

Not Every Drug-Related Problem Requires the Same Pharmacist Response: A Risk-Based Triage Framework Integrating Urgency, Complexity, Uncertainty, Preventability, and Expected Intervention Value

Wei Zhang^{1*}, Chen Hui², Michael Tan¹

¹ Department of Clinical Pharmacy and Risk-Based Triage, Faculty of Pharmacy, University of Melbourne, Melbourne, Australia.

² Department of Drug-Related Problem Management, Faculty of Pharmacy, National University of Singapore, Singapore.

*E-mail ✉ wei.zhang@unimelb.edu.au

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ABSTRACT

Drug-related problems (DRPs) differ not only in clinical importance but also in how quickly harm may occur, how many variables must be integrated, how much information is missing, how modifiable the problem is, and whether pharmacist effort is likely to generate meaningful value. This paper develops a risk-based method for differentiating pharmacist responses after a DRP has been recognised. A structured conceptual-development approach was used. Contemporary evidence on pharmacist prioritisation, medication-related harm, regimen complexity, clinical decision-making, preventability, intervention outcomes, implementation, and economic value was used to define non-redundant decision dimensions. Evidence-supported premises were kept separate from the article's proposed integrative logic. The framework was constructed as a context-sensitive decision method rather than as a validated score. Five dimensions emerged as analytically distinct: urgency/time-to-harm, complexity, uncertainty, preventability/modifiability, and expected intervention value. Urgency determines how long a response can safely wait; the remaining dimensions shape what kind of response is proportionate. The proposed method therefore allows immediate intervention, structured review, information gathering, escalation or referral, and monitored reassessment to be considered as different response routes rather than assuming that every identified DRP warrants the same intensity of action. The dimensions may conflict, and no numerical weights, universal cut-offs, or performance claims are proposed. Risk-based pharmacist triage is proposed as a method for matching response intensity and type to the characteristics of a DRP. Its value is conceptual and operational at this stage. Reliability, prospective decision performance, patient and process outcomes, implementation burden, equity, and external transferability require empirical evaluation before the method could be treated as a validated clinical instrument.

Keywords: Drug-related problems, Clinical pharmacy, Pharmacist triage, Medication safety, Risk stratification, Pharmaceutical care

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Introduction

Clinical pharmacy has long faced a resource-allocation problem: not every patient can receive the same depth or immediacy of pharmaceutical care. Contemporary pharmacist prioritisation tools help identify which patients should receive attention, but the available evidence does not establish a validated rule for matching the intensity or type of pharmacist response to each individual DRP [1]. This distinction matters because patient prioritisation and problem-response triage answer different questions. The first asks who should be seen; the second asks what should happen once a medication-related concern has been recognised.

Hospital prioritisation tools are heterogeneous in their criteria, development, and validation, and evidence that prioritisation itself changes medication-related outcomes remains limited [2]. Limited outcome evidence should not be interpreted as evidence of ineffectiveness; it instead constrains what can be claimed about downstream benefit. A response-triage method must therefore avoid treating service prioritisation as a surrogate for clinical effectiveness.

Pharmacists already use multiple clinical and medication-related considerations when identifying patients at high risk of medication harm [3]. That practice supports multidimensional judgement, but it does not show that the five dimensions advanced here were empirically derived or that they should receive fixed weights. The proposed contribution is narrower: to make explicit several decision properties that are often blended together during clinical review.

The existing literature includes both prognostic models and consensus-based tools for clinical-pharmacy prioritisation [4]. Such approaches can support patient selection, but they do not by themselves establish which response is proportionate to a particular DRP. This paper therefore proposes a risk-based pharmacist triage method centred on urgency, complexity, uncertainty, preventability, and expected intervention value, while treating its combined architecture as a hypothesis for subsequent validation rather than an established clinical mechanism.

Materials and Methods

The framework was developed as a context-sensitive complex intervention rather than as a finished scoring instrument. Guidance for complex interventions emphasises programme theory, context, uncertainty, refinement, and iterative evaluation [5]. Applied here, that logic required the proposed triage method to specify what each decision dimension contributes, where dimensions overlap, which relationships are supported by existing evidence, and which relationships are new synthesis requiring testing.

The conceptual-development procedure had four stages. First, evidence concerning pharmacist prioritisation and medication-related harm was used to define the unresolved decision problem: response selection after recognition of a DRP. Second, candidate dimensions were retained only when they represented a distinct decision question rather than a different label for severity or general “risk.” Third, the retained dimensions were examined for conditional relationships, including situations in which rapid action could be required despite uncertainty, or in which a modifiable problem might still have low expected intervention value. Fourth, operational boundaries and validation requirements were specified before any attempt to translate the framework into a score.

Structured development and content validation have been demonstrated for adult clinical-pharmacy prioritisation tools [6]. That precedent supports transparent criterion specification, but it does not confer content validity on the dimensions proposed here, and content validity would not establish clinical effectiveness. Similarly, prediction models can identify patients at elevated medication-error risk [7]. Predictive discrimination, however, is conceptually separate from showing that a particular pharmacist response, intensity, or timing produces better decisions or outcomes.

Implementation was treated as part of the method’s boundary conditions rather than an afterthought. The updated Consolidated Framework for Implementation Research describes determinants spanning the intervention, individuals, inner setting, outer setting, and implementation process [8]. Accordingly, the framework was designed to remain sensitive to clinician scope, team configuration, information access, workload, organisational rules, and health-system resources. The analysis produced qualitative decision logic only: no numerical weights, thresholds, causal estimates, or claims of prospective performance were generated.

Results and Discussion

The conceptual analysis produced five non-substitutable dimensions for pharmacist response triage. Their separation was supported by evidence showing that medication-related risk and pharmacy workload are dynamic rather than static. In critical care, medication-regimen complexity changed over the course of admission and was associated with clinical-pharmacist intervention demand, supporting the use of time-varying rather than fixed inputs [9]. This does not establish that regimen-complexity scores should determine response intensity outside that setting.

Operational prioritisation also has consequences for scarce pharmacist time. A risk-scoring pilot altered the ordering of pharmacy-conducted medication histories [10]. That finding supports the premise that triage

reallocates work, but an operational change in sequencing is not equivalent to improved patient outcomes. Likewise, patient characteristics have been associated with the need for pharmaceutical intervention in hospital practice [11]. Such associations can inform stratification without defining universal action thresholds. A further boundary concerns unresolved problems. Unresolved DRPs following pharmacist-led medication review were associated with subsequent hospital readmission in an observational cohort [12]. The association is clinically relevant because unresolved medication-related risk may persist, but it cannot establish that resolving each DRP would have prevented readmission; illness severity, complexity, and other factors may contribute. Taken together, these findings support a framework in which response selection depends on more than the presence of a DRP. The proposed synthesis separates how soon harm may occur, how difficult the case is to reason through, how much critical information is missing, whether the problem can be changed, and whether acting is likely to justify the opportunity cost. These dimensions are elaborated below and remain qualitative until empirically operationalised.

Urgency and time-to-harm

Urgency is defined here as the time available before clinically important harm may emerge or become harder to reverse. It is therefore related to, but not identical with, severity. Prospective validation work in emergency care shows that near-term adverse-drug-event risk can be stratified using clinical criteria [13]. A high-risk classification is not a confirmed adverse drug event, yet it demonstrates why time horizon deserves explicit attention when deciding how rapidly a pharmacist must act.

The relevant horizon can extend beyond the present encounter. In older adults discharged from hospital, medication-related harm has been sufficiently time-dependent to support development and validation of a post-discharge prediction tool [14]. This suggests that a problem can be urgent because its plausible harm window is short even when the patient is currently stable. Conversely, severe potential harm does not always require immediate action if the exposure is remote, controlled, or safely monitorable.

Urgency must also be separated from certainty. External validation of an assessment tool for drug-related emergency-department visits showed that structured identification can retain classification uncertainty [15]. A pharmacist may therefore face a time-critical situation in which the precise medication-related cause is incompletely established. In such cases, uncertainty may shape what information is gathered or what reversible action is chosen, but it should not automatically downgrade time pressure.

Clinical workflow adds another layer. Emergency clinicians have described variable processes for identifying and prioritising potential medication-related harm [16]. This supports explicit escalation and communication rules while remaining insufficient to show that a structured triage method will improve outcomes.

Table 1 converts the time-horizon argument into a proposed register for deciding what cannot safely wait and what information can be gathered first.

Table 1. Time-to-harm triage register for deciding what cannot safely wait

Drug-related problem state	Time-to-harm	Severity if delayed	Reversible window	Immediate action needed	Information that can wait
Active or strongly suspected medication-related deterioration	Minutes to hours	Potentially serious progression	Narrow or uncertain	Address medication-related risk and escalate now	Nonessential history detail
Credible near-term high-risk exposure or care-transition problem	Hours to days	Harm may emerge before routine review	Time-limited	Same-day structured review; verify critical exposure or monitoring data	Lower-priority optimisation detail
Stable DRP with material uncertainty and no current time-critical signal	Usually days	Delay may prolong suboptimal therapy	Wider	Gather decision-critical information before irreversible change	Data not relevant to the immediate choice
Low-current-risk issue with a reliable monitoring pathway	Condition-dependent, often days to weeks	Limited near-term consequence expected	Usually wider	Document, monitor, and schedule reassessment	Detail that does not change the monitoring trigger

Note: The states and routing descriptors are proposed qualitative synthesis, not validated categories or time cut-offs. Individual patient vulnerability, drug properties, reversibility, and local escalation capacity can alter the appropriate response.

Complexity and the number of interacting clinical variables

Complexity is defined as the burden of interacting variables that must be integrated to reach a defensible medication decision. It is not synonymous with the number of medicines or the number of DRPs. Cross-sectional clinical-practice evidence shows that DRPs occur across heterogeneous patient and treatment circumstances and are associated with different pharmaceutical interventions [17]. The inference made here is that triage should recognise interaction burden, not that any particular combination of factors has a proven causal hierarchy.

Complexity can arise outside the medication list. Pharmacist-led medication review in home healthcare identifies DRPs and polypharmacy within a context of multimorbidity, functional limitations, and care-setting constraints [18]. Such evidence supports a multilevel view in which patient capability, caregiver support, monitoring access, and service configuration may alter the difficulty of resolving an otherwise familiar pharmacotherapy problem. Home-care findings, however, should not be assumed to describe all ambulatory populations.

Regimen design adds a distinct form of complexity. Medication-regimen complexity includes dosage forms, dosing frequency, and administration instructions beyond medication count and has been associated with adherence among patients with multimorbidity [19]. The cross-sectional design does not establish that complexity causes non-adherence, but it illustrates why two regimens containing the same number of medicines may impose different reasoning and execution burdens.

Medication count can still be a useful screening signal, but it is an unstable stand-alone proxy. A systematic review demonstrated substantial variation in definitions of polypharmacy [20]. The proposed framework therefore treats complexity as a case-specific interaction property that can rise or fall as disease state, regimen, information, patient capability, and care environment change.

Uncertainty and the need for information before action

Uncertainty concerns whether the available information is sufficient, reliable, and interpretable enough to support a defensible action. It is not simply the absence of knowledge, nor should it be treated as low urgency. Empirical work on pharmacists' clinical decision-making shows that multiple cognitive processes are used to interpret and integrate clinical information [21]. This supports treating uncertainty as an information-processing problem that can vary even when the underlying medication risk is similar.

Clinical decision-making under uncertainty is a core requirement of contemporary pharmacy practice [22]. For triage, the practical question is therefore not whether uncertainty can be eliminated, but whether additional information is likely to change the immediate decision. Missing renal function, unclear medication exposure, uncertain treatment intent, conflicting histories, or incomplete monitoring may justify information gathering before a non-reversible change. By contrast, a plausible time-critical hazard may require a reversible protective action while information collection continues.

A critical review of pharmacists' management of uncertainty during polypharmacy review identified patient-, pharmacist-, and environment-related sources of uncertainty and described information, multidisciplinary input, and training as potential means of mitigation [23]. These findings support a multilevel interpretation: uncertainty can reflect the patient's history, the clinician's knowledge state, the reliability of documentation, or the surrounding care environment. Some uncertainty may nevertheless remain irreducible.

The proposed triage logic therefore treats information gathering as an active response when delay is clinically tolerable and the missing information is decision-relevant. It does not prescribe fixed uncertainty scores. The key boundary is temporal: uncertainty can justify postponing a definitive intervention only when the expected cost of waiting remains acceptably low and a reassessment pathway is credible.

Preventability and modifiability of the drug-related problem

Preventability asks whether the medication-related problem, or the harm to which it may lead, can plausibly be altered through available action. It is not a synonym for severity. A systematic review and meta-analysis found preventable medication harm across healthcare settings, while also showing substantial heterogeneity in preventability estimates and assessment approaches [24]. The relevant triage question is consequently not whether a severe event is "preventable" in the abstract, but whether the identified mechanism is sufficiently modifiable in this patient, at this time, through an available pharmacist or team response.

Acute presentation does not remove that distinction. Preventable drug-related emergency-department visits can be distinguished from drug-related visits more broadly [25]. A medication-related presentation may therefore be

urgent and severe while its underlying mechanism remains only partly modifiable; conversely, a non-urgent prescribing problem may be highly modifiable. Preventability also depends on what resources, monitoring, therapeutic alternatives, adherence support, and professional authority are actually available. Classification should therefore remain contextual rather than becoming a binary moral judgement about whether harm “should” have been avoided.

Modifiability must also be separated from benefit. Medication review and deprescribing can improve prescribing appropriateness without consistently establishing benefit across downstream clinical outcomes [26]. An intervention can therefore successfully change prescribing yet yield uncertain net patient value. In the proposed triage method, preventability asks whether meaningful change is feasible; expected intervention value asks whether making that change is sufficiently likely to matter. This separation avoids equating technical ability to modify therapy with proof that modification will improve safety, function, quality of life, utilisation, or survival.

Expected intervention value and opportunity cost

Expected intervention value concerns the anticipated clinical or service benefit of acting relative to the pharmacist time, coordination, monitoring, patient burden, and competing work displaced by that response. It is not restricted to monetary value, and the framework does not propose a universal cost threshold. Person-centred medicines reviews delivered by general-practice pharmacists have demonstrated favourable economic value within a defined primary-care service model [27]. Such evidence supports considering resource consequences, but the resulting value depends on the population, service design, perspective, and assumptions used.

Direct inpatient economic modelling illustrates the same boundary. The financial impact of clinical-pharmacist medication review has been estimated using identified DRPs, probabilities of potential adverse drug events, local hospital costs, staffing costs, and sensitivity analyses [28]. This supports the feasibility of evaluating value at DRP and service levels. It does not establish that modelled avoided costs are realised clinical benefits, nor that a favourable return in one hospital can be transferred to another health system.

Across non-hospitalised pharmacist services, reported return on investment is often favourable, but methods, perspectives, and reporting are heterogeneous [29]. Expected value should therefore be treated as conditional. A pharmacist may rationally devote greater effort to a modifiable problem when substantial benefit is plausible and the response does not displace more urgent work; the same problem may warrant a lighter response where benefit is marginal, implementation burden is high, or another clinician is better positioned to act. Opportunity cost is thus part of triage rather than an after-the-fact economic calculation.

The proposed risk-based pharmacist triage framework

The proposed framework treats urgency as the time-pressure dimension and uses complexity, uncertainty, preventability, and expected intervention value to shape the response route within that time constraint. Near-term medication-harm risk can be structured without converting the result into a response rule [13]. DRPs arise within heterogeneous interacting clinical variables [17]. Pharmacist decisions require interpretation and integration of information [21]. Preventability varies across medication-harm contexts [24]. Pharmacist interventions can also have context-dependent economic value [27]. These premises support keeping the five dimensions visible, but no available source validates their combination as a single instrument.

The framework deliberately permits discordant profiles. Diagnostic classification can remain uncertain even after structured assessment [15]. Medication count is not a stable stand-alone representation of complexity [20]. Uncertainty may arise from patient, pharmacist, and environmental sources [23]. Prescribing can be modifiable without guaranteed downstream clinical benefit [26]. Economic value varies across service models and methods [29]. A single summed “risk” label could conceal these differences. The proposed method instead asks which response is proportionate given the pattern across dimensions.

Response routes are therefore qualitative rather than score-based: immediate safety action, structured pharmacist review, targeted information gathering, collaborative referral or escalation, and watchful monitoring with a defined reassessment trigger. Their matching logic is proposed. Complex-intervention guidance supports iterative development rather than premature closure [5]. Content-validation methods used for pharmacy prioritisation tools show how criteria might subsequently be tested [6]. Implementation determinants remain context-sensitive [8]. The framework does not confer autonomous prescribing authority and must operate within professional scope and local governance.

Table 2 makes the proposed response-matching logic explicit without assigning numerical weights or universal thresholds.

Table 2. Routing heterogeneous drug-related problems to proportionate pharmacist responses

Urgency	Complexity	Uncertainty	Preventability	Intervention value	Proposed response tier	Escalation or reassessment rule
High/time-critical	Any	Any; may remain high	Actionable or partly actionable	Potentially material	Immediate safety action	Escalate now; collect information in parallel
Moderate/high	High or interacting	Manageable	Moderate/high	Material	Structured pharmacist review	Escalate if instability, unresolved high-stakes uncertainty, or scope boundary emerges
Low/moderate	Any	High and decision-relevant	Uncertain until clarified	Uncertain	Targeted information gathering	Reassess when critical information arrives; escalate if time-to-harm shortens
Any	High or specialist-dependent	Any	Potentially modifiable outside pharmacist authority	Potentially material	Collaborative referral/escalation	Maintain feasible safety measures; confirm handover and follow-up
Low/currently stable	Low/moderate	Acceptable	Low or uncertain	Low/marginal at present	Watchful monitoring	Specify trigger, responsible clinician, and review interval

Note: These case patterns and response tiers are proposed qualitative synthesis. They are not validated categories, cut-offs, or prescribing directives; patient preference, drug characteristics, care setting, and professional scope may alter routing.

Figure 1 visualises why heterogeneous DRP profiles should not be forced into an identical pharmacist response.

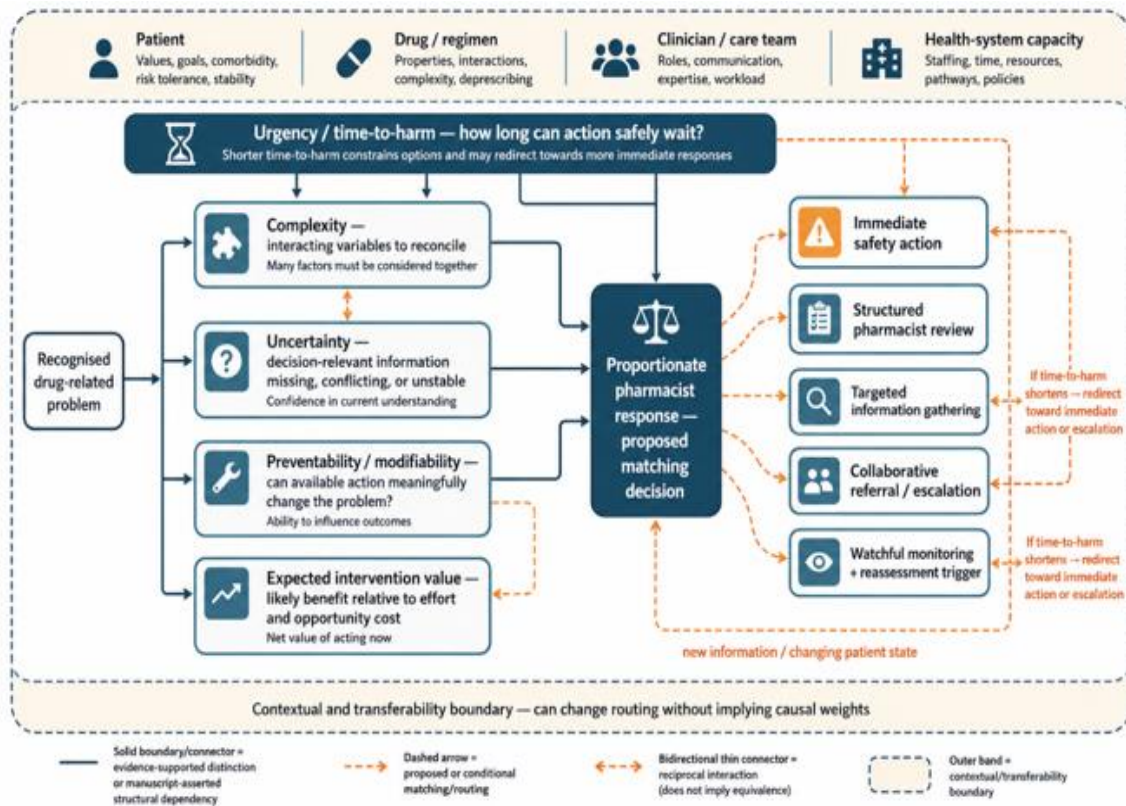


Figure 1. Time pressure constrains choice while four additional dimensions redirect the pharmacist response

The principal contribution is to move one step downstream from conventional patient prioritisation. Existing prioritisation evidence supports deciding which patients warrant pharmacist attention [1]. Prognostic and consensus tools likewise organise patient selection but do not establish a validated DRP-level response rule [4]. Patient factors can be associated with pharmaceutical-intervention need without yielding universal action thresholds [11]. The proposed framework therefore complements rather than replaces prioritisation: after a concern is recognised, it asks how rapidly and intensively the pharmacist should respond, what information must first be obtained, and when another professional or monitoring pathway may be more proportionate.

The potential advantage is conceptual consistency, not demonstrated clinical benefit. Complex-intervention methodology indicates that a coherent programme theory and explicit context are prerequisites to meaningful evaluation [5]. Prediction-model performance does not validate the action subsequently triggered [7]. Observational association between unresolved DRPs and readmission similarly cannot establish that resolving each problem would prevent the outcome [12]. A formal triage structure might improve reproducibility or resource allocation, but it could also add documentation burden, generate false reassurance, oversimplify preference-sensitive decisions, or redirect effort away from clinically important work. Those competing possibilities must be tested.

Hard cases are central rather than exceptional. Structured assessment may leave residual diagnostic uncertainty [15], and clinical uncertainty itself can have patient-, clinician-, and environment-related origins [23]. A highly modifiable prescribing problem may still have uncertain patient-level benefit [26], while an intervention with favourable economic value in one service model may not retain that value elsewhere [29]. Urgency can also change while information is being collected. For this reason, the proposed architecture preserves domain disagreement instead of resolving it automatically through addition.

Temporal instability is another reason not to operationalise the dimensions as static labels. A DRP that initially permits information gathering can become urgent after new symptoms, laboratory results, exposure changes, treatment failure, or loss of follow-up capacity. Conversely, rapid clarification may reduce uncertainty and permit a less intensive response. Reassessment is therefore part of the proposed decision architecture rather than a separate administrative step. This temporal feature should itself be tested, because repeated reassessment could improve responsiveness but could also increase workload without changing clinically meaningful decisions.

The framework should consequently be understood as a decision aid for disciplined clinical reasoning. It does not replace patient preferences, pharmacological judgement, therapeutic goals, multidisciplinary negotiation, or local scope-of-practice rules. Its strongest test will not be whether pharmacists can populate five boxes, but whether explicit multidimensional triage produces more consistent, proportionate, and useful decisions than existing practice without unacceptable workload, delay, or inequity.

Operational boundaries and validation needs

Operationalisation should proceed in stages. Structured development and content validation are feasible for clinical-pharmacy prioritisation criteria [6], but content validity would be only an early step. Prediction-model research illustrates the separate problem of prospective performance [7], while implementation evidence shows that organisational and external context can change how an intervention functions [8]. The proposed framework therefore requires evaluation of comprehensibility and content, reliability, prospective decision behaviour, consequences of triggered actions, implementation burden, and external transportability; none of these properties has been established here.

Reliability should test whether pharmacists given the same clinically sufficient case information reach similar domain judgements and response routes. Existing evidence indicates that pharmacist prioritisation is multifactorial [3] and that clinical decisions depend on cognitive information integration [21]. Some disagreement may be error, but some may reflect legitimate differences in patient preference, therapeutic goals, or unresolved evidence. Validation should therefore examine disagreement rather than assuming perfect concordance is desirable.

Prospective evaluation must also separate the performance of triage from the effectiveness of actions triggered by triage. A predictive model can identify risk without validating its downstream intervention [7]. Unresolved DRPs may be associated with outcomes without proving causal benefit from resolution [12]. Medication review may alter prescribing appropriateness without consistently improving every clinical outcome [26]. Pragmatic evaluation should therefore measure decision processes, timeliness, workload and patient-relevant outcomes while accounting for co-interventions and case mix.

External validation must address patient heterogeneity and service capacity. Implementation determinants vary across organisational contexts [8]; home-healthcare evidence illustrates how functional and care-setting factors can reshape medication complexity [18]; uncertainty can arise from environmental as well as patient or pharmacist factors [23]; and economic value varies across pharmacist-service methods and settings [29]. Access to information, specialist support, monitoring, medicines, and follow-up may therefore change what constitutes a feasible response.

Figure 2 marks the boundary between the proposed routing architecture and the evidence required before it could be treated as a validated scoring instrument.

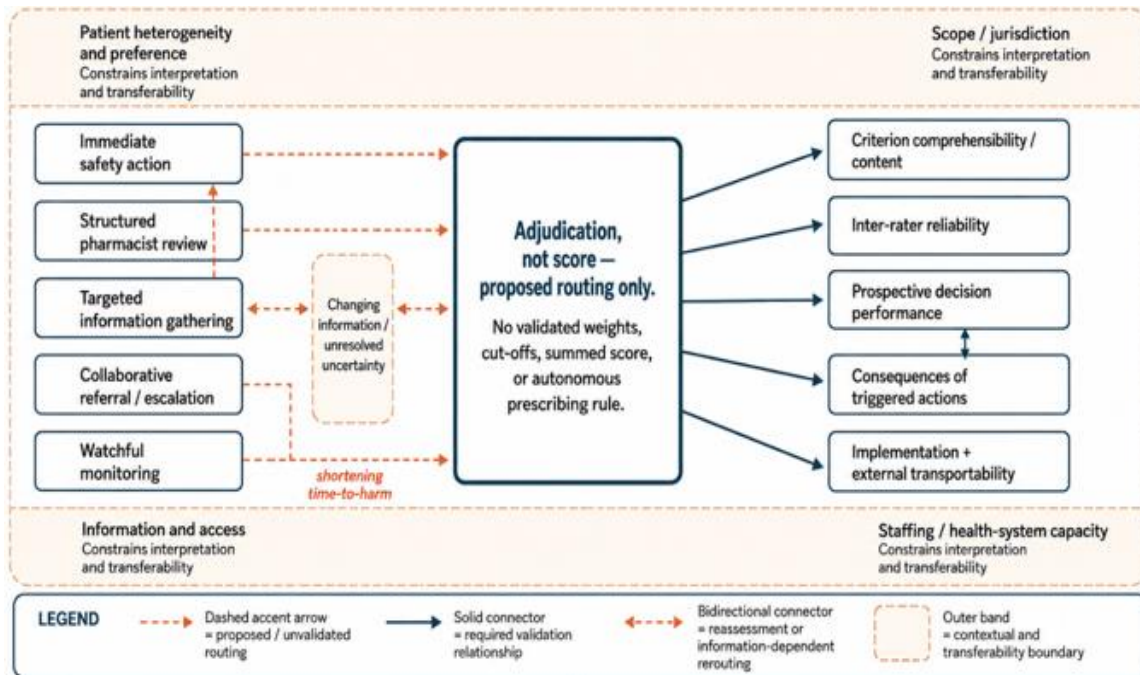


Figure 2. Response routes remain provisional until reliability, consequence, and transportability are demonstrated

Conclusion

Drug-related problems should not be assumed to warrant identical pharmacist responses merely because each can be labelled a DRP. This paper proposes a risk-based triage method that separates five questions: how quickly clinically important harm may occur, how many interacting variables must be reconciled, how much decision-relevant uncertainty remains, how modifiable the problem is, and whether intervention is likely to justify its clinical and resource opportunity cost. Their integration is intended to support proportionate response selection rather than produce a universal risk score.

The framework remains a methodological proposition. Its domains can conflict, change over time, and operate at patient, regimen, clinician, team, organisational, and health-system levels. A time-critical problem may require protective action despite uncertainty; a readily modifiable problem may have limited expected benefit; and a reasonable response in one service may be infeasible where information, authority, staffing, medicines, monitoring, or follow-up differ.

Before clinical use as a formal instrument, the method requires operational definition, reliability testing, prospective evaluation, assessment of triggered actions, and external validation across heterogeneous settings. Patient preferences and professional judgement remain indispensable. The intended contribution is therefore not a claim that pharmacist triage has been solved, but a testable structure for asking a more precise question: what response is proportionate to this drug-related problem, for this patient, at this time, in this care system?

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References

1. Van Nederkassel E, Van Eyken E, Hubrechts I, Tomlin S, Garfield S. Pharmacist prioritization tools for paediatric patients: Development, implementation, validation, and impact—a systematic review. *Int J Pharm Pract.* 2026. doi:10.1093/ijpp/riag086
2. Alshakrah MA, Steinke DT, Lewis PJ. Patient prioritization for pharmaceutical care in hospital: A systematic review of assessment tools. *Res Social Adm Pharm.* 2019;15(6):767-79. doi:10.1016/j.sapharm.2018.09.009
3. Falconer N, Barras M, Cottrell N. How hospital pharmacists prioritise patients at high-risk for medication harm. *Res Social Adm Pharm.* 2019;15(10):1266-73. doi:10.1016/j.sapharm.2018.11.003
4. Botelho SF, Neiva Pantuzza LL, Marinho CP, Moreira Reis AM. Prognostic prediction models and clinical tools based on consensus to support patient prioritization for clinical pharmacy services in hospitals: A scoping review. *Res Social Adm Pharm.* 2021;17(4):653-63. doi:10.1016/j.sapharm.2020.08.002
5. Skivington K, Matthews L, Simpson SA, Craig P, Baird J, Blazeby JM, et al. A new framework for developing and evaluating complex interventions: Update of Medical Research Council guidance. *BMJ.* 2021;374. doi:10.1136/bmj.n2061
6. Botelho SF, Neiva Pantuzza LL, Moreira Reis AM. Development, content validation and standardization of an adult patient prioritization tool for hospital clinical pharmacy services. *Res Social Adm Pharm.* 2024;20(9):893-904. doi:10.1016/j.sapharm.2024.05.005
7. Abdo A, Gallay L, Vallecillo T, Clarenne J, Quillet P, Vuiblet V, et al. A machine learning-based clinical predictive tool to identify patients at high risk of medication errors. *Sci Rep.* 2024;14(1):32022. doi:10.1038/s41598-024-83631-w
8. Damschroder LJ, Reardon CM, Widerquist MAO, Lowery J. The updated Consolidated Framework for Implementation Research based on user feedback. *Implement Sci.* 2022;17(1):75. doi:10.1186/s13012-022-01245-0
9. Balaban U, Yalcin N, Kaya EK, Ortac Ersoy E, Demirkan K. Optimizing critical care pharmacotherapy: Dynamic prospective evaluation of the medication regimen complexity–intensive care unit (MRC-ICU) score in critically ill patients. *Sci Rep.* 2026;16(1):4264. doi:10.1038/s41598-025-34552-9
10. Mouser A, Attia E, Adeola M, Zafar N, Fuentes A. Impact of a patient risk-scoring tool pilot on prioritization of pharmacy-conducted medication histories. *J Am Pharm Assoc (2003).* 2024;64(4):102100. doi:10.1016/j.japh.2024.102100
11. Plourde M, Gilbert C, Noël M, Ruelland S, Carmichael PH, Laurin D. Patient prioritization for pharmaceutical intervention in the hospital setting: A retrospective cross-sectional study. *Int J Pharm Pract.* 2025;33(4):431-8. doi:10.1093/ijpp/riaf033
12. Zorjan K, Tašker B, Marovič A, Petre M. Association between unresolved drug-related problems and 6-month hospital readmissions following pharmacist-led medication reviews: A retrospective observational study. *Int J Clin Pharm.* 2026;48(4):1585-93. doi:10.1007/s11096-026-02139-7
13. Hohl CM, Badke K, Zhao A, Wickham ME, Woo SA, Sivilotti MLA, et al. Prospective validation of clinical criteria to identify emergency department patients at high risk for adverse drug events. *Acad Emerg Med.* 2018;25(9):1015-26. doi:10.1111/acem.13407
14. Parekh N, Ali K, Davies JG, Stevenson JM, Banya W, Nyangoma S, et al. Medication-related harm in older adults following hospital discharge: Development and validation of a prediction tool. *BMJ Qual Saf.* 2020;29(2):142-53. doi:10.1136/bmjqs-2019-009587
15. Nymoen LD, Pettersen JLS, Flatebø TE, Øie E, Viktil KK. Drug-related emergency department visits: External validation of an assessment tool in a general emergency department population. *Int J Clin Pharm.* 2024;46(6):1327-34. doi:10.1007/s11096-024-01760-8

16. Bullock B, Allen R, Grant G, Hattingh HL. Managing emergency department patients with potential medication-related harm: A qualitative study. *Int J Clin Pharm*. 2026;48(1):236-45. doi:10.1007/s11096-025-02040-9
17. Garin N, Sole N, Lucas B, Matas L, Moras D, Rodrigo-Troyano A, et al. Drug-related problems in clinical practice: A cross-sectional study on their prevalence, risk factors and associated pharmaceutical interventions. *Sci Rep*. 2021;11(1):883. doi:10.1038/s41598-020-80560-2
18. Salom-Garrigues C, Aragonès E, Giralt M, Campabadal Prats C, Bejarano-Romero F, Martín-Luján F, et al. Prevalence and associated factors for drug-related problems and polypharmacy identified by a pharmacist-led medication review in patients enrolled in a home healthcare program. *BMC Geriatr*. 2026;26(1):316. doi:10.1186/s12877-026-07045-1
19. Kassaw AT, Sendekie AK, Minyihun A, Gebresillassie BM. Medication regimen complexity and its impact on medication adherence in patients with multimorbidity at a comprehensive specialized hospital in Ethiopia. *Front Med (Lausanne)*. 2024;11:1369569. doi:10.3389/fmed.2024.1369569
20. Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. *BMC Geriatr*. 2017;17(1):230. doi:10.1186/s12877-017-0621-2
21. Mertens JF, Kempen TGH, Koster ES, Deneer VHM, Bouvy ML, van Gelder T. Cognitive processes in pharmacists' clinical decision-making. *Res Social Adm Pharm*. 2024;20(2):105-14. doi:10.1016/j.sapharm.2023.10.007
22. Wright DFB, Anakin MG, Duffull SB. Clinical decision-making: An essential skill for 21st century pharmacy practice. *Res Social Adm Pharm*. 2019;15(5):600-6. doi:10.1016/j.sapharm.2018.08.001
23. Kallis TJ, Mattick K, Scott J, Payne RA. How do pharmacists navigate clinical uncertainty when reviewing polypharmacy? A critical literature review. *BMC Prim Care*. 2025;26(1):412. doi:10.1186/s12875-025-03122-3
24. Hodkinson A, Tyler N, Ashcroft DM, Keers RN, Khan K, Phipps D, et al. Preventable medication harm across health care settings: A systematic review and meta-analysis. *BMC Med*. 2020;18(1):313. doi:10.1186/s12916-020-01774-9
25. Phoemlap P, Vadcharavivad S, Musikatavorn K, Areepium N. Prevalence and factors associated with preventable drug-related emergency department visits (DREDp) in elderly patients. *BMC Emerg Med*. 2024;24(1):197. doi:10.1186/s12873-024-01102-x
26. Carollo M, Cristini I, Crisafulli S, Fontana A, Forti A, Lanaro A, et al. Evaluating the impact of medication review and deprescribing on prescribing appropriateness and clinical outcomes in older people residing in long-term care facilities: A systematic review and meta-analysis. *Age Ageing*. 2026;55(4). doi:10.1093/ageing/afag084
27. O'Mahony C, Dalton K, O'Hagan L, Murphy KD, Kinahan C, Coyle E, et al. Economic cost-benefit analysis of person-centred medicines reviews by general practice pharmacists. *Int J Clin Pharm*. 2024;46(4):957-65. doi:10.1007/s11096-024-01732-y
28. Jermini M, Fonzo-Christe C, Blondon K, Milaire C, Stirnemann J, Bonnabry P, et al. Financial impact of medication reviews by clinical pharmacists to reduce in-hospital adverse drug events: A return-on-investment analysis. *Int J Clin Pharm*. 2024;46(2):496-505. doi:10.1007/s11096-023-01683-w
29. Almodovar AS, Blankenship B, Miller J, Trombetta M, Murphy EM. Return on investment of pharmacists' services among non-hospitalized patients: A scoping review. *Res Social Adm Pharm*. 2025;21(5):321-31. doi:10.1016/j.sapharm.2025.01.012