Skip all front matter: Jump to Page 1

This product is part of the RAND Corporation technical report series. Reports may include research findings on a specific topic that is limited in scope; present discussions of the methodology employed in research; provide literature reviews, survey instruments, modeling exercises, guidelines for practitioners and research professionals, and supporting documentation; or deliver preliminary findings. All RAND reports undergo rigorous peer review to ensure that they meet high standards for research quality and objectivity.

TECHNICAL
REPORT

Improving Joint Expeditionary Medical Planning Tools Based on a Patient Flow Approach

Edward W. Chan, Heather Krull, Beth E. Lachman,
Tom LaTourrette, Rachel Costello, Don Snyder,
Mahyar A. Amouzegar, Hans V. Ritschard,
D. Scott Guermonprez

Prepared for the United States Air Force

RAND PROJECT AIR FORCE

The research described in this report was sponsored by the United States Air Force under Contract FA7014-06-C-0001. Further information may be obtained from the Strategic Planning Division, Directorate of Plans, Hq USAF.

Library of Congress Cataloging-in-Publication Data

Improving joint expeditionary medical planning tools based on a patient flow approach /
Edward W. Chan ... [et al.].
p. cm.
Includes bibliographical references.
ISBN 978-0-8330-5900-0 (pbk. : alk. paper)
1. Battle casualties—Medical care—Planning. 2. Battle casualties—Medical care—Mathematical models. 3. United States—Armed Forces—Medical care—Planning. 4. United States—Armed Forces—Medical care—Mathematical models. 5. Medicine, Military—United States—Planning. I. Chan, Edward Wei-Min, 1970-

UH394.I67 2912
355.3'450684—dc23

2012000928

Published 2012 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
RAND URL: http://www.rand.org
To order RAND documents or to obtain additional information, contact
Distribution Services: Telephone: (310) 451-7002;
Fax: (310) 451-6915; Email: order@rand.org

Summary

The current concept of operations (CONOPS) for expeditionary medical care emphasizes quickly moving patients to a series of successively more sophisticated medical facilities that provide the patients with the care necessary to ultimately treat their injuries or conditions. This process requires close coordination between the treatment facilities and the evacuation resources that link them. However, the processes and tools currently used in planning for expeditionary medical resources do not fully reflect the current CONOPS. Currently, the capability of treatment facilities is typically measured and expressed in terms of the number of hospital beds in the facility, and aeromedical evacuation capabilities are typically measured and expressed in terms of the number of teams or aircraft available. Thus, planning is not aligned with operational practice and is not well integrated across the full spectrum of echelons and functions.

Expressing treatment and evacuation capabilities in terms of such measures as the numbers of beds and aircraft has two disadvantages. The first is that such measures are static measures of *capacity*: Beds and aircraft are fundamentally measures of the numbers of items. However, what is of concern to planners is not the number of items at each facility or function but rather the *capability* that can be provided by those resources. The second disadvantage is that the treatment and evacuation functions use different units of measure. With treatment resources being measured in beds and evacuation assets being measured in aircraft, it is not readily apparent how many aircraft are necessary to provide support to a field hospital of a given size.

We propose a planning concept that is consistent with the military medical CONOPS and that helps integrate medical planning across treatment and evacuation functions, across the increasing levels of care, and across the different military services. Our concept begins by proposing that treatment and evacuation functions at all levels use patient flow rate as the common unit of measurement. The goal of every treatment facility and every evacuation asset is the stabilization, triage and treatment, and evacuation of patients (STEP) to the next and higher level of care as quickly as is prudent. Therefore, a measure of the capability of a component to provide care is the rate at which that component can carry out these activities.

We propose that the patient flow rate, or STEP rate,[1] be applied across the entire medical network. For treatment facilities, the STEP rate would be the number of patients treated per

[1] RAND introduced the STEP rate in an earlier report (D. Snyder, E. W. Chan, J. J. Burks, M. A. Amouzegar, and A. C. Resnick, *How Should Air Force Expeditionary Medical Capabilities Be Expressed?* Santa Monica, Calif.: RAND Corporation, MG-785-AF, 2009) that argues why the STEP rate is a more appropriate unit of measurement than beds and illustrates how the STEP rate would apply in different scenarios and configurations of the medical network. The authors suggest that treatment facility unit type codes be re-expressed in terms of STEP rates.

unit of time; for evacuation assets, the STEP rate would be the number of patients evacuated per unit of time. This approach has the following advantages:

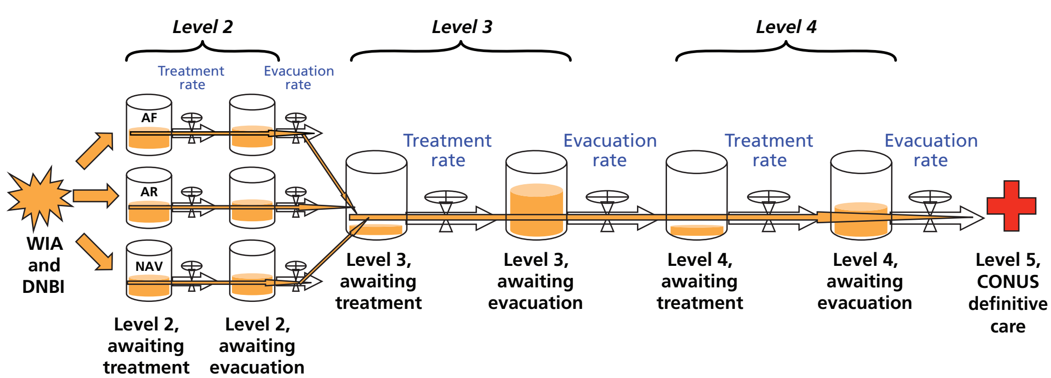
- It corresponds to the CONOPS of flow of patients away from the point of injury and toward facilities that can provide proper care.
- It applies across all resources, levels of care, and the military services.
- It measures capability rather than capacity. That is, rather than measuring resource levels (e.g., the number of beds, aircraft, and medical staff), the patient flow rate measures the capability provided by the resources.

The CONOPS of patient care can be likened to the flow of fluid through a system of valves and holding tanks. In such a system, the valves govern the rate at which fluid flows into and out of the holding tanks. Ideally, the flow of fluid out of a tank is at least as fast as the flow of fluid into a tank; otherwise, fluid backs up in the tank. Figure S.1 illustrates this analogy with an example of a medical deployment laydown.

In the figure, the flow starts with patients entering the medical facilities of the Air Force, Army, or Navy and Marine Corps because they have been wounded in action (WIA) as a result of combat or enemy action or because they are suffering from a form of disease or nonbattle injury (DNBI). Different scenarios will produce casualties at different rates for the different services and yield different mixes of injuries and illnesses. The mix of injuries and illnesses can have a major effect on the patient flow rate that can be achieved with a given set of resources.

The flow of patients next progresses to the first treatment facility, which is represented by two holding tanks. The contents of the first tank represent patients who arrive requiring stabilization or treatment; this tank can be thought of as the waiting room of a hospital emergency department. The first valve represents the rate at which patients receive care at the facility, and it governs the rate at which the first tank is emptied. The rate at which patients receive care is a function of the treatment resources available, including capacity at the emergency room, operating room, and intensive care unit and the capacity of the staff. Patients who have been

Figure S.1
Analogy of Patient Flow in a System of Holding Tanks and Valves



NOTE: AF = Air Force. AR = Army. CONUS = continental United States. NAV = Navy and Marine Corps.
RAND *TR1003-S.1*

treated and are stable enough for transport are moved to the second tank, where they await evacuation to the next-higher level of care. This second tank corresponds to holding beds at the treatment facility or at an aeromedical staging facility.[2] The rate at which patients leave this holding tank is governed by the rate at which the aeromedical evacuation system (or some other transport resource) can transport them.[3] From there, the patient flow continues on to higher levels of care.

Actual operations may be more complex, involving multiple locations and multiple paths of flow; patients may skip levels of care or remain at one level until they are released. Even in these situations, the principles of flow rate apply. Regardless of the specific path, the system still requires coordination between treatment and evacuation resources to ensure that the flow of patients is not unnecessarily delayed.

For the planner seeking to put together into a medical system a series of treatment facilities linked by evacuation assets, the goal is to prevent resource imbalances that impede the rapid movement of patients across the entire medical system. The STEP rate helps by allowing planners to better understand the interdependencies among treatment and evacuation functions, levels of care, and the military services. With this understanding, planners will be better able to assign resources in a way that ensures that these elements work together.

The STEP rate shows how shortages in resources in one area affect resources needed in other areas. For example, reductions in the number of available airlifters would reduce the evacuation rate between treatment facilities to a number below the rate needed to keep up with the flow of casualties. This reduced evacuation rate would mean that patients would have to wait longer at the lower-level facility. Consequently, planners would need to increase holding capacity at that location in the form of holding beds within the theater hospital facility.

The STEP rate concept also illustrates the importance of coordination between the services. The Air Force, for example, needs to know the casualty stream from Army and Marine Corps units to plan for the right number of aeromedical evacuation flights, crews, and patient movement items. Conversely, it is also vital that Army and Navy medical planners be aware of Air Force capabilities for aeromedical evacuation because these capabilities could affect the holding capacity required at Army and Navy forward field hospitals and casualty receiving ships.

As is the case with using any method for estimating medical resource requirements, using the patient flow rate or STEP rate concept requires an understanding of the number, type, and timing of casualties in the scenario. If the estimates of casualties are inaccurate, the resulting estimates of medical resources required will be inaccurate, regardless of the resource estimation algorithm. Although no casualty forecast is likely to predict with certainty the events that will unfold in an actual contingency, efforts can and should be made to develop forecasts that are appropriate to the different types of scenarios the U.S. military may face in the future.

The primary medical planning tool approved by the Joint Staff for use by combatant commands for developing their operational plans is the Joint Medical Analysis Tool (JMAT),

---

2 Patients in the holding facility are likely to require continuing medical care and therefore to consume medical resources. The distinction we make is that some patients in the holding facility are undergoing treatment because they are not yet well enough to be transported, whereas other patients in the holding facility are there only because they are waiting for transportation to become available. The latter patients are the ones who would be in the "awaiting evacuation" tank.

3 Transportation is not continuous but rather usually occurs in discrete vehicle loads. Therefore, a more exact analogy might be a valve that periodically opens, releasing a measured amount of fluid each time.

which is managed by the Joint Staff Theater Medical Information Program. (As of September 2010, the version of JMAT currently in use is 1.0.1.0.) Because JMAT simulates the flow of patients within and across facilities, it already operates in a manner consistent with the patient flow rate concept just described, even though it does not explicitly express treatment or evacuation capabilities in terms of the STEP rate. To more fully implement the STEP concept, three main modifications to JMAT would be required:

- **Extend JMAT to include the entire chain of care.** The flow concept we present in this report emphasizes the interdependence among treatment and evacuation functions and among treatment facilities in different echelons. This interdependence requires a planning tool that encompasses all levels of care. JMAT 1.0.1.0 models Levels 3, 4, and 5. We recommend that JMAT be extended to include support for modeling Level 2 care. In addition, we recommend that JMAT allow more flexibility in the paths taken by patients, including the fact that they may skip echelons and that stopover locations in between echelons may be involved. (The latter may be necessary in scenarios in which the flying time between the theater and definitive care facilities is long.)
- **Enhance JMAT modeling of patient holding capacity.** The number of holding beds needed at a treatment facility will vary and depend on evacuation availability. Modifications to JMAT would help planners more readily see this effect by distinguishing between patients who cannot yet be evacuated because they are recovering and patients who could be evacuated but are waiting for transport. Reporting the patient waiting times would allow the deterioration of patient condition to be modeled. (Patient deterioration would apply both to patients awaiting treatment and to patients awaiting transport to higher levels of care.) In addition, some patients, such as host country nationals, might not be evacuated. This would increase the need for holding capacity at the treatment facility and should therefore be included in planning tools.
- **Enhance JMAT modeling of patient evacuation.** The patient flow concept we describe illustrates how, in the current CONOPS, the treatment and evacuation of patients are closely linked. Because resources in one function affect the resources required in the other, it is necessary for a planning tool to include both in its modeling. We recommend that JMAT be modified to provide calculations of the numbers of aeromedical evacuation (AE) crews and critical care air transport (CCAT) teams that are needed to handle the patient flow, particularly on long-duration flights. In addition, JMAT 1.0.1.0 models AE by requiring the user to assign aircraft to locations. This is inconsistent with the current CONOPS, in which AE is carried out by aircraft of opportunity. Modifying JMAT to allow users to model airlift availability in terms of number and frequency of sorties would be more consistent with the CONOPS and would facilitate AE and CCAT crew calculations as well as calculations of patient holding requirements at treatment facilities.

Investments in these areas would greatly enhance the effectiveness of medical planning and, ultimately, enable commanders to deploy the right resources in the right areas. This would allow the whole system to be brought up to operational capability more quickly and would ensure that patient care and transport occur with a minimum of delay.