

The ReSupply Validation Program (RSVP): Developing ESP Into a Tool That Validates Patient-Driven Fleet Marine Force Medical Resource Requirements



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Introduction

The United States Marine Corps (USMC) has changed its doctrine and policy to achieve more flexible and effective combat operations. To accomplish this goal (as expressed in Operational Maneuver from the Sea), Concept of Naval Force Medical Protection for the 21st Century, Joint Vision 2020, Marine Corps Strategy 21, and Sea Power 21 illustrate the need for highly mobile medical units with improved responsiveness.¹⁻⁵ The success of such units is impossible without the development of more modular, flexible, and efficient Authorized Medical Allowance List/Authorized Dental Allowance List (AMAL/ADAL) configurations that match the speed and mobility of Marine Corps contingency response operations.

In response to USMC's need to streamline medical supplies, the Naval Health Research Center (NHRC) expanded the Estimating Supplies Program (ESP) into a simulation tool called the ReSupply Validation Program (RSVP). RSVP is designed to configure AMALs/ADALs by validating the total number of each consumable supply item required to support a patient stream.

This validation was a two-step process: first, ESP was used to develop a patient stream and generate a supply inventory needed to treat that patient stream. The quantities for each line item in the inventory were compared to the quantities currently in the AMALs to determine how well the configurations matched the item consumption rates. Second, RSVP was used to model an ESP-generated inventory as resupply blocks delivered at different intervals throughout a defined scenario. RSVP validated these patient-driven, time-phased blocks by assessing how well the inventory would meet the needs of patients as they arrived into the health care system.

This paper describes this validation process in detail. The Background section provides the context necessary to understand why a validation tool is useful for

USMC. The next two sections describe the methods and results of each step in the process: using ESP to assess item consumption rates against the current AMAL configurations, and using RSVP to simulate consumption of an ESP inventory to validate the resupply block configurations. The Discussion section highlights the benefits of configuring supplies based on a patient stream, reviews the lessons learned from the development process, and explores possible future work.

Background

NHRC's Role in Streamlining USMC Supplies

The Modeling and Simulation Department at NHRC has been at the forefront of streamlining USMC Class VIII medical resources for several years. NHRC's work has developed into three primary initiatives: the NHRC supply review process, the development of ESP, and, most recently, the development of RSVP.

In the first initiative, NHRC developed a systematic process to review medical supplies by (1) identifying the medical tasks required to treat patients with specific injuries and illnesses, and (2) determining the supplies and equipment required by each medical task. This supply review model included only those items with an identified clinical requirement in the supply stream, thereby eliminating the weight, cube, and cost of extraneous items. This process achieved substantial reductions (approximately 30%) in the number of items, weight, and cube.⁶⁻¹⁵

In the second initiative, NHRC used the data gathered from the supply review process to develop ESP, a software program for medical planners, providers, and trainers that calculates the supplies needed to treat an expected patient stream. ESP contains treatment briefs for over 400 patient conditions (PCs) treated at far-forward areas of care. Using the data from the NHRC review process, each task in ESP is linked to the specific medical materiel needed to perform that task. The user inputs the number and types of patients and selects the functional areas expected to provide treatment; ESP then estimates the items and quantities required to treat the patients.¹⁶

In the third initiative, ESP has been expanded into RSVP, a simulation program that stochastically generates multiple iterations of a patient stream, generates the supplies necessary to treat the patients, and compares these needs with a time-phased inventory to identify the most efficient way to package resupply blocks. RSVP answers some limitations associated with the method used to originally configure the AMALs.

Areas of Improvement in Current AMAL Configurations

The AMALs consist of quantity and types of equipment and consumables required to accomplish the health care mission of the Marines.¹⁷ The equipment AMALs provide the minimum type and quantity of equipment required to establish a specific health care function. The consumable AMALs provide the supplies to support a predetermined patient health care load associated with a specific health care function. The current consumable AMALs are based on a notional casualty rate of 8381 patients per Marine Expeditionary Force (MEF) incurred in a high-intensity conflict for a 60-day period. The current number of AMALs, defined under FMFM 4-5, for MEFs I and II are the same, while those for MEF III are approximately 75% of those levels due to a smaller force structure.¹⁸

There are two areas of improvement for the current consumable AMAL configurations. The first concerns the way the AMALs were initially organized. The casualty rates used to configure the AMALs are notional figures and, therefore, are not based on any modeling methodology nor are they linked to current Operation Plans (OPLANS). As a result, there is a gap between the patient streams likely to occur in theater and the patient stream the AMALs are configured to treat. Although each type and quantity of the supply items in the AMAL are linked to each PC (as a result of the NHRC supply review process), the total quantity of each supply item is linked to a notional number of patients.

The second area of improvement concerns the sustainment of supplies. Troops typically carry multiple blocks of each AMAL in preparation for a specific mission. Once the supplies in the first block are used, the resupply is pulled from the additional blocks. In this process, the initial and resupply blocks have the same configuration, which assumes that each line item is always entirely

consumed by the patient stream. However, when each line item is assessed against the needs of a defined patient stream, the consumption rates across items vary significantly. For example, bandages are consumed more frequently than airways. Therefore, an item that is used infrequently is included in each block and carried for the mission even though the amount in one AMAL may be sufficient for the patient stream. As a result, supply requirements are overstated, thereby initially causing significant quantities of excess inventory.

The Class VIII Conference, held December 2001 at Headquarters, Marine Corps (LPC-3), proposed changes that would “right size” medical supplies and equipment inventories at the MEF level.¹⁹ One significant modification is that AMALs will be separated into initial setup blocks and sustainment/resupply blocks. The initial blocks will have the capability to stand up a Health Service Support functional capability with an initial working stock of medical consumable supplies. The sustainment blocks will be based on casualty rates linked to OPLANS.

USMC identified NHRC to lead this effort through the expansion of ESP into a simulation tool that helps streamline the resupply process. NHRC’s first initiative, the supply review model, established a valid configuration for a single AMAL/ADAL by mapping PCs to medical tasks to the individual supplies needed to perform those tasks. USMC requested that NHRC use this same process to determine the total materiel requirement for a defined patient stream, this time mapping the quantity of PCs to the individual supply item quantities.

Using ESP to Assess Consumption Rates Against the Current AMALs

Methods

NHRC first evaluated how the current AMAL configurations served a user-defined patient stream. NHRC developed a patient stream using ESP, which incorporated the patient probabilities from the ground casualty projection system FORECAS. Eight thousand three hundred and thirty-one patients (the notional number of patients for which the current AMALs are configured) were entered into ESP and distributed over 350 PCs. ESP then generated the consumable supplies and equipment necessary for treating these patients.

Next, each item quantity was compared with the quantity in the current AMALs. The total quantity for each line item was divided by the quantity of that item in one consumable AMAL, producing the number of “AMALs worth” required for the patient stream. For example, the ESP quantity of a bandage Elastic Coban Flesh 3" X 5YD 24S required to treat 8381 patients at the battalion aid station (BAS) was 5155. The amount in one consumable BAS AMAL is 4 packages of 24, which equals 96. 5155 divided by 96 equals 53.70; therefore, 53.70 “AMALs worth” of bandage Elastic Coban Flesh 3" X 5YD 24S is needed to treat the patient stream at BAS. To determine any excesses or shortages in the current AMALs, the “AMALs worth” of each item was compared with the authorized MEF quantities, 156 BAS AMAL blocks for MEFs I and II and 100 AMALs for MEF III.

Results

The analysis showed that the consumption rates of each item in the AMAL vary significantly. In fact, the current inventory levels of approximately 70% of the consumable supply items exceeded the actual requirements of the defined patient stream. Figure 1 on page 8 compares the authorized MEF allowance of each item in BAS AMAL 636 needed for the patient stream with number of “AMALs worth” of each 636 item. Currently, the total authorized allowance for AMAL 636 for I and II MEF is 156 AMALs, denoted by the dark horizontal line. The NHRC analysis, as shown by Figure 1, concluded that significantly smaller quantities of the majority of the BAS items – not the full 156 “AMALs worth” – were needed to treat the defined patient stream. Therefore, linking the configuration of AMALs to the expected patient stream would reduce excess supplies.

The few items in the current BAS AMAL configuration that did not exceed the requirements of the defined patient stream were significantly deficient. These items are denoted in Figure 1 by the vertical lines extending higher than the dark horizontal line. For these supplies, linking the configuration of AMALs to a defined patient stream would improve the ability to treat patients requiring those line items by ensuring that US forces had enough of these supplies to provide optimal treatment.

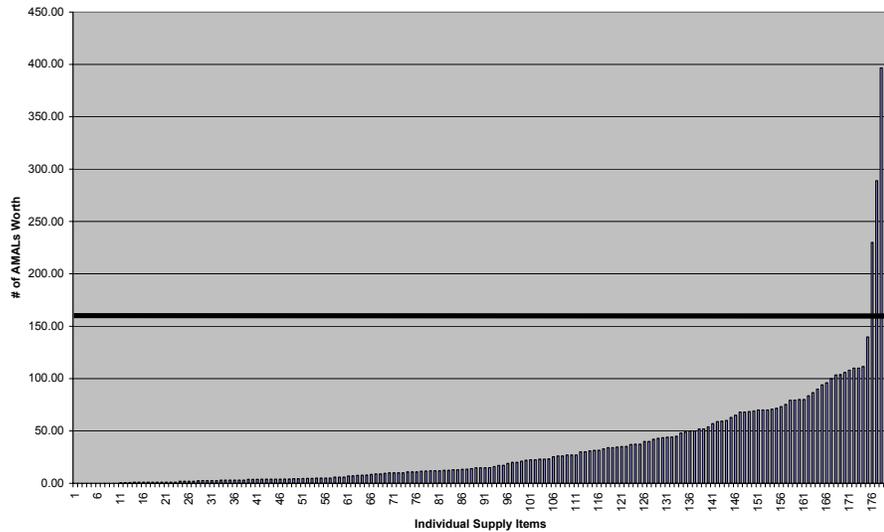


Figure 1. Number of “AMALs worth” of each item in BAS AMAL 636.

It is important to note that the patient stream used in this process reflects a heavy battle intensity situation. Battle intensity may make a considerable difference in the quantity and/or type of supplies needed at some functional areas. Therefore, particular attention must be given to the patient stream when generating the supply requirements. It is possible that a low battle intensity scenario would reduce the quantity of operating room supplies but increase the quantity of the supplies for disease and nonbattle injury patients. The overall result of applying the NHRC analysis, however, is a decrease in the number of “AMALs worth” of each line item for all the functional areas expected to provide treatment.

Using RSVP to Simulate Consumption to Validate Resupply Configurations

Methods

After discovering the excess in the original AMAL configuration, NHRC proposed to simulate the consumption of an ESP-generated inventory that was linked to a patient stream. The goal was to assess whether the necessary items and quantities were available to treat patients as they arrived into the health care system. To achieve this goal, several capabilities were incorporated into ESP: the ability to time phase the patient stream and the inventory, the ability to decrement supply quantities from an inventory as they were used, and an expanded selection of

reports. NHRC named the new program RSVP to acknowledge its new functionality.

First, Marine Forces Pacific provided NHRC in January 2003 with a specific number of patients (9632) that was based on a Southwest Asia scenario built in the Medical Analysis Tool. This number was entered into RSVP, which stochastically generated 100 iterations of the patient stream based on the PC probabilities.

Next, NHRC investigated different methods of generating the supply stream. Using the 80th percentile supply method, RSVP generated the supplies for each of the 100 iterations, ranked each item in descending order by quantity, and selected the 80th percentile of each line item. Using the 80th percentile PC method, each PC code of the 100 iterations was ranked in descending order by quantity and the 80th percentile of the each PC code was extracted. This patient stream was used to generate the supplies for each consumable AMAL. Of these two methods, NHRC used the 80th percentile PC method for this study because it created a more robust inventory that could treat 80 % of heavy battle intensity patient streams.

To test the inventory, RSVP simulated the consumption of the blocks by a defined patient stream:

1. The inventory was time-phased into resupply blocks (note: this is a user-defined function that can be time-phased according to user needs). The resupply delivery block quantities were scheduled to arrive at the beginning of each period.
2. A 101st patient stream iteration was generated in RSVP with the same casualty numbers as the first 100 iterations.
3. The 101st patient stream was distributed unevenly over six time periods to simulate the flow of battle intensity (note: this is a user-defined function that can be time-phased according to user needs). Figure 2 shows a sample patient stream of 9632 patients spread over six intervals.
4. The supply quantities were calculated in order of each patient arrival.

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5. These quantities were subtracted from the amount in the inventory at the time the patient arrived in the system. Each patient's supply usage was logged throughout the simulation.
 6. If the quantity of supply required by the patient exceeded the amount left in inventory, the "date depleted" was logged.

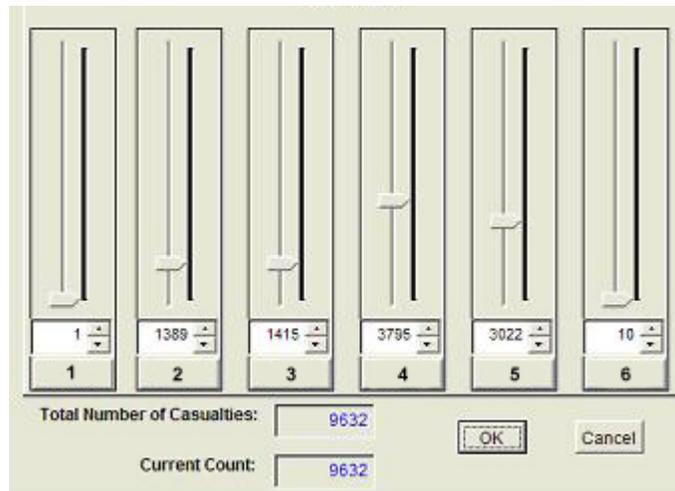


Figure 2. Patient stream spread over six time periods.

Each resupply block calculated by RSVP contained the minimum amount needed to treat at least one patient in that time period (see time period 1 in Figure 2). This minimum quantity of supply was determined by selecting the largest quantity of the supply – including both the initial dose and any needed for recurring treatment – across all the PCs present in the stream. For example, 30 acetaminophen tablets are used in BAS on a single patient with PC 212 – Pilonidal Cyst/Abscess Requiring Major Excision. Other PCs treated at BAS requiring acetaminophen receive 6 to 10 tablets. Therefore, to properly supply BAS for one of any type of PC that requires acetaminophen, RSVP assigns at least 30 tablets for the specified period.

This process used to simulate the consumption of an inventory made visible the quantity and type of supplies consumed, when those supplies were consumed, and the patient who consumed them. It also provided insight into whether the supply

quantities were sufficient and whether the supply delivery schedule successfully accommodated the flow of patients.

Results

The results of the simulation showed that the RSVP time-phased inventory would be successful in treating the patient stream. Figure 3 shows the Supply Quantity report, which displays the quantity of each supply consumed by the patient stream. For example, the patient stream required 5174 of Bandage Elastic Coban Flesh 3” x 5 YD 24S. The RSVP-generated inventory suggests 5211 be sent over the six periods, enough to treat the total needs of the patients.

Battalion Aid Station							
6505009857301	ACETAMINOPHEN TABLETS .325GM 1000 TABS						Units TB
Pkg Qty	1000.000	Medication		Day Depleted	50		
	Period1	Period2	Period3	Period4	Period5	Period6	Total
Qty In	30.00	3574.31	3641.21	9765.66	7776.51	30.00	24817.69
Qty Out	0.00	3360.00	3560.00	9780.00	8898.00	26.00	25624.00
6515011676637	AIRWAY NASOPHARYNGEAL ROBERTAZZI 30FR 12S						Units EA
Pkg Qty	12.000	Consumable		Day Depleted	20		
	Period1	Period2	Period3	Period4	Period5	Period6	Total
Qty In	0.10	5.32	5.42	14.54	11.58	0.10	37.06
Qty Out	0.00	6.05	5.95	14.40	10.70	0.00	37.10
6515011649637	AIRWAY PHARYNGEAL CUT AWAY FLANGE 30FR 30S						Units EA
Pkg Qty	30.000	Consumable		Day Depleted	20		
	Period1	Period2	Period3	Period4	Period5	Period6	Total
Qty In	0.40	21.29	21.68	58.15	46.31	0.40	148.23
Qty Out	0.00	24.20	23.80	57.60	42.80	0.00	148.40
6510001055807	BANDAGE ELASTIC COBAN FLESH 3" X 5YD 24S						Units RL
Pkg Qty	24.000	Consumable		Day Depleted	30		
	Period1	Period2	Period3	Period4	Period5	Period6	Total
Qty In	3.00	751.10	765.16	2052.14	1634.15	5.41	5210.96
Qty Out	0.00	726.22	828.07	2062.08	1551.12	5.56	5173.05

Figure 3. Sample Supply Quantity Report.

This report also compares the quantity in the inventory (qty in) to the quantity used to treat the patient stream (qty out) for each period. Therefore, this report not only identifies any excesses and shortages in supply items, but it provides visibility of *when* in the scenario they occur. Figure 3 shows that each period would receive enough resupply to cover the demands of the patients as they arrived.

Figure 4 on the following page shows a sample Supply Consumption Report. The report shows the item name, its unit of packaging, and the number of units in a package. Figure 4 shows Bandage Elastic Coban Flesh 3” X 5 YD 24S, which comes in rolls (as denoted by RL) and packaged in groups of 24. To highlight

different methods of precision resupply, the report displays three different calculations of each line item. The UM row shows units of measure (UM), the quantity of supply to be sent irrespective of packaging. The UI row shows the UM quantity rounded up to the nearest unit of issue, the lowest quantity available by package size. The UI- row is the UM rounded up to the nearest package (UI), minus the packages already in stock. Also, the Out row is the quantity of the supply used by the patient stream in the single iteration.

							UM	Pkg Size
6510001055807	BANDAGE ELASTIC COBAN FLESH 3" X 5 YD 24S						RL	24.000
	Period1	Period2	Period3	Period4	Period5	Period6	Total	Qty Left
In UM	3.00	751.10	765.16	2052.14	1634.15	5.41	5210.96	37.91
UI	24.00	768.00	768.00	2044.00	1656.00	24.00	5304.00	130.95
UI-	24.00	744.00	768.00	2040.00	1632.00	24.00	5232.00	58.95
Out	0.00	726.22	828.07	2062.08	1551.12	5.56	5173.05	

Figure 4. Sample Supply Consumption Report

Each process of resupply produces different quantities of excess. For example, if using UM, 751.10 of Bandage Elastic Coban Flesh 3" x 5 YD 24S would be scheduled to be sent at the start of period 2 (see shaded area in Figure 4). Because the bandage comes in packages of 24, if using UI, the quantity would be rounded up to 768.00. If using UI- to account for the inventory sent in period 1 (24 bandages), then only 744 would be delivered. In looking at the totals (see shaded area in Figure 4), the total quantity used by the patient stream was 5173.05. Therefore, sending supplies by the UM is the most precise with an excess of 37.91 (5210.96 – 5173.05), followed by UI- with an excess of 58.95 (5232.00 – 5173.05), then by UI with an excess of 130.95 (5304.00 – 5173.05).

Figure 5 on the following page is a Supply Delivery versus Usage graph of Bandage Elastic Coban Flesh 3" x 5 YD 24S in UM. This graph is dynamic, including several reports in one screen. The drop-down menus allow the user to display UM, UI, or UI- in order to easily evaluate how packaging affects the excess of the selected supply. In addition, the user can change the functional area to view the consumption differences of the selected supply across functional areas and levels of care.

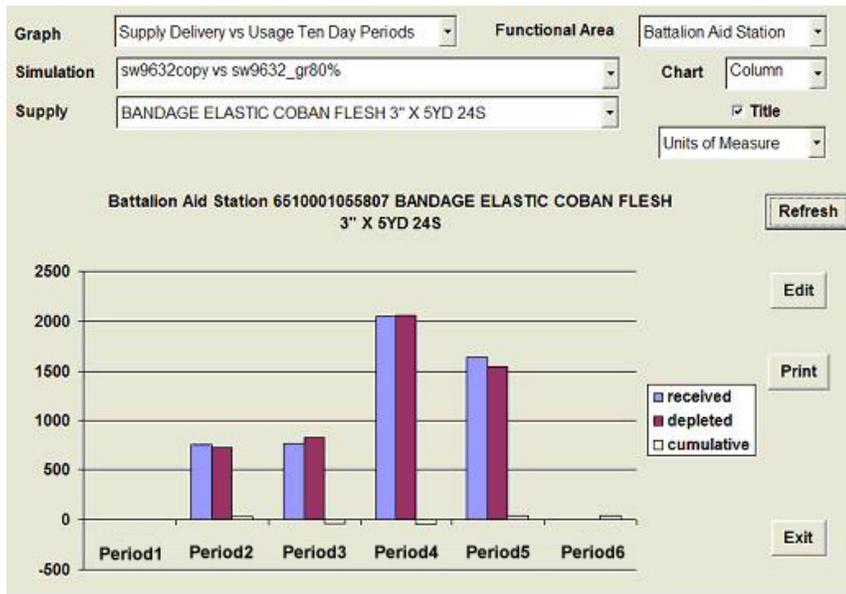


Figure 5. Supply Delivery vs. Usage graph.

Figure 5 shows that zero bandages were needed in period 1, 726 in period 2, 828 in period 3, 2062 in period 4, 1551 in period 5, and 6 in period 6. The needs of the patients would be met with the time-phased inventory: 3 bandages were resupplied in period 1, 751 in period 2, 765 in period 3, 2052 in period 4, 1634 in period 5, and 5 in period 6.

Discussion

Benefits of Patient-Driven Resupply Blocks

The analyses described in this paper demonstrate that configuring resupply blocks to fit a specific contingency have crucial benefits for USMC. These include:

- Decreased medical logistics footprint ashore.
- Reduced costs of acquiring, storing, and maintaining medical assets.
- Decreased on-hand quantities of supplies.
- Decreased inventory holding costs.
- Reduced manpower needs associated with storing, maintaining, and inventorying medical supplies.
- Improved medical care where previously undersupplied items are sufficiently supplied.

Furthermore, due to the decreased logistical demands, more corpsmen are freed from the warehouse to train for their wartime mission.

One additional lesson learned through the investigation is that the larger the quantity of the supply required by the patient stream and the smaller the package size (UI), the less excess the inventory accumulates. For example, if the patient stream needs 500 of a supply, and the supply were issued in packages of 1000, an excess of 500 would result. However, if the supply were issued in packages of 100, no excess would result. Therefore, packaging supplies based on patient stream needs would decrease excess inventory.

Future Work

There are several areas of future work concerning RSVP. First, RSVP's method of validating resupply blocks can be applied to the initial setup blocks. Configuring the initial blocks based on a defined patient stream can further lessen the logistical burden on USMC by reducing the excess supplies ordered, transported, stored, and maintained. RSVP can offer the ability to have an entire inventory, both initial and resupply blocks, "made to order" based on the expected scenario. In addition, the AMALs can be further tailored by medical capability or medical tasks to create more modular configurations of supplies. Such modularity will allow medical planners to research the most effective and efficient way to package supplies for a given mission with specific types of threats.

Second, although the program works for functional areas and levels of care, it currently only considers the packaging and distribution of supplies to one facility of a certain type. It does not yet account for the necessity of distributing the supplies among more than one of the same type of facility. Therefore, RSVP will be expanded to include, for example, the capability to calculate the packaging for more than one BAS.

Third, NHRC will be working with Marine Corps Materiel Command (MATCOM) to determine how RSVP can best meet its needs. Some issues to be discussed are the design of the graphic user interface, the types of reports that are useful, possible additional simulation capabilities, and the types of training needed to use the program most effectively.

Fourth, RSVP's output can be seamlessly integrated into the online portal of the Directorate of Medical Materiel (DMM) (www.dmmonline.com). The objectives of DMM online are to improve the ability of the Medical Directorate to conduct electronic commerce and provide critical support to the war-fighter by streamlining the medical materiel purchasing process. Among other capabilities, DMM online offers the ability to order supplies over the Web. RSVP's output can be formatted to meet the needs of vendors, facilitating the ordering and purchase of supplies.

Conclusion

ESP and RSVP were used to map the quantities of PCs to individual supply item quantities to generate the total materiel requirement for a mass casualty scenario. RSVP time-phased this inventory into resupply blocks over the length of a scenario, assessing how well the inventory would meet the needs of the patients as they arrived into the health care system. The results of the analysis showed that this method of configuring resupply blocks maximizes efficiency by reducing excess quantity and volume of consumable supplies.

RSVP presently has the ability to help USMC achieve more flexible and efficient mobile medical units by streamlining the medical resupply process. RSVP also offers the potential to further improve the efficiency of organizing and procuring supplies by configuring initial blocks based on a defined patient stream, accounting for multiple facilities of the same type, serving the needs of MATCOM, and integrating seamlessly with DMM online.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT (maximum 200 words) To help the United States Marine Corps streamline its medical materiel, the Naval Health Research Center expanded the Estimating Supplies Program (ESP) into the ReSupply Validation Program (RSVP) to link medical materiel to a defined patient stream. RSVP is a simulation program that validates medical supply configurations by stochastically generating multiple iterations of a patient stream, generating the supplies necessary to treat the patients, and comparing these needs to a time-phased inventory. This report provides the context necessary to understand why a validation tool is useful for USMC; describes the methods and results in using ESP to assess item consumption rates against the current supply block configurations and in using RSVP to simulate consumption of an ESP inventory to validate the resupply block configurations; highlights the benefits of configuring supplies based on a patient stream; reviews the lessons learned from the development process; and explores possible future work.

15. SUBJECT TERMS Authorized Medical Allowance List (AMAL), supply estimation, inventory readiness, patient stream
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