WORKING
PAPER

The RSS-POD Supply Chain Management Game

An Exercise for Improving the Inventory Management and Distribution of Medical Countermeasures

EDWARD W. CHAN, CAROL E. FAN, MATTHEW W. LEWIS, KATHLEEN KING, PAUL DREYER, CHRISTOPHER NELSON

WR-661-DHHS

September 2009

Prepared for the U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response

RAND HEALTH

Preface

This paper introduces and explains the RSS-POD Supply Chain Management Game, a Microsoft Excel-based simulation game designed to provide practice in managing inventory of medical countermeasures during large-scale public health emergency. Players perform the role of inventory manager at a receipt, storing, and staging (RSS) facility and must allocate inventory among multiple points of dispensing (PODs). The simulation is part of a larger set of tools developed by the RAND Corporation that states and localities can use to assess and improve their readiness to work with the Strategic National Stockpile (SNS). Since 2006, RAND has been working with the Center for Disease Control and Prevention's Division of the Strategic National Stockpile (CDC DSNS) to develop assessments of jurisdictions' SNS-related capabilities.

The paper briefly describes the methods and considerations that informed development of the simulation game (Chapter 1), provides a brief overview to the game (Chapter 2), and recommends next steps in the development and testing of the game (Chapter 3). Readers well versed in countermeasure delivery and the SNS might wish to proceed directly to the player's guide provided in Appendix A.

Development of the game is continuing, and the goal of this paper is to make the initial version available for broader review and comment. Comments should be directed to Dr. Edward Chan (echan@rand.org).

This work was sponsored by the U.S. Department of Health and Human Services' Office of the Assistant Secretary for Preparedness and Response (HHS ASPR) and carried out between January 2008 and December 2008 within the RAND Health Center for Domestic and International Health Security. RAND Health is a division of the RAND Corporation. A profile of the center, abstracts of its publications, and ordering information can be found at www.rand.org/health/centers/healthsecurity. More information about RAND is available at our Web site at http://www.rand.org.

Contents

Preface iii
Figures vii
Summary ix
Acknowledgments xiii
Abbreviations xv

1. Introduction 1
    Existing RSS Exercises Often Do Not Adequately Test Inventory Management 1
    Exercise Designed to Aid Improvement 2
    Process for Developing the Exercise 3
    Report Overview 3

2. The RSS-POD Supply Chain Management Game 5
    Justification 5
    Players 6
    Activities 6
        Module 1: Limited POD Information 6
        Module 2: POD Inventory Levels Visible 7
        Module 3: An Algorithm for Managing Inventory 8
    Lessons of the Game 9

3. Next Steps 11

Appendix. RSS-POD Supply Chain Management Game Player's Guide 13
    Introduction 13
    Goal 13
    RSS-POD Supply Chain Management Game 14
        Background 14
    Launching the Game 15
    How the Game Is Played 15

References 17

Figures

Figure 1. Countermeasures Will Be Distributed to the Population via RSS Warehouse and PODs 13

Figure 2. Timeline Depicting POD 14

Summary

In the event of a large-scale public health emergency, mass dispensing of medical countermeasures (e.g., antibiotics, vaccines, antidotes) could be required to prevent illness and death. In many such instances, the CDC would send materiel from the SNS—a cache of medical countermeasures maintained at undisclosed locations around the country—to a warehouse (known as the receiving, staging, and storing facility or RSS) designated by the relevant state or local authority. From there, state and local health departments are responsible for *distributing* the materiel to points of dispensing (PODs), at which the countermeasures would be *dispensed* to the public.

Existing RSS Exercises Often Do Not Adequately Test Inventory Management

The distribution of SNS assets from RSS warehouses to PODs has been exercised in most states, usually in conjunction with full-scale exercises that test most or all SNS functions. However, these exercises typically do not test the ability of the distribution system to handle inventory shortages at PODs or at the RSS warehouse. Exercises typically assume that the RSS warehouse will have sufficient inventory to fulfill the orders that are placed by (or for) the PODs. In a real emergency situation, however, there may not be enough stock at the RSS to satisfy all the requests at a given point in time. Decisions will have to be made about how to allocate the limited materiel that is available. Poorly made decisions could result in shortages in some locations and surpluses in others, thereby taxing the distribution system because, even if inventory does become available, additional "emergency" shipments to correct imbalances require the use of more transportation resources. Even if there are enough supplies in the aggregate, improper allocation across PODs could cause some to run out of materiel, resulting in backlogs at those locations—patients[1] who have arrived at the PODs waiting for countermeasures to arrive because the PODs have run out—and thus delaying the overall delivery of countermeasures to the public.

This concern about the ability of the distribution system to appropriately allocate inventory across PODs and to handle inventory shortages is the subject of the exercise described in this paper. In this computer-based exercise, players perform the role of inventory manager at an RSS and must allocate inventory among PODs. The computer game walks the players through a set of modules to teach

- the dangers of blindly following orders from PODs
- the value of having the proper information for making decisions
- key principles of inventory management (e.g., ordering in a way that accounts for expected demand and variability in demand).

[1] In this document and in the game, we have used the term *patient* to mean any person who comes to the POD to pick up countermeasures. There is some debate about the use of *patient* in this contect; persons who are sick or injured should not go to PODs but rather to health care facilities for treatment. However, we opted to use the term both for convenience and to be consistent with the terminology used in other POD computer modeling tools.

This exercise is primarily designed as a learning experience. While it could be used for formative assessment, it is *not* designed to support measurement for accountability purposes. The game is intended to be played by staff or volunteers who would be responsible for managing inventory at the RSS or at PODs. This target audience includes the personnel operating the inventory management system at each of those locations, as well as more-senior decision makers (perhaps located at a health department operations center) who may have to adjudicate the allocation of scarce inventory.

The RSS-POD Supply Chain Management Game

We created an exercise that allows players to practice managing inventory via a Microsoft Excel-based computer game called the RSS-POD Supply Chain Management Game. The game can be played by individuals or in small groups.

In the game, the player (regardless of his or her job in an actual emergency) performs the role of the inventory manager at the RSS. This inventory manager is assumed to have all the decision-making authority necessary to allocate inventory among PODs. PODs place orders with the RSS according to their own perceived needs. (In the game, the computer determines POD orders.) In many cases, the available RSS inventory is insufficient to meet the perceived needs of the PODs. The player with the role of RSS inventory manager must allocate his/her available inventory among the PODs, with the goal of distributing countermeasures to as many people as possible.

The exercise consists of three rounds of play called *modules*. These three modules play through the same time period, so that after all three modules have been completed, performance comparisons can be made across the modules.

- *Module 1.* In the first module, the player has access to limited information about the PODs. The player has information about the design of the PODs (e.g., maximum hourly throughput) and can see POD orders. The player does not have information about the inventory levels at the PODs. The player receives feedback during the game regarding his/her performance, in the form of reports on whether PODs are experiencing backlogs of patients (patients who have arrived at the POD to receive countermeasures, but who must wait because the POD has run out).
- *Module 2.* In the second module, the player has access to greater information. The inventory levels at each POD are made visible to the RSS inventory manager, with the intent that the player will be able to make better decisions as a result.
- *Module 3.* In the final module, the player is presented with a simple mathematical algorithm to make distribution decisions. Players may choose to use this algorithm during their third module, to see if they can improve their performance.

By the end of the game, players can then see the value of information and the value of good inventory management displayed in terms of the reduced backlog of patients who are at the POD waiting for countermeasures to arrive from the warehouse, and thus an increased number of patients who will receive countermeasures within the prescribed amount of time.

We hope that this game will be a learning experience for RSS and POD inventory managers. At the most basic level, players will learn the value of increased POD-level information. While this may be an obvious concept in principle, playing through the modules provides reinforcement through experiential learning, as players first experience the frustration and pitfalls of operating with limited information (Module 1), and then see the improvement that can be obtained by having more information (Module 2), and finally learning techniques for best making use of this information (Module 3).

Next Steps

This iteration of the RSS-POD Supply Chain Management Game should be considered an initial prototype of an experiential learning exercise. It is being released for testing by users in state and local health departments who would have to manage inventory in an actual emergency, as well as by staff of CDC/DSNS who provide technical assistance to those health departments.

During this period of testing, we are interested in learning

- which aspects of the game are confusing and which can be improved
- whether players actually learn the lessons the game seeks to teach
- whether, in a more general sense, experiential learning games such as these are an effective strategy for teaching technical concepts to health department users
- how the use of stand-alone games such as this may improve performance in more-general exercises, such as warehouse drills and full-scale mass-dispensing and mass-distribution exercises. This would be the ultimate test of validity and usefulness and would require the development of good metrics for the larger exercises, as well as data collection over time.

Acknowledgments

We thank the many state and local health departments who let us attend their exercises and observe their warehousing and distribution operations. In particular we would like to thank the health departments of State of Missouri, the State of California, and the County of Los Angeles. These visits gave us insight into the systems that are used to manage inventory and transportation, and the potential problems that may arise. We also benefited from the comments of users who played early prototypes of the game. We would like to thank Bernard Benecke, Rick Pietz, and Kas Salawu at CDC/DSNS, as well as Michael Melton and Glen Tao at the County of Los Angeles Department of Public Health. We alone bear responsibility for the content of the report and the game.

Finally, we thank Pamela Nonnenmacher of the Centers for Disease Control Division of Strategic National Stockpile and William F. Raub, Lara Lamprecht, and Matthew Minson of the Department of Health and Human Services Office of the Assistant Secretary for Preparedness and Response for their support and guidance throughout this project.

Abbreviations

AAR	After Action Report
ASPR	Office of the Assistant Secretary for Preparedness and Response, U.S. Department of Health and Human Services
CDC	Centers for Disease Control and Prevention
DSNS	Division of the Strategic National Stockpile
HHS	U.S. Department of Health and Human Services
POD	Point of Dispensing
RSS	Receiving, Staging, and Storing
SNS	Strategic National Stockpile
TAR	Technical Assistance Review

1. Introduction

In the event of a large-scale public health emergency, mass dispensing of medical countermeasures (e.g., antibiotics, vaccines, antidotes) could be required to reduce illness and death. State officials can request supplies from the Centers for Disease Control and Prevention's (CDC) Strategic National Stockpile (SNS). Materiel from the SNS would be sent by the federal government to the receiving, staging, and storing (RSS) warehouse designated by the relevant state or local authority. From there, state and local health departments are responsible for *distributing* the materiel to points of dispensing (PODs), at which the countermeasures would be *dispensed* to the public. Thus, *dispensing* involves direct interaction with the public, whereas *distribution* involves supplying PODs.

Existing RSS Exercises Often Do Not Adequately Test Inventory Management

While the distribution function has been exercised in most states (usually in conjunction with full-scale exercises that test most or all SNS functions), such exercises typically do not test the system's ability to meet the complexity and timing of a large-scale emergency. Tests of distribution networks usually consist of a small number of PODs, and resupply of the PODs is generally not required during the exercise. Moreover, distribution exercises typically assume that the RSS warehouse will have sufficient inventory to fulfill the orders that are placed by (or for) the PODs. In a real emergency situation, however, there may not be enough stock at the RSS to satisfy all the requests at a given point in time, and decisions will have to be made about how to allocate the limited materiel that is available. Poorly made decisions could result in shortages in some locations and surpluses in others, thereby taxing the distribution system because, even if inventory does become available, additional "emergency" shipments to correct imbalances would require the use of more transportation resources.[2] Even if there are enough supplies in the aggregate, improper allocation across PODs could cause some PODs to run out of material, resulting in backlogs at those locations—patients[3] who have arrived to receive countermeasures but who must wait because the POD has run out—and delaying delivery of countermeasures to the public.

---

[2] These weaknesses do not mean that these exercises are not useful. Rather, they represent necessary compromises that have been made to ensure that other objectives are met. For example, exercises that are intended to teach or practice warehouse and dispensing operations may be complex enough without the introduction of a shortage of staff or materiel. Similarly, exercises that include distribution may be focused on working out detailed escort procedures between truck drivers and law enforcement, in which case requiring large numbers of trucks and escorts would be a burden. These exercises serve an important purpose and should continue.

[3] In this document and in the game, we use the term *patient* to mean any person who comes to the POD to pick up countermeasures. There is some debate about the use of the term in this context; persons who are sick or injured should not go to PODs but rather to health care facilities for treatment. However, we opted to use the term here both for convenience and to be consistent with the terminology used in other computer POD modeling tools.

Small-scale exercises[4] can address these deficiencies by testing operational capabilities related to distribution that are ordinarily missed in other exercises without having to resort to large-scale movement of personnel and materiel.

This concern—the ability of the distribution system to handle inventory shortages—is the subject of the exercise described in this document. In this exercise, players participate in the RSS-POD Supply Chain Management Game, a computer game in which they perform the role of inventory manager at an RSS and must allocate inventory among PODs. The computer game walks the players through a set of modules that teach

- the dangers of blindly following orders from PODs
- the value of having the proper information for making decisions
- key principles of inventory management, e.g., ordering in a way that accounts for expected demand and variability in demand.

Exercise Designed to Aid Improvement

These exercises are part of a larger suite of assessments designed by RAND to help jurisdictions measure and improve *operational capabilities* required for the SNS program. As such, the assessment tools are intended as a supplement to the Technical Assistance Review tool (TAR), which focuses on plans, personnel, and other aspects of SNS capacity (Nelson et al., 2007).

While many of the earlier SNS assessments that RAND developed are intended to be used for accountability purposes, this distribution exercise is intended to be used as a *formative* assessment. That is, it can help jurisdictions identify problems and improve their performance. However, it is not designed for use in systems that link performance levels to funding or other incentives. While such uses might be possible in the future, considerable additional development and testing would be required to ensure that the assessments provide an unbiased and low-error estimate of true distribution capabilities.

Our goals for designing this exercise were to create an experience that would

- give users the opportunity to practice or assess their capabilities for managing inventory in an environment that resembles real-world conditions (e.g., allocating resources under time constraints and in the face of limited information)
- teach some basic principles of supply chain management, including the importance of having information and how it may be used
- be suitable for individuals playing alone or in small group settings that could mimic decision making by a management team
- be playable without imposing a large burden:
  - operable on most existing computer systems

[4] Nelson et al. (2007) introduce the general approach to assessment and provides early versions of assessment manuals. Revised versions of the drill manuals contained in that report are available from the Centers for Disease Control and Prevention, Division of the Strategic National Stockpile. In addition, a new version of the full report, including results from field-testing, and revised drill manuals, is currently in progress and is expected to be released in mid 2009. See also Parker et al. (2009) for a tool to assess crisis decision-making capability as it pertains to public health emergency preparedness.

- use software (Microsoft Excel), with which players would likely already be familiar
- not require a large commitment of time to play
- not necessarily require an exercise facilitator.

Process for Developing the Exercise

The exercise was developed as follows:

Step 1: Observe exercises and review after action reports (AARs). First, the RAND team observed a number of RSS and distribution exercises and reviewed after action reports from other exercises in order to understand the current state-of-the-art in distribution exercises and to define a set of design requirements for the development of new exercises. RAND attended these exercises as observers and guests of the jurisdictions, in coordination with staff of CDC/DSNS. The exercises that we observed were primarily at the state level and focused on warehouse operations (i.e., distribution and inventory management were secondary to the exercising of the warehouse itself). In addition, for one exercise run by a large local health department, RAND was invited to undergo training in the use of the department's warehouse inventory management software system and to assist in evaluating an exercise that focused on the operation of that system.

Step 2: Consult with expert practitioners. Next (and often in tandem with Step 1), the RAND team consulted with subject matter experts in order to refine design requirements and to explore approaches for meeting them. These experts are practitioners primarily from state health departments, but experts from two large local jurisdictions participated as well.

Step 3: *Develop draft of exercises.* Next, the RAND team drafted exercise materials in response to design requirements.

Step 4: *Obtain feedback from expert practitioners and revise*. Finally, the RAND team circulated the draft exercise materials with practitioners at the state and federal level. The practitioners played the game while being observed by RAND staff. RAND staff noted areas of confusion, as well the decision-making process used by the game players. In one case, they also made note of the "back-seat driving" done by the player's colleagues who observed the game play. Following the game play, we received comments and suggestions from the players. The materials were then revised based on this feedback.

Report Overview

In this next chapter, we provide background for the exercise, including justification for its development, the players who could benefit from the exercise, and the activities involved in the exercise. Chapter 3 concludes with some suggested next steps in the development and testing of the exercise.

A short guide to the purpose and play of the game, intended for game players, is included as Appendix A.

2. The RSS-POD Supply Chain Management Game

This prototype computer game is intended primarily as a learning experience. Players perform the role of inventory manager at an RSS and must allocate inventory among PODs. During the course of the game, players will cope with inventory shortages. The computer game walks the players through a set of modules to teach principles of inventory management.

Justification

Distribution is intricately tied to proper inventory management, yet inventory management is typically not a focus of most distribution exercises. Decisions that are made regarding the inventory to be shipped to PODs have a major impact on the transportation requirements of the distribution plan. For example, if each shipment to the PODs consists of a small amount of material, then there will be a need for more frequent deliveries. Conversely, the amount of materiel that PODs should request from the RSS warehouse will depend on how often and when they can expect delivery of materiel. If the decisions are poorly made by the PODs or RSS regarding POD shipments, then some PODs could find themselves short of material while other PODs have too much, reducing the effectiveness of the countermeasures distribution process and increasing morbidity.

In exercises that we have observed, inventory management (by POD or RSS managers) was typically not tested. From the standpoint of a POD's operations, the dispensing exercise is usually short. PODs start with all the materiel that is needed for the exercise and do not have to place orders for resupply. On the other hand, from the standpoint of the RSS, the initial orders placed by or for PODs are typically small with respect to the total amount of inventory that is available. The RSS is thus able to simply fulfill the orders from the POD as is. Consequently, in these exercises the inventory managers at the RSS have typically not had to make decisions regarding how to ration their stock. The only inventory-related difficulty we have seen in exercises has been instances when the RSS for one reason or another does not have an initial set of orders from the PODs, at which point all activity at the RSS comes to a halt while the matter is discussed. Since many exercises leave plenty of time between RSS operations and POD operations (often the POD exercises occur the day after the RSS exercise), even this delay at the RSS does not impact operations at the POD and consequently does not challenge the exercise's participants. Thus, inventory management is an under-exercised function.

In a real emergency, supplies could be limited, especially during the early stages of the emergency. The initial shipment that arrives from the SNS will almost surely not be sufficient to supply every POD for the entirety of the mass prophylaxis operation. Decisions must be made as to how to allocate the inventory. Any delay at the RSS that causes material to stop moving will result in a delay in the PODs' ability to dispense medications to the public. Meanwhile, POD inventory managers may not understand inventory management well enough to know how to prevent either under-ordering or over-ordering supply.

Players

This game is primarily designed as a learning experience. It is intended to be played by staff or volunteers who would be responsible for managing inventory at the RSS or at PODs. This target audience would include the personnel operating the inventory management system at each of those locations, as well as more-senior decision makers (perhaps located at the health department operations center) who may have to adjudicate the allocation of scarce inventory.

Activities

We created an exercise that allows players to practice managing inventory via a Microsoft Excel-based computer game called the RSS-POD Supply Chain Management Game. The game can be played by individuals or in small groups.

In the game, the player (regardless of his or her job in an actual emergency) performs the role of the inventory manager at the RSS. This inventory manager is assumed to have all the decision-making authority necessary to allocate inventory among PODs. PODs place orders with the RSS according to their own perceived needs. (In the game, the computer determines POD orders.) In many cases, the available RSS inventory is insufficient to meet the perceived needs of the PODs. The RSS inventory manager (player) must allocate his/her available inventory among the PODs, with the goal of distributing as many countermeasures to people as possible. If inventory is not managed well, PODs will run out of material, and backlogs at PODs will result: Patients will have arrived at PODs but be waiting for material to show up. Players are given feedback on the backlogs at PODs and the overall number of patients that receive countermeasures. This provides a means for the player to assess his or her performance.

The exercise consists of three rounds of play called *modules*, in which the player is progressively given more information for managing inventory. In the first module, the player is forced to manage inventories with little information. In the second module, the player is given additional information that will enable better decision making. In the third module, the player is given guidance on how to use the additional information in a simple algorithm for managing inventory. These three modules play through the same sequence of events, which enables comparisons about the player's performance to be made across the modules. Together, this series of modules allows the player to learn, through experience, the benefits of using information to manage inventory.

Module 1: Limited POD Information

In the first module, the player has access to limited information about the PODs. The player has information about the design of the PODs, such as the maximum hourly throughput of the POD, and can see orders from the POD, but he or she does not have information about the inventory levels at the PODs. The player receives feedback during the game regarding his/her performance in the form of reports on whether PODs are experiencing backlogs of patients waiting to receive countermeasures (because PODs have run out).

The assumption that the warehouse has no visibility into POD inventory levels may represent a pessimistic view of RSS situational awareness, but it reflects the conditions at some of the warehouse exercises that we have observed. For example, jurisdictions that use a simple spreadsheet may only track receipt of materiel into the RSS warehouse and the amount of materiel shipped to PODs for each of the different items stocked. An RSS inventory manager in such a jurisdiction may see only the orders that the PODs have placed and may not have visibility into POD inventory levels. [5]

As a teaching tool, this first module enables the player to become familiar with the play of the game and to see some of the pitfalls associated with having limited information. Players may find that they do not have enough inventory to fulfill all the orders placed by PODs. They then have to decide which PODs they will shortchange, and by what amount. Players begin to wish for additional information with which they can make better decisions.

The game records the results of this round of play, including the size of the backlog and the number of patients served at the PODs. This information is retained for comparison against the results of later modules.

Module 2: POD Inventory Levels Visible

In the second module, the inventory levels and number of people served during the previous period at the POD are also made visible to the RSS inventory manager, with the intent that the player will be able to make better decisions as a result.

Some inventory systems do track inventory at the PODs. For example, one large local department uses a Web-based system that connects the RSS warehouse and all the PODs. PODs use the system as a tool for managing their own inventory and for placing orders to the warehouse. The system enables the warehouse to have visibility into POD orders and POD inventory levels. However, as noted earlier, in some jurisdictions, the inventory system being used to manage inventory at the warehouse may not have include information about the inventory levels at the PODs. Even in such jurisdictions, it should be realistic to expect that the warehouse can regularly obtain information about the inventory levels at the PODs,[6] e.g., through phone call updates when the POD places an order: "How much inventory do you want? How much inventory do you currently have?"

As a teaching tool, this module allows the player to replay through the same time period as in Module 1, but with additional information. Equipped with the POD inventory levels, the player can see which PODs are in most need of scarce resources, and direct shipments to those locations. The player will also see whether PODs are ordering properly; some may be over ordering while others are under ordering. The player may choose to overrule the requests made by PODs and make inventory allocation decisions that will benefit a larger number of people.

The game records the results of this module, including the size of the backlog and the number of patients served at the PODs. The results from Module 2, with the increased POD information, are shown alongside those from Module 1, with POD information. If the

---

[5] In at least one inventory system that we observed, the RSS inventory manager cannot simultaneously see the orders placed by all the PODs. Instead, the inventory manager processes orders one by one, potentially making decisions without information about what other PODs are requesting. This condition is not addressed by this game.

[6] Some reviewers of the game thought it was *un*realistic that a warehouse would not have this information, given the ease by which it could be obtained even without sophisticated networks, and were surprised to hear that some warehouses did operate in this fashion.

player has used the additional information well, then the player will most likely see the improvement in reduced backlogs and increased numbers of patients served. This comparison quantifies the value of additional information.

Module 3: An Algorithm for Managing Inventory

In the final module, the player is presented with a simple mathematical algorithm to make distribution decisions. The algorithm is a version of a standard periodic-review, "order-up-to" inventory policy that is presented in many inventory management texts as an appropriate algorithm for distribution systems such as the one simulated in this game.[7] The algorithm is described in a series of slides built into the game, shown before Module 3. While a full lesson in inventory theory is beyond the scope of the game, players are guided through the thinking used in developing the algorithm.

Players are taught that each POD has an ideal *target inventory level*, which is based on the number of patients expected to arrive at the POD until the next shipment arrives. At the beginning of each period, each POD should be given inventory to raise their inventory level back up to their target inventory level.

The target inventory level for each POD is computed by:

Target inventory level = ((Expected hourly demand) × (Lead time + Review period)) + Safety stock

where:

- *Expected hourly demand* is the anticipated number of patients arriving at that POD per hour. Planners may have an estimate of this based upon which PODs they expect various neighborhoods to go to. If planners don't have such an estimate, they may use the designed throughput of the POD, or "Maximum Hourly Throughput" of the POD, as an upper bound.
- *Lead time* is the time between when the POD places an order to the RSS to when they receive the shipment from the RSS.
- *Review period* is the time from when a POD places an order to the next time it places an order.
- *Safety stock* is the extra inventory to be held by the POD to cover unexpected delays and variability in demand.

In this third Module, players are then given the opportunity to replay the scenario using information regarding POD inventory levels and backlogs and equipped with this inventory management algorithm. In addition, the module now offers a *Suggest Shipment* button, which offers advice on amount that should be shipped to each POD using this algorithm. This enables players to proceed rapidly through the module and see the effect the algorithm would have on inventory management performance in terms of the size of the backlogs and the number of patients served at each of the PODs.

[7] See, for instance, section 7.9 in Silver, Pyke, Peterson (1998).

Lessons of the Game

After each module, the game displays the performance attained in that module. The game concludes by comparing the performance attained in each of the three modules. Players can then see the value of information and the value of good inventory management in terms of the reduced backlog of patients who must await delivery of supplies and the resulting increase in the number of patients who will receive countermeasures within the prescribed amount of time. Specifically, players are taught three lessons:

- *Lesson 1: Value of information.* At the most basic level, players will be shown the value of increased information. While this may be an obvious concept in principle, playing through the modules provides reinforcement through experiential learning, as players will first experience the frustration and pitfalls of operating with limited information (Module 1), then see the improvement that can be obtained first by having more information (Module 2), and finally learning techniques for best making use of this information (Module 3).
- *Lesson 2: Attributes of inventory management information systems*. A second lesson, related to the first, may be of value to preparedness planners who are developing (or contracting out for) inventory information systems for their jurisdictions. Having been shown the value of information, planners should ensure that the information systems that are being purchased or developed capture the right information in a form that enables users to make use of it. At the very least, such an information system should include not only warehouse and POD inventory levels but also information about the anticipated demand and throughput at the PODs. In addition, planners may desire algorithms built into the systems in order to facilitate inventory management during a real emergency.
- *Lesson 3: Ordering behavior.* A third and final lesson is a cautionary tale for inventory managers in general. During a real emergency, POD inventory managers may be tempted to play it safe by padding their orders so as not to run out of materiel. Or they may simply overestimate anticipated demand or throughput capability, and thereby order more than is needed. This game shows the adverse effects that over ordering can have on the whole system: Supplies build up at PODs that hoard, while other PODs run out of supplies. Ordering behavior that appears reasonable from an individual POD perspective can be destructive to the larger goal of treating as many patients as possible within a limited time frame.

3. Next Steps

During a large-scale, public health emergency, health departments will rely on staff and volunteers to manage the supply chain that distributes countermeasures from the SNS and other suppliers to RSS warehouses down to the PODs. To effectively manage this supply chain, users need to understand what information is needed and how that information can be used to minimize population morbidity. The RSS-POD Supply Chain Management Game is designed to introduce staff to some basic concepts in inventory and supply chain management, so that they may serve as more effective managers of inventory in a time of crisis.

This RSS-POD Supply Chain Management Game should be considered an initial prototype of an experiential learning exercise. As part of its development, a handful of staff from health departments and from CDC/DSNS, including both individuals as well as small groups, played the game. Initial feedback has been positive. Users found the game easy to use and appreciated the lessons presented in the sequence of modules. Comments regarding the teaching of the mathematics of inventory management were incorporated into revisions of the game.

Because of the limited number of testers thus far, however, more field testing is required. Thus, the game is being released for testing by users in state and local health departments who would have to manage inventory in an actual emergency, as well as by staff of CDC/DSNS who provide technical assistance to those health departments. During this period of testing, we are interested in learning

- what aspects of the game are confusing and what can be improved
- whether the anticipated lessons of this game are learned by players
- whether, in a more general sense, experiential learning games such as these are effective for teaching technical concepts to health department users
- how the use of stand-alone games such as this may improve performance in more general exercises, such as warehouse drills and full-scale mass dispensing and distribution exercises. (This would be the ultimate test of validity and usefulness, although it will require the development of good metrics for the larger exercises, as well as data collection over time.)

In addition to refining the game based on received comments, we are also interested in expanding the usage of the game by the addition of further modules. One area under development is the linkage of computer games with larger exercises for practicing and assessing decision-making (Parker et al., 2009). Future versions could incorporate additional *injects*—unforeseen circumstances which occur in the midst of play to which players must react, such as a breakdown in communication or a delay in shipment. Future versions could also couple with epidemiological models that would better show the consequences of decisions, such as by calculating the increased morbidity and mortality as a result of logistical delays. Another possibility would be to enable multiple players to play in real-time so that decisions made by one player (e.g., orders placed by a POD) would affect the decisions that must be made by another (e.g., fulfillment of orders by RSS).

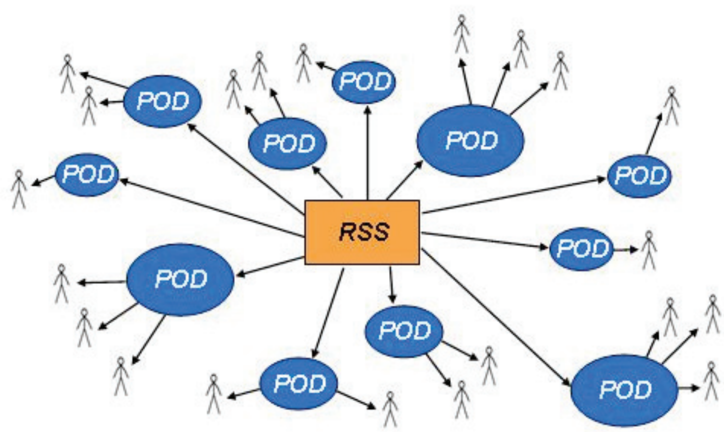
Computer games such as these can provide fast feedback for players in tabletop or functional exercises. The enrichment offered by computer games can allow players in exercises to not only practice making decisions, but to see the consequences of those decisions, and take them into account when making subsequent decisions.

Appendix. RSS-POD Supply Chain Management Game Player's Guide

Introduction

In the event of a large-scale, public health emergency such as an anthrax attack or pandemic influenza outbreak, state and local health departments may need to distribute countermeasures to affected populations via Points of Dispensing (PODs). Supplies of countermeasures will be distributed from Receiving-Staging-Storing (RSS) warehouses to PODs (see Figure 1). The establishment of the supply chain that distributes supplies from RSS warehouses to PODs must occur quickly and efficiently to minimize population morbidity. Yet, the personnel who are asked to manage the RSS and PODs often have minimal experience with supply chain management, and they may not be familiar with the information systems used by the health department to manage the supply chain.

Figure 1. Countermeasures Will Be Distributed to the Population via RSS Warehouse and PODs



Goal

The accompanying RSS-POD Supply Chain Management Game is designed to teach players some basic principles of supply chain management through hands-on training experiences. Three modules gradually increase the players' understanding of how to implement best practices in managing scarce resources during a public health emergency.

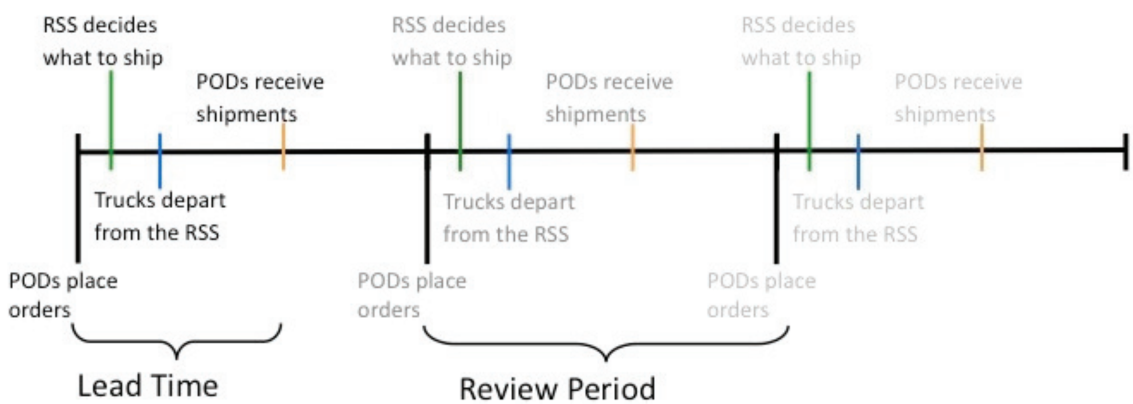
The intended users of this RSS-POD Supply Chain Management Game include public health staff or volunteers who, in an emergency, would be expected to function as warehouse inventory managers, POD inventory managers, transportation planners, or operations center staff. The game can be played by individuals or in small groups.

RSS-POD Supply Chain Management Game

Background

In the RSS-POD Supply Chain Management Game, players are responsible for the distribution of countermeasures from the RSS to PODs. For simplicity, the distribution network consists of one warehouse serving ten PODs. We assume that only one countermeasure is needed and distributed: doxycycline. The RSS receives deliveries of additional supplies of doxycycline every six hours and has a sufficient number of trucks available to serve all ten PODs during each shipment from the RSS. PODs are able to treat patients at a constant rate, without interruption or rest.[8] It is assumed that patients[9] who arrive at a POD with no supplies of countermeasures will wait at that POD until it has been resupplied, forming a *backlog*. Proper supply chain management requires understanding the timeline of activities (see Figure 2).

Figure 2. Timeline Depicting POD



After a POD places an order for countermeasures, the RSS allocates the available inventory and dispatches truck(s) from the RSS to the POD.[10] Later, the POD receives the shipment. The time between the order and receipt at the POD is the *lead time.* In this game, the lead time is constant for each POD but varies across the PODs based on distance from the RSS. Over the course of the game, PODs must place multiple orders; the time between POD orders is the *review period*. For simplicity, in the RSS-POD Supply Chain Management Game, the review period is four hours for all PODs. POD orders, RSS

8 At each POD, the hourly patient arrivals are independent and identically absolute normally distributed.

9 In this document and in the game, we have used the term *patient* to mean any person who comes to the POD to pick up countermeasures. There is some debate about the use of this term; persons who are sick or injured should not go to PODs but rather to healthcare facilities for treatment. However, we opted to use the term here both for convenience and to be consistent with the terminology used in other computer POD modeling tools.

10 In the game, it is assumed that it takes a fixed amount of time to perform each of these activities: load a truck at the RSS, drive from the RSS to a given POD, and unload a truck at the POD.

allocation decisions, and truck departures occur simultaneously for all PODs. In this game, the computer plays the roles of the POD inventory managers who place POD orders.

Launching the Game

The game is written for Microsoft Excel for Windows. Detailed instructions are provided on-line in the game. Users need only open the game and follow the instructions. The game uses macros in Microsoft Excel. In order to run the game, users must adjust the security settings in Microsoft Excel to allow macros to be run. In Windows, go to Tools -> Macro -> Security, and set your security level to "Medium." Close the game without saving, then re-open it. Upon re-opening, users will be prompted with a dialog box; choose "Enable Macros."

How the Game Is Played

The RSS-POD Game begins with an anthrax attack module. The user plays the role of the inventory manager at the warehouse who must allocate inventory in response to POD orders with the goal of effectively managing his or her inventory to meet demands during a crisis.

The user plays through a sequence of three modules, making decisions on how to allocate medications under different conditions. Each module ends with an "After Action Review" where one can see how well one managed the inventory in the system. In each module, the game covers the same 24-hour period so that comparisons of performance can be made across modules.

In Module 1, the user must make decisions based on a limited amount of information. Users know information about the expected hourly demand and maximum throughput of each POD (by way of a "POD Information" pop-up window that can be printed out), and about what PODs have ordered. However, in this module users will not have information about what the PODs have in inventory. Users then allocate available inventory based upon this information. It should be noted that POD managers may or may not be ordering rationally; they may not know how quickly their inventory is being depleted or how many patients will be coming to their POD to receive countermeasures. The game then simulates the activities of the next review period, tracking the remaining inventory at the POD, the number of patients served, and backlog, i.e., number of patients waiting for countermeasures. Performance is based upon the total number of patients served and backlog across all PODs.

In Module 2, the user has access to more information. Users have access to information about the throughput of the PODs, what PODs have ordered, inventory remaining at PODs, number of patients served during the previous review period, and backlog of patients at PODs. This additional information allows the manager to make more informed decisions regarding allocation of inventory in response to POD orders.

In Module 3, the user may choose to allocate inventory based on an inventory algorithm, a simple mathematical formula that determines a target inventory level based on the expected hourly demand rate, lead time, and review period. (The algorithm is described on-screen in the game.) The target inventory level includes safety stock to account for variability in lead time and demand rate. Orders are then filled based on inventory remaining at the POD.

References

Nelson, C., Chan, E. W., Sloss, E. M., Caldarone, L. B., & Pomeroy, A. (2007). *New Tools for Assessing State and Local SNS Readiness*. Santa Monica, Calif.: RAND Corporation, WR-455-DHHS.

Parker, A. M., Nelson, C., Shelton, S. R., Dausey, D. J., Lewis, M. W., Pomeroy, A., et al. (2009). *Measuring Crisis Decision-making for Public Health Emergencies* Santa Monica, Calif.: RAND Corporation, WR-577-DHHS.

Silver, D., Pyke, D.F., Peterson, R. (1998). *Inventory Management and Production Planning and Scheduling, Third Edition* New York, NY: John Wiley & Sons.