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Predictive Logistics for Class VIIIa in Large-Scale Combat Operations

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Abstract: As the People's Republic of China emerges as the pacing threat for the United States, strategic focus has rapidly shifted from counterinsurgency (COIN) environments, as seen in Operation Enduring Freedom/Iraqi Freedom (OEF/OIF) to large-scale combat operations (LSCO), paralleling both World Wars and the Korean War (Lt. Col. Graham, 2023). The possibility of a LSCO in the Indo-Pacific Command (INDOPACOM) region poses long-unseen challenges, with expected casualty volumes that will quickly surpass those of OEF/OIF, as well as limited opportunity for resupply and casualty evacuation. Therefore, developing a process to predict the casualty stream would help optimize the efficiency of equipping the Army Medical System with the proper supplies and personnel needed to respond to mass casualty events. Initial calculations indicate that 73.2% of the casualties will be disease-related, 9.20% non-battle injury (NBI) related, and 17.6% wounded in action (WIA). These calculations will be used to conduct simulations through software that predicts the Class VIIIa supplies necessary to sustain Role 1 medical care in a LSCO in INDOPACOM.

Keywords: LSCO, INDOPACOM, DNBI, Predictive Logistics, Class VIIIa, Role 1 Medical Care

1. Introduction

Since the United States ended the long-lasting war in Afghanistan in 2021, the U.S. military diverted its primary focus from counterinsurgency (COIN) warfare to preparation for forecasted near-peer conflict and large-scale combat operations (LSCO). The possibility of a LSCO poses various new challenges to the U.S. military, primarily near-peer enemies' capabilities to deny the freedom of maneuver for both Casualty Evacuation (CASEVAC) and resupply of Class VIIIa, the class of supply which encompasses all medical supplies other than blood and blood products. Pertaining to these challenges, the U.S. questions whether its capacity to support the expected casualty stream in LSCOs is sufficient (LTC Marsh & CPT Hampton, 2023, p.106). In anticipation of these challenges, the Medical Capability Development Integration Directorate (MED CDID) is working to develop requirements for a predictive simulation model for Class VIIIa demand in combat. A predictive model for Class VIIIa will provide commanders at echelon the ability to prioritize medical equipment, synchronize assets for resupply operations, and anticipate casualty streams during LSCO.

2. Research

Research for a predictive logistic model stemmed from understanding past LSCOs, non-battle injuries (NBI) induced from recent conflicts, and potential diseases prevalent in the area of operations within INDOPACOM. Casualty streams from World War II, and the Cold War were used to understand wounded-in-action (WIA) rates that might exist in a future LSCO. The admission rates during World War II illustrated the WIA and disease nonbattle injury (DNBI) admissions throughout multiple years of the war (The Ohio State University, n.d.). Additionally, data developed in preparation for an outbreak of conflict during the Cold War found in FM 101-10-1 was referenced for its projections of casualties characterized as either DNBI or WIA (Department of the Army, 1978). Referencing the Cold War presents a parallel manner of thinking to the growing tensions with China. While these projections contribute to the project's end goal, they lack the accuracy of lethality and technology in modern warfare. Therefore, Operation Enduring Freedom/Iraqi Freedom (OEF/OIF) data was used to minimize this gap in data collection. Casualty identification codes provided by MED CDID yielded the WIA and DNBI that will likely be seen in a modern LSCO. These codes considered the increased lethality and protection of modern weaponry and body armor respectively. The addition of these considerations not present in past LSCOs makes the data more pertinent to MED CDID's desired outcomes. Another critical part of participating in LSCO in INDOPACOM is understanding the diseases of the region, such as waterborne, bloodborne, and vector-borne diseases. The DNBI considerations from Cold War projection doctrine consider the plethora of disease vectors throughout INDOPACOM, including the following prevalent diseases: gastroenteritis, cholera, diarrheal diseases caused by contaminated water, diseases caused by poor air quality, and bloodborne diseases such as Chagas (Cholera Fact Sheet, 2017; Dansie, 2020; CDC, 2019). Additional considerations such as clean drinking water, immunizations for soldiers, and cleaning supplies will be imperative to protect warfighters from disease in a LSCO. The culmination of these research topics created a holistic perspective allowing conversion of qualitative considerations to quantitative data.

Initial research also focused on the specifications for each category of casualty (WIA, Disease, and NBI) and general familiarization of the Army medical system. WIA accounts for all casualties generated as a direct exposure to enemy actions. Disease casualties represent any physical ailments to an individual which correlates to an identified source of infection. Finally, NBI encapsulates physical conditions which are not associated with either enemy actions or disease vectors. To treat these respective categories, the Army breaks down the medical structure into four roles of care. Role 1 care is the initial trauma care and forward resuscitation excluding surgical care and occurs the closest to the front lines. Role 2 care is the advanced trauma management and emergency surgery required for resuscitative care of casualties. Role 3 care includes emergency and specialty surgery as well as intensive care units. Finally, Role 4 care provides a full range of medical treatment that can be expected in United States hospitals (Health.Mil, 2018).

3. Methodology

Based on research and stakeholder analysis, MED CDID required an updated data set to accurately predict Class VIIIa supplies to reflect the modern challenges that a future LSCO presents. The project flow depicted in Figure 1 below illustrates the progression used to consider all factors relevant to the prediction of required Class VIIIa supplies in a LSCO, enabling the formulation of recommendations for medical commanders' logistical decision-making. The project flow consisted of four phases: redefined problem statement, data analysis, model design, and output analysis.

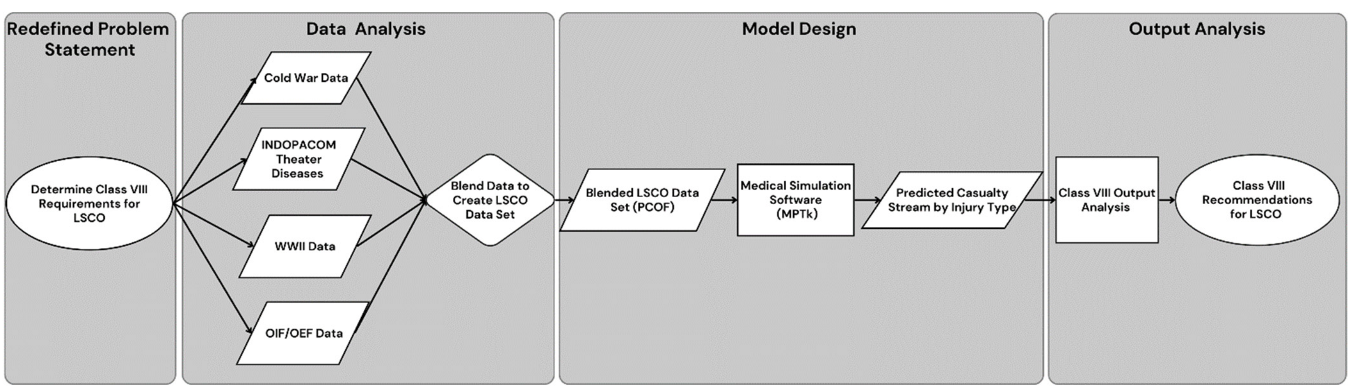

Figure 1: Project Flow Chart

To solve the redefined problem statement, research and stakeholder analysis on casualty streams from historical conflicts such as WWII, the Cold War, and OEF/OIF were conducted. The data was then combined into a singular data set extracting World War II casualty volumes, Cold War casualty predictions for injury and illness proportions, and casualties' illnesses and injury types during OEF/OIF. This combination best represents the expected challenges that Role 1 facilities will face when stabilizing casualties over an extended period until a safe window emerges for medical evacuation. As a result, the model will specifically focus on the projected casualties and corresponding medical resources at Role 1 facilities. This level of care will be the most critical point to stabilize victims due to extended periods of inconsistent evacuation windows. Moving to the model design phase, the blended LSCO data set was converted into a patient condition frequency (PCOF), a data set in a format required to be imported into simulation software, then inputted into MED CDID's Medical Simulation Software, the Medical Planning toolkit (MPTk). Adjustment of the MPTk model parameters produced a projected casualty stream by injury type. From this generated casualty stream, Class VIIIa requirements were drafted to enable logistical recommendations for commanders at the Role 1 level of care.

3.1 Data Analysis

3.1.1 Cold War Proportions

The Cold War was the most recent instance of LSCO preparation and provides the evaluation of accepted casualty projections against a near-peer adversary. Casualty projections were based on proportions as shown in Table 1. This table established the baseline proportions of DNBI and WIA by region of INDOPACOM. The data from the table below shows the proportions used in the final PCOF. The Cold War proportions of DNBI and WIA set the baseline for the blended PCOF with respect to the INDOPACOM region.

Table 1: Excerpt from Table 5-18 from FM 101-10-1: Rate of admissions to hospitals per 1000 strength per day.

	DNBI	WIA
Northeast Asia	2.07	0.37
Southeast Asia	0.6	0.2

The values in Table 1 show the expected admissions from Cold War predictions of DNBI and WIA to hospitals per 1,000 soldiers per day. Since INDOPACOM encompasses both Northeast and Southeast regions, admissions were combined to form a new DNBI and WIA rate for the entire theater of operations. Utilization of the aggregate expected admissions across both regions per casualty category developed the proportions of DNBI and WIA for the entirety of the conflict and the corresponding results depicted below in Table 2, which sets the fundamental DNBI and WIA rates for the blended PCOF.

Table 2: Baseline Proportions of Expected LSCO Casualty in INDOPACOM

DNBI	WIA
82.40%	17.60%

This transformation of Cold War data generates an updated representation for the distribution of expected casualties. For PCOF development, these proportions will be the fundamental breakdown. WIA will be derived from these calculations, and DNBI will be further broken down into disease and NBI using WWII data for the final PCOF.

3.1.2 WWII Casualty Stream

The utilization of WWII data provided a casualty stream accounting for the extensive volume of casualties expected to occur in a LSCO. As the Cold War presents the most recent historical example of LSCO preparation, WWII gives the best confirmed LSCO ramifications. Historical data collected by The Ohio State University shown in Table 3 reports the volume of casualties and their relative proportions according to disease, NBI, and WIA classifications.

Table 3: Aggregate Hospital Admissions , U.S. Army, 1942-45

	Disease	NBI	WIA
Number of Admissions:	14,345,000	1,800,000	599,724
Percentage of Total Admissions:	85.67%	10.75%	3.58%

One key disparity between the Cold War and WWII data is the proportion of DNBI to WIA. Likely this gap relates to the reduced access and development of antibiotics and the inflexible timelines for casualty evacuation. Therefore, the proportions in Table 2 will remain the baseline breakdown of proportions. The WIA value will remain constant; however, the DNBI category will be broken down in accordance with the ratio between disease and NBI in WWII. This prevents the extremely high percentage of disease from confounding the overall future projections, but it still preserves its statistical significance within the DNBI category for the blended PCOF. The resulting disease and NBI percentages were joined to identify their relative proportions within DNBI during WWII (See Table 4).

Table 4: Proportional Breakdown of DNBI during WWII.

Disease	NBI
88.90%	11.10%

Following these transformations, the percentages from this table were directly multiplied by the DNBI Cold War projection listed in Table 2 to yield specific proportions for both disease and NBI while still complementing the WIA projection of 17.60%. The resulting distribution for the PCOF is listed in Table 5.

Table 5: Projected Admissions Rates by Category During Future LSCO.

Disease	NBI	WIA
73.20%	9.20%	17.60%

3.1.3 OEF and OIF Data

An identified limitation of the projected admissions rate is that it fails to account for the modern weaponry of a future LSCO. OEF/OIF data addresses this concern by accounting for the types of injuries and illnesses prevalent during this recent conflict. A previously developed dataset containing 456 specific casualty codes was referenced to apply these updates to the blended PCOF. These casualty codes specifically correlate to the entire range of medical diagnoses recorded during this conflict. These codes' frequency of occurrence during OEF/OIF was incorporated into the blended PCOF within the category parameters developed in Table 5. The OEF/OIF data ensured the blended PCOF accounted for the evolving military technology to complement the accepted projections from the Cold War and the experienced volume of casualties from WWII.

3.2 Model Design

After developing the PCOF by incorporating World War II casualty volume, Cold War projections, and OEF/OIF technological advances, it was inputted as the baseline for the MPTk simulation. MPTk allows for the user to modify 15 different inputs, such as type of operation, duration of event, sample size of soldiers, roll-up factor (days between resupply), etc., to best replicate projected LSCO characteristics.

3.2.1 Medical Planner's Toolkit

MPTk allows for the customization of 15 variables that affect the system's output. The three most fundamental variables were the situations identified as: a scenario where friendly forces initiate an attack against an enemy force posing heavy resistance, a similar friendly attack yet facing an enemy with light resistance, and an additional scenario where friendly forces are defending against an enemy attack or counterattack. These specific scenarios were directly loaded into the "Posture/Corresponding Actions" input. Following this, the "Operation" input matched either the offensive or defensive nature of the "Posture/Corresponding Actions" input. The changing of these variables showcased the Class VIIIa needed in different scenarios while keeping all other variables, such as a 60-day duration, and a sample size of 24,000 soldiers (a division-sized element), constant.

3.3 Output Analysis and Recommendations

After developing the necessary inputs, MPTk produced predicted casualty streams and Class VIIIa requirements for each of the three scenarios discussed. The successful production of an output verified that the updated and adjusted PCOF was effective. Following this, the PCOF model and its output were valid with the help of stakeholders and experts from MED CDID, concluding that they were reasonable outputs for each scenario.

MPTk's output included a variety of data, such as National Stock Numbers (NSNs) and descriptions for each Class VIIIa supply. Additionally, it provided the weight and volume of each NSN for every day during each scenario. While this information was valuable, daily roll-up was deemed impractical. As a result, some data transformation was necessary to display the weight and volume for each 10-day roll-up.

Pertaining to division resupply assets, the Light Medium Tactical Vehicle (LMTV) holds significant importance due to the inconsistent air superiority anticipated in near-peer warfare. With a carrying capacity of 6,000 lbs. and 519 cubic feet, it was essential to convert the weight and volume of each roll-up into the number of LMTVs required to transport Class VIIIa. Ultimately, volume was found to be the limiting factor, dictating the necessary number of LMTVs based on the volume of supplies needed for each roll-up. Figure 2 below displays the required volume of Class VIIIa for each roll-up.

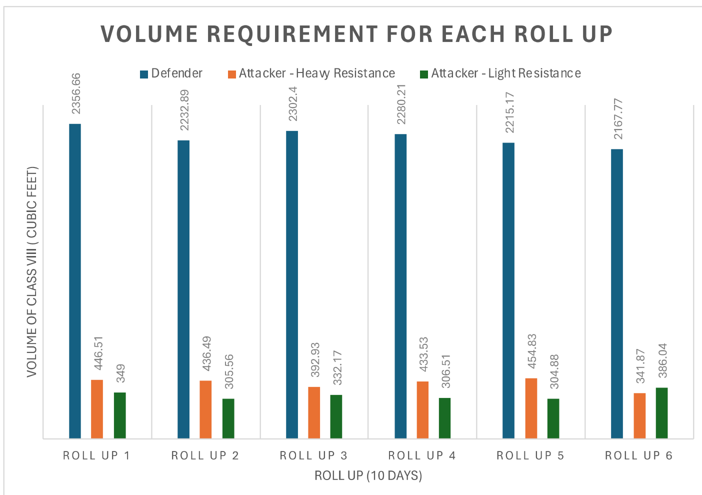

Figure 2: Volume Requirement for each Roll-Up

The defensive scenario demands a much larger quantity of supplies compared to the other two scenarios. When engaging in a LSCO, the United States of America's enemies possess similar war-fighting capabilities and utilize numerous warfare domains. As a result, the enemy will resort to indirect fires on the United States' stationary defensive positions, leading to a higher rate of wounded-in-action and the need for more Class VIIIa supplies. In contrast, the attack against heavy and light resistance generates relatively similar casualty streams, which are significantly lower than those in the defensive scenario. This information was translated and adjusted to fit the LMTV's volume limitations. For defensive operations, a division requires 5 LMTVs every 10 days, while for offensive scenarios, only 1 LMTV every 10 days is needed to replenish and meet the demand for Role 1 care.

The MPTk outputs equip military commanders and decision-makers with crucial information regarding projected Class VIIIa logistical demands. By presenting weight and volume requirements, senior leaders can strategically incorporate Class VIIIa supplies with other classes during resupply missions. This data enables senior leaders to prioritize the most necessary supplies, in terms of quantity, for the duration of the battle. With this knowledge, they can execute preassembled resupply missions efficiently and effectively.

4. Conclusion

Using a systems thinking framework, the blended PCOF combined casualty volumes from WWII, casualty types from OEF/OIF, and Cold War projections. This methodology provides MED CDID with a data-driven and systematic approach to predict Class VIIIa logistical requirements in a LSCO in INDOPACOM. This approach enables commanders across the Army to be better informed, plan, and rehearse the movement of medical supplies up to the front lines of a battle. In the future, commanders and medical professionals can analyze predicted casualty streams to create preassembled medical supply packs that address the most frequent casualties. This process, along with future steps, will ensure the right supplies are closest to the point of injury, keeping U.S. soldiers mission-ready during a LSCO.

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