

Dispensing Safety Depends on How Work Resumes After Interruption: Connecting Cognitive Recovery, Unfinished Tasks, and the Organization of Community Pharmacy Practice

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Abstract

Interruptions are common in community pharmacy, but interruption counts alone provide an incomplete account of dispensing safety. An interruption can occur while little task state needs to be remembered, during a sequence whose verification context must later be reconstructed, or because another activity has become more urgent. These events impose different recovery demands. This conceptual article develops a Sociotechnical Interruption-Resumption Safety Model linking interruption characteristics with cognitive recovery, unfinished-task state, workflow organization, technology, and the distribution of work. The central mechanism is the quality of task resumption: safety depends on what information survives the interruption, what must be reconstructed, what cues and checkpoints are available, and whether competing demands permit verification before work continues. Evidence from community pharmacy, medication administration, healthcare human factors, task-interruption research, and clinical technology shows that interruption consequences vary with timing, task complexity, fatigue, cue availability, workflow conditions, and the informational value of the interrupting event. The model therefore predicts heterogeneous consequences even at similar interruption frequencies. Community-pharmacy safety strategies should preserve resumable task state, support deliberate reconstruction when state has been lost, and organize work so that high-consequence tasks are resumed with appropriate contextual and verification support.

Keywords: Interruptions, Resumption lag, Task state, Community pharmacy, Sociotechnical systems, Medication safety

Introduction

Interruptions are a visible feature of community-pharmacy work. Direct observation has documented frequent interruptions arising from patients, colleagues, telephones, workflow demands, self-initiated task changes, and other sources [1]. Counting such events is useful for describing workload exposure, yet an

interruption does not contain its own safety consequence. The same interruption frequency can occur in pharmacies whose tasks, staffing arrangements, technologies, and recovery opportunities differ substantially.

Healthcare evidence also resists a simple interruption-to-error equation. Reviews of causal evidence, medication-administration observations, and naturalistic studies show heterogeneous relationships between interruptions, performance, and patient-safety outcomes [2-4]. Some interruptions impose switching costs or displace attention, whereas others communicate information that is urgent or necessary for coordinated care. A safety theory therefore needs to explain when an interruption creates consequential loss of work state and when its informational or coordination value outweighs the local cost of switching.

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This problem becomes clearer when interruption is treated as a multilevel event. Team-level modeling indicates that the consequences of interrupting depend simultaneously on the needs of the interrupter, the interrupted worker, task importance, urgency, and the costs of delay or error [5]. In community pharmacy, those interactions occur within dispensing queues, patient-facing encounters, prescription technologies, staffing arrangements, verification practices, and competing service demands. The relevant question is consequently not only how often work is interrupted. It is what must be recovered before the interrupted work can again be performed safely.

Interruptions as sociotechnical events in community pharmacy

Medication-safety work is produced by interactions among people, tasks, tools, organizational routines, and the conditions under which those elements are coordinated. Qualitative and systems-oriented healthcare research shows that clinical decision support, adaptive work, and interruption patterns emerge from these relationships rather than from isolated individual behavior [6-8]. This perspective is especially important in community pharmacy, where a pharmacist may simultaneously remain responsible for prescription verification, patient questions, clinical judgments, communication with prescribers, supervision, and the coordination of work performed by other staff.

An interruption should therefore be defined by more than its source. Its consequence depends on the state of the

task at the moment work is suspended. A telephone call arriving between completed prescriptions creates a different recovery problem from a question that arrives while a pharmacist is reconciling dose, indication, patient characteristics, prescriber intent, and product information. Operational research in community pharmacy likewise shows that staffing, service demand, and workflow configuration determine how work accumulates and moves through the pharmacy [9]. Those conditions influence both the probability of switching and the amount of unfinished work that must remain cognitively or externally represented.

Work distribution also determines who absorbs interruptive demand. Models that expand technician responsibility for selected dispensing functions alter the composition of pharmacists' work and the time available for patient-care activity [10]. Such findings do not establish that any particular delegation model prevents interruption-related errors. They do show that interruption exposure is partly produced by work design. A pharmacist's recovery burden can therefore change when responsibilities, queues, communication routes, or verification tasks are redistributed even if the total number of incoming requests remains similar.

The analytically important distinction is between an interruption event and the work state disrupted by that event. **Table 1** organizes interruption configurations around what must be preserved or reconstructed when work resumes.

Table 1. Interruption events distinguished by the state of work that must be recovered

Interruption/resumption event	Work state at interruption	Information likely to require preservation or reconstruction	Recovery demand	Plausible safety significance
External request during active verification	Verification sequence underway	Items already checked; unresolved discrepancy; intended next verification step	Re-establish verification position and rationale	Resumption may be vulnerable if sequence position or checking context is uncertain
Technology-generated alert during another medication task	Primary task active while system presents competing information	Primary-task state plus meaning and relevance of alert	Integrate or dismiss alert while retaining primary-task context	Useful warning may support safety; poorly timed or repetitive alerts may increase attentional competition
Self-initiated switch to manage competing work	Task deliberately suspended for another demand	Reason for suspension; unfinished elements; return point	Reconstruct self-created task queue and priority	Risk depends on whether unfinished state is externally marked or retained only in memory
Interruption at a natural task checkpoint	A coherent subtask has just ended	Completed stage and identity of next stage	Relatively bounded reorientation	Checkpoints may reduce the amount of state that has to be reconstructed

Urgent safety-relevant communication	Ongoing task interrupted by consequential new information	Original task state plus new information requiring integration	Decide whether and how the new information changes current work	Local disruption can coexist with a net safety benefit
Return after delayed resumption	Original task has remained unfinished while intervening work accumulated	Prior reasoning, sequence position, pending checks, contextual cues	Broad reconstruction before continuation	Recovery burden can rise as competing work and time separate interruption from resumption

The taxonomy does not rank these events numerically. Its purpose is to identify the distinct state-recovery problem created by each configuration. An interruption becomes consequential when the work that follows depends on information that was not adequately preserved, cannot be efficiently reconstructed, or is resumed under conditions that discourage renewed verification.

Cognitive recovery and resumption lag

Resumption is itself work. Experimental evidence synthesized across interruption studies indicates that interventions such as cues, planning aids, and external representations can improve primary-task accuracy or reduce resumption lag, although effects vary by task and intervention type [11-13]. The interval between returning to a task and regaining an effective working state should therefore not be treated as idle delay. During that interval, the worker must identify what was being done, recover the relevant goal, reconstruct progress, interpret available cues, and decide what action should follow.

Recovery demand is sensitive to workload. Eye-tracking and performance research shows that interruption recovery changes under higher workload, consistent with competition for attentional resources during reorientation [14]. In a pharmacy, this means that the same interrupted verification may be more difficult to recover when queues, calls, questions, and pending clinical decisions have accumulated during the interruption. Recovery capacity is consequently partly situational.

The timing of interruption also matters. Controlled research indicates that interruption at different task breakpoints can alter resumption burden even when interruption frequency itself does not produce the same effect [15]. Human-automation studies similarly show that the reliability of automated support changes how attention is allocated across concurrent demands [16]. Frequency is therefore only one property of an interruption environment. Recovery safety depends on *where* the task was suspended, how much state was

externally visible, what happened during the interruption, and what cognitive resources remain available when the worker returns.

Unfinished tasks and loss of task state

An interrupted task does not disappear when attention moves elsewhere. Research on attention residue shows that anticipated pressure to resume unfinished work can leave elements of the suspended goal active while the worker performs another task, and that creating a specific ready-to-resume plan can reduce those effects [17]. The practical implication is not that all unfinished work produces identical cognitive residue. It is that task suspension creates a representational problem: some account of the unfinished task must survive the transition. Task-transition theory places this problem within a wider goal system [18]. Workers maintain multiple goals with different priorities, dependencies, and completion states. Community-pharmacy practice is compatible with this structure because prescription processing, clinical assessment, patient communication, troubleshooting, and administrative work may remain active simultaneously. A switch can therefore require both disengagement from one goal and selection of another without erasing the first.

Task state can be stored internally or distributed into the work system. Sociotechnical studies of health information technology show that tools interact with people, tasks, organizational processes, and environmental conditions, sometimes supporting coordination and sometimes creating new barriers [19]. Experimental medication-calculation research provides a more direct illustration: contextual cues marking prior work can improve resumption after interruption, although not every aid produces a significant benefit under every condition [20].

For dispensing safety, task-state loss is defined here as loss or uncertainty concerning information needed to continue the interrupted task with its prior verification

context intact. It can include uncertainty about what has already been checked, why a discrepancy was being investigated, which information remains unresolved, or what action was intended next. This construct is narrower than forgetting in general. It concerns the recoverability of the specific work state necessary for safe continuation.

How workflow and technology shape interruption consequences

Workflow determines whether recovery occurs in an environment that supports reconstruction or competes with it. Naturalistic emergency-care research has found that higher interruption rates can be associated with lower situation awareness even after workload adjustment [21]. Although such associations cannot establish a pharmacy-specific causal effect, they show why interruption analysis should include the worker's ability to rebuild an accurate representation of ongoing work.

Community-pharmacy technology has a similarly dual role. Pharmacists report that electronic prescribing can support medication safety while also introducing ambiguities, incomplete information, or process problems that require additional interpretation and communication [22]. Technology can therefore preserve state by making information visible, yet it can also generate new unfinished tasks when alerts, missing data, interface transitions, or clarification requirements interrupt the current sequence.

Clinical alert research further demonstrates that the design of information presentation matters. A systematic review found substantial variation in alert acceptance according to interface characteristics and clinical role, with interruptive modal alerts particularly vulnerable to poor acceptance [23]. Governance strategies such as multidisciplinary review, monitoring, and refinement of alert systems are widely advocated, but comparative evidence remains insufficient to identify a universally superior approach [24]. Longitudinal audit evidence also shows that accumulated prior alert exposure can reduce later adherence even when the alert itself is noninterruptive [25].

These findings suggest that a technological cue has no fixed safety value outside its workflow. A cue that preserves relevant state may facilitate recovery; a competing notification can demand another transition; an alert that repeatedly proves irrelevant may receive decreasing attention. The design problem is thus not simply whether the technology interrupts. It is whether the technological environment allows workers to

determine where they were, why the task had not yet been completed, what has changed, and whether verification needs to be restarted or extended.

Distribution of interruption risk across pharmacy work

Interruption consequences are unlikely to be evenly distributed across pharmacy activities. Observational medication research shows that workers use different responses—switching, delaying, multitasking, or continuing the original activity—depending on the source and meaning of the interruption [26]. At the same time, a large multicentre study of intravenous medication administration found no significant association between interruption occurrence and complete protocol compliance [27]. This null result is theoretically important because it demonstrates that interruption exposure cannot automatically be translated into failure. Task context provides one explanation for such variation. Large-scale observational work in intensive care indicates that relationships between interruptions and hazards differ across the work being performed [28]. Experimental medication-administration research likewise shows that external interruption can extend task duration and stimulate additional self-interruptions, creating a potential cascade of further switching [29]. The relevant safety unit is therefore the interrupted activity together with its recovery conditions.

Within community pharmacy, tasks can differ in how much state must be retained, how easily progress can be seen, how reversible an incorrect next action would be, whether a natural checkpoint exists, and whether technology externalizes the prior work state. A brief administrative activity with a visible completion marker may tolerate interruption differently from a medication assessment requiring integration of several patient- and prescription-specific facts. Final verification may present yet another configuration because the recovery requirement includes confidence about which elements were already checked and whether earlier reasoning remains valid.

The resulting landscape should not be interpreted as a fixed hierarchy of “safe” and “unsafe” pharmacy tasks. Task complexity, consequence, checkpoint availability, workflow support, and competing workload combine differently across episodes.

Proposed interruption–resumption safety model

The evidence reviewed above supports a model in which interruption exposure is only the entry condition. The

safety-relevant process begins when ongoing work is suspended and some part of its task state must survive until resumption. The causal status of interruptions in healthcare is too heterogeneous to justify treating exposure itself as the operative mechanism [2]. A more discriminating account asks whether the interrupted worker can recover the task's prior state accurately enough to continue with appropriate verification.

The model therefore distinguishes five analytically separate states: interruption exposure, task-state retention or loss, recovery work, resumption conditions, and post-resumption verification. These states are linked but not interchangeable. An interruption may occur without substantial state loss when work is paused at a natural checkpoint. Conversely, a brief interruption can create considerable recovery work if it occurs while several pieces of unresolved information are being integrated. Task-transition research supports this distinction because suspended goals remain embedded within broader goal systems instead of simply disappearing when attention changes [18].

Recovery burden is the next mechanism. Experimental evidence indicates that recovery can be improved by external cues and other interruption-management interventions [11]. It also varies with mental fatigue [12], cue-utilization capacity [13], workload [14], and interruption timing [15]. The model therefore treats resumption lag as one observable manifestation of recovery work, not as the whole mechanism. A worker

may resume quickly yet reconstruct the wrong state, or resume more slowly because deliberate rechecking is occurring.

The work system modifies this process. Contextual cues can improve recovery in medication-calculation tasks [20], while technology can also generate additional competing demands. Alert research shows that interaction design [23], governance [24], and accumulated alert exposure [25], alter how information is received and acted upon. Human-automation research further indicates that concurrent demands can change whether transparency or additional information improves performance or instead encourages workload and overreliance [30]. Technology is therefore represented in the model as part of the resumption environment rather than as an inherently protective layer.

Post-resumption verification provides the final safety-relevant distinction. A worker may reconstruct enough state to continue, yet still require a deliberate checkpoint before relying on that reconstruction. The null association between interruptions and complete medication-protocol compliance observed in a large multicentre study demonstrates why such intermediate mechanisms matter [27]. If workflow, task structure, or verification practices absorb the disruption, interruption exposure need not translate into observable failure.

Figure 1 integrates these relationships while distinguishing evidence-supported conditions from the article's proposed synthesis.

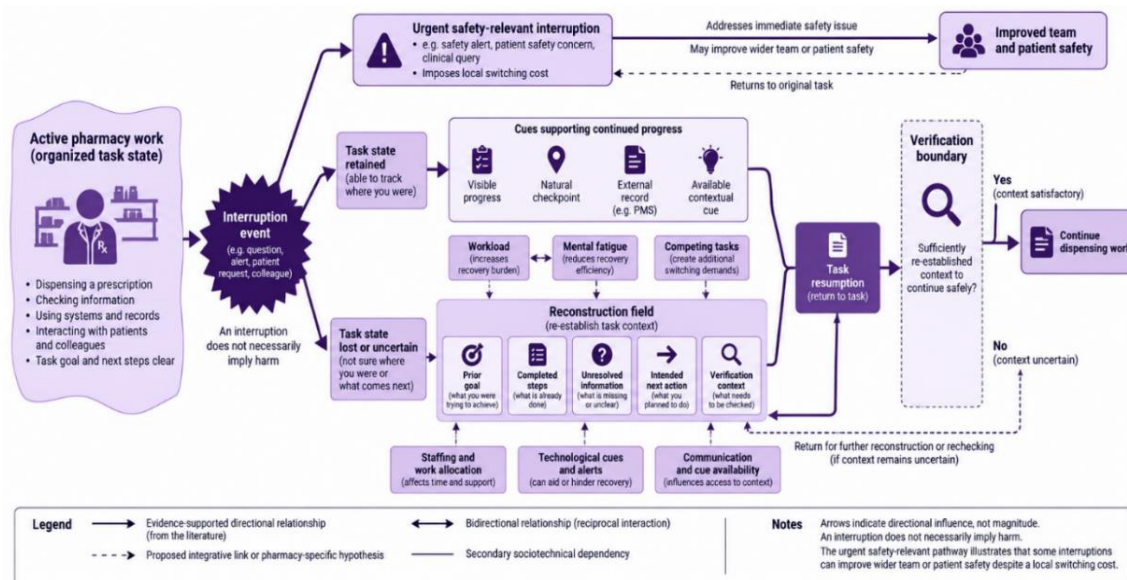


Figure 1. Safe resumption depends on what task state survives interruption and what must be reconstructed before verification

Safer resumption through work-system design

The model changes the design target from removing every interruption to preserving the conditions under which interrupted work can be reconstructed safely. A design can therefore reduce risk even when it does not reduce interruption frequency.

The first principle is task-state preservation. Experimental research shows that interruption-management interventions can improve post-interruption performance [11], and ready-to-resume planning can reduce the cognitive consequences of leaving an unfinished task [17]. Medication-calculation studies similarly show that contextual cues can improve recovery [20]. In pharmacy practice, analogous design responses could include persistent indicators of unresolved work, visible return points, structured pause markers, or interfaces that preserve the reasoning context surrounding an unfinished prescription. These are mechanism-based design possibilities rather than validated pharmacy interventions.

The second principle is checkpoint-sensitive interruption routing. Timing studies show that interruption effects vary according to where disruption occurs within a task

[15]. Work systems can therefore distinguish moments when a task can be paused with little reconstruction from moments when interruption would sever a fragile verification sequence. This does not require making pharmacists inaccessible. It requires routing nonurgent demands when feasible and preserving pathways for urgent information.

The third principle is workload-sensitive support. Technology should not add cues without considering the concurrent demands under which those cues will be interpreted. Sociotechnical analysis of health information technology shows that benefits and barriers arise through interactions across person, task, organization, environment, and technology [19]. Alert research similarly supports active governance rather than unchecked accumulation of interruptive signals [23, 24]. Experimental automation evidence shows that additional system transparency can have different consequences when concurrent demands are high [30].

These principles organize **Table 2** around specific resumption vulnerabilities rather than around generic “barriers” or “solutions.”

Table 2. Work-system responses matched to specific failures of interrupted-task resumption

Resumption vulnerability	State that must be protected or recovered	Workflow response	Technology/cueing response	Staffing or role response	Necessary caution
Unclear return point after task switching	Last completed step and intended next action	Create recognizable pause/checkpoint practices where feasible	Preserve visible progress and unfinished status	Reduce unnecessary reassignment during fragile task phases	Checkpoints cannot be assumed equally useful for all tasks
Loss of verification context	What was checked, what remains unresolved, and why	Require renewed verification when prior state is uncertain	Make prior actions and unresolved information retrievable	Protect sufficient time for rechecking after complex interruptions	Rapid continuation should not be treated as successful recovery by itself
Competing demands during recovery	Priority of the resumed task and active competing work	Route deferrable requests away from recovery periods when practical	Avoid adding low-value alerts during already overloaded states	Redistribute incoming questions or routine demands where roles permit	Urgent communication must remain deliverable
Repeated alert-driven switching	Primary-task state plus relevance of successive alerts	Govern alert timing and escalation pathways	Tailor alerts to relevance, role, and contextual need	Clarify who is responsible for responding to specific alert classes	Lower alert volume alone does not demonstrate greater safety
Long delay before return	Original task goal, intervening changes, outstanding checks	Mark delayed unfinished work explicitly	Maintain persistent contextual cues across task transitions	Ensure ownership of suspended work remains visible	Some long-delayed tasks may require restart rather than simple continuation

Interruption during cognitively dense integration	Current reasoning chain and unresolved patient/prescription information	Minimize avoidable switching during high-state-dependency work	Keep relevant clinical and prescription context jointly visible	Provide alternate routes for nonurgent requests where staffing allows	“Protected work” should not block safety-critical escalation
Useful urgent interruption	Original task state plus new safety-critical information	Permit immediate escalation while marking suspended work	Surface consequential information without erasing primary-task context	Define escalation responsibilities	Local interruption cost may be justified by larger safety benefit

The table intentionally avoids claims that these responses have proven effectiveness in community pharmacy. Their value follows from the model's mechanisms and from evidence showing that cues, interruption timing, workload, alert design, and task organization influence recovery under different conditions.

Implications for staffing, technology and workflow

Staffing decisions should be evaluated partly by how they distribute interruption absorption and recovery work. Community-pharmacy resilience research shows that staff adapt roles and practices when operational demands change [7]. Systems modeling likewise demonstrates that service configuration and staffing alter workflow conditions [9]. Community-pharmacy work redesign can shift pharmacists away from some dispensing activities and toward patient-care work [10]. The implication is not that one staffing ratio or delegation model is universally safer. Staffing should instead be examined for whether high-state-dependency activities repeatedly coexist with unmanaged competing demands.

Technology should make interrupted work more resumable. Electronic prescribing illustrates the dual possibility: digital systems can improve access to medication information while also creating ambiguities and clarification work [22]. Design evaluation should therefore include whether an interface preserves unfinished status, prior reasoning, and unresolved discrepancies across transitions. Alert systems should also be evaluated as part of this recovery environment. Interaction design influences alert burden [23], accumulated exposure can change later responsiveness [25], and alert-governance processes determine which signals continue to compete for attention [24].

Workflow governance provides the third lever. Pharmacy managers can examine where interruptions originate, which requests genuinely require immediate escalation, which task phases are difficult to reconstruct, and where the system already contains reliable checkpoints.

Systems work in pharmacy suggests that interruption patterns can change when upstream communication and workflow arrangements change [8]. The practical unit for redesign is therefore the interruption–resumption episode: who initiated it, what work was suspended, what state survived, how long return was delayed, and what verification occurred before continuation.

Research agenda

The primary empirical test of the model should compare episodes with similar interruption exposure but different resumption conditions. If interruption count remains constant while externally preserved task state, checkpoint availability, or reconstruction support differs, the model predicts differences in recovery processes. Such studies would distinguish the proposed mechanism from an exposure-only account.

A second program should examine interactions among task complexity, fatigue, and interruption timing. Experimental evidence already shows that complexity and fatigue modify post-interruption performance [12], while breakpoint location influences resumption burden [15]. Pharmacy-specific research could identify which dispensing and clinical tasks depend most heavily on internal state, which have reliable external checkpoints, and when recovery requires renewed verification.

A third requirement is multilevel measurement. An interruption can be costly for one pharmacist yet valuable for the pharmacy or patient if it transmits urgent information. Naturalistic healthcare work demonstrates that clinicians use several strategies to manage competing prompts [4], and team models predict that interruption decisions involve trade-offs between the interrupter and interrupted worker [5]. Future pharmacy studies should therefore measure both local recovery cost and the informational value of the interrupting event.

Research should also distinguish fast resumption from safe resumption. Shorter resumption lag may indicate effective cueing, but it could also reflect premature

continuation. Measures should include reconstruction accuracy, repeated checking, unresolved-state detection, downstream correction, and whether the worker recognizes when prior context is insufficient.

Finally, technology studies should test whether persistent contextual information improves recovery under real workload conditions. Medication-calculation experiments support contextual cueing [20], but automation research warns that additional system information can behave differently under competing task demands [30]. The strongest test would compare designs that expose similar quantities of information while differing in whether they preserve the specific state needed to resume the interrupted pharmacy task.

Results and Discussion

The Sociotechnical Interruption–Resumption Safety Model reframes interruption risk around recoverability. Its distinctive claim is that exposure becomes safety-relevant through the condition of unfinished work and the work required to restore sufficient task state for continued performance. This interpretation is consistent with intervention research showing modifiable recovery [11], with task-transition theory emphasizing unfinished goals [18], and with healthcare evidence showing that interruption outcomes are heterogeneous [2].

The strongest rival explanation is that interruption is primarily a marker of underlying workload or coordination demand. Busy periods produce more calls, questions, alerts, competing tasks, and opportunities for error, so an association between interruptions and poorer performance may reflect the common influence of workload. Observational work linking interruptions with situation awareness illustrates this interpretive challenge even when statistical adjustment is attempted [21]. The proposed model does not eliminate that rival. It generates a stronger test: after accounting for workload and task characteristics, does preservation or reconstruction of task state explain additional variation in recovery quality?

A second challenge is that interruptions can be useful. Clinicians sometimes interrupt because information is urgent, because another task has greater immediate importance, or because coordination requires rapid response [4]. A theory that classified such communication as intrinsically unsafe would confuse local cognitive cost with overall system value. The present model therefore allows an interruption to

produce both a resumption burden and a net safety benefit.

A third limitation concerns transfer. Much of the mechanistic evidence comes from laboratory interruption studies, nursing medication administration, emergency medicine, or other complex work domains. Community pharmacy provides direct evidence about interruption sources, workflow, electronic prescribing, resilience, and work redesign, but pharmacy-specific causal evidence about task-state loss and post-interruption reconstruction remains sparse. Accordingly, **Figure 1** represents the integration of these literatures as a proposed theoretical synthesis rather than as a validated causal model.

Counterevidence also constrains the claim. The absence of a significant association between interruptions and protocol compliance in multicentre medication administration research demonstrates that interruption exposure can be absorbed without measurable failure in some settings [27]. Human–automation studies likewise show that added support does not produce uniformly positive effects across concurrent-demand conditions [30]. Such results are compatible with the model only if recovery conditions are explicitly measured instead of inferred from interruption presence.

The model's main practical implication is therefore conditional. Reducing unnecessary interruptions may still be valuable, but interruption reduction and safe resumption are not equivalent interventions. A work system can experience relatively few interruptions yet remain vulnerable if unfinished task state is poorly represented. Conversely, a highly interactive pharmacy may tolerate substantial communication if task boundaries, cues, responsibilities, and verification practices allow workers to recover accurately.

Conclusion

Dispensing safety depends partly on interruption exposure, but exposure alone cannot explain what happens when work resumes. The more discriminating safety mechanism is whether the unfinished task remains recoverable: what state survives the interruption, what must be reconstructed, what competing demands shape that reconstruction, and whether adequate verification occurs before continuation.

This account does not imply that every interruption is harmful or that every delay in resumption is unsafe. Some interruptions transmit information whose value exceeds

their local switching cost, and some tasks remain readily recoverable because progress is externally visible or naturally checkpointed. The central theoretical claim is therefore conditional: interruptions become most consequential when they disrupt work whose safety depends on reconstructing task state that the surrounding sociotechnical system has failed to preserve or make recoverable.

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