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Why Technically Successful Drug-Delivery Innovations Fail in Routine Care: A Critical Interpretive Synthesis of Usability, Infrastructure, Affordability, and Monitoring Constraints, 2017–2025

Peter Nagy[1], Aisha Khan[2]*, Luca Ferrari[3]

[1]Department of Pharmaceutical Technology and Translation, Faculty of Pharmacy, Corvinus University of Budapest, Budapest, Hungary.
[2]Department of Pharmacy Practice and Health Systems, Faculty of Pharmacy, Lahore University of Management Sciences, Lahore, Pakistan.
[3]Department of Clinical Pharmacy and Drug Delivery Translation, Faculty of Pharmacy, University of Florence, Florence, Italy.

***E-mail** ✉ aisha.khan@lums.edu.pk

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ABSTRACT

Drug-delivery innovation is commonly judged through formulation performance, pharmacokinetics, dosing interval, device functionality, safety, or therapeutic efficacy. These achievements are necessary for translation but do not establish that a technology can be delivered repeatedly within ordinary care. This critical interpretive synthesis examined how product requirements interact with patient capabilities and health-system conditions after credible technical or clinical performance has been demonstrated. Targeted searching identified 112 records or documents. After removal of 37 duplicate or version-equivalent records, 75 unique records were screened and 51 underwent in-depth assessment. Thirty-one core sources were retained, and five purposive or theoretical sources were subsequently added, yielding a final synthesis corpus of 36 evidence sources. The synthesis distinguished technical performance from the recurrent work required to preserve that performance in practice. Across long-acting injectable therapy, microneedle and microarray-patch vaccination, inhaler-based delivery, continuous glucose monitoring, and self-injected contraception, recurrent requirements included administration competence, appointment capacity, storage and supply logistics, reimbursement processes, monitoring infrastructure, data interpretation, and patient willingness or capability. Several technologies successfully shifted work away from clinics, demonstrating that operational complexity does not inevitably impede adoption. Conversely, strong efficacy or attractive dosing intervals did not remove the need for reliable service capacity. The evidence supports a conditional interpretation of translation failure: technically successful delivery systems become workable routine care when their technology-specific recurrent requirements can be sustained by the patient, care team, and service environment. The relevant translational question is therefore not whether an innovation is intrinsically simple or complex, but whether the work it requires is feasible where care is actually delivered.

Keywords: Drug-delivery translation, Long-acting drug delivery, Implementation, Human factors, Healthcare infrastructure, Treatment monitoring

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Introduction

Drug-delivery technologies increasingly alter not only how a medicine reaches its biological target but also how treatment is organized. Long-acting parenteral systems can extend exposure and reduce dosing frequency, yet each platform retains formulation-, administration-, and follow-up requirements that determine how it can be used outside controlled development settings [1]. Subcutaneous combination products make the same issue visible at the product–patient interface: injection volume, device configuration, administration time, tolerability, handling,

and patient preference can influence the treatment experience even when pharmacological delivery is satisfactory [2]. Technical performance and routine workability are therefore related outcomes, but they are not interchangeable.

Implementation science already provides strong tools for examining this transition. The updated Consolidated Framework for Implementation Research distinguishes characteristics of an innovation from the inner setting, outer setting, individuals, and implementation processes that surround it [3]. Implementation-outcome research similarly separates acceptability, adoption, appropriateness, feasibility, fidelity, cost, penetration, and sustainability rather than treating uptake as a single endpoint [4]. These approaches establish that context matters. For drug-delivery technologies, however, an additional analytical problem remains: the relevant contextual demand is often generated by the technology itself. A monthly intramuscular injection, a self-administered patch, an inhaler requiring correct technique, or a device producing continuous physiological data does not merely enter an existing service environment; each creates a different recurrent specification for what patients and services must be able to do.

This review therefore examines translation after a delivery innovation has already achieved credible technical or clinical performance. Its central question is which usability, infrastructure, affordability, monitoring, and service conditions explain why some apparently successful delivery technologies become workable routine care while others remain difficult to sustain. The objective is not to rank universal barriers. Instead, the synthesis retains technology-specific mechanisms and asks whether the work required by a product is matched by available patient and service capacity. Contradictory cases are particularly informative: technologies that shift work successfully to patients, clinics that absorb substantial implementation demands, and settings in which technically valuable products remain inaccessible all test the limits of a simple “innovation failure” narrative.

Materials and Methods

Interpretive scope, review unit, and inclusion logic

The review was conducted as a critical interpretive synthesis of evidence published from 2017 through 2025. Eligible evidence addressed a drug-delivery technology, administration platform, monitoring-dependent delivery system, or closely linked service process and contributed directly to at least one of four questions: what counted as technical or clinical success; what recurrent work the technology required; which patient or health-system capacities were necessary to perform that work; and under which conditions apparent success or failure changed. The analytic unit was a distinct empirical study, implementation programme, review, framework paper, or theoretically relevant report. Multiple publications from one programme were retained separately when they provided non-equivalent evidence, such as patient and provider perspectives, but were treated as a common programme when interpreting the number of independent evidence configurations. Eligibility was based on substantive relevance and evidentiary contribution rather than journal quartile. The final synthesis deliberately included clinical trials, implementation studies, qualitative research, observational studies, systematic or scoping reviews, technical reviews, framework papers, and consensus sources because the research question concerned relations among product performance, human use, and service organization rather than a single comparable intervention effect. Methodological and reporting references used only to describe search reporting and the critical interpretive synthesis approach were not counted as synthesis sources.

Technical success was operationalized as demonstrated formulation or device performance and/or credible clinical efficacy and safety under the conditions studied. A care requirement was defined as recurrent skill, resource, workflow, logistical, financial, data, or follow-up work necessary to deliver the technology as intended. Workable routine care denoted repeatable delivery under ordinary service conditions without continuing dependence on exceptional trial-only infrastructure or ad hoc workarounds.

Search, purposive sampling, and theoretical sampling

The search combined targeted retrieval of PubMed-indexed literature, journal and publisher records, citation chaining, and focused methodological searching. Search concepts combined terms relating to drug-delivery translation and implementation with long-acting administration, injectable delivery, microneedles or microarray patches, inhalers, digital monitoring, continuous glucose monitoring, self-administration, usability, human factors, infrastructure, affordability, reimbursement, access, monitoring, workflow, and implementation failure. Search

reporting identifies the information-source types, publication-year limit, and concept domains used in the review, drawing on PRISMA-S terminology [5].

Critical interpretive synthesis permits searching to become progressively more concept-driven as the emerging interpretation is tested against additional evidence [6]. The search therefore proceeded in two distinguishable components. First, structured topic-based retrieval identified the principal clinical, delivery, implementation, access, and monitoring evidence. Second, purposive and theoretical sampling was used to seek disconfirming cases, mechanisms that could produce superficially similar implementation outcomes, and evidence capable of testing whether an emerging interpretation generalized across delivery classes.

The topic-based retrieval identified 112 records or documents. Thirty-seven duplicate or version-equivalent records were removed, leaving 75 unique records for relevance screening. Twenty-four were excluded at that stage, leaving 51 records for in-depth article-level assessment. Twenty were excluded after assessment because they lacked direct relevance to routine delivery, remained exclusively technical or preclinical without a usable care-environment contribution, fell outside the 2017–2025 publication range, or represented non-incremental secondary reporting. Thirty-one core sources were retained. Five additional sources were subsequently added through purposive or theoretical sampling to test the emerging interpretation: Aderoba *et al.* [7] for scale-up and system-dependency testing; Mathias *et al.* [8] for product–patient interface constraints in subcutaneous administration; Karve *et al.* [9] for relocation of administration work in long-acting transdermal delivery; Chien *et al.* [10] for separation of exposure engineering from care delivery; and Pastorin *et al.* [11] for the boundary between technical validation and routine implementation. The final synthesis corpus therefore comprised 36 evidence sources. PRISMA-S [5] and the CIS methodological reference [6] were used for reporting and method description and were not counted in the synthesis corpus.

The distinction between topic-based retrieval and later theoretical sampling is preserved in the review flow rather than collapsed into one conventional screening sequence (**Figure 1**).

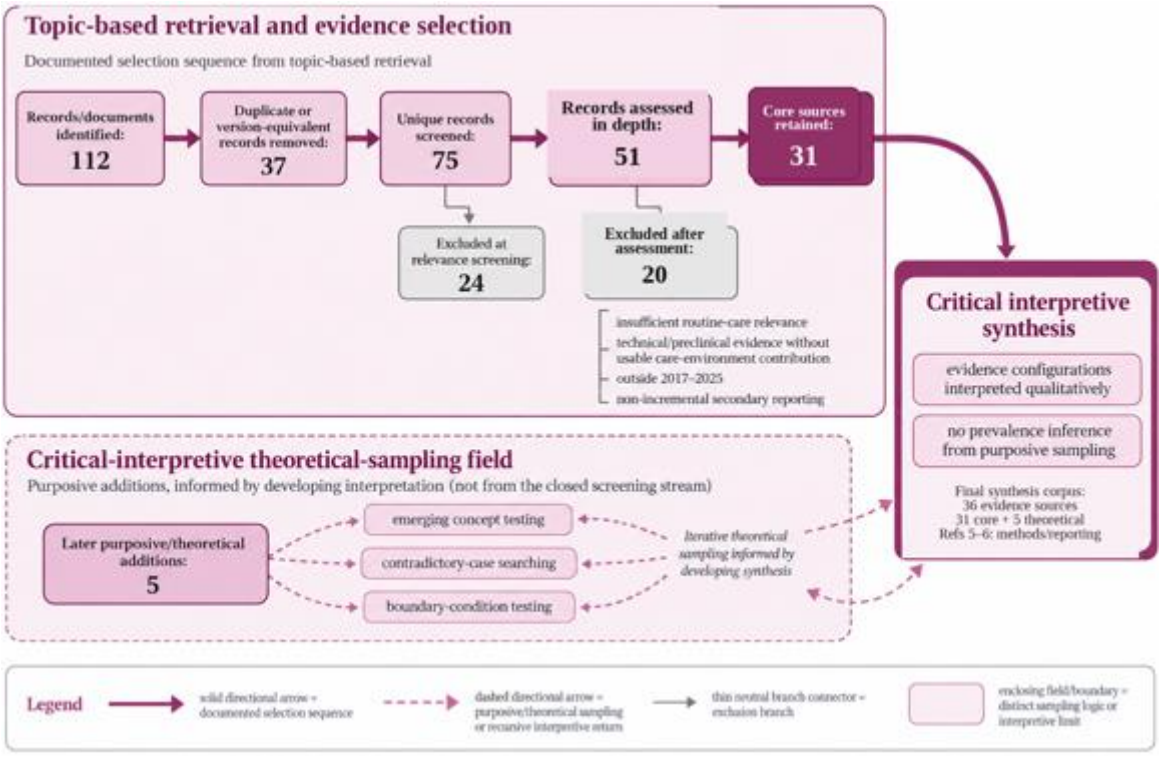

Figure 1. Search, critical selection, and theoretical sampling across the evidence-development process

Evidence extraction, appraisal, and contradiction handling

Extraction was organized around both reported evidence and the limits of the claim each source could support. For empirical studies, fields included technology, population, setting, intervention or design variable, comparator where relevant, implementation or clinical construct, measurement source, main finding, contradictory or null evidence, and applicability boundary. Technical reviews were used for properties such as prolonged release,

administration route, device requirements, or in-vitro/in-vivo translation, but not as evidence that routine implementation had occurred. Implementation and access studies were used to identify observed service demands but not to infer that the same demand occurred at the same frequency elsewhere.

Appraisal was therefore claim-specific. Randomized trials provided comparatively strong evidence for efficacy or continuation under the studied conditions, while qualitative and implementation studies provided direct evidence about workflow, acceptability, staff experience, and implementation determinants. Observational studies were retained for access and use patterns without assigning a single causal explanation to demographic or geographic associations. Reviews and consensus sources were used according to their design and underlying evidence base. Contradictory cases were retained intentionally rather than resolved into a common direction of effect. Formal RoB 2 or ROBINS-I judgments were not assigned because the information available for the retained sources was insufficient for domain-level judgments and because many sources were qualitative, review, consensus, framework, or technical designs for which those instruments are not applicable.

Critical interpretive synthesis and claim calibration

Evidence was compared across technologies using constant comparison of three elements: what the technology achieved, what recurrent work remained after that achievement, and who or what had to perform that work. Similar observed outcomes were not assumed to arise from the same mechanism. Treatment discontinuation, for example, could reflect inability to pay, inability to attend scheduled administration, poor technique, patient refusal, supply interruption, monitoring failure, or biological treatment failure. These mechanisms were kept analytically separate even when they produced the same apparent endpoint.

The synthesis did not calculate pooled barrier frequencies or a universal implementation score. An emerging interpretation was retained only when it remained compatible with disconfirming cases and when its variables could be operationalized without redefining established implementation concepts. The resulting analysis therefore treats technology–care fit as an interpretive relation between recurrent product requirements and sustainable care capacity, not as a new scored framework.

Findings

Technical success leaves a residual care-work specification

Long-acting cabotegravir plus rilpivirine provides an unusually clear example because strong clinical performance was established before many routine-care questions were resolved. In pivotal randomized trials, long-acting cabotegravir and rilpivirine maintained virological suppression with efficacy noninferior to oral comparator regimens under controlled clinical conditions [12, 13]. Extended-interval dosing subsequently showed that administration every eight weeks could remain noninferior to every-four-week dosing through prolonged follow-up [14]. These results establish meaningful pharmaceutical and clinical success: exposure can be sustained, dosing frequency can be reduced, and virological control can be maintained in appropriately selected patients.

The residual operational specification is nevertheless substantial. Long-acting treatment requires medication acquisition, correct storage and handling, repeated attendance within clinically acceptable windows, appropriately trained staff, intramuscular administration, documentation, management of missed or delayed injections, and follow-up when failure is suspected. Patient reports from implementation studies indicate that many people value freedom from daily oral dosing, while provider evidence shows that successful implementation requires deliberate workflow adaptation [15, 16]. In an urban safety-net system, implementation was shaped by staffing, flexible appointments, prior authorization, medication-assistance processes, pharmacy coordination, and other resource constraints that were not visible in the pivotal efficacy endpoint [17]. Populations with ongoing viraemia may require still more individualized implementation strategies and adherence support [18].

The distinction matters because long duration can change the consequences of failure as well as the convenience of success. Detailed evaluation of patients experiencing virological failure after long-acting cabotegravir–rilpivirine illustrates the continuing importance of pharmacokinetic exposure, resistance assessment, patient factors, and clinical follow-up [19]. Such cases do not show that long-acting therapy is broadly unworkable; they show that once a long-acting product has been administered, missed visits, inadequate exposure, or emerging failure cannot always be managed as though the patient had simply missed a short-acting oral dose.

The same analytical separation can be applied to other delivery systems. A technically successful device or formulation specifies what the product can do. Routine implementation additionally depends on what must be

done repeatedly to preserve that performance. **Table 1** separates these evidence functions for the long-acting injectable example.

Table 1. Clinical performance and recurrent care requirements across the long-acting cabotegravir–rilpivirine evidence configuration

Evidence configuration and demonstrated success		Residual care specification			Applicability boundary
Evidence configuration	**Technical or clinical success criterion**	**Delivery cadence or operational feature**	**Care setting represented**	**Residual recurrent care requirement visible in the evidence**	**What the evidence does not establish**
Pivotal monthly maintenance trial	Maintenance of virological suppression with noninferiority to oral therapy	Repeated intramuscular administration	Multinational phase 3 trial sites	Scheduled administration, trained injection delivery, ongoing clinical follow-up	Feasibility in every routine clinic
Long-acting therapy after oral induction	Virological suppression after transition from oral induction	Monthly injectable maintenance	Multinational phase 3 trial sites	Transition procedures, injection appointments, eligibility assessment	Universal patient preference or access
Every-eight-week regimen	Durable virological control with extended dosing interval	Less frequent but still scheduled administration	Multinational phase 3b trial sites	Reliable appointment systems and management of delayed dosing	Elimination of service dependence
Patient implementation experience	Acceptable treatment experience in participating clinics	Repeated clinic-based injections	US implementation sites	Appointment attendance, communication, adaptation to injectable care	Equivalent experience in all populations
Provider implementation experience	Feasible delivery after workflow adaptation	Integration into existing HIV services	US implementation sites	Staffing, training, scheduling, pharmacy and documentation work	Implementation without organizational change
Urban safety-net implementation	Successful programme operation in a resource-constrained system	Clinic-based injectable delivery	Safety-net health system	Prior authorization, medication assistance, flexible appointments, pharmacy coordination	Fixed prevalence of these constraints elsewhere
Documented virological-failure cases	Identification and clinical characterization of failure after switching	Long-acting exposure persists between dosing events	Routine HIV care	Timely recognition, PK/resistance evaluation, follow-up and alternative-treatment planning	Population-level incidence of failure

Administration work can move between patient, clinician, and service

Not all advanced delivery technologies increase professional workload. Some primarily redistribute administration work. Long-acting microneedle systems are being developed precisely because the skin can support minimally invasive delivery while avoiding some requirements of conventional injections [20]. Clinical evaluation of an influenza microneedle patch showed that immunogenicity, safety, acceptability, and self-administration could be examined together rather than treating device delivery as a purely formulation-level problem [21]. Across vaccine microarray-patch studies, systematic review evidence is broadly favorable for usability and acceptability while also showing substantial variation in platforms, study maturity, and outcome measurement [22]. A randomized measles-rubella microneedle-patch trial in The Gambia further demonstrates that technically and clinically credible patch delivery can be evaluated in settings where simplification of conventional vaccine administration could have practical value [23]. Yet mixed-methods evidence also shows that

perceived convenience can coexist with concern about unsupervised or home administration, particularly when users or professionals remain uncertain about safety responsibilities [24].

Inhalers illustrate the opposite possibility: a familiar, portable, apparently simple technology can continue to place substantial work on both user and service. Smart-inhaler implementation has been associated with questions of workflow, payment, data governance, usability, and stakeholder responsibility [25]. More fundamentally, correct administration technique cannot be assumed. A systematic review of healthcare professionals found persistent errors in inhaler demonstration, showing that a delivery route that is technically mature may still depend on repeated instruction and competence at the point of use [26]. The relevant implementation variable is therefore not whether professional work or patient work is intrinsically preferable. It is whether the work is located where the required capability can be sustained.

This distinction prevents self-administration from being treated as a synonym for simplification. Moving an administration task from a clinic to a patient may reduce appointment demand, transport burden, or professional time, but it can also create new requirements for training, storage, confidence, privacy, recognition of adverse effects, and resupply. A delivery innovation succeeds operationally when the transfer of work is feasible for the intended users and service, not merely when a device can technically be operated outside the clinic.

Infrastructure becomes part of the delivery mechanism

Infrastructure becomes analytically inseparable from delivery when treatment performance depends on recurring activities that no formulation can perform by itself. Digital inhalers make this visible because objective sensor data can characterize real-world inhaler use and technique at a granularity unavailable from retrospective recall [27]. That informational advantage is useful only if data can be captured, transferred, interpreted, and incorporated into care. A structured adherence toolkit has demonstrated high usability and feasibility in participating respiratory practices, showing that monitoring-intensive care can be embedded successfully when the surrounding workflow is compatible with it [28].

Continuous glucose monitoring provides an even stronger example of this duality. Population-based evidence indicates that CGM can be associated with lower risks of severe hypoglycaemia and diabetic ketoacidosis than blood-glucose monitoring in young people with type 1 diabetes [29]. International consensus work simultaneously emphasizes that dense CGM data require standardized metrics and clinically interpretable summaries [30]. The device therefore does not end at sensor insertion. It presupposes supply continuity, compatible digital infrastructure, data access, interpretation capability, and clinical processes able to respond to the information generated.

Strong clinical utility also does not guarantee equal realization of that utility. Studies in US diabetes care have documented racial differences in CGM discussion, prescription, initiation, and use [31], as well as disparities in pediatric initiation and continued use [32]. Geographic context can matter independently: rural residence and related service characteristics have been associated with lower CGM use in pediatric populations [33]. Similar concerns are visible in federally qualified health centers, where access to diabetes technology can remain uneven despite the existence of an effective underlying device [34]. These observations do not establish one universal causal pathway from social position to technology use. They show that realized delivery depends on acquisition and continued access as well as pharmacological or device performance.

Self-injected contraception demonstrates that infrastructure requirements can also be deliberately reduced. Randomized evidence from Malawi showed that self-administration of subcutaneous depot medroxyprogesterone acetate could improve continuation compared with provider administration [35], and systematic-review evidence similarly supports higher continuation with self-injection across the available comparative studies [36]. Preference, however, is not uniform: population evidence from several African settings indicates that willingness to self-inject cannot be assumed merely because the technology permits it [37]. Among adolescents and young people in Uganda, self-injection could be performed successfully while privacy and unwanted discovery remained practically important [38]. At health-system scale, implementation reviews identify training, financing, workforce organization, commodity supply, policy integration, and distribution as continuing determinants of successful expansion [7].

Infrastructure should therefore not be represented as a background list of generic barriers. Refrigeration, appointment capacity, professional injection skill, digital connectivity, sensor supply, data interpretation, contraceptive resupply, or privacy are relevant only when a particular technology makes them functionally

necessary. Conversely, when redesign removes a requirement or transfers it successfully to a capable user, infrastructure burden can fall. The translational problem is the match between the recurrent requirement and the setting expected to satisfy it.

Affordability is a continuity mechanism, not a price attribute alone

Affordability becomes a delivery constraint when obtaining the product repeatedly depends on coverage decisions, authorization, administrative work, travel, or service capacity. The safety-net experience with long-acting cabotegravir–rilpivirine shows that prior authorization, medication-assistance processes, pharmacy coordination, and staffing can affect whether scheduled administration remains achievable [17]. Similar dependencies appear around digitally supported inhaler care, where payment and responsibility for monitoring infrastructure influence implementation [25].

Access studies of continuous glucose monitoring make the distinction especially clear. Racial differences in discussion, prescription, and use have been documented within US diabetes services [31], while pediatric studies show that initiation and continued use can diverge across racial and ethnic groups [32]. Rural residence and associated service conditions can further alter realized access [33], and disparities remain visible in federally qualified health centers [34]. These studies do not demonstrate that acquisition cost is the sole mechanism. They show that clinical value can remain unrealized when financing, administrative access, supply continuity, or service reach fails between prescription and sustained use.

Affordability is therefore treated here as continuity of feasible access rather than a single product price. A technology may be affordable at purchase yet operationally inaccessible if repeated authorization, travel, professional administration, consumables, or digital infrastructure cannot be sustained.

Monitoring can create a second delivery system around the product

Monitoring-dependent technologies generate work after the product has been supplied. Digital inhaler sensors can produce detailed event-level evidence about use and technique [27], while structured adherence tools can be feasible when their information can be incorporated into existing clinical workflow [28]. Continuous glucose monitoring illustrates the same principle at greater intensity: substantial clinical utility has been demonstrated in young people with type 1 diabetes [29], but the resulting continuous data stream requires standardized metrics and interpretable clinical summaries [30].

Long-acting treatment creates a different monitoring problem. Because exposure persists after administration, suspected failure may require timely virological, pharmacokinetic, or resistance assessment rather than simply stopping the latest dose [19]. Monitoring is consequently part of deliverability whenever the technology requires data capture, interpretation, follow-up, or recovery actions that must recur alongside treatment.

The technology-specific requirements across the principal evidence configurations are compared in **Table 2**.

Table 2. Recurrent care requirements generated by technically distinct delivery technologies

Technology configuration	Administration work	Time and logistics requirement	Monitoring or information requirement	Access-continuity requirement	User capability that remains consequential
Provider-administered long-acting therapy — Long-acting CAB/RPV	Professional intramuscular administration	Scheduled repeat visits; drug acquisition and clinic coordination	Virological follow-up; failure investigation when indicated	Coverage, authorization, medication supply	Willingness and ability to attend injection visits
		User-applied or self-injected delivery			
Vaccine microarray patch	Patch application may shift toward user or minimally trained personnel	Product distribution and appropriate storage	Post-vaccination safety assessment appropriate to product and programme	Reliable vaccine and patch supply	Correct application and confidence in unsupervised use
DMPA-SC self-injection	Administration transferred partly to user	Training, resupply, safe storage and	Follow-up appropriate to contraceptive service	Commodity availability and distribution	Injection competence,

		repeat dosing interval			preference and privacy
Data-intensive chronic devices					
Inhaler / smart inhaler	Repeated patient technique	Device availability and replacement	Technique/use data may require review and response	Device coverage and digital-service support	Correct inhalation technique and device handling
Continuous glucose monitoring	Sensor insertion/replacement and continuous wear	Recurrent sensor supply and compatible digital access	Continuous data generation, standardized interpretation and clinical response	Ongoing coverage and consumable supply	Sensor use, response to information, data engagement

Contradictory cases reveal conditional fit rather than universal barriers

The evidence does not support a hierarchy in which greater technological complexity inevitably produces poorer implementation. Long-acting HIV therapy can be integrated successfully after workflow adaptation, despite substantial scheduling and pharmacy requirements. Microneedle vaccination can reduce dependence on conventional injection skills, although perceptions of unsupervised use remain context dependent [24]. Monitoring tools can achieve high usability in participating services even when similar technologies encounter implementation constraints elsewhere [28].

Self-injected contraception provides a stronger disconfirming case. Randomized evidence showed improved continuation with DMPA-SC self-administration in Malawi [35], and meta-analysis supports a continuation advantage across available comparative studies [36]. Yet preference for self-injection is not uniform [37], and privacy can remain salient for younger users [38]. Scale-up still requires training, commodity supply, financing, policy integration, and workforce planning [7].

Thus, the relevant contrast is not technologically simple versus technologically complex. It is whether a particular configuration of work is sustainable for the patient and service expected to perform it.

Table 3. Contradictory evidence configurations that test a universal barrier interpretation

Technology	**Fit contrast**		**Condition-dependent interpretation**	
Technology	**Evidence of successful fit**	**Evidence of constrained fit**	**Variable that changes between configurations**	**Interpretation supported**
Long-acting HIV therapy	Durable efficacy and feasible implementation after clinic adaptation	Authorization, staffing, scheduling and occasional failure-management demands	Clinic organization and support capacity	Strong clinical performance can coexist with variable operational fit
Vaccine microarray patches	Favorable early clinical usability and acceptability	Concern about unsupervised or home administration	Required supervision and user confidence	Reduced administration burden is conditional rather than automatic
Digital inhaler care	Detailed objective use data and feasible adherence assessment	Payment, workflow, technique and data-governance constraints	Ability to convert device data into routine care	Information generation is not equivalent to usable monitoring
Continuous glucose monitoring	Important clinical benefit	Unequal initiation, persistence and access across populations/settings	Financing, geography and service reach	Efficacy and equitable realization are separate outcomes
DMPA-SC self-injection	Improved continuation and demonstrated self-administration	Variable preference, privacy concerns and scale-up requirements	User preference, training and commodity systems	Moving work to patients can help when the transferred work is acceptable and supportable

Results and Discussion

What a technology–care fit interpretation adds to implementation frameworks

Established implementation frameworks already distinguish innovation characteristics, context, individuals, processes, and implementation outcomes [3]. The present synthesis does not replace those constructs. Its narrower contribution is to preserve the technology-generated requirement as an explicit analytical unit. An injectable

requiring professional administration, a self-injection system, a sensor producing continuous data, and an inhaler requiring learned technique may all encounter "feasibility" problems, but the work generating that problem differs. The relation is therefore directional in both practical and analytical terms: product design determines recurrent requirements, while care environments determine whether those requirements can be sustained. Successful redesign can reduce, relocate, or eliminate work; abundant service capacity can absorb demanding technologies; and failure can persist for biological reasons even when service capacity is adequate. **Figure 2** represents these conditional relationships without imposing a common gate sequence.

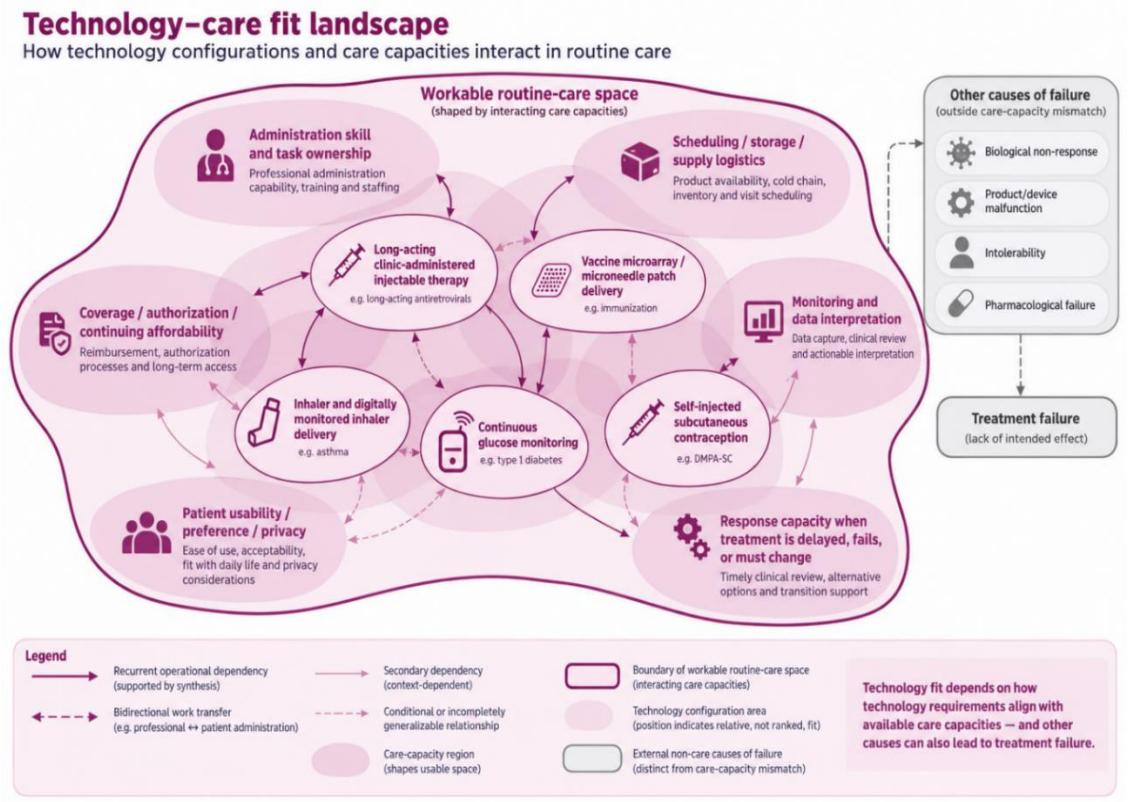

Figure 2. Technology-specific care requirements reshape the space in which delivery remains workable

Implications for formulation development, trials, procurement, and service design

Care requirements should be characterized before late implementation whenever they arise predictably from product design. Subcutaneous tolerability depends jointly on formulation, injection conditions, device characteristics, and the patient interface [8]. Long-acting transdermal systems likewise redistribute administration and formulation constraints rather than simply removing them [9]. Prodrug strategies can extend exposure through deliberately engineered release and conversion kinetics [10], while long-acting in-vitro/in-vivo correlation requires formulation-specific mechanistic validation [11].

These advances concern different levels of translation, but together they show why technical validation should be accompanied by an explicit description of recurrent care work. Trials can document who administers treatment, what scheduling flexibility exists, what monitoring is necessary, and what happens after missed or failed dosing. Procurement can evaluate repeated service cost and consumable availability alongside acquisition price. Service redesign can then target the requirement actually produced by the technology rather than applying a generic implementation intervention.

Boundary conditions, disconfirming cases, and testable propositions

The interpretation would be weakened if technologies repeatedly failed despite adequate administration skill, reliable supply, affordable access, appropriate monitoring, and willing users. Such cases would require biological, pharmacological, device, or other explanations. It would also be weakened if a requirement assumed to be essential could routinely be absent without loss of safe and sustained delivery.

Conversely, evidence from self-administration predicts that reducing or successfully relocating recurrent professional work can improve continuity when the transferred task is acceptable and supportable. The synthesis therefore makes no claim that technologically demanding products are inherently difficult to implement. Its narrower prediction is that routine workability will deteriorate when a recurrent, consequential requirement exceeds the sustainable capacity of the patient or service expected to meet it.

Table 4. Evidence-derived interpretive propositions and the observations that would challenge them

Proposed interpretive proposition	Evidence configuration supporting it	Disconfirming or limiting configuration	Observation that would weaken the proposition
Persistent or relocated care work			
Technical success leaves recurrent care work	Long-acting injectable therapy remains appointment- and service-dependent after efficacy is established	Some services absorb the work successfully	Durable use despite persistent absence of requirements presumed essential
Administration burden can be relocated	Microneedle patches and self-injection move tasks toward users	Safety, privacy, preference or training may constrain self-use	No improvement when work is transferred to capable, willing users with adequate support
System continuity dependencies			
Infrastructure can function as part of delivery	Scheduled injections, digital inhaler monitoring and CGM depend on service or data systems	Compatible workflows can make demanding technologies feasible	Equivalent performance where the supposedly required infrastructure is consistently absent
Affordability affects continuity through more than price	Coverage, authorization, recurrent consumables and geographic access influence realized use	Resource-rich systems may absorb these demands	Sustained equal access despite large, persistent differences in these requirements
Monitoring can create an additional care system	CGM, digital inhalers and long-acting failure management require information capture and response	Some monitoring tools integrate efficiently into routine workflow	Equivalent safe use without the monitoring capability considered necessary
Explanatory boundary — Care fit is not a complete theory of failure	Biological failure, resistance, intolerance and device malfunction can occur despite service capacity	—	Any attempt to explain these failures solely through implementation mismatch

Conclusion

Technically successful drug-delivery innovations do not enter routine care as pharmacological products alone. They carry recurrent requirements for administration, logistics, access, monitoring, interpretation, and user participation. Those requirements differ by technology and can be reduced, relocated, or absorbed successfully; consequently, no universal barrier hierarchy explains translation.

The evidence supports a conditional conclusion. Strong technical or clinical performance is most likely to remain workable when the recurrent requirements generated by the delivery system fit the sustainable capabilities of the patient, care team, and service environment. When that fit is poor, clinical value may remain inaccessible despite an effective technology. When fit is strong, even operationally demanding systems can become routine care. Drug-delivery translation should therefore be evaluated as the joint performance of the product and the environment required to keep it functioning.

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