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). Diabetes Care Diabetes Care; 2018 Dec;41(12). PMID:30291106

Supplementary Files

Figures

The likelihood of physician behaviors in a given clinical scenario changes with disease severity.