ACCSCIENCE PUBLISHING

Journal of Clinical Informatics

EDITORIAL

Clinical protocols: Stability and efficiency

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In modern healthcare, clinical protocols are often regarded as the gold standard for delivering safe, effective, and reproducible care. They are designed to synthesize evidence, reduce variation, and provide a clear path for action in complex and often high-pressure environments. From trauma resuscitation algorithms to sepsis bundles and cancer staging pathways, protocols are meant to be our guardrails. Yet in daily clinical practice, those guardrails often give way. The collapse of a protocol can be sudden, triggered by missing information, unavailable resources, or an unexpected patient trajectory, or gradual, as small deviations accumulate until the intended pathway is unrecognizable. This raises a provocative question: Can protocols themselves actually solve the problem of protocol failure, or does the very nature of clinical work limit the capacity of any fixed algorithm to withstand reality?

Protocol failure rarely results from a single cause, but is often the product of interacting factors: The inherent ambiguity of medical presentations, the probabilistic nature of diagnosis, and the rigid structural requirements of some protocols. The decision solvability index (DSI) and protocol solvability index (PSI) framework provides a quantitative lens for dissecting why this fragility occurs. DSI is defined as the sum of three measurable components: Ambiguity (α), the uncertainty in interpreting patient data; misclassification risk (β), the probability of being wrong; and consequence severity (δ), the harm if wrong concepts are aligned with established risk theory, where risk is the function of probability and severity.[1,2] This simple scoring (DSI = $\alpha + \beta + \delta$, on a 0–9 scale) allows decisions to be quantified according to their risk profile. PSI extends this concept to entire protocols by summing the DSIs of each decision node and applying structural penalties for cycles, high in-degree nodes, order sensitivity, and resource constraints. A higher PSI denotes a fragile, failure-prone protocol, while lower scores suggest more stable pathways. These formulations, derived from graph-theoretic models, enable the operationalization of solvability in reproducible ways.[3,4]

Importantly, the parameters required for DSI/PSI can be obtained from real-world data sources. For example, α may be estimated from inter-observer variability or diagnostic test sensitivity/specificity data in electronic health records (EHRs). β can be derived from audit datasets and decision support logs, while δ can be stratified using outcomes data. Structural penalties—such as cycles or order-sensitive nodes—can be mapped computationally by mining protocol flowcharts or EHR order sets. In this way, DSI/PSI moves from a conceptual framework to a reproducible informatics tool that integrates seamlessly with existing methods in workflow mining, clinical decision support, and protocol adherence analysis.[3]

In theory, protocol development is a rational process that includes expert consensus, literature synthesis, pilot testing, and periodic review. In practice, mismatches emerge. Protocols are static rules in a dynamic reality—frozen snapshots of best practice at a given time, applied to patients whose conditions may evolve in minutes. Clinical protocols often include steps assuming ideal resource availability; in PSI terms, this

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Citation: Bartsokas C. Clinical protocols: Stability and efficiency. *J Clin Inform*. 2026;2(1):025330028. doi: 10.36922/JCI025330028

Received: August 14, 2025

Published online: September 9, 2025

raises the number of resource-constrained nodes and lowers solvability. Uniform pathways are applied to heterogeneous populations, ignoring that ambiguity and error differ markedly between patient subgroups. Hidden complexity is another hazard: Diagrams that appear linear may conceal cycles or convergence points requiring multiple prior results, both of which increase structural fragility.[3,4] These mismatches explain why adherence to guidelines in real-world settings is often far lower than in controlled trials and why well-trained teams deviate from prescribed steps under pressure.

A common response to protocol failure is to provide more detail, such as decision points, contingencies, and embedded checklists. This is aimed at reducing ambiguity and misclassification risk by narrowing choices. However, the PSI framework warns that this may have adverse effects. Each additional node increases cumulative decision risk and opportunities for structural penalties, such as higher in-degree, greater order sensitivity, and increased resource dependencies. As protocols become denser, they may paradoxically become less executable, particularly in acute care settings. A massive transfusion protocol with 12 sequential steps may have excellent face validity, but in the chaos of an exsanguinating patient, deviations are almost inevitable. The protocol has not failed because the evidence is incorrect—it has failed because the structural complexity exceeded the solvability threshold of the environment.[4,5]

Protocol collapse is not uniform across settings. A pathway that functions in a tertiary center may unravel in a rural hospital. Based on PSI, this is due to resource constraints and structural bottlenecks that carry different weights depending on the environment. For example, an acute stroke protocol requiring immediate neuroimaging has a low penalty where computed tomography is available at all times, but a high penalty where imaging is intermittent. Similarly, cycles that are manageable with ample staff can become insurmountable when one clinician is covering multiple roles.[3] Solvability is therefore not an intrinsic property of the protocol alone—it is a property of the protocol-in-context, and the same pathway may oscillate between solvable and unsolvable as circumstances change.

The central question is not "how do we fix this protocol?" but "can any protocol, no matter how well-crafted, truly solve the problem of its own fragility?" Protocols operate in a domain of human clinical judgment that is inherently variable and probabilistic. Even if ambiguity is minimized and error risk reduced with accurate tests, severity will always loom over high-stakes decisions. Similarly, structural penalties, such as cycles, high in-degree, order sensitivity, and resource constraints, cannot be eliminated without stripping protocols to the risk of oversimplification. The implication is sobering: Protocols cannot eliminate the problem of protocol collapse but only shift its threshold. We can design pathways with higher PSI, train teams to handle low-DSI nodes, and adapt structures to context—but there will always be clinical scenarios where the pathway is too fragile to hold.[4,5]

Linking DSI and PSI metrics directly to patient outcomes provides an additional layer of validation and relevance. For example, in sepsis care, higher PSI scores for fluid resuscitation pathways may correlate with increased delays in timely antibiotic delivery, ultimately impacting mortality and length of stay. Similarly, in acute stroke protocols, nodes with elevated DSI values—such as decisions around imaging prioritization—can be mapped to door-to-needle times and functional recovery rates. By associating solvability scores with outcome measures, such as adverse event rates, complication profiles, or quality indicators, such as hospital readmissions, the framework has the potential to move beyond abstract modeling and serve as a predictor of safety and quality. In this way, DSI/PSI metrics cannot only highlight fragile decision points but also guide targeted interventions where protocol instability translates into measurable patient harm.

The objective is to elucidate and render fragility observable. The DSI/PSI framework offers a quantitative map of where collapse is most likely to occur. Rather than relying solely on retrospective audits, we can model in advance which decisions are likely to break and which structures will fracture under stress. Such modeling does not address the philosophical limitation that protocols cannot self-repair, but provides a realistic risk profile. This enables empirical testing that compares PSI scores across institutions, embeds solvability alerts into EHR-based decision support, and links protocol fragility metrics to patient outcomes.[6] In doing so, DSI/PSI serves as both a conceptual critique and a reproducible informatics method.

The belief that a better protocol can solve the problem carries the risks of a perfectionist trap. Pursuing flawless adherence may, in turn, lead to the over-engineering of protocols to the point of impracticality. The DSI/PSI approach suggests a different goal of resilience instead of perfection. Resilient protocols acknowledge that collapse is possible and design for recovery with streamlined fallback steps, flexible branching, and explicit thresholds for abandoning the pathway. Measuring solvability must be understood not only as a property of the protocol on paper, but as a living interaction between structure, decision difficulty, and context.[5] Clinical protocols remain essential, but they are not infallible maps; they are scaffolds that will sometimes bend or break under the weight of reality. The challenge is not to abolish that reality, but to equip clinicians to navigate the protocols when, inevitably, the neat lines on the flowchart dissolve into the messy truth of practice.

Conflict of interest

The author declares no conflict of interest.

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