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Systemic Challenges in the Pre-Hospital Medical Reporting Framework: A NATO-Aligned Concept Development and Experimentation Study

Systémové výzvy v rámci přednemocničního zdravotnického hlášení: Studie rozvoje konceptů a experimentování v souladu s NATO

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Abstract: Pre-hospital medical reporting is critical for MEDEVAC activation and Medical C2. However, NATO exercises frequently reveal data inconsistencies and information loss. This study evaluates information flow within a Czech Army mechanized battalion and verifies a new Pre-Hospital Care (PHC) concept designed to address these friction points.
A Table-Top Exercise (TTX) involving forty participants was conducted to test the concept. Results revealed significant deviations from NATO standards (9-liner, MIST), with critical information loss occurring between company and battalion levels. Conversely, the PHC concept demonstrated improved structure, clarity, and time discipline. The study concludes that the PHC concept effectively addresses systemic shortcomings, offering a user-friendly tool to enhance Medical C2. It recommends further validation in field exercises (LIVEX) and gradual integration into national training and doctrine.

Abstrakt: Přednemocniční hlášení je klíčové pro aktivaci MEDEVAC a efektivní velení (Medical C2). Ačkoliv doktríny NATO vyžadují strukturovaná data, praxe

ukazuje na časté nekonzistence a ztráty informací. Tato studie prezentuje výsledky experimentu (TTX) u mechanizovaného praporu AČR, který ověřoval nový koncept přednemocniční péče (PHC) s cílem tyto problémy zmírnit. Do experimentu se zapojilo 40 účastníků celého řetězce péče. Výsledky odhalily výrazné odchylky od standardů NATO, zejména u hlášení 9-liner a MIST, a kritickou ztrátu dat mezi stupněm rota a prapor. Testování konceptu PHC naopak prokázalo zlepšení ve struktuře, srozumitelnosti i časové disciplíně a byl účastníky hodnocen kladně. Studie uzavírá, že koncept PHC má potenciál stát se efektivním nástrojem pro Medical C2. Doporučuje se jeho další validace v polních podmínkách (LIVEX) a integrace do výcviku.

Keywords: MEDEVAC; Medical C2; NATO CD&E; PHC Concept. Pre-hospital Care; Tactical Medicine.

Klíčová slova: MEDEVAC; Medical C2; NATO CD&E; přednemocniční péče; Taktická medicína.

1 INTRODUCTION

Pre-hospital care (PHC) constitutes the most critical and vulnerable segment of the medical support chain in modern military operations. The collection, structure and transmission of casualty information directly influence the accuracy of triage, the timeliness of MEDEVAC activation, and the situational awareness (SA) available to tactical and medical decision-makers. NATO doctrine clearly articulates the requirement for *standardised, complete, and timely medical reporting* as an integral component of Medical Command and Control (Medical C2) (AJP-4.10 2019; AJMedP-2 2018; MC 326/4 2018). However, despite this strong doctrinal basis, cumulative operational experience demonstrates that reporting practices often deviate substantially from doctrinal expectations.

Multinational exercises, analyses and discussions produced by the NATO Committee of the Chiefs of Military Medical Services (COMEDS) and the NATO Centre of Excellence for Military Medicine (MilMed CoE) consistently highlight systemic deficiencies in reporting behaviour: incomplete MEDEVAC requests, omission of time markers, inconsistent MIST briefing, fragmented information transfer between platoon, company and battalion levels, and cognitive overload of TOC staff under stress (MilMed CoE 2019; MilMed CoE 2022; COMEDS 2020). These issues are not isolated events, but recurring patterns observed across allied armed forces including the USA, UK, NLD, POL, SVK, HUN and others. The persistence of these deficiencies suggests a structural challenge rather than a nation-specific issue, warranting systematic analysis and experimentation.

1.1 NATO Doctrinal Context and Known Systemic Gaps

AJP-4.10 (2019) defines the medical support framework and the responsibilities of commanders at each echelon, specifying the flow of medical information required for operational effectiveness. AJMedP-2 (2018) further details the standardised reporting formats—9-liner and MIST—and the mandatory time markers that form the backbone of interoperable MEDEVAC processes. However, Lessons Learned from large-scale NATO exercises repeatedly demonstrate that these formats are seldom used as intended under operational conditions (MilMed CoE 2019; COMEDS 2020). Documentation from the *Vigorous Warrior* (multinational medical exercises) series and Allied medical evaluations indicate recurrent issues:

- incomplete or unstructured reporting,
- missing mechanism-of-injury and vital sign data,
- inaccurate or absent time markers (T0, TX, T_MEDEVAC call),
- multiple retransmissions due to ambiguous or partial information,
- reduced synchronisation between tactical and medical SA,
- delays in MEDEVAC activation attributable to communication gaps.

These patterns reveal a mismatch between doctrinal expectations and actual reporting behaviour, underscoring the need for more intuitive tools and reinforced training in Medical C2.

1.2 National PHC and C2 Framework in the Czech Armed Forces

The Czech Armed Forces (CAF) structure their medical support system in alignment with NATO doctrine and national regulations such as Med-22-1 (Role 1 Capability), Med-6-2 (Medical Support to Training), and SOP 3-2/450 (Medical Evacuation) (Šedivcová et al. 2023). Within a mechanised battalion, the PHC chain comprises:

- Combat Lifesavers (CLS) at the squad level,
- Platoon leaders (PL) and company commanders (CC) responsible for tactical consolidation of medical information,
- the Battalion Tactical Operations Centre (TOC) as the Medical C2 hub,
- Role 1 personnel charged with triage, treatment, and onward movement.

Internal unit assessments and previous exercises have identified similar friction points to those observed in NATO exercises:

- high variability in quality and completeness of CLS reports,
- inconsistent use of structured reporting formats (9-liner, MIST),
- information fragmentation across PL – CC – TOC transitions,
- insufficient integration of medical reporting tasks into routine manoeuvre training,
- lack of coherent filtering of tactical and medical information at TOC,
- incomplete medical information reaching Role 1 medical personnel.

These challenges confirm that the CAF face the same foundational problem observed across NATO: the reporting chain is vulnerable to information loss, particularly under stress, radio congestion, and tactical complexity.

1.3 Rationale for Developing the Pre-Hospital Care (PHC) Concept

The Pre-Hospital Care (PHC) concept was created to address these systemic deficiencies and to reduce friction in the reporting chain. The PHC concept introduces a simplified and operationally intuitive reporting format, designed to support first responders and tactical commanders in producing clear, complete, and standardised medical reports even under demanding conditions. The concept emphasises:

1. Essential information only, reducing cognitive load compared to more complex formats.
2. Mandatory time markers, improving chronological accuracy of events.
3. Balance of tactical and clinical data, addressing the needs of both commanders and Role 1 personnel.
4. Compatibility with NATO reporting expectations, enabling potential interoperability.
5. Ease of training, even for non-medical personnel (CLS, PL, CC).

Given that the challenges identified in CAF reporting closely resemble those documented across NATO, evaluating the PHC concept within a structured experimental framework may generate insights of relevance beyond national boundaries.

1.4 Aim, Research Questions, and Hypotheses

Aim

The aim of this study is to experimentally assess the effectiveness of the PHC concept in improving the accuracy, completeness and structure of medical reporting within the PHC chain of a mechanised battalion, and to determine the potential applicability of the concept in broader NATO Medical C2 contexts.

Research Questions (RQ)

RQ1: How accurate and complete is the medical information transmitted through the CLS → PL → CC → TOC → Role 1 reporting chain under current CAF procedures?

RQ2: In what areas does current practice diverge from NATO doctrinal requirements (AJP-4.10; AJMedP-2)?

RQ3: Does the PHC concept reduce information loss and improve reporting effectiveness during the exercise?

RQ4: Are the observed patterns, challenges and effects of the PHC concept potentially relevant to other NATO member states?

Hypotheses

H1: The current reporting chain demonstrates systemic information loss at multiple echelons, particularly between VR and TOC.

H2: The PHC concept improves structure, clarity and completeness of medical reporting compared to existing practice.

H3: Given the NATO-wide patterns of reporting deficiencies, the findings from this experiment may hold broader NATO relevance.

2 METHODS

This study was conducted as an exploratory Discovery Experiment following the NATO Concept Development and Experimentation (CD&E) framework (ACT 2021) and the Manual for Medical Experimentation in Exercises (NATO 2020). The aim was to analyse the flow, accuracy, and completeness of medical information within a mechanised battalion during a controlled Table-Top Exercise (TTX), and to assess the potential contribution of the Pre-Hospital Care (PHC) concept to reducing known frictions in Medical Command and Control (Medical C2).

The methodological approach combined structured scenario design, observer-based data collection, time tracking, questionnaires, and cross-source comparison of findings.

2.1 Study Design and CD&E Framework

The study was designed as a CD&E Discovery Experiment, which focuses on identifying patterns, feasibility, and operational relevance of a concept rather than statistically testing hypotheses. The experiment followed the standard CD&E phases: scoping, design, execution, analysis, and insights.

A Table-Top Exercise (TTX) format was selected to enable controlled observation of communication processes and information flow. The TTX allowed standardised inject delivery and reduced confounding factors such as physical movement or environmental stressors, while preserving functional realism.

2.2 Operational Setting and Scenario Development

The experiment was conducted within the organisational structure of a mechanised battalion of the Czech Armed Forces (CAF), representing the standard configuration of the 7th Mechanised Brigade. The command structure, medical support chain, and reporting pathways were modelled in accordance with Czech and NATO doctrine.

2.2.1 MEL/MIL Scenario Construction

Detailed scenarios, including full inject sequences and casualty profiles, are provided in Supplementary Material S1.

Two tactical-medical incidents were developed using the MEL/MIL (Main Event List / Main Incident List) methodology:

- Incident 1: Initial attack with multiple casualties
- Incident 2: Follow-on incident requiring sequential decision-making and MEDEVAC activation

Each scenario included:

- predefined mechanism-of-injury profiles,
- time-stamped injects,
- decision points at CLS, PL, CC, TOC, and Role 1 levels,
- expected reporting requirements,
- communication pathways allowing observation of potential information degradation.

2.3 Participants and Organisational Roles

A total of 40 personnel participated, representing all levels of the PHC and Medical C2 chain:

- Combat Lifesavers (CLS) (n = 14)
- Platoon leaders (PL) (n = 8)
- Company commanders (CC) (n = 4)
- TOC staff (n = 6)
- Role 1 personnel (n = 3)

In addition, 15 trained observers were assigned to individual echelons to collect structured data.

Participants performed their actual operational roles; no role simulation or substitution was used.

2.4 PHC Concept and Briefing

The PHC concept represents a simplified reporting tool designed to support clear, structured transmission of essential medical information. It includes:

- a reduced set of essential reporting elements,
- mandatory time markers,
- integration of tactical and clinical information,
- compatibility with NATO reporting principles.

The concept was introduced through a short pre-exercise briefing focused on explaining its structure and use. No practical training or rehearsal was conducted prior to the exercise.

Participants also did not receive refresher training on standard NATO reporting formats (9-liner, MIST). This design aimed to reflect routine operational conditions and to assess the intuitive usability of the PHC concept.

2.5 Data Collection

Data were collected using multiple complementary instruments. A structured overview of all parameters and measurement methods is provided in Supplementary Material S2.

2.5.1 Questionnaires

Questionnaires were administered immediately after the exercise and before the After-Action Review (AAR), ensuring independent individual responses.

Four questionnaires targeted:

- participants (reporting behaviour, SOP use),
- observers (report quality),
- TOC personnel (decision usability),
- Role 1 personnel (clinical usability).

A binary coding scheme was applied: YES = 1, NO = 0, missing = X.

Full questionnaires are provided in Supplementary Material S3.

2.5.2 MEL/MIL Time Tracking

Designated observers recorded time markers at each echelon:

- T0 – casualty occurrence
- TX – first CLS intervention
- T_report – report transmission
- T_MEDEVAC call – MEDEVAC activation
- T_load – simulated handover

Data were recorded in real time using structured templates. Where applicable, consistency was cross-checked across observer records.

2.5.3 Structured Observation Sheets

Observers at each echelon used structured observation sheets (Supplementary Material S4) to record:

- completeness and structure of reports,
- missing or unclear information,
- adherence to reporting procedures,
- retransmission frequency,
- indicators of information integration between tactical and medical domains.

Behavioural indicators (e.g. stress, overload) were recorded using predefined observational criteria and interpreted qualitatively.

2.5.4 After-Action Review (AAR)

A structured AAR followed the exercise. Qualitative data from participant and observer discussions were analysed using thematic coding to identify recurring patterns.

2.6 Outcome Measures and Analytical Framework

Measures of Performance focused on procedural aspects of reporting, including:

- completeness of predefined reporting elements,
- use of structured formats,
- presence of time markers,
- frequency of omitted or distorted information,
- adherence to SOP 3-2/450 (national MEDEVAC procedure).

"Completeness" was defined as the presence of predefined elements derived from MIST and selected MEDEVAC-relevant data.

2.6.1 Measures of Performance (MoP)

MoP focused on procedural accuracy, including:

- completeness of initial and follow-up reports,
- use of structured formats (9-liner, MIST)
- presence and accuracy of time markers,
- rate of omitted or distorted information,
- consistency with SOP 3-2/450.

2.6.2 Measures of Effectiveness (MoE)

- MoE assessed operational usability, including:
- usability of reports for TOC decision-making,
- timeliness of MEDEVAC activation (time markers),
- clinical usability at Role 1,
- observed frictions across echelons,
- These aspects were assessed using observer ratings, questionnaire responses, and time data,
- Data aligned with NATO doctrinal expectations (AJP-4.10, 2019; AJMedP-2, 2018).

2.6.3 Analytical Approach

Data analysis combined:

- descriptive statistics (questionnaires, time data),
- qualitative thematic analysis (observer records, AAR),
- cross-source comparison (triangulation).

Triangulation was performed by comparing findings across independent data sources. Patterns identified consistently across sources were interpreted as more robust within the exploratory framework.

2.7 Ethical and Administrative Considerations

The study involved no real patients and no medical interventions. All activities were conducted within standard military training.

Approval was obtained from the Brigade and Battalion Command, the Military Medicine Division, and the Military Faculty of Medicine (University of Defence).

3 RESULTS

This section presents the quantitative and qualitative findings derived from the Discovery Experiment. Results are structured along the Measures of Performance (MoP) and Measures of Effectiveness (MoE) defined during the planning phase. Data triangulation included structured questionnaires (YES = 1, NO = 0, X = missing), observer evaluation sheets, MEL/MIL timeline analysis and After-Action Review (AAR) transcripts. Together, these sources provide a comprehensive picture of information flow, reporting accuracy and the operational impact of the PHC concept.

3.1 Participant Overview and Data Completeness

Forty personnel participated in the experiment, covering all functional roles of the PHC and Medical C2 chain:

- CLS (n = 14),
- Platoon leaders / PL (n = 8),
- Company commanders / CC (n = 4),
- TOC staff (n = 6),
- Role 1 personnel (n = 3),
- Observers (n = 15).

Questionnaire response coverage was 92%, with missing data coded as X. Observer coverage was complete for all echelons.

3.2 SOP Awareness, Perceived Sufficiency and Application (MoP)

Table 1: Knowledge and Use of SOPs (n = 40)

Item	YES (%)	NO (%)
Unit has established medical SOP	83%	17%
I know the SOP content	85%	15%
SOP is sufficient for PHC/MEDEVAC	35%	65%
Training routinely follows SOP	40%	60%
Regular MEDEVAC System/PHC training	38%	62%

Observed response patterns suggest that, despite high reported awareness of SOPs, their perceived sufficiency and routine application remain limited.

Observers captured this mismatch in statements such as: "The SOP exists, but platoon and company commanders often rely on free-text radio communication.""Soldiers know about the SOP but do not operate through it."

3.3 Personnel and Material Conditions (Observers' Evaluation)

Table 2: Observer Assessment (n = 15)

Area	YES (%)	NO (%)
Personnel level sufficient	10%	90%
Material support sufficient	0%	100%

Observer assessments indicated limited personnel and material readiness across the exercise.

3.4 Reporting Behaviour and Use of Structured Formats

Analysis showed variability in the use of structured NATO reporting formats (9-liner and MIST), with frequent omissions of selected elements. A proportion of reports were transmitted in an unstructured (ad hoc) manner. A total of 24% of reports omitted pre-defined essential medical information (mechanism of injury, vital signs, or treatment performed).

3.5 MEL/MIL Timeline Analysis and Reporting Delays (MoE)

Observers recorded key time markers, allowing reconstruction of event chronology. Observed delays across reporting segments showed consistent patterns, as illustrated below:

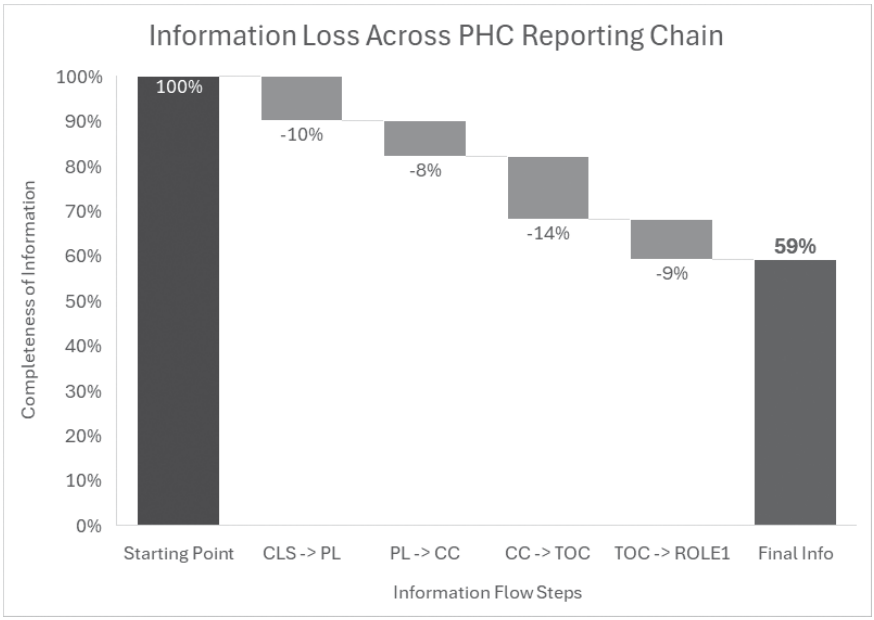
Table 3: Average Delays

Reporting Segment	Mean Delay (min)	Range	Notes
CLS → PL	**3.5 min**	1–7	Incomplete or unclear initial reports
PL → CC	**4.2 min**	2–8	Information consolidation varied greatly
CC → TOC	**6.1 min**	3–11	Largest information degradation occurred here
TOC → Role 1	**7.0 min**	4–12	Fragmented input slowed MEDEVAC activation

3.6 Information Loss Across Echelons

Based on quantitative and qualitative evidence, information degradation followed this pattern:

Figure 1 (textual representation): Information Loss



Information degradation across echelons was associated with:
- inconsistent terminology,
- omission of mechanism-of-injury and time markers,
- mixing tactical and medical content,
- repeated clarifications.

3.7 Qualitative Findings from Observers and AAR

Theme 1 – CLS Performance

CLS often focused on clinical tasks at the expense of reporting discipline. Time markers were frequently missing.

"MIST was rarely completed in full."

Theme 2 – Platoon Leaders and Company Commanders (PL, CC)

CC frequently transmitted free-text summaries rather than structured reports, leading to substantial loss of detail.

"Information forwarded by CC was often incomplete or ambiguous."

Theme 3 – TOC Workload and Information Reconstruction

TOC staff struggled to merge fragmented tactical and medical data streams under time pressure.

"TOC had to rebuild the story from pieces, delaying MEDEVAC activation."

Theme 4 – Role 1 Clinical Information Deficits

Role 1 received inadequate mechanism-of-injury data in several cases.

"Arrival information was insufficient for effective triage."

3.8 Perceived Value and Utility of the PHC Concept

Observers reported the experiment as useful, and a majority recommended further use of similar exercises and consideration of the PHC concept in training.

Qualitative feedback included:

"PHC concept is clearer and more user-friendly than current practice."

"Even with minimal briefing, soldiers applied it intuitively."

"PHC was reported to reduce ambiguity and support TOC decision-making. These findings confirm RQ1 and RQ2."

3.9 Summary of Findings

The experiment identified variability in medical reporting, information loss across echelons, and deviations from structured reporting practices. Observations also suggested potential improvements in clarity and usability when the PHC concept was applied.

4 DISCUSSION

The results suggest that the current reporting chain is associated with information loss, variability in the use of structured formats, and deviations from NATO doctrinal expectations. At the same time, the PHC concept appeared to improve clarity and reduce friction in tactical-medical communication.

Given the exploratory nature of the study and the limited number of participants at certain echelons, quantitative findings should be interpreted as indicative patterns rather than statistically generalisable results. The study relies on triangulation of multiple data sources to strengthen validity.

4.1 Reporting Performance in the Context of NATO Doctrine

The findings indicate that reporting practices may diverge from expectations established in NATO doctrine. AJP-4.10 (2019) outlines the imperative for timely, structured information transmission, and AJMedP-2 (2018) specifies the use of mandatory reporting formats such as the 9-liner and MIST, including chronological markers (T0, TX, T_MEDEVAC call). However, in this experiment:

- the 9-liner was only sporadically used in a complete and structured manner across observed cases,
- the MIST format was complete in fewer than 20 % of reports,
- a substantial proportion of transmissions omitted essential medical information.

These observations are consistent with previously reported NATO-wide issues, where reporting variance and incomplete MEDEVAC requests appear as recurring themes (MilMed CoE 2019; MilMed CoE 2022; COMEDS 2020). The pattern observed in this battalion-level experiment is therefore fully consistent with multinational observations and should be interpreted with caution and in the context of broader multinational observations.

The temporal analysis further supports this conclusion: delays were not random but clustered at the same vulnerability points repeatedly documented in Allied exercises, particularly the transition between company command (CC) and the battalion TOC.

4.2 Mechanisms of Information Loss and Systemic Vulnerabilities

The findings suggest several factors associated with information degradation across echelons:

1. **Fragmented verbal transmission** – reports often consisted of short, unstructured messages rather than structured, complete formats.
2. **Cognitive overload at TOC** – appears to be a consequence of fragmented and incomplete information flow. TOC personnel were required to reconstruct incomplete information while simultaneously managing tactical inputs.
3. **Omission of time markers** – missing or inconsistent chronological data slowed MEDEVAC activation.
4. **Insufficient integration of tactical and medical reporting tasks** – tactical leaders (PL, CC) often prioritised manoeuvre reporting over medical structure.
5. **Under-resourcing of medical support** – material and personnel insufficiencies (0–10 % observer satisfaction) amplified procedural weaknesses.

These patterns are consistent with previously described challenges in Medical C2. The observed degree of information loss—particularly at the CC–TOC interface— was substantial and consistently identified across data sources, particularly between CC and TOC. This is consistent with reports, is consistent with reports from the *Vigorous Warrior* and other NATO exercises, where the same C2 junction represents a known weak link (MilMed CoE 2019; COMEDS 2020). This further underscores that observed deficiencies reflect systemic behaviour within Medical C2.

4.3 Added Value and Operational Potential of the PHC Concept

The PHC concept was associated with several potential advantages:

1. **Increased Completeness of Reports:** Observers reported fewer omissions, improved clarity, and better time marker usage when PHC was applied.
2. **Improved Clarity and Standardisation:** The format's concise structure allowed both medical and non-medical personnel to provide essential information reliably.
3. **Better Time Discipline:** The requirement to record T0, TX and downstream time markers led to more consistent chronological data.
4. **Lower Cognitive Burden:** Even with minimal prior instruction, participants understood and applied the PHC format intuitively.
5. **High user acceptability:** More than 90 % of observers and participants recommended adopting PHC concept in regular training.

These findings suggest that the PHC concept may improve reporting consistency and usability under the conditions tested.

Given the alignment of observed deficiencies with NATO-wide patterns, the PHC concept has potential for broader applicability within Alliance Medical C2. Its simplicity and low training requirement make it a strong candidate for multinational experimentation.

4.4 Implications for Training, Doctrine and Interoperability

These observations suggest several areas where training and doctrine could be further developed:

4.4.1 Integrating Structured Reporting into Routine Unit Training

The divergence between SOP knowledge (85 %) and SOP application (40 %) underscores a need for regular, scenario-based training in medical reporting for CLS, PL and CC. Reporting tasks must be inherent to manoeuvre training—not an isolated medical activity.

4.4.2 Revising and Harmonising SOPs

The clear discrepancy between SOP sufficiency (35 %) and actual operational needs suggest the need for doctrinal revision. Incorporating the PHC concept or PHC-derived elements may help streamline SOPs and harmonise them with AJMedP-2 expectations.

4.4.3 Strengthening TOC Medical C2 Competencies

The TOC remains a critical node and a systemic bottleneck. Targeted training in Medical C2, structured information management and prioritisation under time pressure could significantly improve MEDEVAC coordination.

4.4.4 Enhancing NATO Interoperability

Given that similar issues are present in numerous NATO forces (MilMed CoE 2019; MilMed CoE 2022), findings from this experiment should be shared with:

- COMEDS Medical Evacuation working group,
- MilMed CoE working groups,
- NATO medical doctrine development teams.

The PHC concept could be explored as a complementary reporting tool during multinational exercises.

4.5 Strengths and Limitations

Strengths

- **High ecological validity:** Real functional roles were preserved, increasing realism.
- **Multi-source triangulation:** Quantitative results were supported by qualitative observer data and AAR insights.
- **CD&E methodological rigour:** The study followed ACT guidance and the Manual for Medical Experimentation (ACT 2021; NATO 2020).

Limitations

- **TTX format constraints:** Although ideal for observing communication processes, TTX cannot fully replicate the stressors of a field environment. A LIVEX is required for validation.
- **Single-unit sample:** Results reflect one mechanised battalion; broader generalisation requires further studies.
- **Short familiarisation with PHC concept:** Minimal pre-training may have influenced the learning curve—but also demonstrates the concept's usability.
- The study did not capture the recency of participants' prior training in medical reporting, which may have influenced individual performance. Future research should include this variable to allow more detailed analysis of training effects.
- The absence of inferential statistical analysis limits the strength of causal conclusions.

4.6 Summary

The findings suggest that deficiencies in medical reporting within the Czech Armed Forces are consistent with patterns described in NATO exercises.

The findings suggest that deficiencies in medical reporting within the Czech Armed Forces mirror those documented across NATO. Information loss, inconsistent use of structured formats and cognitive overload at TOC represent systemic issues are consistent with systemic patterns that degrade Medical C2 across the Alliance. The PHC concept appears to offer a potentially useful approach to improving clarity and reducing reporting variability.

5 CONCLUSION

This Discovery Experiment provided a comprehensive evaluation of pre-hospital medical reporting within a mechanised battalion of the Czech Armed Forces and assessed the operational potential of the Pre-Hospital Care concept as a tool to improve Medical Command and Control (Medical C2). Through integrated quantitative and qualitative analysis, several important findings emerged that have direct implications for unit training, national doctrine and NATO interoperability.

5.1 Summary of Key Findings

1. **The current reporting chain was associated with information loss.** Significant degradation of information occurred across CLS → PL → CC → TOC → Role

1, with the greatest loss observed between CC and TOC. This led to delays, incomplete situational awareness and uncertainty in MEDEVAC decision-making.

2. **Structured reporting formats are inconsistently used in practice.** Despite high knowledge of SOPs, structured formats (9-liner, MIST) were used inconsistently and often incompletely across observed situations. This gap between doctrinal expectations and operational behaviour reflects well-documented NATO-wide challenges.

3. **The PHC concept was associated with improved clarity, completeness and time discipline.** Observers consistently noted that PHC reports were more coherent and easier to interpret, even with minimal pre-training. The format reduced cognitive burden and helped mitigate information loss across reporting echelons.

4. **Participants expressed strong support for the PHC concept.** More than 90% of observers recommended integrating PHC into routine training and pursuing further experimentation, including field-based validation.

5. **The experiment's findings align with NATO Lessons Identified.** The documented reporting issues mirror those repeatedly observed in multinational NATO exercises, suggesting that these challenges may be systemic rather than nation-specific. This increases the potential relevance of the PHC concept at the Alliance level.

5.2 Answers to Research Questions

RQ1 – Accuracy and completeness of current reporting:

Reporting was consistently observed as incomplete, inconsistent, and subject to significant information loss across echelons, especially between company and battalion levels.

RQ2 – Divergence from NATO doctrine:

Multiple deviations from AJP-4.10 and AJMedP-2 were identified, including incomplete 9-liners, missing MIST fields and absence of time markers.

RQ3 – Effectiveness of the PHC concept:

The PHC format improved reporting accuracy, structure and usability across all echelons. It demonstrated operational feasibility and strong user acceptance.

RQ4 – NATO relevance:

Because the observed deficiencies reflect well-established Alliance-wide patterns, the PHC concept has clear potential for broader NATO applicability and multinational experimentation.

5.3 Implications and Recommendations

1. Integrate structured reporting into routine manoeuvre training for CLS, PL, CC and TOC personnel.
2. Revise and harmonise unit SOPs to incorporate clearer, more intuitive reporting standards, potentially including PHC or PHC-derived elements.
3. Conduct a Validation Experiment (LIVEX) to test PHC under full operational conditions.
4. Strengthen Medical C2 competencies at TOC, particularly in information filtering, prioritisation and MEDEVAC decision-making.
5. Share findings with NATO medical working groups, including COMEDS and MilMed CoE, to explore multinational relevance and potential doctrinal integration.

5.4 Final Remarks

Ensuring accurate, timely and standardised transmission of medical information remains a critical requirement for the survival of casualties and the effectiveness of military medical support. This study demonstrated that the PHC concept provides a practical and low-burden tool to enhance Medical C2 at the battalion level. Its simplicity, user acceptance and alignment with NATO Lessons Identified indicate clear potential for operational value, both nationally and within the Alliance.

Future experimentation and multinational collaboration should continue to refine and validate the concept, contributing to improved medical interoperability, doctrinal coherence and readiness across NATO.

LIST OF ABBREVIATIONS

CAF	The Czech Armed Forces
CC	Company commander
CLS	Combat Life Saver
COE	Centre of Excellence
COMEDS	NATO Committee of the Chiefs of Military Medical Services
MIST	Mechanism of Injury, Injuries, Signs, Treatment

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Supplementary Material S1
Scenario Design and Casualty Profiles

1. Scenario description (MEL/MIL context)

The TTX scenarios were constructed using a MEL/MIL (Main Event List / Main Incident List) framework reflecting battalion-level defensive operations. Tactical context was derived from standard operational planning elements (e.g., defensive posture, unit deployment, and enemy activity).

The scenario simulated a defensive operation with the following general parameters:

- readiness for defence: 09:00
- operational time (incident initiation): 09:50
- friendly forces activity: occupation of platoon defensive positions
- enemy activity: preparatory fires preceding assault

The MEL/MIL structure enabled controlled delivery of time-stamped injects, supporting observation of information flow, reporting behaviour, and decision-making across echelons.

2. Scenario structure (example extract)

Time	Event	Tactical context	Expected action	Expected reporting
09:50	Start of enemy fire	Fire preparation phase	CLS intervention	Initial casualty report
+2 min	Casualty identified	Platoon defensive position	Treatment + report to PL	MIST / PHC
+5 min	Multiple casualties	Company sector	Consolidation	Report to CC
+8 min	CC communication	Battalion level	MEDEVAC request	9-liner / PHC
+12 min	TOC decision	Battalion TOC	MEDEVAC activation	Confirmation to Role 1

3. Casualty profiles (MIST framework)

Standardised casualty profiles were developed using the MIST structure (Mechanism, Injuries, Signs, Treatment) and used as scenario injects.

The dataset included multiple casualty categories (P1–P3). To ensure clarity and reproducibility, the full P1 dataset and representative examples of P2 and P3 categories are provided below.

P1 – Critical casualties (complete set)
P1 – Critical casualties (complete set)
P1/1
- *M: Gunshot injury (chest and abdomen)*
- *I: Open pneumothorax, open abdominal wound*
- *S: Pulse 110/min, respiration 22/min, conscious, no active bleeding*
- *T: Chest seal, abdominal dressing, fentanyl 800 µg*

P1/2
- *M: Gunshot injury (face and neck)*
- *I: Severe facial trauma, penetrating neck injury*
- *S: Pulse 115/min, respiration 25/min, impaired consciousness, active bleeding*
- *T: Airway management (nasopharyngeal airway), wound packing*

P1/3
- *M: Gunshot injury (chest and lower limb)*
- *I: Open pneumothorax, penetrating injury to thigh*
- *S: Pulse 80/min, respiration 23/min, impaired consciousness, active bleeding*
- *T: Chest seal, tourniquet (lower limb), fentanyl 800 µg*

P1/4
- *M: Combined burn and gunshot injury*
- *I: 2nd–3rd degree burns (upper extremities, face), gunshot wound to lower limb*
- *S: Pulse 115/min, respiration 23/min, conscious, active bleeding*
- *T: Burn dressing, tourniquet, fentanyl 800 µg*

P1/5
- *M: Fragmentation injury*
- *I: Injuries to chest and upper extremities*
- *S: Pulse 100/min, respiration 21/min, impaired consciousness, active bleeding*
- *T: Chest seal, tourniquet (upper limb), fentanyl 800 µg*

P1/6
- *M: Fragmentation injury with burns*
- *I: Chest injury, 2nd–3rd degree burns (face and upper extremities)*
- *S: Pulse 100/min, respiration 21/min, conscious, no active bleeding*
- *T: Chest seal, burn dressing, airway support, fentanyl 800 µg*

P1/7
- *M: Fragmentation injury (head and lower extremities)*
- *I: Severe head injury (including brain involvement), bilateral thigh injuries*
- *S: Pulse 30/min, respiration 10/min, impaired consciousness, active bleeding, vomiting*
- *T: Head wound dressing, bilateral tourniquets*

P1/8
- *M: Fragmentation injury (chest and abdomen)*
- *I: Open pneumothorax, open abdominal wound*
- *S: Pulse 110/min, respiration 22/min, conscious, no active bleeding*
- *T: Chest seal, abdominal dressing, fentanyl 800 µg*

P1/9
- *M: Fragmentation injury (abdomen and lower extremities)*
- *I: Open abdominal wound, bilateral thigh injuries*
- *S: Pulse 32/min, respiration 14/min, conscious, active bleeding*
- *T: Abdominal dressing, bilateral tourniquets, airway support, fentanyl 800 µg*

P1/10
- *M: Explosion injury*
- *I: Traumatic amputation of both upper extremities*
- *S: Pulse 38/min, respiration 25/min, impaired consciousness, active bleeding*
- *T: Bilateral tourniquets, fentanyl 800 µg*

P2 – Representative sample
P2/1
- M: Gunshot injury
- I: Penetrating injury to left upper limb (arm)
- S: Pulse 62/min, respiration 18/min, conscious (alert), active bleeding
- T: Tourniquet

P2/3
- M: Gunshot injury
- I: Bilateral thigh injuries
- S: Pulse 72/min, respiration 20/min, impaired consciousness, active bleeding
- T: Bilateral tourniquets

P2/5
- M: Explosion
- I: Burn injury to left upper limb
- S: Pulse 62/min, respiration 20/min, conscious, no active bleeding
- T: Burn dressing

P2/7
- M: Combined gunshot and explosion injury
- I: Gunshot wound to lower limb and burn injury to upper limb
- S: Pulse 75/min, respiration 20/min, conscious, active bleeding
- T: Burn dressing, tourniquet

P2/10
- M: Fragmentation injury
- I: Bilateral lower limb injuries
- S: Pulse 55/min, respiration 18/min, conscious, active bleeding
- T: Bilateral tourniquets

P3 – Representative sample
P3/1
- M: Concussion
- I: Mild traumatic brain injury
- S: Stable, conscious, headache, confusion
- T: Monitoring

P3/3
- M: Gunshot injury (simple)
- I: Upper limb injury without complications
- S: Stable, conscious, limb pain
- T: Wound dressing

P3/7
- M: Blunt trauma
- I: Closed fracture of upper limb
- S: Stable, conscious, swelling and pain
- T: Immobilisation

P3/10
- M: Laceration
- I: Superficial wounds (back and chest)
- S: Stable, conscious, minor bleeding
- T: Wound dressing

4. Casualty distribution overview

Category	Role in scenario
P1	Critical casualties requiring MEDEVAC decision-making
P2	Moderate casualties requiring prioritisation
P3	Minor casualties contributing to reporting load

Supplementary Material S2
Measured Parameters and Data Collection Framework

The study used a structured set of quantitative and qualitative parameters to evaluate reporting performance and Medical Command and Control (Medical C2) effectiveness.

Parameter	Type	Measurement method	Data source
Report completeness	Binary	Presence of required elements (MIST/PHC)	Observer
Structured reporting use	Binary	Use of 9-liner / MIST / PHC	Observer
Time delays	Continuous (min)	MEL/MIL time tracking	Observer
Time markers presence	Binary	T0, TX, MEDEVAC call	Observer
Clarity of report	Qualitative	Structured observer rating	Observation sheet
Need for clarification	Binary	Retransmissions recorded	Observer
TOC usability	Binary/qualitative	Questionnaire	TOC
Clinical usability	Binary/qualitative	Questionnaire	Role 1

Parameter	Type	Measurement method	Data source
Information loss	Derived	Missing data across echelons	Triangulation

Measurements were based on a combination of binary coding, time tracking, and structured qualitative observation, enabling cross-validation of findings.

Supplementary Material S3
Questionnaires
Standardised questionnaires were used to collect perspectives from training participants, observers, TOC personnel, and Role 1 personnel immediately after the exercise. The questionnaires included:

- assessment of SOP awareness and usage,
- perceived quality and completeness of reporting,
- usability of information for decision-making,
- perceived benefits of the PHC concept.

Full questionnaires are provided below (original language preserved).

Supplementary Material S4
Observation Framework
Observers used structured observation sheets to evaluate reporting behaviour across all echelons.

Parameter	Description
Completeness	Presence of key report elements
Structure	Use of standard format
Clarity	Ease of interpretation
Communication flow	Who reports to whom
Communication method	Radio / phone / data
Time to report	Processing duration
Retransmissions	Need for clarification
Medical–tactical integration	Presence of both clinical and tactical data

Behavioural indicators such as stress, overload, and confusion were assessed using observable markers (e.g., hesitation, repeated clarification requests, fragmented communication).