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Scaling What Works: Evidence-Based Phase Transitions for Digital Technologies in Healthcare Supply Chains (PRISM-HSC)

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Abstract

This paper explains why digital tools that perform well within a single hospital or firm often stall at inter-organizational handoffs in healthcare supply chains. It draws on 12 semi-structured interviews with managers from manufacturers, distributors, providers, and IT integrators in the United States, China, India, and the United Arab Emirates; 10 interviews were retained for comparative analysis. Using thematic coding and cross-case comparison, the analysis identifies recurring boundary conditions, including inconsistent product identifiers, divergent data definitions, and limited partner-level verifiability of upstream events. Adoption progressed when partners created shared master data and code governance, integrated basic data flows to remove duplicate entry, and formalized role-based access and change control. Scaling across sites required standardized identifier rules, label templates, and validated mapping files. Scaling across networks depended on partner-verifiable evidence, including timestamped event logs, staged releases with rollback, and, where appropriate, third-party checks. The paper proposes PRISM-HSC, a phase-by-level model that makes these boundary conditions explicit and supports planning for network-wide adoption in regulated healthcare supply chains. A limitation is that the study relies on a small, interview-driven sample and does not quantify effects or test causality.

Keywords
Healthcare Supply Chains; Digital Technology Adoption; Inter-organizational Handoffs; Artificial Intelligence; Cloud ERP

1. Introduction
Healthcare supply chains are investing in ERP and warehouse management systems, UDI scanning, AI decision support, telemedicine with remote monitoring, and data-sharing platforms. Many deployments deliver clear within-site benefits, including improved inventory accuracy, faster documentation, and better planning. The larger value depends on whether these gains can be sustained when work and data move across manufacturers, distributors, logistics providers, and multi-site health systems. This matters because cross-partner coordination underpins traceability, patient safety, and service continuity, yet accountability is hardest to maintain at organizational boundaries.

Technologies that perform well inside one hospital or company often stall when extended across supply chain partners. Breakdowns concentrate at inter-organizational handoffs, where partners face inconsistent identifiers, mismatched data definitions, and limited ability to independently verify what occurred upstream. When downstream teams cannot validate key events such as scans, substitutions, and release decisions, accountability weakens, disputes increase, and automation is replaced by manual workarounds, creating costly pilot-to-scale drop-off.

This paper uses cross-country interview evidence to specify the minimum conditions that enable adoption to progress from local use to routinization, diffusion, and network scale. It proposes PRISM-HSC, a phase-by-level framework

that makes handoff requirements explicit and supports planning around interoperability, governance, and partner-verifiable evidence in regulated healthcare supply chains.

1.1 Objectives

This study develops evidence-based guidance for scaling digital technologies across healthcare supply chain partners by making phase-transition requirements explicit. The objectives are to:

1. Diagnose boundary constraints at inter-organizational handoffs. Identify the recurring mechanisms that prevent digital tools from moving beyond local success, with emphasis on identifier misalignment, inconsistent data definitions, and limited partner-level verifiability.

2. Specify phase-transition requirements for reliable scaling. Define the minimum observable conditions that enable progression from entry to routinization, diffusion across sites, and scaling across partner networks, including master data governance, integration to reduce duplicate entry, role-based access, and controlled change practices.

3. Develop PRISM-HSC as an actionable planning framework. Synthesize these findings into a phase-by-level model that links adoption phases to evidence and governance requirements, and provide implementation guidance to reduce pilot-to-scale drop-off in regulated healthcare supply chains.

2. Literature Review

2.1 Context

Healthcare supply chains (HSCs) have strong incentives to digitalize because traceability, inventory accuracy, recall execution, and shortage mitigation depend on fast and reliable information flows across manufacturers, distributors, providers, and regulators (Fallahnezhad et al., 2024). Yet the literature repeatedly indicates that local digital gains often degrade when processes cross organizational boundaries, where requirements shift from “system use” to “system-to-system portability,” auditability, and shared accountability (Li et al., 2022). In this setting, technology adoption is increasingly treated as a progression from first use to routinization and then to diffusion across partners, rather than a single acceptance event.

2.2 Adoption theory lenses

Technology adoption research draws on established theories that explain intention formation, readiness, and diffusion. At the individual level, the Technology Acceptance Model (TAM) links use to perceived usefulness and perceived ease of use (Davis, 1989), such as when handheld mobile scanning interfaces improve the "ease of use" for warehouse staff compared to manual entry. The Unified Theory of Acceptance and Use of Technology (UTAUT) consolidates drivers into performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003), where the "effort expectancy" of AI-powered voice recognition for inventory logging determines its frontline acceptance.

At the organizational level, the Technology–Organization–Environment (TOE) framework explains adoption through technology characteristics, organizational readiness, and environmental pressures such as regulation and vendor ecosystems (Tornatzky and Fleischer, 1990). The Diffusion of Innovations (DOI) theory explains spread through innovation attributes including relative advantage, compatibility, and complexity (Rogers, 2003). These theories structure key adoption drivers, but they often assume a bounded adopting unit and therefore under-specify the conditions required for reliable inter-organizational operation. Within this environmental context, Cloud ERP serves as a critical facilitator; by providing a standardized, vendor-supported infrastructure, it reduces the complexity of cross-organizational data sharing and allows for the "quick deployment" necessary to meet environmental demands for transparency and inventory consistency.

To ground PRISM-HSC, the Practical, Robust Implementation and Sustainability Model (PRISM) focuses on why interventions are implemented and sustained in real-world settings (Feldstein and Glasgow, 2008). PRISM emphasizes fit between the intervention and the external environment, implementation and sustainability infrastructure (resources, workflows, accountability, measurement), and recipient/organizational characteristics. For example, implementing AI-driven automated audit trails acts as the sustainability infrastructure that ensures accountability and measurement

persist across different sites. This sustainability lens explains why pilot success may not persist when governance and infrastructure requirements change, providing a foundation for adapting PRISM to healthcare supply chains.

2.3 Phase-sensitive determinants

Recent evidence supports a phase-sensitive interpretation in which early adoption is often driven by usability and perceived value, while routinization and scaling are constrained by organizational and cross-organizational conditions. Clinical digital health studies show that intention and early use are explained well by UTAUT-family constructs, but effects can vary by role and phase (Alsyouf et al., 2024). As initiatives transition into rollout and routine operation, studies emphasize interoperability maturity, master-data quality, change capacity, leadership sponsorship, and vendor capability as binding constraints, consistent with TOE's focus on readiness and environment (McDermott et al., 2025). This phase shift is also consistent with broader evidence that healthcare digital transformation benefits depend on organizational enablers and governance, not only user beliefs (Brommeyer et al., 2024).

2.4 Interoperability and portability

Interoperability is repeatedly identified as the core technical–organizational boundary condition for HSC digitalization because it determines whether item identities, events, and records remain consistent across systems and partners(Alsyouf et al., 2024). Evidence from interoperability research links interoperability to safety and quality outcomes, while industry reports indicate persistent gaps between clinician and operational needs and what interoperability implementations deliver in practice. Standards-based approaches, including HL7 FHIR profiles, are emphasized for enabling cleaner exchange between EHRs, ERPs, WMS platforms, and laboratory systems; however, adoption still hinges on local configuration, governance, and partner alignment (Gazzarata et al., 2024). In parallel, identification infrastructure such as UDI is framed as a prerequisite for reliable device capture, traceable recalls, and consistent downstream reconciliation across sites (Dhruva et al., 2023).

2.5 Assurance, governance, and risk

As adoption moves beyond local use, the literature increasingly treats assurance as a distinct requirement: partners require evidence they can verify rather than relying on informal trust. In healthcare contexts this includes validation protocols, audit trails, and clear procedures for lawful data sharing, particularly where cross-border constraints and data residency concerns exist (de Kok et al., 2023). Procurement and contracting are also shown to influence adoption trajectories by shaping incentives, usability expectations, and long-term total cost of ownership; recent work on responsible AI adoption highlights the role of procurement frameworks in specifying governance and accountability expectations (Evans et al., 2025). At the people level, systematic reviews emphasize that digital competence and structured training interventions materially affect sustained use, especially when workflows change and exception handling increases (Kulju et al., 2024).

2.6 Explainability and AI-enabled adoption

AI-enabled applications add further adoption conditions because decisions must remain interpretable and defensible under audit and clinical governance. Systematic reviews report that explainable AI can increase or decrease professional trust depending on how explanations are designed and whether they match user tasks and accountability expectations (Rosenbacke et al., 2024). Operations and supply chain research similarly links explainability to decision support quality, accountability, and resilience under cyber risk, implying that explainability is not an optional feature when decisions require justification and traceability (Olan et al., 2025). In parallel, security and privacy constraints are treated as durability conditions for scaling connected systems, particularly in IoMT and data-sharing contexts where weak protections can block integration and diffusion (Kamalov et al., 2023).

2.7 PRISM-HSC rationale

A recurring gap across adoption research in healthcare supply chains is the limited specification of minimum, testable conditions that enable progression from pilot success to routine operation and then to inter-organizational scale. Many studies identify barriers and facilitators, but fewer distinguish which determinants are phase-specific, which are level-specific (individual, workflow, organization, inter-organization), and which can be evidenced through portable artifacts rather than local familiarity (Heeres et al., 2023). PRISM-HSC is introduced to address this gap by structuring adoption as a phase-by-level progression and integrating implementation science and adoption theory in a way that matches regulated, interdependent settings. Conceptually, it adapts PRISM's implementation-and-sustainability logic (Feldstein and Glasgow, 2008) and leverages CFIR as a determinant framework (Damschroder et al., 2022), while

preserving adoption-model insights for early use (Davis, 1989; Rogers, 2003). Its central premise is that scaling requires not only perceived value and usability, but also interoperability, governance, and verifiable assurance mechanisms (e.g., validation, auditability, explainability, and security/privacy controls) that remain stable across organizational boundaries.

2.8 Summary

Overall, the literature supports a category-based, phase-sensitive view of adoption in healthcare supply chains. Early-phase use is commonly explained by usability, perceived value, and facilitating conditions (TAM/UTAUT), while routinization depends on integration capacity, master-data discipline, training, and operational ownership (TOE and implementation lenses). Diffusion and scaling introduce portability and assurance constraints, elevating standards alignment (e.g., HL7 FHIR, UDI), lawful data-sharing procedures, procurement governance, and AI-specific explainability and security/privacy requirements. These patterns motivate PRISM-HSC as a synthesis that converts broad adoption constructs into phase-appropriate, verifiable conditions for moving from pilot to routine use and durable scale in healthcare supply chains.

3. Methods

3.1 Research approach and design

This study adopts an interpretivist, constructivist stance to explain how healthcare supply-chain professionals understand, justify, and act on technology adoption decisions in regulated and interdependent settings. Interpretivism is appropriate because adoption outcomes in healthcare vary substantially by context and role, and the mechanisms that enable adoption are best surfaced through participants' situated accounts rather than through statistical generalization.

Methodologically, the study uses a deductive qualitative multiple-case design. Deduction is appropriate because the analysis begins with theory-derived propositions (developed from established adoption models and healthcare-specific adoption constraints) and evaluates their support across real-world adoption episodes.

Semi-structured interviews were selected over surveys or experiments because they allow respondents to reconstruct concrete adoption episodes, including decision points, constraints, and consequences, in environments where controlled intervention is impractical and documentation is often incomplete.

The study is mono-method qualitative and cross-sectional. Data collection occurred within a single fieldwork window suitable for the availability constraints of healthcare professionals.

3.2 Unit of analysis and analytical logic

The unit of analysis is the technology adoption decision episode described by each participant. Each interview focused on one recent adoption episode to reduce recall bias and to elicit time-ordered details (triggers, implementation choices, and stabilization or breakdown points).

Analysis proceeded in three linked steps aligned to the research questions. First, transcripts were coded against nine theory-derived propositions to assess which technological, organizational, and institutional mechanisms were supported within each case; this produced case-level verdict tables (supported/partly supported/not supported). Second, the study moved from verdicts to reflexive thematic analysis to identify where standard adoption models held and where gaps emerged in healthcare supply chains. Third, cross-case matrices compared patterns across roles, organization types, and geographies to refine a phase-by-level interpretation consistent with the PRISM-HSC logic.

3.3 Rigor and trustworthiness

Credibility was strengthened through explicit alignment of interview prompts to the barrier–enabler synthesis and to theory-driven propositions. Participants were guided to reconstruct timelines and decision points during the adoption episode to increase factual specificity and support cross-role plausibility checks.

Reliability and dependability were supported by a standardized interview protocol applied across interviews, verbatim transcription, and a structured deductive codebook that was updated in a documented manner when recurring patterns required refinement. Coding decisions were recorded using reflexive memos and an audit trail. The study judged sufficiency through thematic saturation, observed when later interviews added no substantively new insights and themes were stable across cases.

3.4 Ethical considerations
The study followed standard ethics principles for management research: informed consent, voluntary participation, confidentiality, and data minimization. No patient data were collected. Interviews were anonymized at source, stored securely with access controls, and retained for a limited period before deletion.

4. Data Collection
4.1 Sampling and recruitment
Participants were recruited using purposive maximum-variation sampling to capture diversity across healthcare supply chain roles, organization types, and regions. Recruitment drew on professional networks in India, China, the United States, and the UAE, with limited snowball referrals to reach specialized decision roles while maintaining the maximum-variation sampling aim. Twelve interviews were conducted; two were excluded due to insufficient episode detail for analysis. The final analytical sample comprised ten participants representing upstream, midstream, downstream, and cross-functional decision roles.

4.2 Interview procedure and instrumentation
Semi-structured interviews were used, with each participant asked to describe one recent technology adoption episode. The interview guide was developed to elicit context, decision points, implementation processes, and outcomes relevant to the study's research questions. The guide was piloted with two industry colleagues and refined for clarity and applicability across roles and settings.

4.3 Fieldwork window, format, and data handling
Interviews were conducted by video or phone over a two-week window beginning 15 August 2025, lasted approximately 45–60 minutes, and were recorded with consent, transcribed verbatim, and anonymized at source. A short pre-interview form captured role, organization, experience, and focal technologies to support contextual interpretation in analysis.

5. Results and Discussion
5.1 Numerical Results
This section reports and interprets the core empirical output of the study, which is the proposition verdict table derived from ten interview cases. Each case was analyzed as a concrete adoption episode and coded against nine propositions (P1–P9) that operationalize PRISM-HSC phase transitions. The numerical verdicts therefore represent structured pattern-matching results rather than statistical inference, but they allow consistent cross-case comparison and provide a compact basis for discussing why adoption advances in some phases and stalls in others.

Table 1 summarizes the verdict distribution across the ten cases. The strongest support concentrates in the early transitions from Pilot to Rollout and from Rollout to Routine. In contrast, later transitions that require inter-organizational verifiability and governance show high neutrality, which indicates partial or uneven establishment of those conditions across settings.

Table 1. Proposition verdicts across ten interviews (N = 10).

Theme (Phase Transition Focus)	Proposition	Supported	Neutral	Contested
First Use (Pilot → Rollout)	P1: Coordination enables action	7	2	1
First Use (Pilot → Rollout)	P2: Clear functions lift use	8	1	1
Sustained Use (Rollout → Routine)	P3: Data quality enables routinization	9	1	0
Sustained Use (Rollout → Routine)	P4: Ownership stabilizes routines	7	2	1
Cross-Site Replication (Routine → Diffusion)	P5: Shared formats enable replication	8	1	1

Scaling Trust (Diffusion → Scale)	P6: Transparent systems strengthen adoption	3	6	1
Scaling Trust (Diffusion → Scale)	P8: Security sustains use	1	8	1
Scaling Trust (Diffusion → Scale)	P9: Data readiness enables scale	3	6	1
Ecosystem Integration (Diffusion → Durable Use)	P7: Clear terms enable durable use	3	6	1

Three numerical patterns drive the interpretation. First, early-phase mechanisms are consistently observed and repeatedly credited by participants as the reason adoption moved from intention to first use and then to routine. P1 and P2 indicate that first use depends on practical coordination and clear, usable functions, not on abstract willingness. Second, routinization is the most stable transition in the dataset. P3 has the highest support of all propositions, and P4 is also strongly supported, which indicates that routine emerges when data integrity and integration are enforced and when ownership is explicit enough to maintain identifiers, manage exceptions, and prevent workarounds from becoming the real process. Third, later-phase propositions are dominated by neutral verdicts, especially P8 and, to a lesser extent, P6, P9, and P7. This neutrality does not imply that security, transparency, readiness, and terms do not matter. It indicates that these conditions are frequently incomplete, unevenly implemented, or not sufficiently partner-verifiable to be described as established drivers of scale and durable inter-organizational use.

The verdict table therefore supports five phase-transition findings that explain why digital gains are often achieved locally yet weaken at organizational boundaries. Pilot to Rollout is gated by "safe first action" design that makes a first task small, supported, and reversible, which aligns with the high support for P1 and P2. Rollout to Routine is gated by label-to-dictionary integrity and stewardship, which aligns with the near-universal support for P3 and strong support for P4. Routine to Diffusion is gated by transportable standards, which aligns with the high support for P5 and recurring accounts that replication fails when formats drift. Diffusion to Scale is gated by partner-verifiable assurance rather than explanation alone, which aligns with the high neutrality for P6, P8, and P9 and with repeated references to logs, auditable trails, matched protocols, and third-party evidence as the practical basis for cross-organizational trust. Diffusion to Durable Use is gated by contractible governance and change control, which aligns with the mixed evidence for P7 and with accounts that adoption decays when responsibilities, permissions, and updates cannot be negotiated and enforced across partners.

5.2 Graphical Results

The graphical results focus on two added-value objectives. First, they show how the verdict profile shifts when propositions are aggregated into the study's three phase-blocks, which makes phase transition fragility visually explicit. Second, they operationalize PRISM-HSC as a phase-by-level pathway so that the contribution is not only descriptive but also usable as an adoption design logic for healthcare supply chains.

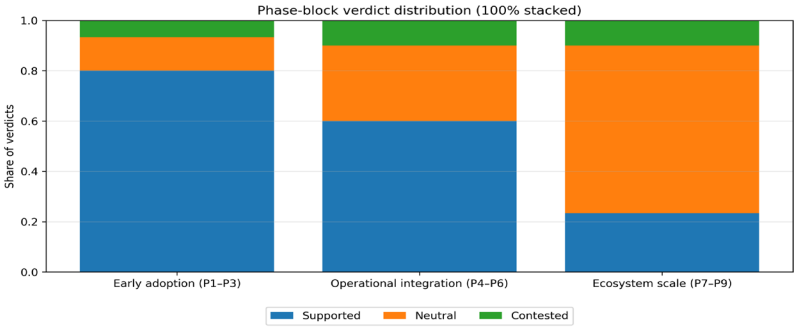

Figure 1. Phase-Block Proposition Verdicts Distribution

Figure 1 aggregates proposition verdicts into three phase-blocks that correspond to the study's central progression logic: early adoption (P1–P3), operational integration (P4–P6), and ecosystem scale (P7–P9). Each block is presented as a 100% stacked distribution of verdict categories across the propositions in that block, normalized so that the visual comparison reflects how the balance of evidence changes across phases rather than differences in raw counts. This representation is analytically useful because it makes the phase transition story legible at a glance without requiring the reader to mentally synthesize nine separate proposition rows.

The dominant pattern is a monotonic shift from strong support in early adoption to high neutrality at ecosystem scale. Early adoption is visually characterized by a large supported share with only limited neutral and contested evidence. This indicates that the mechanisms that move adoption from intention to first use and from first use to routine are consistently observed across cases. In contrast, operational integration shows a clear increase in neutrality, suggesting that even when technologies are in use, integration and stabilization conditions are frequently only partially implemented or are uneven across roles and sites. The most pronounced shift appears at ecosystem scale, where neutrality becomes the dominant outcome. In interpretive terms, this figure reinforces the core argument that scaling is not blocked by a lack of local performance gains, but by the lack of conditions that must be accepted across organizational boundaries, including partner-visible assurance and enforceable governance. Importantly, neutrality is treated as a substantive result rather than a missing value. It represents incomplete establishment of the relevant conditions or an inability to claim that those conditions are present in a partner-verifiable way.

Figure 2 provides a structural translation of the study's phase-transition findings into a phase-by-level pathway across four decision levels: individual, workflow, organizational, and inter-organizational. Unlike the verdict table, the diagram does not introduce new evidence. Its role is to make the model's logic explicit and testable by showing where each phase transition must be executed and stabilized. The swimlane format is particularly appropriate for healthcare supply chains because failure modes often occur not within a single organization but at handoffs between roles, units, and partner entities.

The pathway clarifies a key mechanism underlying the numerical patterns reported in 5.1: early adoption can succeed even when inter-organizational requirements are weak, because the constraints bind primarily at the individual and workflow levels. As adoption advances, the binding constraints move upward and outward toward organizational integration and inter-organizational alignment. This is the conceptual reason the dataset shows stable routinization but increasing neutrality at ecosystem scale. In practice, the diagram makes clear that late-phase success requires artifacts and controls that sit above local user behavior, including shared identifiers and standards, auditable traces, agreed protocols, and partner-governed change control. The visual therefore operationalizes the paper's contribution by pr senting PRISM-HSC as an adoption design logic rather than a retrospective explanation.

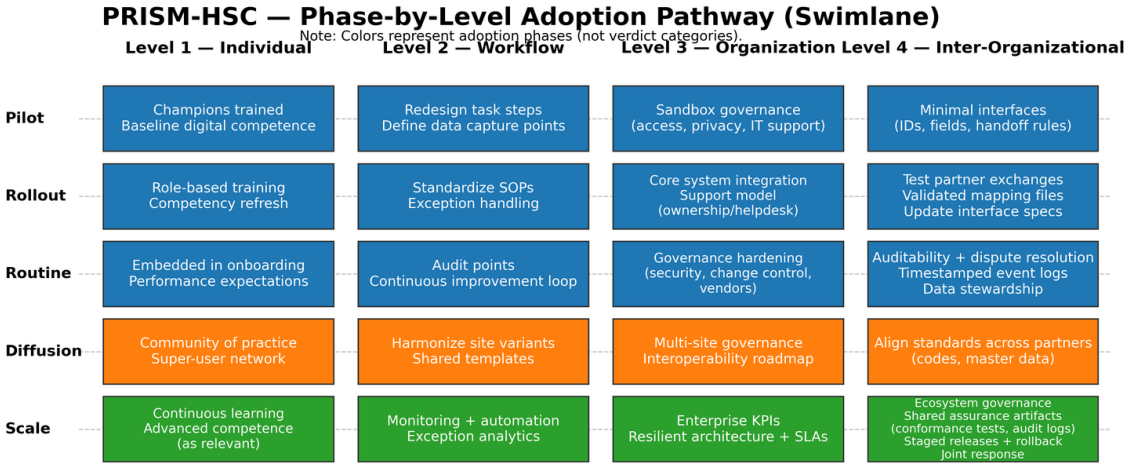

Figure 2. PRISM-HSC Phase-by-Level Adoption Pathway

5.3 Proposed Improvements

The verdict profile implies that improvement should be designed as phase-gate engineering rather than as generic adoption encouragement. The first improvement is to treat Pilot to Rollout as a controlled “first action” problem. Organizations should specify a single low-risk first task, ensure nearby support at the moment the task is performed, and define who can reverse a change if the new routine creates operational or clinical risk. This recommendation is justified by the strong support for P1 and P2, which indicates that first use reliably follows when coordination reduces perceived risk and functions are clear enough to succeed on the first attempt.

The second improvement is to treat Rollout to Routine as a master-data and stewardship program, increasingly supported by Cloud ERP techniques. The evidence shows that routine stabilizes when physical identifiers, labels, and locations match the system’s dictionary and when someone is explicitly responsible for maintaining that alignment. By integrating Cloud ERP, organizations can better handle inconsistencies in inventory and purchasing management through centralized data structures that offer quick deployment across sites. The operational implication is that data exceptions should be treated as process failures with owners and closure expectations, rather than as user mistakes to be corrected ad hoc. This recommendation is justified by the strongest verdicts in the dataset, since P3 and P4 (Data Quality and Ownership) are consistently supported.While the transition to Cloud ERP requires a significant upfront investment in data cleansing to establish a baseline of integrity, its primary value lies in its ability to sustainably manage and protect that data once cleaned, preventing the 'information decay' that typically occurs when inventory and purchasing records are handled across fragmented, on-premise legacy systems.

The third improvement is to package replication. Routine to Diffusion should not be pursued as “install the same software elsewhere” but as “move the same meaning elsewhere.” Replication is more likely to succeed when a shared codebook and an exact label or identifier template move together, so that scanning, tracking, and downstream interpretation remain consistent across sites. The evidence for P5 suggests that portability is a decisive condition for diffusion and that inconsistency in formats creates friction that reintroduces manual work and weakens comparability.

The fourth improvement is to convert Diffusion to Scale from a trust aspiration into verifiable assurance, enhanced by Artificial Intelligence (AI). The neutrality in P6, P8, and P9 suggests that many settings have baseline security and internal controls that work locally but do not satisfy partners who require independently checkable evidence. Organizations seeking scale should therefore prioritize partner-visible artifacts(such as AI-driven event logs, automated auditable trails, and protocol alignment) that can be referenced in procurement and compliance discussions. Integrating AI allows for real-time monitoring of these logs to provide the "system-to-system portability" and defensible evidence required in regulated healthcare settings. This shift targets the practical mechanism behind cross-organizational refusal or hesitation, since partners cannot rely on internal claims when liability and data exposure are shared.

The fifth improvement is to make durable use governable through explicit terms and change control. Even when diffusion occurs, durability weakens when updates, permissions, and responsibilities are negotiated informally or inconsistently. The mixed verdicts for P7 support an emphasis on contractible governance that specifies data-sharing responsibilities, incident handling, audit rights, and how changes are requested, approved, and documented. Durable inter-organizational adoption is more likely when the operational reality of change is treated as a shared process rather than an internal IT action.

5.4 Validation

Validation in this study concerns credibility of qualitative pattern matching and plausibility of the proposed gate improvements. Credibility is supported when the same propositions are evidenced across different roles and nodes rather than being driven by a single setting, which the cross-case verdict structure is intended to test. Credibility is also strengthened by negative case handling, since contested verdicts indicate that propositions fail in predictable boundary conditions, such as when privacy rules prevent integration, when identifiers drift across partners, or when governance terms are absent. An auditable chain from interview anchors to codes to proposition verdicts further supports trustworthiness, because it allows readers to see that conclusions are grounded in observed mechanisms rather than in generalized claims.

Practical validation can be stated as testable expectations at the phase gates. If Pilot to Rollout is improved, first-use completion should increase and reliance on parallel manual channels should decrease during the initial window. If Rollout to Routine is improved through stewardship, mismatch incidents and rework should decline, and the system

should become the primary workflow rather than a reporting layer. If Routine to Diffusion is improved through portable standards, replication should require fewer local reconfigurations and fewer site-specific workarounds. If Diffusion to Scale is improved through partner-verifiable assurance, partner onboarding decisions should become faster and less dependent on informal trust, because shared logs, aligned protocols, and attestations reduce uncertainty. If governance and change control are strengthened, durable use should persist through staff turnover and system updates with fewer regressions to informal channels. These validation expectations are consistent with the study's focus on phase transitions as observable handoffs where adoption succeeds or fails based on concrete evidence rather than intention alone.

6. Conclusion

This study examined why digital technology adoption in healthcare supply chains frequently delivers "inside-the-fence" improvements but breaks down when processes, data, and accountability must travel across organizational boundaries. Building on the motivating paradox of visibility without verifiability, the study framed adoption as a set of phase transitions and level-specific constraints, emphasizing that cross-site reliability depends on conditions that partners can independently examine and accept, not only on local performance gains.

All research objectives were met. First, the study mapped adoption factors across phases and levels by synthesizing the literature and case evidence into a structured account of technological, organizational, and institutional drivers and barriers operating at the individual, workflow, organizational, and inter-organizational network levels. This mapping clarifies how early success can be locally rational yet structurally fragile when handoffs depend on shared identifiers, aligned label templates, stable data objects, and enforceable governance across actors.

Second, the study evaluated and extended established adoption theories by showing where their explanatory strengths concentrate and where they leave boundary conditions implicit in regulated healthcare settings. Technology Acceptance Model and Unified Theory of Acceptance and Use of Technology contribute strong explanations for early intention and use behavior, Technology–Organization–Environment helps interpret internal readiness and organizational support, and Diffusion of Innovations clarifies spread mechanisms. However, none of these models, on their own, specifies the minimal, verifiable conditions required for adoption to survive cross-site transfer under compliance and patient-safety constraints. The study addresses this gap by translating the boundary problem into explicit phase-by-level requirements that can be observed and tested.

Third, the study specified phase-specific checks for cross-site reliability by developing PRISM-HSC as a context-sensitive framework that links adoption phases to the level where work happens and to the assurance required for progress. PRISM-HSC is positioned as an integrative extension that incorporates healthcare-specific elements such as regulatory compliance, clinical safety, and inter-organizational dependencies that are commonly under-modeled in general adoption approaches. The framework defines a small set of practical checks, including actionable explanation at the point of work, stewardship of shared identifiers and formats to prevent drift, basic access and change control for templates and labels, and partner-verifiable validation through logs, conformance evidence, or certifications where relevant.

The unique contribution of this research is therefore not merely another list of barriers and enablers, but a clarifying theoretical account of how adoption travels across sites in healthcare supply chains, and why it stalls at specific phase transitions when gate conditions are missing. PRISM-HSC makes the boundary problem actionable by locating each condition at the correct phase and level and by distinguishing between explanation (which supports safe early use) and verification (which enables acceptance beyond a single organization). By turning a recurring implementation failure into a concise set of phase-by-level propositions and minimal checks, the study provides a transferable basis for cumulative research and for practical adoption design in other high-assurance, regulated supply chains.

The findings should be interpreted with the study's scope constraints in mind, including a bounded set of cases and limited access to standardized, independent performance logs across all partner organizations. Furthermore, while the integration of Cloud ERP and AI offers significant pathways for scaling, a limitation of this study is the high barrier to entry regarding initial data-cleansing costs and the 'black box' nature of AI algorithms, which may clash with the strict regulatory transparency requirements inherent in healthcare supply chain compliance. Future research can operationalize each proposed check as measurable constructs, test causal ordering longitudinally across technologies and

nodes, and quantify how verification strength influences inter-organizational acceptance, routinization stability, and scale outcomes in healthcare supply networks.

References

Aarons, G.A., Hurlburt, M. and Horwitz, S.M., "Advancing a conceptual model of evidence-based practice implementation in public service sectors," *Administration and Policy in Mental Health and Mental Health Services Research*, vol. 38, no. 1, pp. 4–23, 2011.

Alsyouf, A., Alsubahi, N., Alali, H., Lutfi, A., Al-Mugheed, K.A., Alrawad, M., et al., "Nurses' continuance intention to use electronic health record systems: The antecedent role of personality and organisation support," *PLOS ONE*, vol. 19, no. 10, e0300657, 2024.

Damschroder, L.J., Aron, D.C., Keith, R.E., Kirsh, S.R., Alexander, J.A. and Lowery, J.C., "Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science," *Implementation Science*, vol. 4, no. 1, p. 50, 2009.

Damschroder, L.J., Reardon, C.M., Opra Widerquist, M.A. and Lowery, J., "The updated Consolidated Framework for Implementation Research based on user feedback," *Implementation Science*, vol. 17, no. 1, p. 75, 2022.

Davis, F.D., "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quarterly*, vol. 13, no. 3, pp. 319–340, 1989.

Dhruva, S.S., Mahoney, K., Amoroso, P.J., Vangala, S., Fraser, J., Shelton, S., et al., "Exploring unique device identifier implementation and use for real-world evidence: A mixed-methods study with NESTcc health system network collaborators," *BMJ Surgery, Interventions & Health Technologies*, vol. 5, no. 1, 2023.

do Nascimento, I.J.B., et al., "Barriers and facilitators to utilizing digital health technologies by healthcare professionals: A systematic review and meta-analysis," *npj Digital Medicine*, vol. 6, p. 161, 2023.

Evans, T.D., Stupple, A. and Brown, A., "The role of procurement frameworks in responsible AI adoption in the NHS," *BMJ Health & Care Informatics*, 2025.

Fallahnezhad, M., Langarizadeh, M. and Vahabzadeh, A., "Key performance indicators of hospital supply chain: A systematic review," *BMC Health Services Research*, vol. 24, p. 1610, 2024.

Heeres, T.J., Tran, T.M. and van den Noort, B.A.C., "Drivers and barriers to implementing the Internet of Things in the health care supply chain: Mixed-methods multicase study," *Journal of Medical Internet Research*, vol. 25, e48730, 2023.

Ngusie, H.S., et al., "Understanding the predictors of health professionals' intention to use electronic health record systems: Extend and apply UTAUT3 model," *BMC Health Services Research*, vol. 24, 11378, 2024.

Venkatesh, V. and Bala, H., "Technology acceptance model 3 and a research agenda on interventions," *Decision Sciences*, vol. 39, no. 2, pp. 273–315, 2008.

Venkatesh, V. and Davis, F.D., "A theoretical extension of the technology acceptance model: Four longitudinal field studies," *Management Science*, vol. 46, no. 2, pp. 186–204, 2000.

Weik, L., et al., "Understanding inherent influencing factors to digital health adoption," *npj Digital Medicine*, vol. 7, 2024.

Wenderott, K., Hartley, J., Brooks, N., et al., "Effects of AI implementation on efficiency and workload: A systematic review and meta-analysis," *npj Digital Medicine*, vol. 7, p. 248, 2024.

Yadav, A.K., Kumar, P., Singh, A.R., et al., "Blockchain technology and vaccine supply chain: Exploration and analysis of the adoption barriers in the Indian context," *International Journal of Production Economics*, vol. 255, 108708, 2023.

Yadav, P., "Digital transformation in the health product supply chain: A framework for analysis," *Health Systems & Reform*, vol. 10, no. 2, 2386041, 2024.

Biography

Diyun Zhang is a business owner with experience in agricultural commodities and applied research. She recently completed an MSc in Supply Chain Management from the University of Birmingham (Dubai), focusing on digital technology adoption in supply chains and cross-organizational implementation. Her work bridges operational practice and research on scalable, reliable technology use in regulated environments. Diyun holds a bachelors' degree from Emory University(Atlanta, U.S.A.).