

Beyond Static High-Risk Medicine Lists: A Dynamic Patient-Level Model Integrating Drug Hazard, Susceptibility, Monitoring Capacity, and Rescueability for Medication-Harm Prevention

Mikko Lahtinen^{1*}, Elina Salo¹, Juhani Virtanen²

¹ Department of Medication-Harm Prevention and Patient Safety, Faculty of Pharmacy, University of Helsinki, Helsinki, Finland.

² Department of Dynamic Risk Modeling and Monitoring Capacity, Faculty of Pharmacy, University of Eastern Finland, Kuopio, Finland.

*E-mail ✉ mikko.lahtinen@helsinki.fi

Received: 04 February 2026; Revised: 27 April 2026; Accepted: 02 May 2026

ABSTRACT

Medication-safety programs commonly identify medicines, classes, interactions, or prescribing situations associated with elevated harm. These approaches are clinically useful, but a medicine categorized as high risk does not confer a constant probability of harm across patients, settings, or time. This Current Opinion argues that medication-harm prevention requires a more explicitly patient-level and dynamic interpretation of risk. Intrinsic and regimen-dependent drug hazard should be considered alongside three additional domains: patient susceptibility, monitoring capacity, and rescueability if deterioration occurs. Susceptibility determines how strongly a given exposure may translate into injury; monitoring capacity determines whether an emerging problem is likely to become observable while action remains possible; and rescueability concerns whether recognition can be translated into timely, effective mitigation before consequences become severe or irreversible. These domains can change independently during acute illness, treatment modification, discharge, deterioration in organ function, loss of follow-up, or changes in care setting. The proposed synthesis therefore treats “high risk” as a state that may migrate rather than as a permanent property of a medicine. Existing explicit prescribing criteria, medication-safety tools, and risk-prediction approaches remain important, but they answer different questions and should not be interpreted as interchangeable patient-harm estimates. The proposed model is conceptual rather than validated: its constructs require operational definition, temporal measurement, external validation, and prospective evaluation before clinical implementation. Its principal value is to sharpen how medication-safety priority is reasoned about when the same drug can be relatively manageable in one patient-state yet substantially more hazardous in another.

Keywords: High-risk medicines, Medication harm, Drug hazard, Patient susceptibility, Monitoring capacity, Rescueability

How to Cite This Article: Lahtinen M, Salo E, Virtanen J. Beyond Static High-Risk Medicine Lists: A Dynamic Patient-Level Model Integrating Drug Hazard, Susceptibility, Monitoring Capacity, and Rescueability for Medication-Harm Prevention. *Ann Pharm Pract Pharmacother*. 2026;6(1):113-22. <https://doi.org/10.51847/88kKZ3TNi5>

Introduction

Medication-related harm remains a clinically important problem beyond inpatient prescribing and administration. Contemporary outpatient evidence shows that adverse drug events occur during routine ambulatory care and that at least some are judged preventable, reinforcing the relevance of medication-safety work after prescribing decisions have left the hospital or specialist encounter [1]. At the same time, preventable medication harm is not a uniform phenomenon. Evidence synthesized across healthcare settings demonstrates substantial heterogeneity in how harm is defined, detected, attributed, and distributed, cautioning against treating a single prevalence estimate or setting-specific pattern as a general patient-level probability [2].

That heterogeneity matters because medication risk is generated by combinations rather than medication identity alone. Recent latent-class analysis in an older population identified distinct combinations of patient and treatment characteristics associated with different patterns of medication-related harm [3]. Such findings do not establish universal patient phenotypes, but they support a central distinction: the same pharmacological exposure can operate within very different vulnerability contexts. A static label attached to a medicine may therefore preserve information about hazard while discarding information needed to estimate the patient's current likelihood of clinically important harm.

The care environment further changes what happens after a hazard is present. Professional, organizational, and structural medication-safety interventions in primary care have produced heterogeneous evidence, with uncertainty around the effects of many intervention types on medication-related hospitalization and mortality [4]. This suggests that risk prevention cannot be reduced to identifying the “right” medicine or producing another warning. Whether deterioration is detected, interpreted, and acted on depends partly on clinical and organizational conditions surrounding the patient.

This Current Opinion therefore separates four domains that are often compressed into the single expression “high-risk medicine”: drug hazard, patient susceptibility, monitoring capacity, and rescueability. Drug hazard describes the capacity of a treatment or regimen to generate injury under relevant exposure conditions. Susceptibility concerns characteristics that alter the patient's vulnerability to that hazard. Monitoring capacity concerns whether meaningful deterioration can be detected while intervention remains possible. Rescueability concerns whether recognition can be converted into effective action before consequences become severe, persistent, or irreversible. The argument developed here is that patient-level medication-harm priority arises from the configuration of these domains at a particular time and setting, rather than from drug-list membership alone.

Why static high-risk medicine lists misclassify patient-level risk

Explicit prescribing criteria remain valuable because they efficiently identify medications and prescribing situations deserving scrutiny. The 2023 AGS Beers Criteria, however, are considerably more contextual than the phrase “high-risk list” implies: recommendations incorporate disease states, drug–drug interactions, kidney function, exceptions, and circumstances in which use may remain reasonable [5]. The problem therefore is not that explicit criteria ignore context by design. Misclassification occurs when a context-sensitive prescribing signal is operationally reduced to a binary surrogate for the probability that a particular patient will experience preventable harm.

STOPP/START version 3 makes the same point from another direction. Its criteria encompass inappropriate treatment, omission, duplication, duration, indication, and clinical conditions rather than ranking medicines solely by intrinsic toxicity [6]. Meeting a criterion identifies a prescribing problem worthy of assessment; it does not by itself establish how likely harm is, how rapidly it might develop, whether it would be detectable, or whether it could be reversed.

Implementation guidance for STOPP/START further emphasizes that explicit criteria require patient information and clinical interpretation [7]. Consequently, “high-risk” status should be understood as a prompt for reasoning rather than the endpoint of reasoning. A flagged exposure may deserve urgent intervention in one patient yet careful continuation with surveillance in another.

This distinction is reinforced by the broader landscape of medication-appropriateness and deprescribing tools. An umbrella review found substantial diversity in the constructs, purposes, and content represented across available approaches [8]. Tools that identify potentially inappropriate prescribing, deprescribing opportunities, medication burden, or specific safety concerns therefore should not be assumed to estimate the same underlying quantity. For medication-harm prevention, the critical question is not simply whether a medicine appears on a list, but how its hazard interacts with the current patient's susceptibility and the care system's ability to detect and contain emerging injury.

Drug hazard as only one component of preventable harm

Drug hazard remains indispensable to medication-safety assessment. Certain pharmacological classes create recognizable patterns of potential injury, and sedative exposure in hospitalized older adults illustrates why drug-specific knowledge must remain visible [9]. Yet a hazard classification cannot specify patient-level risk without information about dose, indication, co-exposures, baseline function, and vulnerability. Hazard is therefore best treated as one component of risk rather than as its synonym.

Regimen-level exposure further complicates any medicine-by-medicine approach. Evidence concerning the Drug Burden Index indicates that cumulative anticholinergic and sedative exposure is associated with clinically important outcomes across older populations [10]. The relevance is conceptual as well as pharmacological: several individually familiar therapies can create a combined burden that differs from the apparent risk of any one drug considered in isolation.

Drug–drug interactions provide an additional form of context-dependent hazard. Population evidence links specific interactions with adverse-drug-reaction-related hospital admission in older people [11]. This does not mean that every interaction warning denotes clinically important injury. It does show that the hazard attached to one agent can change when the surrounding regimen changes, making a supposedly stable drug classification dependent on co-exposure.

The phenotype of harm also matters. Drug-induced cognitive impairment spans different mechanisms, presentations, onset patterns, and possibilities for reversibility [12]. Consequently, two drugs with meaningful toxicity may pose different prevention problems even when their nominal “risk” category is similar. A rapidly detectable, reversible toxicity with a clear intervention pathway is not operationally equivalent to an insidious syndrome that is difficult to distinguish from underlying disease.

These distinctions are condensed in **Table 1** to separate pharmacological hazard from the conditions that convert that hazard into patient-specific preventable harm.

Table 1. Separating Medication Hazard from Patient-Specific Harm Potential

Drug-hazard feature	Patient susceptibility modifier	Exposure or context dependency	Detectable precursor	Preventability	Rescueability relevance
Sedative/CNS-depressant effect	Baseline cognition, frailty, functional reserve, concurrent vulnerability	Dose, indication, concurrent sedatives and clinical setting alter expression	New somnolence, confusion, functional decline or instability may precede more serious consequences	Potentially modifiable when exposure and contributing medicines can be reassessed	Greater when deterioration is recognized early and exposure can be reduced without creating a competing treatment risk
Cumulative anticholinergic–sedative burden	Lower physiological and cognitive reserve may increase sensitivity to combined burden	Total regimen matters more than isolated medicine identity	Progressive cognitive, functional or tolerability change may signal increasing burden	Depends on whether contributors can be reduced, substituted or rationalized	Limited when deterioration is nonspecific, attributed to ageing/disease, or recognized only after major functional loss
Clinically important drug–drug interaction	Susceptibility depends on the interacting drugs, organ function and therapeutic margin	Hazard appears or increases when the interacting exposure is present	Laboratory, physiological or clinical changes may precede overt injury for some interactions	Potentially preventable through avoidance, adjustment or surveillance when the interaction is actionable	Depends on speed of toxicity, monitoring availability and the existence of a practicable intervention
Drug-related cognitive toxicity	Pre-existing cognitive impairment, neurological disease and limited reserve can complicate recognition	Mechanism, exposure, concomitant medicines and competing causes shape presentation	Cognitive or behavioral change may be observable before irreversible downstream consequences	Potentially modifiable for some causes when drug attribution is recognized	Lower when onset is insidious, attribution is uncertain, or recovery after withdrawal is incomplete

Note: The table distinguishes analytical components rather than assigning quantitative risk. Detectability, preventability, and rescueability are context-dependent and should not be interpreted as fixed properties of a medicine.

Patient susceptibility and context-dependent vulnerability

If hazard describes what a drug or regimen can do, susceptibility describes how readily a particular patient may be harmed by that exposure. Frailty and polypharmacy illustrate this distinction. In a multicentre cohort of older adults, these characteristics were related to medication-related harm and subsequent healthcare use [13]. They

should not be interpreted as deterministic causes, but they demonstrate why equivalent prescribing can have unequal consequences across patients with different physiological reserve and treatment complexity.

Susceptibility is also heterogeneous within populations often treated as a single “older adult” category. Multi-database evidence shows differences in polypharmacy and potential prescribing-cascade patterns according to age, sex, and gender [14]. These population patterns cannot establish individual causality, but they caution against assuming that demographic groups experience medication exposure and downstream prescribing processes identically. Patient-level vulnerability can reflect biological characteristics, disease burden, functional reserve, previous adverse effects, and the clinical circumstances in which treatment is delivered.

Advanced chronic kidney disease provides a particularly clear example because disease state can simultaneously modify drug handling, medication choice, dose suitability, and the monitoring needed to maintain treatment safely. Evidence on medication-review interventions in advanced chronic kidney disease shows that management is shaped by disease-specific pharmacological and clinical constraints [15]. Susceptibility therefore should not be modeled as a static “frail/not frail” attribute. It can change when renal function deteriorates, acute illness develops, nutritional state changes, interacting therapy is added, or physiological reserve falls.

The heterogeneity of adverse-drug-reaction and adverse-drug-event admissions among older adults reinforces the same principle [16]. No single susceptibility feature explains the variety of drug-related presentations encountered in practice. A patient can become more vulnerable even when the medicine and nominal dose remain unchanged. Conversely, susceptibility may decrease after recovery from an acute illness, removal of an interacting medicine, or stabilization of organ function. This time dependence is central to the later proposed model: patient-level risk can migrate because the relationship between a drug hazard and the patient's capacity to tolerate it is not fixed.

Monitoring capacity and the detectability of emerging harm

A hazardous exposure in a susceptible patient does not inevitably produce severe harm. One decisive intermediate question is whether clinically meaningful deterioration can be recognized while action is still useful. Monitoring capacity should therefore be separated conceptually from both drug hazard and susceptibility. A five-year primary-care cohort examining selected higher-risk medicines found that recommended laboratory monitoring was sometimes suboptimal among community-dwelling older adults [17]. The finding does not demonstrate that every monitoring gap caused injury; it establishes that designation of a medicine as higher risk does not guarantee that the surveillance needed to manage that risk actually occurs.

Monitoring also involves more than ordering tests. Digital patient-safety interventions in primary care can support identification of prescribing problems or emerging risk, but their effects are heterogeneous and depend on implementation [18]. A generated alert has limited safety value if it is poorly timed, clinically nonspecific, ignored, difficult to act on, or disconnected from the professional responsible for follow-up. Thus, technical detection should not be equated with clinical monitoring capacity.

The concept also operates above the individual clinician. Validation work on a medication-safety self-assessment instrument for long-term care demonstrates that organizational safety processes can be structured and assessed as distinct features of the care environment [19]. Such measurement does not prove that a particular organizational score prevents harm, but it supports treating surveillance capability as partly a system-level property rather than solely a characteristic of the prescribed drug.

Finally, medication safety requires clarity about what monitoring is intended to detect. Work developing methods to identify actual harm from medication errors illustrates the importance of distinguishing an error, its potential for harm, and harm that has actually occurred [20]. This methodological distinction is crucial for the present argument. A patient may have an identifiable prescribing problem without measurable injury; conversely, injury may be developing without a readily interpretable precursor. Monitoring capacity therefore depends on the existence of a signal, access to that signal, the interval before it becomes observable, and the ability to translate recognition into action.

Table 2 characterizes these distinct pathways according to whether deterioration is likely to become observable early enough to support intervention.

Table 2. When Medication Harm Becomes Observable Early Enough to Act

Monitoring pathway	Harm pathway being watched	Observable signal	Monitoring frequency or access requirement	Likely lag to detection	Actionability	Blind-spot condition
--------------------	----------------------------	-------------------	--	-------------------------	---------------	----------------------

Scheduled laboratory surveillance	Biochemical or organ-function deterioration associated with treatment or interaction	Change in a relevant laboratory parameter before overt clinical injury	Drug- and condition-specific testing must be obtainable, completed, reviewed and linked to responsibility for action	Potentially short when testing is timely; prolonged when tests or review are missed	High when a recognized abnormality has a clear adjustment, interruption or escalation pathway	No test, inaccessible testing, delayed result review, unclear ownership, or deterioration between scheduled measurements
Symptom and functional surveillance	Clinically expressed toxicity not captured adequately by routine laboratory testing	New symptoms, cognitive change, functional decline, falls, intolerance or behavioral change	Requires patient/caregiver recognition and access to a clinician able to reassess medication causality	Variable; often longer for nonspecific or slowly evolving manifestations	Depends on whether the symptom is recognized as medication related and treatment alternatives are feasible	Symptoms normalized as ageing/disease, communication barriers, fragmented follow-up, or absent caregiver observation
Digital or rule-based safety surveillance	Detectable prescribing, interaction, monitoring or risk-rule abnormalities	Electronic alert, decision-support trigger or flagged record pattern	Requires usable data, functioning decision support and integration into clinical workflow	Technically rapid, but clinical response may lag	Conditional on specificity, prioritization, clinician trust and authority to intervene	Alert fatigue, incomplete data, excessive false positives, or warning without an actionable pathway
Structured safety-process review	Failures arising from medication-management systems rather than a single drug property	Missing monitoring, reconciliation, review, follow-up or responsibility identified through safety assessment	Requires organizational processes capable of identifying and correcting system gaps	Usually slower than real-time surveillance	Useful for correcting recurring system vulnerabilities rather than immediate bedside rescue	Self-assessment without implementation, fragmented accountability, or safety processes disconnected from individual patient deterioration
Harm adjudication after a medication event	Error or exposure that may already have produced injury	Clinical evidence sufficient to distinguish potential harm from actual harm	Requires reliable event detection, clinical records and structured assessment	Often retrospective relative to the earliest preventable stage	Important for learning and attribution; less useful for rescuing an already missed early signal	Errors counted as harm without confirmation, actual harm missed because attribution is uncertain, or delayed recognition after consequences are established

Note: Monitoring frequency is deliberately qualitative because appropriate intervals depend on the medicine, patient, indication, exposure, and clinical context. The proposed profile distinguishes detectability from prevention: observing a signal does not itself ensure that an effective response will occur.

Rescueability and the consequences of delayed recognition

Detecting an emerging medication problem does not ensure that harm can still be prevented. Post-discharge prediction research demonstrates that medication-related harm can be stratified using combinations of clinical and medication variables, but prediction remains distinct from the ability to intervene successfully once deterioration begins [21]. This distinction is central to rescueability, defined here as the context-dependent capacity to convert recognition of emerging medication harm into sufficiently timely and effective action to limit its consequences. Transitions of care expose the difference particularly clearly. Medication errors and medication-related harm continue after discharge to community settings, with substantial variation in definitions, ascertainment, and follow-up periods [22]. Once responsibility becomes distributed among patients, caregivers, community pharmacists, general practitioners, specialists, and hospital teams, the practical ability to respond can differ markedly from the conditions under which the medicine was initiated.

Prospective evidence also documents medication errors and gaps in discharge planning among hospitalized older adults [23]. Such gaps do not prove that harm will occur, but they may weaken rescue pathways by obscuring which medicine changed, what should be monitored, who owns follow-up, or what response is required when deterioration appears. Rescueability therefore includes more than pharmacological reversibility.

Medication discharge planning consequently needs actionable information, monitoring arrangements, follow-up, and allocation of responsibility [24]. A toxicity that is biologically reversible may nevertheless be poorly rescueable if the patient cannot obtain assessment, if warning signs are nonspecific, if responsibility is fragmented, or if recognition comes after major injury. Conversely, a substantial drug hazard may remain manageable when surveillance is reliable and an effective intervention can be deployed rapidly. Rescueability is therefore proposed as a patient-and-system state, not a fixed characteristic of a medicine.

The proposed dynamic patient-level medication-harm model

Existing risk-prediction studies demonstrate that medication-related outcomes can be stratified using multiple patient, clinical, and treatment variables rather than medicine identity alone [25, 26]. These models do not establish the architecture proposed here, but they show that multidimensional patient-level reasoning is empirically feasible while also illustrating the importance of outcome definition, setting, and validation.

The proposed dynamic patient-level medication-harm model treats current harm priority as arising from four analytically distinct but interacting domains: drug hazard, patient susceptibility, monitoring capacity, and rescueability. No numerical weights, thresholds, additive formula, or universal hierarchy are proposed. Instead, each domain should be reassessed when the patient, regimen, monitoring environment, or care setting changes.

External validation of the ADAPTiP model also illustrates why apparent predictive usefulness within one setting cannot establish universal transportability [26]. Any future operationalization of the present four-domain model would require explicit outcome definitions, reproducible construct measurement, calibration, temporal updating, and validation across populations and health systems.

Clinical risk estimation should also remain separate from resource-allocation judgments. Economic evaluations of medication-safety interventions show substantial heterogeneity in methods, interventions, and evidence [27]. A patient may therefore warrant greater clinical attention without implying that a particular intervention or deployment strategy is cost-effective.

Figure 1 visualizes why the same medicine may move into or out of a high-priority state even when its intrinsic pharmacology is unchanged.

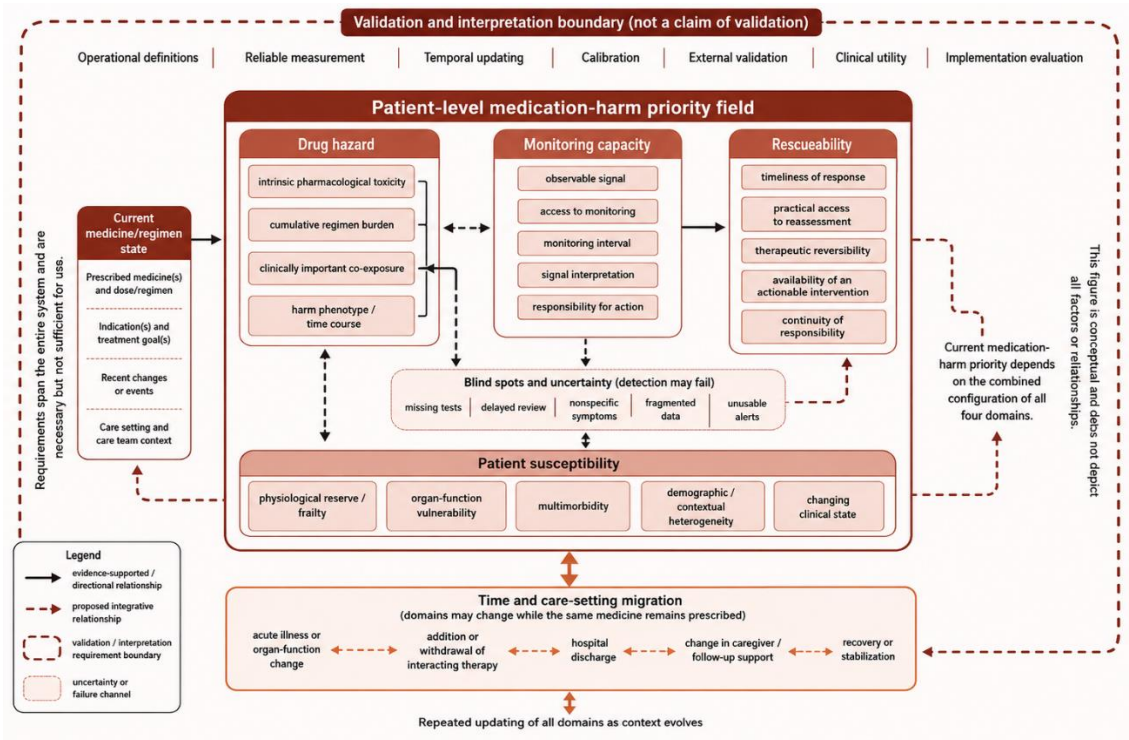


Figure 1. Why the Same Medicine Changes Harm Priority Across Patient States and Care Settings

Risk migration across time and care settings

Medication-harm risk should not be assumed to remain stable between prescribing encounters. Post-discharge adverse events can emerge over months, medication exposure itself can follow distinct longitudinal trajectories, and structured transitional care does not necessarily eliminate post-discharge adverse drug events [28-30]. These findings support the temporal premise of change without establishing a single common mechanism or outcome. The term risk migration is proposed here to describe movement between clinically different harm-priority states as one or more model domains change. Medication exposure can itself evolve longitudinally rather than remaining a fixed baseline characteristic [29]. Even when a medicine is unchanged, susceptibility may rise because organ function deteriorates; monitoring may weaken after transfer between services; or rescueability may decline when access, caregiver support, or responsibility for follow-up changes.

Importantly, additional care activity cannot automatically be equated with improved rescue. In one prospective before–after study, a transitional pharmaceutical-care program did not significantly reduce post-discharge adverse drug events [30]. This null finding cautions against defining rescueability simply by the presence of an intervention.

Table 3 shows how qualitative medication-harm priority can migrate when patient or care conditions change.

Table 3. Context Changes That Can Move Medication-Harm Priority Without a New Drug

Change in patient or care context	Drug hazard unchanged or changed?	Susceptibility shift	Monitoring shift	Rescueability shift	Proposed priority change
Acute illness or deterioration in organ function	Medicine may be unchanged; effective exposure or toxicity potential may increase	Higher	Monitoring requirements may intensify	May fall if deterioration is rapid or alternatives are limited	Increase
Addition of an interacting medicine	Regimen hazard changes even if original medicine is unchanged	May be unchanged or amplified	New surveillance may become necessary	Depends on recognition and ability to modify the regimen	Usually increase
Hospital discharge to fragmented follow-up	Pharmacological hazard may be unchanged	Often unchanged initially	Can fall because testing, review, or information continuity changes	Can fall when responsibility or access becomes unclear	Increase despite unchanged drug
Loss of caregiver or practical access to care	Hazard unchanged	Clinical vulnerability may be unchanged	Symptom detection and attendance may decline	Timely response becomes less feasible	Increase
Recovery, stabilization, or restoration of reliable follow-up	Hazard may remain unchanged	May decrease	Can improve	Can improve when action pathways are restored	May decrease

Note: Priority changes are proposed qualitative interpretations, not validated categories, scores, thresholds, or treatment rules. Actual direction depends on the medicine, patient, indication, setting, and available response options.

Implications for medication-safety prioritization

The practical implication is not to discard explicit high-risk medicine lists, but to change what happens after a medicine is flagged. Laboratory-monitoring gaps demonstrate that identifying a higher-risk medicine does not guarantee that the corresponding safety process is present [17]. Similarly, discharge-planning gaps show that an actionable response pathway cannot be assumed merely because risk has been recognized [23].

Medication-safety prioritization is therefore proposed as a two-step judgment. First, identify pharmacological or regimen-level hazard. Second, ask whether the current patient-state amplifies that hazard through susceptibility, poor monitorability, or weak rescue conditions. Multidimensional patient profiles and risk-prediction work support the premise that risk differs across combinations of patient and treatment characteristics [3]. Existing validated prediction studies further show that patient-level risk estimation requires explicit variables and transportability testing rather than intuitive weighting alone [26].

This approach could alter priority ordering. A conspicuously hazardous medicine in a stable, well-monitored patient with reliable follow-up may remain clinically important but manageable. A less conspicuous exposure may deserve more immediate attention when vulnerability has increased, deterioration is difficult to detect, or rescue is unlikely to occur promptly. That ordering principle is proposed, not validated.

Resource allocation should remain a subsequent question. Economic evaluation evidence cannot establish that the proposed prioritization approach is cost-effective [27]. Clinical utility, workload consequences, equity effects, alert burden, and opportunity costs would all require separate evaluation.

Boundary conditions and validation needs

The proposed model is not intended to replace explicit prescribing criteria, disease-specific guidance, pharmacological expertise, adverse-event diagnosis, or clinical judgment. Beers criteria, for example, answer an appropriateness and prescribing-safety question that remains valuable [5]. Measurement work distinguishing medication error, potential harm, and actual harm likewise shows that harm attribution requires its own evidential process [20].

The three more novel domains—susceptibility, monitoring capacity, and rescueability—also require operational definition. Organizational medication-safety capacity can be measured in structured ways, but validity in one environment does not establish a universal construct or patient-level threshold [19]. Future work would need to establish reproducibility, responsiveness to change, and whether domain measurements capture genuinely distinct information.

Prediction-model evidence indicates that external validation is essential even when initial discrimination is promising [26]. A future operational model should therefore test calibration and discrimination across settings, assess whether repeated updating improves prediction, examine missing-data behavior, and compare performance against simpler baselines such as drug lists, medication counts, explicit criteria, and existing risk models.

Finally, implementation benefit cannot be inferred from better classification alone. A transitional pharmaceutical-care intervention failed to demonstrate a significant reduction in post-discharge adverse drug events in one study [30], while broader evidence on medication-safety interventions remains heterogeneous and often uncertain [4]. Clinical impact would consequently require prospective and pragmatic evaluation after—not before—measurement and predictive validity are established.

Conclusion

Static high-risk medicine classifications remain useful for identifying exposures that deserve attention, but they should not be interpreted as complete patient-level estimates of preventable medication harm. The same medicine can occupy very different safety states depending on who receives it, under what physiological conditions, whether deterioration can be observed, and whether recognition can be converted into timely action.

This Current Opinion proposes a dynamic four-domain interpretation in which drug hazard is considered alongside susceptibility, monitoring capacity, and rescueability. The framework also introduces risk migration as a way to describe changes in medication-harm priority across illness trajectories, regimen changes, discharge, recovery, and shifting care arrangements.

Its contribution is conceptual rather than predictive. No weighting, scoring rule, threshold, causal mechanism, clinical-effectiveness claim, or implementation strategy is established here. The proposed constructs require reliable operationalization, temporal measurement, external validation, comparison with simpler approaches, and subsequent clinical-utility and implementation evaluation.

If validated, a dynamic approach could help medication-safety programs distinguish a medicine that is inherently hazardous from a patient who is currently difficult to protect from that hazard. Until then, the model should be used as an analytical proposition: a reminder that preventable harm depends not only on what is prescribed, but also on changing vulnerability, the capacity to see deterioration, and the capacity to respond before it is too late.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

References

1. Wasserman RL, Edrees HH, Amato MG, Seger DL, Frits ML, Hwang AY, et al. Frequency and preventability of adverse drug events in the outpatient setting. *BMJ Qual Saf.* 2025;34(8):499-506. doi:10.1136/bmjqs-2024-017098
2. 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
3. Brannigan R, Frydenlund J, Williams DJ, Moriarty F, Wallace E, Kirke C, et al. Identifying predictors of medication-related harm in older populations: A latent class analysis approach. *Age Ageing.* 2025;54(8):afaf227. doi:10.1093/ageing/afaf227
4. Khalil H, Bell BG, Keers RN, Lewis PJ, Foreman M, Taylor A, et al. Systematic review examining the effectiveness of professional, organisational and structural interventions in primary care to reduce medication-related hospitalisations and deaths. *Drug Saf.* 2026;49(4):389-403. doi:10.1007/s40264-025-01619-5
5. American Geriatrics Society Beers Criteria Update Expert Panel. American Geriatrics Society 2023 updated AGS Beers Criteria® for potentially inappropriate medication use in older adults. *J Am Geriatr Soc.* 2023;71(7):2052-81. doi:10.1111/jgs.18372
6. O'Mahony D, Cherubini A, Renom Guiteras A, Denking M, Beuscart JB, Onder G, et al. STOPP/START criteria for potentially inappropriate prescribing in older people: Version 3. *Eur Geriatr Med.* 2023;14(4):625-32. doi:10.1007/s41999-023-00777-y
7. Lunghi C, Domenicali M, Vertullo S, Raschi E, De Ponti F, Onder G, et al. Adopting STOPP/START criteria version 3 in clinical practice: A Q&A guide for healthcare professionals. *Drug Saf.* 2024;47(11):1061-74. doi:10.1007/s40264-024-01453-1
8. Anlay DZ, Paque K, Van Leeuwen E, Cohen J, Dilles T. Tools and guidelines to assess the appropriateness of medication and aid deprescribing: An umbrella review. *Br J Clin Pharmacol.* 2024;90(1):12-106. doi:10.1111/bcp.15906
9. Desormeau B, Huang A, Downar J, Wu PE, Bortolussi-Courval E, Ross SB, et al. Prescribing patterns and impact of sedatives in hospitalized older adults: A secondary analysis of the MedSafer study. *J Am Geriatr Soc.* 2025;73(6):1753-61. doi:10.1111/jgs.19437
10. Liu BM, Kouladjian O'Donnell L, Redston MR, Fujita K, Thillainadesan J, Gnjdjic D, et al. Association of the Drug Burden Index (DBI) exposure with outcomes: A systematic review. *J Am Geriatr Soc.* 2024;72(2):589-603. doi:10.1111/jgs.18691
11. Hughes JE, Moriarty F, Bennett KE, Cahir C. Drug-drug interactions and the risk of adverse drug reaction-related hospital admissions in the older population. *Br J Clin Pharmacol.* 2024;90(4):959-75. doi:10.1111/bcp.15970
12. Reimers A, Odin P, Ljung H. Drug-induced cognitive impairment. *Drug Saf.* 2025;48(4):339-61. doi:10.1007/s40264-024-01506-5
13. Stevenson JM, Parekh N, Chua KC, Davies JG, Schiff R, Rajkumar C, et al. A multi-centre cohort study on healthcare use due to medication-related harm: The role of frailty and polypharmacy. *Age Ageing.* 2022;51(3):afac054. doi:10.1093/ageing/afac054
14. Rochon PA, Li J, O'Mahony D, Onder G, Petrovic M, Sternberg SA, et al. The impact of age, sex, and gender on polypharmacy and potential prescribing cascades: Lessons from five databases. *J Am Geriatr Soc.* 2025;73(2):520-32. doi:10.1111/jgs.19282
15. Pogson CM, Austin R, Patel JP, Wheeler DC. Medication review interventions for adults living with advanced chronic kidney disease: A scoping review. *Br J Clin Pharmacol.* 2025;91(4):1132-56. doi:10.1111/bcp.16363
16. Cosgrave N, Frydenlund J, Beirne F, Lee S, Faez I, Cahir C, et al. Hospital admissions due to adverse drug reactions and adverse drug events in older adults: A systematic review. *Age Ageing.* 2025;54(8):afaf231. doi:10.1093/ageing/afaf231

- Lahtinen *et al.*, Beyond Static High-Risk Medicine Lists: A Dynamic Patient-Level Model Integrating Drug Hazard, Susceptibility, Monitoring Capacity, and Rescueability for Medication-Harm Prevention
17. McCarthy C, Moriarty F, Doherty AS, Feighery M, Boland F, Fahey T, et al. Prevalence and predictors of sub-optimal laboratory monitoring of selected higher risk medicines in Irish general practice: A 5-year retrospective cohort study of community-dwelling older adults. *BMJ Open*. 2025;15(1):e086446. doi:10.1136/bmjopen-2024-086446
 18. Tsang JY, Planner C, Low CN, Stewart S, Morris C, Wong B, et al. Digital patient safety interventions in primary care: A systematic review and meta-analysis. *BMC Med*. 2026;24(1):407. doi:10.1186/s12916-026-05048-8
 19. Poudel RS, Burer SJM, Williams KA, Pont LG. Validity of the Medication Safety Self-Assessment for Long-Term Care tool in Australian long-term care: A RAND appropriateness method study. *Br J Clin Pharmacol*. 2025;91(10):2892-901. doi:10.1002/bcp.70115
 20. Mumford V, Raban MZ, Li L, Fitzpatrick E, Woods A, Merchant A, et al. Developing a process to measure actual harm from medication errors in paediatric inpatients: From design to implementation. *Br J Clin Pharmacol*. 2024;90(7):1615-26. doi:10.1111/bcp.16052
 21. 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
 22. Alqenae FA, Steinke D, Keers RN. Prevalence and nature of medication errors and medication-related harm following discharge from hospital to community settings: A systematic review. *Drug Saf*. 2020;43(6):517-37. doi:10.1007/s40264-020-00918-3
 23. Anderson TS, Wilson LM, Wang BX, Steinman MA, Schonberg MA, Marcantonio ER, et al. Medication errors and gaps in medication discharge planning for hospitalized older adults: A prospective cohort study. *J Gen Intern Med*. 2026;41(3):697-706. doi:10.1007/s11606-025-09973-x
 24. Zhang FH, Lauzon J, Payette J, Courtemanche F, Papillon-Ferland L, Firoozi F, et al. Promoting medication safety for older adults upon hospital discharge: Guiding principles for a medication discharge plan. *Br J Clin Pharmacol*. 2024;90(11):2939-46. doi:10.1111/bcp.16216
 25. Glans M, Kempen TGH, Jakobsson U, Kragh Ekstam A, Bondesson Å, Midlöv P. Identifying older adults at increased risk of medication-related readmission to hospital within 30 days of discharge: Development and validation of a risk assessment tool. *BMJ Open*. 2023;13(8):e070559. doi:10.1136/bmjopen-2022-070559
 26. Frydenlund J, Cosgrave N, Moriarty F, Wallace E, Kirke C, Williams DJ, et al. Adverse drug reactions and events in an Ageing Population risk Prediction (ADAPTiP) tool: The development and validation of a model for predicting adverse drug reactions and events in older patients. *Eur Geriatr Med*. 2025;16:573-81. doi:10.1007/s41999-024-01152-1
 27. Amritlal ST, Chandler R, Mahboub-Ahari A, Paterson L, Avery AJ, Ashcroft DM, et al. Economic evaluations of medication safety interventions in primary and long-term care: A systematic review. *Pharmacoeconomics*. 2026;44(3):299-316. doi:10.1007/s40273-025-01567-z
 28. Hwang JI, Chang YS, Chin HJ. Characterising adverse events in postdischarge high-risk patients with 6-month follow-up in a Korean tertiary hospital: A retrospective cohort study. *BMJ Open*. 2025;15(12):e108519. doi:10.1136/bmjopen-2025-108519
 29. Elhussein L, Williams RD, Man WY, Burn E, Delmestri A, Strauss VY, et al. Longitudinal trajectories of polypharmacy in older people, and their association with the risk of mortality: A joint latent class model analysis of real-world data from the UK and the Netherlands. *Age Ageing*. 2025;54(8):afaf233. doi:10.1093/ageing/afaf233
 30. Uitvlugt EB, Heer SE-N, van den Bemt BJB, Bet PM, Sombogaard F, Hugtenburg JG, et al. The effect of a transitional pharmaceutical care program on the occurrence of ADEs after discharge from hospital in patients with polypharmacy. *Res Social Adm Pharm*. 2022;18(4):2651-8. doi:10.1016/j.sapharm.2021.05.009