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Military medicine in transparent large-scale combat operations: rethinking medical timelines as operational planning variables

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ABSTRACT
Large-scale combat operations (LSCO) are increasingly shaped by persistent surveillance, precision strike capability, electronic warfare, contested mobility and repeated attacks on healthcare personnel and facilities. These conditions challenge a core assumption of military medical planning: that casualties can be moved rapidly and predictably through a linear evacuation chain. This article asks how commanders and medical planners should treat medical timelines when evacuation, protection, logistics and information are themselves contested. Drawing on a directed qualitative content analysis of doctrinal, empirical, institutional and clinical sources, it identifies three linked mechanisms: evacuation becomes a contested operational activity rather than a predictable transport function; clinical responsibility shifts forward across an extended continuum of care and survivability depends on interdependence among mobility, protection, logistics, command-and-control, information and clinical capability. The implication is not that rapid evacuation has become obsolete, but that fixed evacuation timelines are brittle planning assumptions in transparent LSCO—a battlespace in which persistent, multi-domain surveillance makes concealment, massing and uncontested evacuation difficult. Military medicine should therefore be planned as a coupled operational capability that shapes course of action development, command risk assessment, wargaming and force generation. The policy challenge is to design medical systems that preserve combat power when movement, visibility, capacity and information are contested.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Large-scale combat operations expose casualty evacuation, treatment nodes and healthcare infrastructure to surveillance, precision strikes, air denial, electronic warfare and mass-casualty pressure. Prolonged and delayed evacuation are recognised but their implications for operational planning remain poorly integrated.

WHAT THIS STUDY ADDS

⇒ Three recurring mechanisms—contested evacuation, forward displacement of clinical responsibility and system interdependence—show that medical timelines are conditional operational variables rather than fixed assumptions.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Medical timelines should be treated as conditional operational planning variables and military medicine integrated into operational design, command risk assessment, wargaming and force generation.

INTRODUCTION: THE UNRESOLVED PROBLEM

Military medicine has long assumed that casualties can be moved through a broadly predictable chain of care, reaching progressively higher levels of treatment within clinically desirable timelines. That assumption underpins modern combat casualty care doctrine and has shaped force design, medical planning and operational decision-making for decades. Contemporary large-scale combat operations (LSCO) increasingly challenge whether this still holds.

Persistent intelligence, surveillance and reconnaissance (ISR), precision strike capability, electronic warfare, dense unmanned systems and contested mobility have altered the operational environment.[1–4] Evacuation routes, collection points, medical facilities and supporting logistics are now observable, targetable and vulnerable to disruption; rather than protected support activities, they have become part of the battlespace itself. The 2022 full-scale invasion of Ukraine—an escalation of a war that began in 2014—provides the most comprehensive contemporary illustration. The WHO has verified more than 3000 attacks on healthcare in Ukraine, while operational reporting describes drone- and missile-driven delay, displacement of medical facilities and rising requirements for prolonged casualty care under persistent threat.[5–7]

These developments do not invalidate established principles. Rapid haemorrhage control, early resuscitation and timely surgery remain the clinical standard because they optimise survival.[8–11] The challenge is operational rather than clinical. Commanders must simultaneously balance force protection, mission, manoeuvre, enemy action and medical support. Medical planners must therefore communicate the operational consequences of delayed evacuation rather than assume that ideal timelines can always be achieved.

Throughout, *transparent LSCO* denotes a battlespace rendered continuously observable by persistent, multi-domain ISR, precision strikes, electronic warfare and dense unmanned systems, in which casualty movement, medical facilities and logistics remain detectable and potentially

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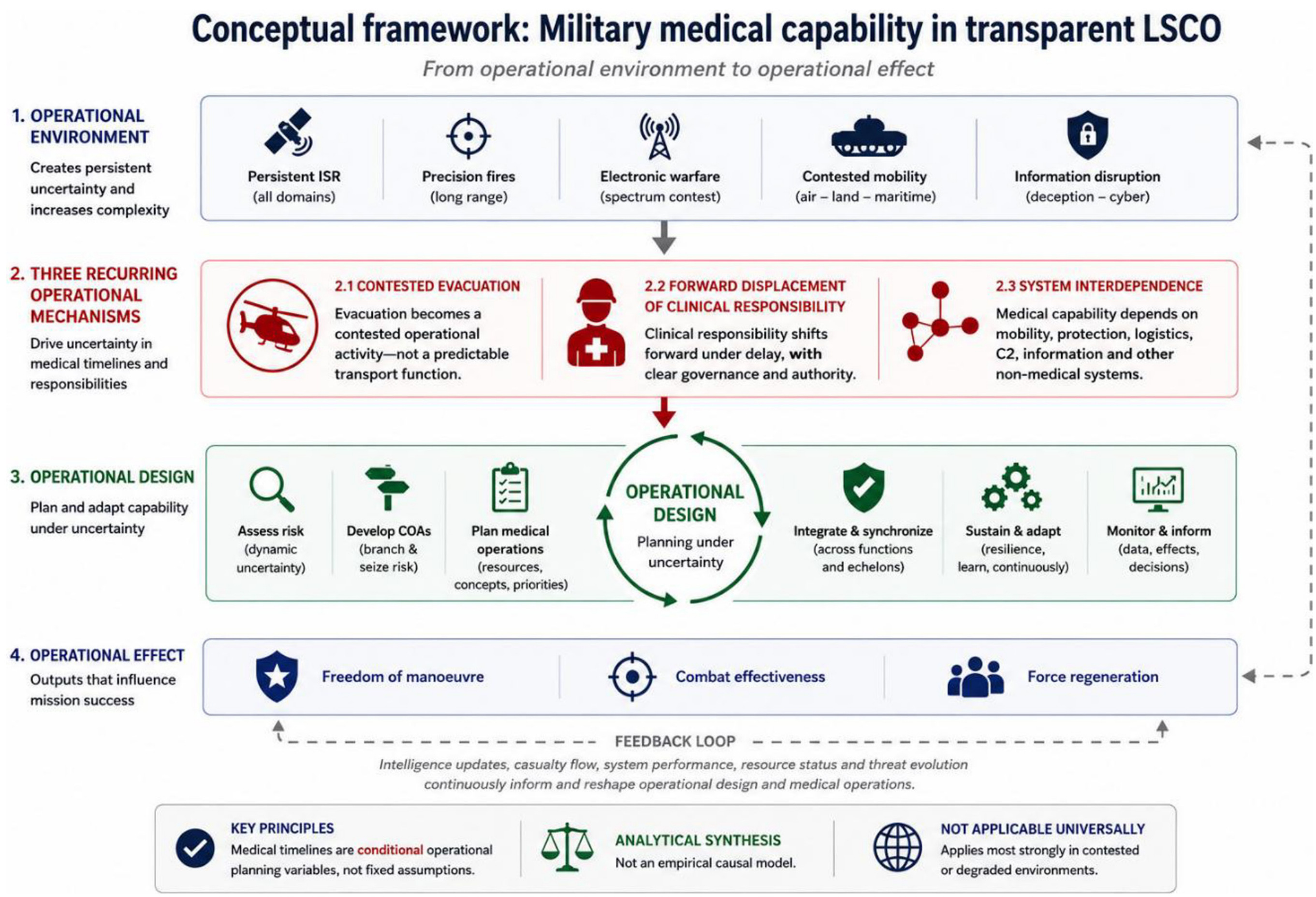

Figure 1 Conceptual framework illustrating how transparent large-scale combat operations (LSCO) reshape military medical capability through three recurring operational mechanisms: contested evacuation, forward displacement of clinical responsibility and system interdependence. These mechanisms influence operational design by transforming medical timelines from fixed planning assumptions into conditional operational variables. The framework represents an analytical synthesis derived from the present study and is intended as a conceptual aid for operational planning rather than an empirical causal model. C2, command-and-control; ISR, intelligence, surveillance and reconnaissance.

targetable. Under these conditions medical timelines become conditional rather than guaranteed.

Existing work describes many individual facets of this shift—prolonged casualty care, contested evacuation, dispersed medical support, medical logistics, attacks on healthcare—but largely as separate problems. Less attention has been paid to how they interact as one operational system, or how their combined effect bears on command decision-making, tempo and force generation. This article argues that, in transparent LSCO, military medicine must be understood as a system-of-systems capability whose performance depends on mobility, protection, logistics, command-and-control, information and clinical governance.[12 13] When these assumptions fail, medical risk is transmitted into operational risk—expressed as lost tempo, constrained manoeuvre and degraded combat power. The central question shifts from whether ideal timelines can always be achieved to how capability should be designed when they cannot. The conceptual framework developed from the directed qualitative content analysis is summarised in figure 1.

ANALYTICAL APPROACH

This article is presented as an analysis paper rather than a systematic review. It applies *directed qualitative content analysis* to identify recurring system-level mechanisms across contemporary doctrine, peer-reviewed research, clinical guidance, institutional reporting and operational analysis rather than to estimate treatment effects. This analytical approach follows the principles of directed qualitative content analysis described by Hsieh and Shannon.[14] Relevant sources were identified through structured searches of PubMed, Web of Science, Scopus and Google Scholar (last updated 17 May 2026), supplemented by targeted retrieval of NATO doctrine, Joint Trauma System clinical practice guidelines, WHO publications and other institutional reports. Sources were screened for operational relevance against predefined analytical themes. The identification, screening, coding framework and reflexive audit trail are described in full in the online supplemental material. No original patient, participant or classified operational data were analysed; all sources were publicly available.

Mechanism 1: evacuation becomes contested and prolonged

The first mechanism is that evacuation is no longer a reliable constant. Under persistent ISR and precision strikes, moving casualties can expose routes, vehicles, evacuation windows and medical nodes, turning evacuation from a medical transport problem into a contested tactical activity that competes with manoeuvre, concealment, deception, fire support, airspace control and asset preservation. Ukraine provides the strongest contemporary empirical illustration; missiles and drones have extended the battlefield, pushed care facilities rearward,

Table 1 Turning medical assumptions into operational planning questions

Planning assumption	Why it is brittle in transparent LSCO	Command/staff question	Evidence needed during planning/execution
Rapid evacuation	Air denial, ISR, interdiction and exposed routes can make movement intermittent.	What happens if MEDEVAC is unavailable for 8–12 hours?	Evacuation windows, route risk, asset availability, holding capacity.
Forward care	Responsibility shifts forward faster than training, governance and logistics may follow.	Which tasks can safely move below Role 2, and with what support?	Competence, blood/oxygen, monitoring, documentation, escalation criteria.
Protected medical nodes	Legal protection does not remove detectability or targetability.	How are medical signatures, dispersion and redundancy managed?	Node location, hardening, mobility, deception, force protection.
C2 and data	Poor casualty tracking degrades triage, routing and operational assessment.	When does medical overload change tempo, routes or objectives?	Casualty flow, Role 2 saturation, blood depletion, handover quality.
Civil-military surge	Military casualty flow may become a national health-system problem.	When do military medical assumptions depend on civilian capacity?	Cross-border pathways, hospital capacity, legal authorities, liaison structures.

C2, command-and-control; ISR, intelligence, surveillance and reconnaissance; LSCO, large-scale combat operations.

delayed definitive trauma care and increased the requirement for prolonged casualty care from point of injury to Role 2+.[6] Other LSCO analyses describe 8–12-hour evacuation delays and comparable pressure on forward stabilisation.[15–17] These findings do not abolish the clinical value of speed; they show that speed depends on air superiority, route security, concealment, communications, asset availability and tactical risk. The planning error is to convert an aspirational clinical standard into an assumed operational guarantee.

Mechanism 2: clinical responsibility shifts forward

The second mechanism is a forward displacement of clinical responsibility. Tactical Combat Casualty Care remains foundational, but delayed evacuation increasingly makes it the beginning rather than the end of forward care.[8–10] Recent LSCO work describes casualty care as a continuum—point-of-injury care, en-route care, damage control resuscitation, forward surgery and prolonged casualty care—rather than brief stabilisation followed by rapid evacuation.[18–22] Forward personnel must therefore sustain casualties for longer, managing reassessment, analgesia, antibiotics, warming, monitoring, documentation and handover under austere conditions.[9–11 18–20] This strengthens resilience, but only when matched by training, blood and oxygen supply, equipment, communications, clinical governance and decision support. Where responsibility shifts forward without that adaptation, the system redistributes risk to less supported personnel rather than reducing it.

Mechanism 3: survivability depends on system interdependence

The third mechanism is system-level interdependence. The same casualty can have very different prospects depending not only on injury and first-responder action but on evacuation windows, protection of medical nodes, availability of blood and oxygen, documentation quality and whether command-and-control preserves clinical information across handovers. Medical data are therefore not merely administrative. Consistent with NATO medical doctrine, they underpin casualty regulation, routing, prioritisation and operational assessment while enabling recognition of Role 2 saturation, blood depletion or casualty accumulation.[2 23 24] In LSCO, *delayed recognition of medical overload can become delayed recognition of operational culmination*. International humanitarian law protects medical personnel, vehicles and facilities, yet contemporary conflict shows repeated attacks on healthcare;[5 25 26] under persistent ISR, legal status alone cannot guarantee survivability, and signature management, dispersion, mobility, hardening, redundancy and integration with force protection become medical enablers. Military medicine is therefore best understood not as a linear evacuation chain but as a coupled operational system whose performance emerges from these interactions—the relationship the figure is intended to convey. The figure is a conceptual synthesis, not an effect-size model, and should be read as a staff-planning aid.

Table 2 Planning implications for contested LSCO

Planning implication	What it requires
Make evacuation uncertainty explicit in operational design	Treat evacuation timelines as a variable (range+confidence) and stress-test courses of action against degraded evacuation windows during wargaming.
Define forward-care thresholds and clinical authority	Specify which tasks move forward under delay, with clear governance: escalation criteria, decision authority, documentation and handover standards.
Resource “forward-care packages”, not isolated skills	Provide integrated packages—competence, blood/oxygen, warming, monitoring, analgesia/antibiotics, communications and sustainment—wherever responsibility shifts forward.
Integrate casualty flow into C2 as an operational metric	Track holding capacity, evacuation backlog, blood depletion and data/handover quality, with pre-defined decision triggers for tempo, route or objective adjustment.
Protect the medical system as a signature-management and force-protection problem	Plan dispersion, mobility, redundancy, deception and hardening of medical nodes; assume legal protection alone is insufficient under persistent ISR and fires.
Build logistics resilience for contested movement	Stress-test blood/oxygen supply chains, resupply intervals, spares and repair of evacuation assets and alternate routes, including civil–military interfaces.
Standardise coalition assumptions for interoperability	Align expectations for MEDEVAC versus CASEVAC, forward clinical authority, data standards and civil-system absorption to avoid “same terms, different assumptions”.

C2, command-and-control; ISR, intelligence, surveillance and reconnaissance.

From medical support to operational design

These mechanisms suggest that the central task is no longer to preserve traditional timelines under all circumstances, but to design operations for when they cannot be met. Medical timelines remain clinically important; they should simply be treated as conditional planning variables whose feasibility depends on threat, mobility, protection, logistics and command decisions, rather than as fixed constants.

This changes the role of military medicine in planning. Instead of a downstream service that reacts to decisions already taken, medical analysis should inform force design, course-of-action comparison, casualty estimates, force posture, dispersion, sustainment and tempo before combat begins. For the medical planner, the task is not only to meet a fixed surgical window but to weigh threat and protection against it; a hardened, dispersed or protected facility beyond the notional timeline may offer greater overall resilience than an exposed one within it. The central planning question is not whether established timelines remain desirable—they unquestionably do—but whether the residual clinical risk of delayed evacuation is recognised, articulated and consciously accepted within the operational plan. Medical timelines thereby become one input to command risk assessment, which the commander may knowingly accept rather than bend the tactical plan to satisfy.

The same principle applies during battle. When evacuation windows close, blood stocks fall, documentation degrades, communications are disrupted or forward holding saturates, the problem is not confined to the medical chain; it may alter tempo, reserve employment, routes and objectives. Casualty flow should therefore be read as an operational indicator, not only a medical metric. After battle, the same system supports return-to-duty, replacement, rehabilitation and learning, so medical capability shapes not only survival but the regeneration of combat power over time.[23 27–29]

For NATO and national planners, this reaches beyond medical doctrine. AJP-4.10[1], AJMedP-2[2] and AJP-5[3] provide sound anchors for medical support, evacuation and operational-level planning, but transparent LSCO demands explicit assumptions about evacuation uncertainty, forward-care thresholds, casualty tracking, cross-border movement, civil–military integration and continuity of medical information when MEDEVAC cannot be assumed. The question is not only whether a force has medics, ambulances or Role 2 capacity, but whether that capacity can be reached, protected, supplied, connected and kept clinically effective under observation and strikes. Table 1 turns these assumptions into staff questions; its aim is not to prescribe a universal model but to expose assumptions that often remain implicit, which matters most where allies share terminology but hold different expectations about evacuation, forward authority, tracking, legal risk and civilian health-system absorption.

Recommendations and operational implications

These mechanisms translate into seven planning implications for contested LSCO, summarised in table 2. They are offered as design principles rather than a fixed model and apply most strongly where the battlespace is contested or degraded rather than as a universal baseline for all NATO operations.

Boundaries of the argument

This analysis examines operational mechanisms; it does not estimate incidence, effect size or patient-level probability, and its findings are a conceptual framework for planning under transparent LSCO rather than universal rules. The analytical corpus was constructed for conceptual sufficiency rather than exhaustive coverage. Directed qualitative content analysis was selected because it allows heterogeneous evidence—including doctrine, empirical studies, clinical guidance and institutional reports—to be interpreted within a common analytical framework while remaining anchored in predefined analytical concepts. This analytical approach follows the principles described by Hsieh and Shannon.[14] Ukraine provides the richest illustration of transparent LSCO, but the mechanisms are not derived from it alone; doctrine, NATO publications and other theatres support the broader reading, and the mechanisms are accordingly best treated as a model for contested or degraded LSCO rather than a universal NATO baseline. As with any interpretive method, the findings reflect the framework applied; this was mitigated through predefined themes, eligibility criteria, evidence-role labelling, reflexive memos, independent coding of a stratified subset and documented consensus, all set out in the online supplemental file. Future work should test these mechanisms with prospective operational data, simulation and multinational exercises—quantifying evacuation uncertainty, medical-system resilience and casualty-flow dynamics, and linking medical capability to tempo, force regeneration and command decision-making.

CONCLUSION

Transparent LSCO make evacuation, treatment capacity, protection, logistics and information part of operational design. Under persistent surveillance, precision strikes, contested mobility and degraded evacuation, medical timelines can no longer be treated as fixed assumptions; they are conditional operational variables. The three mechanisms—contested evacuation, forward displacement of clinical responsibility and system interdependence—show that survivability depends on interactions among clinical care, protection, logistics, mobility, command-and-control and information, not on individual interventions alone. The central policy question is no longer only to improve battlefield medicine but to design medical systems that stay effective when movement, communication and support are themselves contested. Military medicine should therefore be integrated into operational design before combat, continuously inform adaptation during operations, and enable force regeneration afterwards. In transparent LSCO, medical capability is not simply a consequence of operational planning—it is one of its determining conditions.

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