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EpiPOD: Community Vaccination and Dispensing Model User's Guide

Decision and Information Sciences Division

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by
M.S. Berry, M.E. Samsa, and D.M. Walsh
Decision and Information Sciences Division, Argonne National Laboratory

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ACKNOWLEDGMENTS

We also thank the communities and health departments that invited the *EpiPOD* development team to observe seasonal vaccination clinics in action. These observations gave the team a great appreciation for the variability in the ways clinics can be managed successfully.

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EXECUTIVE SUMMARY

EpiPOD is a modeling system that enables local, regional, and county health departments to evaluate and refine their plans for mass distribution of antiviral and antibiotic medications and vaccines. An intuitive interface requires users to input as few or as many plan specifics as are available in order to simulate a mass treatment campaign. Behind the input interface, a system dynamics model simulates pharmaceutical supply logistics, hospital and first-responder personnel treatment, population arrival dynamics and treatment, and disease spread. When the simulation is complete, users have estimates of the number of illnesses in the population at large, the number of ill persons seeking treatment, and queuing and delays within the mass treatment system — all metrics by which the plan can be judged.

1 INTRODUCTION

EpiPOD was developed as a tool to facilitate the design, evaluation, and refinement of local, regional, and county health departments' plans for mass distribution of antiviral and antibiotic medications and vaccines. *EpiPOD* was developed with the support of the U.S. Department of Homeland Security (DHS), Directorate for Science and Technology (S&T) as a part of the Critical Infrastructure Protection Decision Support System (CIPDSS) Project. Concerns over the cascading impacts of mass casualty events and an increase in published reports addressing a possible influenza pandemic led analysts to examine the impact of a pandemic on the critical infrastructures of the United States. As part of a multilaboratory team that included Los Alamos National Laboratory and Sandia National Laboratories, Argonne National Laboratory sought to address several important issues concerning the impacts of a pandemic on critical infrastructures through understanding how responsible agencies would respond to such an event. The resulting model is the core of the *EpiPOD* framework.

One objective of the CIPDSS Program was to leverage the work that DHS has supported in modeling interdependent consequences of critical infrastructure disruptions into a desktop tool that infrastructure owners or operators can use to their direct benefit. *EpiPOD* provided such an opportunity. In order to appropriately capture and model the dynamics of mass vaccination and dispensing logistics and operations and to ensure that the interface and metrics displayed by *EpiPOD* were appropriate for the task, Argonne invited several public health departments to participate in a series of group model-building sessions. This group of subject matter experts included representatives from the Illinois Department of Public Health; Chicago Department of Public Health; and the Cook, DuPage, Will, and Kane County Health Departments who have responsibility for planning, operating, and evaluating mass vaccination and dispensing operations in their respective districts, and others who have logistics responsibilities for ordering, receiving, and redistributing supplies from the Strategic National Stockpile (SNS). This group formed the core model-building, advisory, and verification group that met periodically during the development and testing of *EpiPOD*.

Numerous other public health professionals from a wide range of jurisdictions and organizations also contributed their expertise and in other ways supported the development and verification of *EpiPOD*. For example, in the fall of 2007, four Illinois public health jurisdictions allowed Argonne researchers to perform detailed time-in-motion studies of their seasonal influenza mass vaccination clinics. Analysis of the detailed, patient-by-patient data collected at these clinics was highly valuable in quantifying key input parameters for *EpiPOD* and in validating *EpiPOD* results. Furthermore, observations of clinic operations as part of the time-in-motion studies served a much broader function of providing the Argonne research staff with valuable insights into the importance of (sometimes subtle) differences in layout, logistics, flow control, and personnel performance characteristics in the efficiency and throughput rate of mass vaccination processes. The individuals and organizations that contributed their time, facilities, and expertise to the *EpiPOD* model development are recognized in the Acknowledgments section.

2 INSTALLATION AND SYSTEM REQUIREMENTS

The *EpiPOD* model and Sable® runtime environment run on PC hardware and are compatible with Windows® 95/98/NT/2000/XP/Vista operating systems. *EpiPOD* and Sable require 20 megabytes of disk space for a full installation and run with any reasonable amount of memory typically installed on contemporary desktop computers and laptops.

To install *EpiPOD* and the Sable runtime environment, double-click on the *setup.exe* file contained on the installation disc or in the installation folder. Follow the installation instructions.

3 SABLE RUNTIME ENVIRONMENT

The *EpiPOD* Community Vaccination and Dispensing Model is written with Vensim®, a system dynamics modeling and simulation software tool. The user interface was developed with Sable. Sable was designed specifically as a user interface development tool and runtime environment for Vensim simulation models. However, the current version of Sable exhibits certain characteristics that may cause the user some concern, especially if the user is unaware of these limitations. In particular, during an *EpiPOD* simulation run, if the user attempts to perform any other task with the computer, the Sable interface will cease to update the run status indicators described in Section 5.6. *Although the EpiPOD simulation will continue to run and will complete properly, visual status feedback provided on the Scenario Definition, or Home, screen will cease to update.*

Should this situation arise, the user should wait for the hourglass to disappear and the normal pointer to return when the pointer is moved over the *EpiPOD* screen. This is the indication that the simulation run is complete and further tasks can be performed with *EpiPOD*. Argonne is in communication with the developers of Vensim and Sable and will correct this limitation as soon as a fix is available.

Also, note that because of similar limitations, all *EpiPOD* model default values are reset after each model run. Therefore, the user must select and/or specify each of the simulation input parameters that are not the default values each time the model is run.

4 OVERVIEW OF *EpiPOD* MODEL

EpiPOD is a modeling system that enables local, regional, and county health departments to evaluate and refine their plans for mass distribution of antiviral and antibiotic medications and vaccines. An intuitive interface facilitates user input of as few or as many plan specifics as are available in order to simulate a mass treatment campaign. Default values are provided for required inputs that are not jurisdiction-specific. Behind the input interface, a system dynamics model simulates pharmaceutical supply logistics, hospital and first-responder personnel treatment, population arrival dynamics and treatment, and disease spread. When the simulation is complete, users have estimates of the number of illnesses in the population at large, the number of ill persons seeking treatment, and queuing and delays within the mass treatment system — all metrics by which the effectiveness of a jurisdiction's mass treatment plan should be judged.

Default settings in the model are based on detailed time-in-motion studies and on observations of several public health jurisdictions operating seasonal influenza vaccination clinics during the fall of 2007. However, the goal of this model is for users to be able to input observations of and statistics from their own department or clinic operations. This feature increases the accuracy of model results and allows usage of data that have been collected over several years.

The objective of this model is to improve mass public health treatment efficiency and to support the mass dispensing and vaccination planning and exercise efforts of public health departments. The goal is to have public health departments use the data collected from their exercises or clinic operations. By using their own data and observations, public health jurisdictions will be better able to understand and predict their capabilities in an actual emergency. Furthermore, with *EpiPOD,* public health departments are able to subject their plans to uncertainty by varying the numbers of personnel available, the time for performing specific tasks, and other factors. Rather than calculating a single *optimized* solution for the planner, *EpiPOD* is built on the concept of a learning environment. The capability of running numerous alternative what-if scenarios provides a robust learning environment that facilitates contingency analysis and the development of knowledge based on an understanding of what would happen if, for example, staff levels are less than expected, supplies are delayed, or measured process rates are not achieved. In the midst of an emergency, public health departments, having learned from *EpiPOD* how certain factors affect mass dispensing and vaccination operating performance — including the ultimate measure, number of illnesses — will have valuable insights into how performance can be immediately improved.

The underlying model in the *EpiPOD* system is a system dynamics model written in Vensim. Mass prophylaxis systems and operations are most easily described by three interconnected parts: the population being served; the pharmaceutical supply chain that provides medical interventions; and the public health system, including hospitals, that treats the population. Schematically illustrated in Figure 4-1, these three important sectors are represented within *EpiPOD* as individual submodels: (1) the population/disease model, (2) the pharmaceutical logistics model, and (3) the mass treatment model. Triggers within and between each sector set each process in motion.
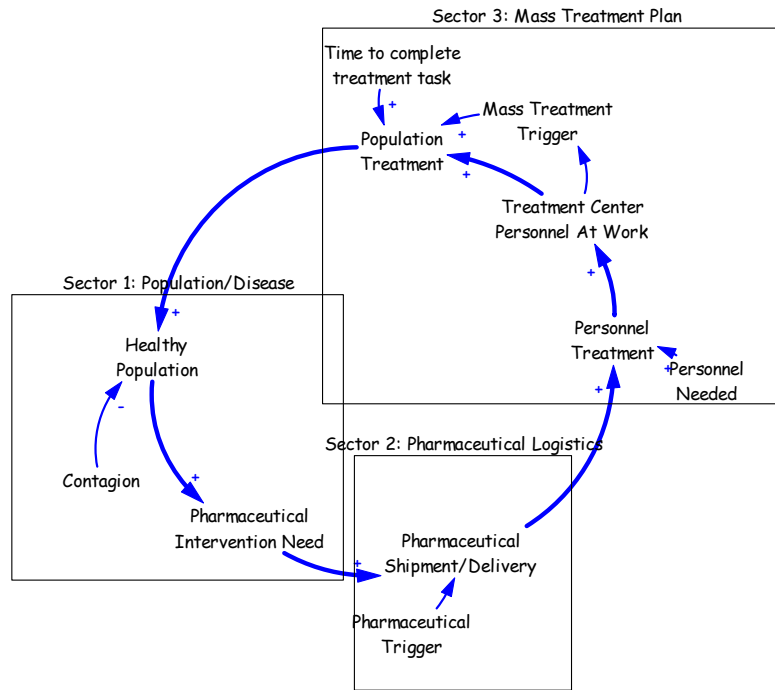
FIGURE 4-1 High-Level View of the Three Sectors in *EpiPOD*

The *Population/Disease Sector* model is a five-stage SEIR (Susceptible, Exposed, Infectious, Removed) model based on a similar three-stage model from Sterman's *Business Dynamics*.[1] At the beginning of an *EpiPOD* run, the entire population is Susceptible (stage 1). A contagion is introduced when a user-specified number of exposed persons are added to the population. The disease then begins to progress through the population as individuals in the disease model become Exposed (stage 2), Infectious, Presymptomatic (stage 3), Infectious, Symptomatic (stage 4), and finally, Recovered and Immune or Deceased (stage 5). The infection rate equation is given by:

$$NewInfections_{t+1} \equiv \frac{Infectivity \times ContactRate_t \times SusceptiblePop_t \times InfectiousPop_t}{TotalPop_t},$$

where *NewInfections$_{t+1}$* is the new infections in time period *t* + 1.

    Infectivity is the probability of a susceptible person being infected given contact with an infectious person.

    ContactRate is the number of contacts in time period *t*.

    SusceptiblePop$_t$ is the number of persons in the population who are susceptible in time period *t*.

    InfectiousPop$_t$ is the number of infectious persons in the population in time period *t*.

    TotalPop$_t$ is the total number of persons in the population (living) in time period *t*.

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[1]   John D. Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World.* (New York: McCraw-Hill, 2000), 304–323.

Population demographics in *EpiPOD* are specified in age cohorts, an approach that is consistent with U.S. Census tables. Contact rates are also by age cohort, and the contact rates between and among age groups vary depending on age cohort, with children having more epidemiologically significant contacts than adults per unit of time.

In the model, a portion of those who become ill from the disease choose to seek medical attention for their sickness. This is the first trigger point in the model; users define a threshold of known cases at which the public health jurisdiction would seek assistance in obtaining pharmaceutical interventions. Two possibilities are available: antiviral drugs and vaccines. When the trigger threshold is met, the *Pharmaceutical Logistics Sector* of the model processes the shipment and distribution of medication from a federal stockpile to the state and then to the local government entity that will manage distribution. Follow-on shipments of federally managed or vendor-managed inventory are processed as well and are based on delivery intervals set by the user.

As the pharmaceutical interventions become available for local use, they are distributed first to those who will treat the sick and staff the mass treatment centers. When this treatment has been completed, dispensing or vaccination center personnel are assigned to specific process tasks within the centers. Process tasks are for the most part fixed; however, there is an option to increase the number of personnel available to staff the processes with the use of allied medical personnel or to remove certain forms-related tasks from the process. Users define how personnel are distributed among the treatment center processes.

The population is then notified to travel to the mass treatment centers and begin receiving treatment in the *Mass Treatment Plan Sector* of the model. The number of centers and the average capacity of all the centers are specified by the user. While the user can specify any number of centers and the average capacity across all centers, the centers are treated aggregately by the model. The time to treat an individual is a function of the number of personnel working at each task and the time to complete each task, on average across all centers. Results are provided at the campaign level, including all centers, and for an individual, average center.

The treated population is removed from the disease model temporarily or permanently, depending on the pharmaceutical intervention used (antivirals or vaccine). A combination approach is available to users by designating initial shipments (vaccine or antivirals) and follow-on shipments.

EpiPOD was designed to simulate mass dispensing and vaccination campaigns concurrent with a related disease propagation model. This unique feature makes it possible to provide public health planners with both physical metrics on point of dispensing (POD) operations and, more importantly, metrics on the effect of varying POD operations on reduced human illnesses and fatalities, the ultimate measure of success. However, the current version of *EpiPOD* includes only two available diseases: a Pandemic Influenza characteristic of the 1918 Spanish Influenza, and Pneumonic Plague.

If either of these is not the disease of interest, two options are available. If the user knows the characteristics of the disease, the user may be able to simulate it by adjusting either the Pandemic Influenza or Pneumonic Plague disease parameters. If this is not possible, SNS supply and POD operations can still be modeled accurately even if the disease characterization is the wrong one. For the most part, the SNS supply and POD operations affect disease propagation, rather than the other way around (i.e., the disease affecting SNS and POD operations), unless the number of symptomatic persons[2] or fatalities is so high that the need for SNS supplies or the load on the mass dispensing or vaccination operations is significantly reduced.

If the user wishes to model SNS and POD operations for a disease that cannot be approximated by adjusting either the Pandemic Influenza or Pneumonic Plague characteristics, then the user can simply adjust either of the disease characteristics to minimize the impact on the population, run *EpiPOD* with those conditions, and pay little attention to the disease model results. Adjusting disease parameters is addressed Section 5.5.

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[2]   Symptomatic persons are screened out and not treated in the mass dispensing or vaccination centers.

5 MODEL SETUP AND INPUT DATA

This section describes the steps that need to be completed to set up *EpiPOD,* input the basic data, and select the user-specified options needed to run a mass dispensing or vaccination simulation. Setup and data input for an *EpiPOD* model simulation involve four primary types of inputs: (1) defining the scenario to be simulated; (2) loading or inputting the appropriate demographic information; (3) specifying the mass dispensing or vaccination plan, including pharmaceutical logistics and POD operations factors; and (4) setting or adjusting the disease parameters. Each of these inputs is detailed following the instructions on how to start *EpiPOD*.

5.1 STARTING *EpiPOD*

To start *EpiPOD*, double-click on the *EpiPOD* icon. When *EpiPOD* loads, the *EpiPOD* splash screen appears on the screen. Click on the Enter button to begin the data input and model simulation process.

5.2 SCENARIO DEFINITION

The first screen is the Scenario Definition, or Home, screen similar to that shown in Figure 5-1. This screen actually serves two purposes. The top portion of the screen provides for the input of a number of scenario variables and features three buttons on the right side that access the other input screens described below. Clicking on the Home button on any other *EpiPOD* screen returns the user to this screen.

The bottom portion of the Scenario Definition screen is used to manage the simulation runs, access the model output displays, and, together with the status bar at the top of the screen, monitor the progress of a running simulation.

This section focuses only on the top portion of the screen, which is used to define the simulation scenario and access other data input screens. The run management and output display access functions at the bottom portion of the screen are described in Section 5.6.

A number of different formats are used in *EpiPOD* for data input, including standard drop-down lists, check boxes, radio buttons, and dialog boxes that accept input typed on the keyboard. *EpiPOD* also uses an input format known as a slider bar, or slider. The Run Duration Input on the Scenario Definition screen is an example of a slider input. Sliders are controlled by clicking and holding the left mouse button on the position indicator in the slider panel and moving it left or right until the desired value appears in the indicator next to the slider. Sliders can also be moved by left-clicking on the position indicator and, without holding the mouse button, using the keyboard right and left arrows to move the indicator. Each press of an arrow key moves the slider indicator a standard unit either up or down the scale. Sliders can be reset by being moved completely to the left of the scale.
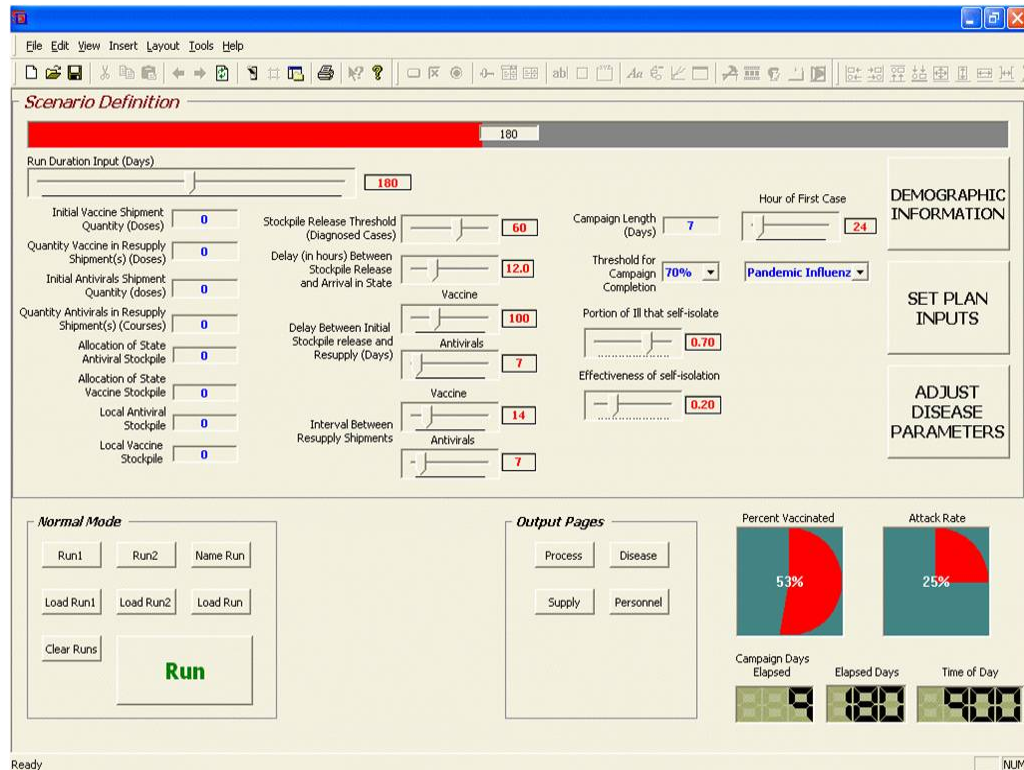
FIGURE 5-1 Scenario Definition, or Home, Screen

Scenario Definition screen inputs are as follows:

> **Run Duration Input (days).** Establish the time period for the entire simulation run in number of days by moving the slider from left to right until the proper number of days appears in the box to the right.

> **Initial Vaccine Shipment Quantity (doses).** Input the number of doses of vaccine expected to arrive from the SNS or the supplier when the initial request is made.

> **Quantity Vaccine in Resupply Shipment(s) (doses).** Use if the supply of vaccine doses available in the early response phase is limited and resupply shipments will be available. Enter the quantity of doses expected in each resupply shipment. *(The model calculates the number of resupply shipments that would be needed to meet the goal of treating the entire population.)*

> **Initial Antivirals Shipment Quantity (courses).** Input the number of courses of antiviral drugs expected to arrive from the SNS or the supplier when the initial request is made.

> **Quantity Antivirals in Resupply Shipment(s) (courses).** Use if the supply of antiviral courses available in the early response phase is limited and resupply shipments will be

available. Enter the quantity of courses expected in each resupply shipment. *(The model calculates the number of resupply shipments necessary to meet the goal of treating the entire population.)*

Allocation of State Antiviral Stockpile (courses). Use if the state stockpile of antiviral drugs will be made available for treating the local population. Enter the number of courses expected to be available.

Allocation of State Vaccine Stockpile (doses). Use if a state stockpile of vaccine will be made available for treating the local population. Enter the number of doses expected to be available.

Local Antiviral Stockpile (courses). Enter the number of antiviral courses stockpiled locally.

Local Vaccine Stockpile (doses). Enter the number of vaccine doses stockpiled locally.

Stockpile Release Threshold (diagnosed cases). Enter the number of cases identified locally that will trigger the request for federal or state pharmaceutical assistance. *(This variable can be set to zero. In this case, the stockpile is immediately released at the start of the model run, immediately starting the mass treatment process. This technique can be used to pre-treat the population, provided that the initial infected individuals are introduced at a later time. See Hour of First Case, below.)*

Delay between Stockpile Release and Arrival in State (hours). Use the slider to enter the number of hours that will pass from the time of the request until the federal pharmaceutical stockpile arrives at the state Receiving, Staging, Storing (RSS) site (0 to 48 hours).

Delay between Initial Stockpile Release and Resupply (days). Use the slider to enter the number of days between the initial shipment of pharmaceuticals from the federal stockpile and the availability of the resupply. Separate sliders are used for vaccine and antiviral medication (0–365 days).

Interval between Resupply Shipments (days). Use if more than one resupply shipment will be required to treat the entire population. Use the slider to enter the number of days between resupply shipments (0–90 days).

Campaign Length (days). Enter the *plan goal,* in number of days, for completion of the mass treatment campaign.

Threshold for Campaign Completion (percentage). Select from the drop-down box the percentage of the population that must be treated for the campaign to be considered successful. When this goal is reached, the virtual treatment centers will be closed.

Portion of Ill that Self-Isolate (fraction). Use the slider to enter the percentage of ill and *symptomatic* persons who isolate themselves when symptoms appear.

Effectiveness of Self-Isolation (fractional reduction in contact rate). Use the slider to enter the effectiveness of the ill population that is self-isolating.

Hour of First Case (hour). Use the slider to enter the time at which the first case(s) of the selected disease is injected into the population (0–1,000 cases).

Disease Selection. Use the drop-down box to indicate the disease to be modeled.

5.3 DEMOGRAPHIC INFORMATION

Click on the Demographic Information button on the right side of the Scenario Definition screen to access the Demographic Information screen shown in Figure 5-2. This screen has two segments: age-based demographics and local hospital information. Age cohorts are based on the U.S. Census tracking groups.

Before delivering *EpiPOD* to a user, Argonne sets up the model with certain default data on the basis of the interests and specifications of the user. One such setup is to populate the model with the population demographics by age cohort for the geographic region of primary interest to the user.

Population (persons). Clicking each radial button in the population column populates the adjacent field with the most current estimates for the jurisdiction. Select only those age cohorts to be included in the simulation run. If results for an alternate population (such as a subgroup or region within the jurisdiction) are desired, the user can replace the numbers in the field by highlighting the input and typing a revised value.

Initial Illnesses (persons). Specify in this column the desired number of initial ill persons, by age cohort, to be introduced into the susceptible population at the Hour of First Case specified on the Scenario Definition screen. These initial ill persons begin to interact with the susceptible population at the hour specified and thus begin the spread of the disease.

Cohort Average Hourly Contacts (contacts per hour). Default average contact rates for each age cohort are included. These are the normal contact rates for nonsymptomatic persons that are adjusted downward for ill and symptomatic persons by the fraction Portion of Ill that Self-Isolate specified on the Scenario Definition screen.

Hospital Capacity/Usage. Click the radio buttons to load the total number of hospital beds and the number of beds in use in hospitals that serve the geographic region of the specified population. Default values are loaded in the model and can be changed by editing the values on the screen.

FIGURE 5-2 Demographic Information Input Screen

Because of limitations in the runtime environment used by *EpiPOD*, all model default values are reset after each model run. Therefore, the user must select and/or specify each of the simulation input parameters that are not the default values each time the model is run.

5.4 PHARMACEUTICAL LOGISTICS AND POD OPERATIONS

From the Demographic Information screen, click on the Next button to go to the Pharmaceutical Logistics and POD Operations input screen, or click on the Home button to return to the Scenario Definition screen. From the Scenario Definition screen, click on the Set Plan Inputs button to go to the Pharmaceutical Logistics and POD Operations input screen. The input screen in Figure 5-3 appears.

This screen is used to specify assumptions about the logistical handling of the pharmaceutical supplies and assumptions about the POD configuration, server process times for each patient process, level of care, hours of operations, and other attributes.

FIGURE 5-3 Pharmaceutical Logistics and POD Operations Input Screen

5.4.1 Pharmaceutical Logistics

State Time to Complete Initial Sort and Delivery (hours). Use the slider to enter the amount of time, in hours, it will take the state to complete the sorting and delivery of SNS resources at the SNS delivery location.

State Time for Secondary Sort and Delivery to County/City (hours). If there are regional sorting facilities between the state SNS arrival point and local sorting and delivery, use the slider to enter the amount of time, in hours, it will take the state to complete its secondary sorting and delivery of SNS resources to the local (city/county) RSS.

City/County Time for Sort and Delivery to First Responder/Receiver Treatment Centers (hours). Use the slider to enter the amount of time, in hours, it will take local personnel to sort and deliver SNS resources to treatment centers servicing first-responders and first-receivers.

City/County Time for Sort and Distribution to Push Program Participants (hours). Use if arrangements have been made with local private entities to dispense or treat patients with stockpile resources. These entities can include, but are not limited to, private employer health departments, long-term-care facilities, or faith-based

organizations. Use the slider to enter the amount of time, in hours, it will take local personnel to sort and deliver SNS resources to push program participants.

City/County Time for Sort and Delivery to Points of Distribution (hours). Use the slider to enter the amount of time, in hours, it will take for local personnel to sort and deliver SNS resources to public treatment centers.

City/County Population to be Treated Through Private Push Programs (persons). Enter into each box the estimated number of people from each age cohort who will be treated with SNS resources by private entities, rather than by the public health department mass dispensing or vaccination centers. These patients are effectively removed from the population that seeks dispensing or vaccination services from public health centers, thus reducing the demand on the centers being modeled. The patients, however, remain as either susceptible or infected individuals in the disease model until they are treated and become temporarily or permanently immune, as may be the case depending on the treatment being applied. The private push program is assumed to treat all patients directed there over a 72-hour period that starts with delivery of pharmaceutical supplies to the push program providers.

5.4.2 POD Operations

Number of PODs (facilities). Enter the number of treatment centers to be used for public mass treatment.

POD Capacity (persons). Enter the average capacity of mass treatment centers to hold patients safely. Calculate by adding the safe occupancy level of each center in the POD system (total safe occupancy minus personnel in center) and divide by the number of centers.

Shifts (number). Use the drop-down box to select the number of personnel shifts per day (1–3).

Shift Duration (hours). Use the drop-down box to select the number of hours personnel will work in a shift.

Standard of Care. Use the drop-down box to select the standard of care level to be applied to patients. The options are as follows:

> *Full Care.* All personnel working in the center are assigned only to activities fully consistent with their skill levels and licensure as required. All process steps are completed for every patient.

> *Augmented Care.* Allied medical personnel are used to augment fully licensed medical professionals in order to increase throughput. These personnel may

include nursing students, pharmacists, veterinarians, dentists, or any others used in the local jurisdiction. All process steps are completed for every patient.

Abbreviated Care. In addition to the use of allied medical personnel, the treatment process is abbreviated, removing the forms evaluation process.

Antiviral/Antibiotic Distribution. Use the drop-down box to select the treatment strategy for oral pharmaceutical treatment. The options are as follows:

Mass Prophylaxis and Treatment. Oral pharmaceutical interventions will be distributed to the entire population as a short-term prophylaxis, as well as used in the treatment of those infected.

Personnel Prophylaxis and Treatment. Oral pharmaceutical interventions will be distributed to first-responders and first-receivers and emergency services personnel, as well as used in the treatment of those infected.

Treatment Only. Oral pharmaceutical interventions will be used only for the treatment of those infected.

Average Seating for Forms Completion. Average number of patient stations that are available for patients to complete their forms.

Forms Distribution Assistance Level. Use the slider to select the appropriate level of forms assistance. The options are as follows:

Level 1. Patients sit down with POD personnel and fill out the entire form with assistance.

Level 2. Patients fill out their own forms while in queue; floating personnel are available to answer questions and assist a minor percentage of patients.

Level 3. Patients fill out their own forms while in queue; minimal staff assistance is provided to answer questions.

Personnel Allocation. Personnel allocation is split into two sections in order to accommodate different POD opening strategies. Listed across the top of the section are the main tasks in the POD process: medical triage; forms distributors; forms evaluators; secondary medical evaluation; vaccinators/dispensers; and allied medical personnel, which may include nursing students, pharmacists, veterinarians, dentists, or any others used in the local jurisdiction. Under each task there are two boxes: the top box is for the *minimum number* of personnel required to be ready and available to complete that process step, and the lower box is for the *total number* of planned personnel assigned to that step. This enables the user to model either (1) the simultaneous opening of all the PODs in the system, or (2) a strategy of rolling openings based on a minimum number of available personnel.

Simultaneous Openings. To model the simultaneous opening of all centers, enter the same number in both boxes under each process step.

Rolling Openings. To model rolling openings, make the minimum number less than the full-capacity number, and the appropriate number of PODs will begin operations when the minimum number of personnel is reached. For example, if the minimum number of staff is half of the full-capacity number, then half of the PODs will open when the minimum number is reached. More PODs will open as more personnel become available from the first-responder/first-receiver treatment center.

Time (minutes). Enter the observed time, in minutes, it takes to complete each process step. Default values supplied with *EpiPOD* are abstracted from detailed time-in-motion studies of four Illinois public health jurisdictions' seasonal influenza mass vaccination clinics in the fall of 2007.

Click on the Previous button to go to the Demographic Information input screen, or click the Home button to go to the Scenario Definition input screen.
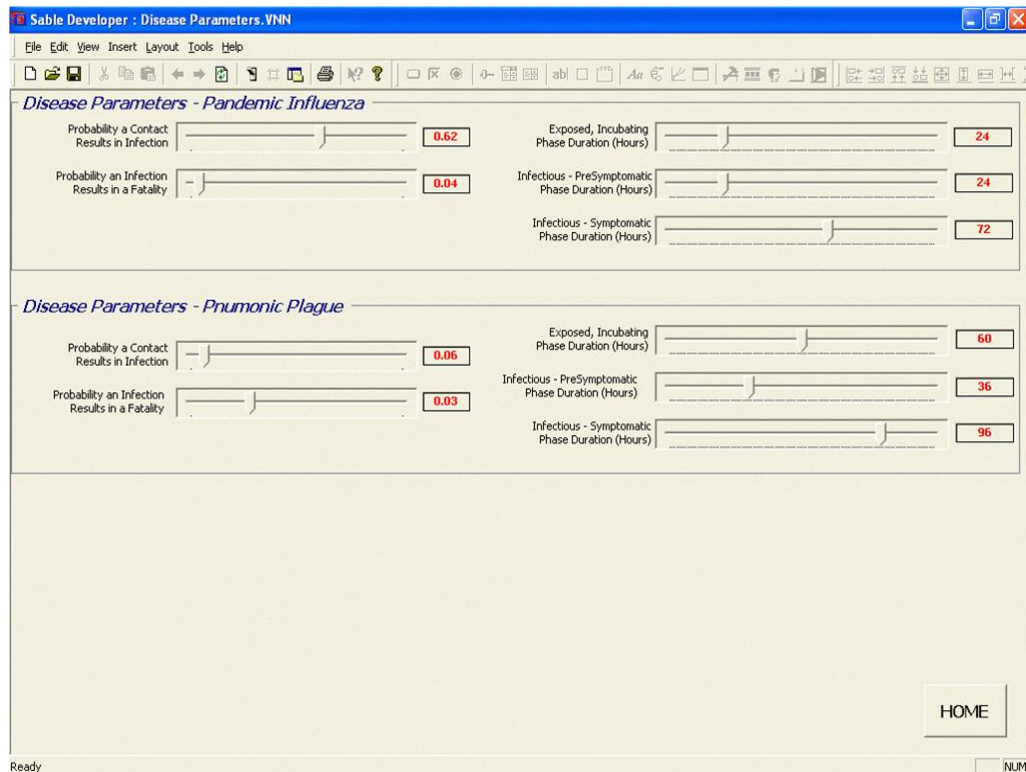
5.5 DISEASE PARAMETERS

Several characteristics of the default diseases modeled by this version of *EpiPOD* can be modified by the user. The current version of *EpiPOD* includes parameters for two diseases: a Pandemic Influenza (characteristic of the 1918 Spanish Influenza) and Pneumonic Plague. To inspect or change these parameters, click on the Adjust Disease Parameters button in the Scenario Definition screen to go to the Disease Parameters screen shown in Figure 5-4.

The following five characteristics of each disease can be adjusted at the user's option:

Probability a Contact Results in Infection (fraction). This is the infectivity of the disease, and it is the probability that a susceptible person will become infected, given a contact between that susceptible person and an infectious person in the population. Infectivity is generally high for respiratory diseases like influenza. A higher infectivity rate causes the disease to spread faster through the population.

Probability an Infection Results in a Fatality (fraction). This is the disease death rate. Although the fatality rate of the 1918 Spanish Influenza was higher in certain age cohorts, particularly young adults, *EpiPOD* does include the detail of modeling age-cohort fatality rates. The specified fatality rate is applied to all age cohorts. A higher fatality rate results in a proportionally larger number of fatalities.

FIGURE 5-4 Disease Parameter Screen

Exposed, Incubating Phase Duration (hours). This duration defines the period of time in which a newly exposed person is in the second phase of the five-phase disease progression: Susceptible (stage 1), Exposed (stage 2), Infectious, Presymptomatic (stage 3), Infectious, Symptomatic (stage 4), and Recovered or Deceased (stage 5). During this phase, the exposed person does not pass the disease on to susceptible persons in the population. An Exposed stage of longer duration causes the spread of the disease to slow down somewhat.

Infectious, Presymptomatic Phase Duration (hours). This phase is usually the most contagious of a disease, during which infected persons are infectious and able to infect susceptible persons but generally do not know they are ill because they do not yet show symptoms of the illness. A longer presymptomatic phase causes the disease to progress faster through the population.

Infectious, Symptomatic Phase Duration (hours). During this phase, ill persons are still infectious, but because disease symptoms are clearly apparent, the ill persons are aware of the illness and thus may modify their normal routine and reduce contact with other persons. The Portion of Ill that Self-Isolate and the Effectiveness of Self-Isolation factors specified on the Scenario Definition screen are applied to ill persons on this phase of the disease, and they serve to constrain the spread of the disease by these individuals. A longer Infectious, Symptomatic Phase Duration causes the disease to progress faster

through the population, whereas higher rates of self-isolation and higher self-isolation effectiveness reduce the rate of new infections caused by persons in this phase of the disease.

EpiPOD was designed to simulate mass dispensing and vaccination campaigns concurrent with a related disease propagation model. As a result of this unique feature, public health planners are provided with both physical metrics on POD operations and, more importantly, metrics on the effect of varying POD operations on reduced human illnesses and fatalities, the ultimate measure of success. However, the current version of *EpiPOD* includes only two available diseases: a Pandemic Influenza (characteristic of the 1918 Spanish Influenza) and Pneumonic Plague.

If one of these is not the disease of interest, two options are available. If the user knows the characteristics of the disease, the user may be able to simulate it by adjusting either the Pandemic Influenza or Pneumonic Plague disease parameters. If this is not possible, the SNS supply and POD operations can still be modeled accurately even if the disease characterization is incorrect. For the most part, it is the SNS supply and POD operations that affect disease propagation, rather than the other way around (i.e., the disease affecting SNS and POD operations), unless the number of symptomatic persons or fatalities is so high that the need for SNS supplies or the load on the mass dispensing or vaccination operations is significantly reduced.

If the user wishes to model SNS and POD operations for a disease that cannot be approximated by adjusting either the Pandemic Influenza or Pneumonic Plague characteristics, then the user can simply adjust either of the disease characteristics to minimize the impact on the population, run *EpiPOD* with those conditions, and pay little attention to the disease model results.

5.6 RUNNING AN *EpiPOD* SIMULATION

When all the above fields have been populated, the model is ready to run. Click on the Home button on any of the data input screens and return to the Scenario Definition screen similar to the one shown in Figure 5-5.

On the bottom portion of the screen, click the Clear Runs button to remove any runs from the output screens. Then select a run name from the buttons provided. Run 1 and Run 2 are reserved run names, and if either of these is selected as the name of the pending simulation, any previously stored results under that name are automatically overwritten with results from the new run. To use the standard Run 1 and Run 2 option, select the name for the simulation by clicking on the appropriate name button. Next, click the **Run** button. To compare two different scenarios, after the first run is complete, re-enter the data by changing the variables from the previous run, choose the run name not chosen previously, and click the **Run** button again. Users also can designate a name of their own choosing by clicking on the Name Run button and entering a file name in the dialog box that appears. All named runs are saved and can be loaded and analyzed later by clicking on the appropriate Load Run button.
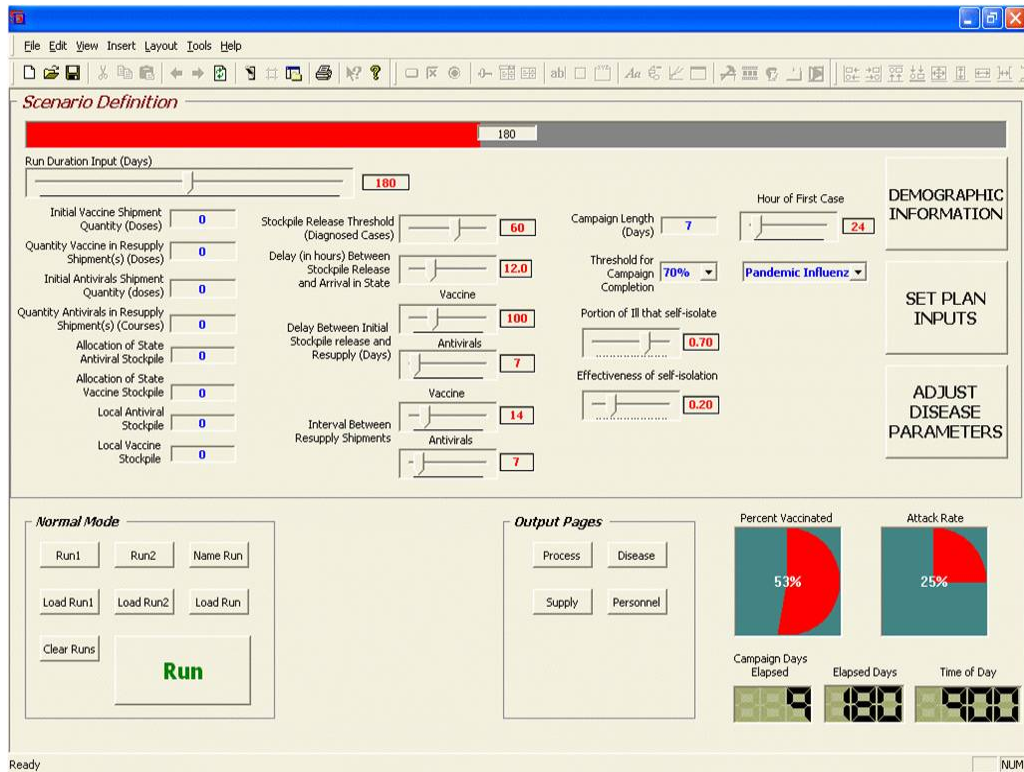
FIGURE 5-5 Running an *EpiPOD* Simulation

While *EpiPOD* is running a simulation, there are multiple information flows from the model to the user. On the Scenario Definition screen, the following seven sources inform the user that the model is running and the simulated campaign is in progress:

Status Bar. The bar across the top of the screen shows the status of the current model run. The gray bar fills in red as model time elapses.

Digital Virtual Timers. The following three digital virtual timers are located at the bottom right of the screen:

Campaign Days Elapsed. This virtual timer counts days only when PODs are open and servicing customers.

Elapsed Days. This timer shows the virtual simulation time from the start of the simulation.

Time of Day. This virtual timer is a 24-hour clock that shows the simulated time of day for the current day of the simulation.

Percent Vaccinated. This pie chart fills as the population to be treated by the public health mass dispensing or vaccination centers is treated.

Attack Rate. This pie chart fills as infections progress through the population and displays the percentage of the population that has become ill from the disease.

During an EpiPOD simulation run, if the user attempts to perform any other task with the computer, the Sable interface will cease to update the run status indicators described in Section 5.6. Although the EpiPOD simulation will continue to run and will complete properly, visual status feedback provided on the Scenario Definition, or Home, screen will cease to update.

Just to the left of the virtual timers and progress pie charts on the Scenario Definition screen is a boxed area labeled Output Pages. The buttons in this box enable the user to view the results of the current simulation or previous simulations that have been loaded into *EpiPOD*. Four categories of results are available, related to POD *Process*, *Disease* Progression, Pharmaceutical *Supply*, and POD *Personnel*. The next section describes how to access, view, and manipulate the graphical results from *EpiPOD*. Detailed descriptions of the information contained in each output graphic are also included.

6 SIMULATION RESULTS

Simulation results are accessible from the Output Pages section of the Scenario Definition, or Home, screen. Four categories of simulation results are available: Process, Disease, Supply, and Personnel. To navigate to each category of result, click on the appropriate Output Page button. As usual, to return to the Scenario Definition screen to view other categories of results, click on the Home button on the results display screen.

6.1 SELECTING THE SIMULATION (FOR GRAPHING)

EpiPOD can display results of one or more simulation runs on each results graph. By including two or more simulation runs on a single graph, the differences resulting from varied assumptions made in the different runs can be compared.

By default, graphs of *EpiPOD* results display the results of the last Run 1, Run 2, or both simulation run(s), unless these have been cleared from the model, and any other previous user-named runs that are loaded into the model. To view the results of a new Run 1, Run 2, or both, follow the procedure described in Section 5.6, Running an *EpiPOD* Simulation. When the simulations are completed, select one of the four categories of simulation results available in the Output Pages area to display the results.

Previously saved, user-named simulation results can also be displayed by navigating to the Scenario Definition, or Home, screen and using the Load Run button to select the previously saved simulation run of interest. Note that the simulation results that were last named Run 1 and Run 2 are also available and can be loaded to view their results by clicking on the Load Run 1 or Load Run 2 buttons, or by selecting the Run 1 or Run 2 files after clicking the Load Runs button.

To unload a simulation run from the *EpiPOD* simulation results graphs, first clear all loaded runs by clicking on the Clear Runs button on the Scenario Definition (or Home) screen, and then the desired simulation runs can be reloaded.

> *By design, some EpiPOD results graphs display multiple variables for each run so that the relationship between the variables can be easily viewed. Including multiple simulation runs on these types of graphs can lead to many variables being displayed on a single results graph. The user should experiment with the number of simulation runs appropriate for display on each results graph to achieve the level of information and clarity desired.*

6.2 VIEWING AND MANIPULATING GRAPHICAL RESULTS

Graphical results can be viewed and manipulated from each of the four simulation results dashboard screens. The viewing and manipulation options vary slightly depending on the number of graphical results available on the category screen. Figure 6-1 is an example of the POD
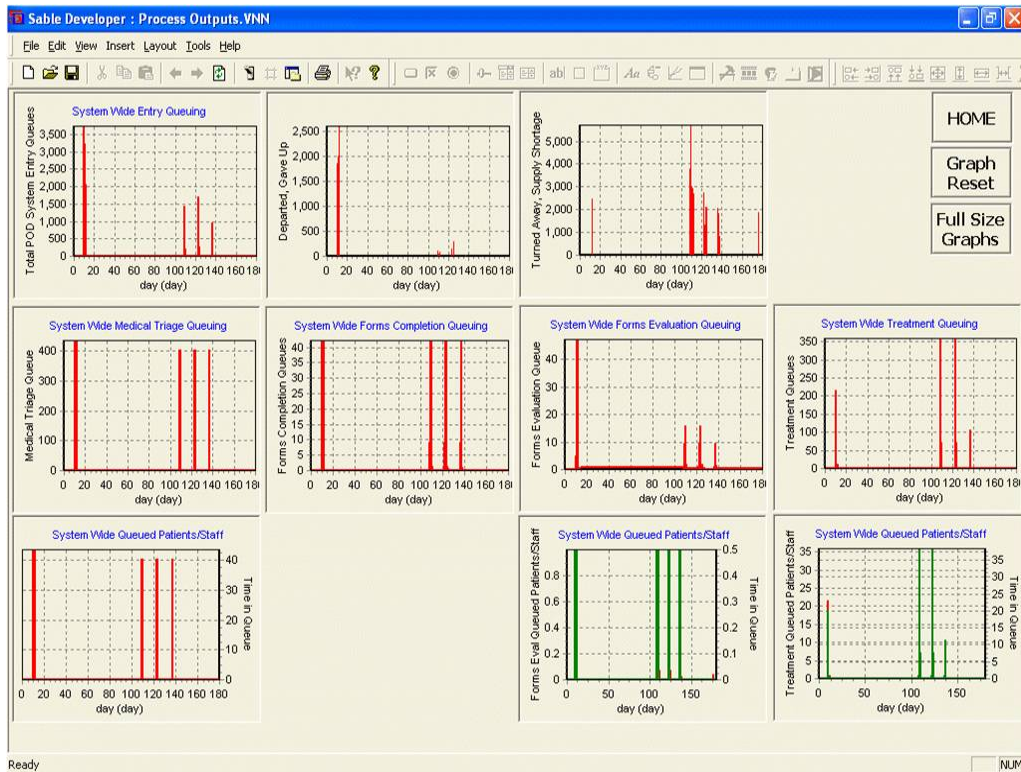
**FIGURE 6-1** *EpiPOD* **Simulation POD Process Results Screen**

Process thumbnail screen and is accessed by clicking on the Page Output Process button on the Scenario Definition, or Home, screen.

6.2.1 Zooming and Repositioning

All the graphs on the dashboard screens can be manipulated by zooming in on the results. To do so, position the pointer to the upper-left boundary of the zoom area desired, click and hold the left mouse button, and drag down and to the right over the zoom area. A lighter background color appears, indicating the zoom target area. When the mouse button is released, the graph zooms and centers over the targeted area. The user can move the zoomed graph around by repositioning or dragging the graph within its frame. To do so, place the cursor within the graph area and click and hold the right mouse button and drag the graph to the location wanted. To reset graphs to their original resolution, click the Graph Reset button.

6.2.2 Full-Size Graphs

Clicking on the Full Size Graphs button on the results dashboard page opens a tabbed array of the graphs on a new screen similar to the example shown in Figure 6-2. Graph names/subjects are listed on tabs across the top of the page. Arrow buttons in the upper left corner next to the
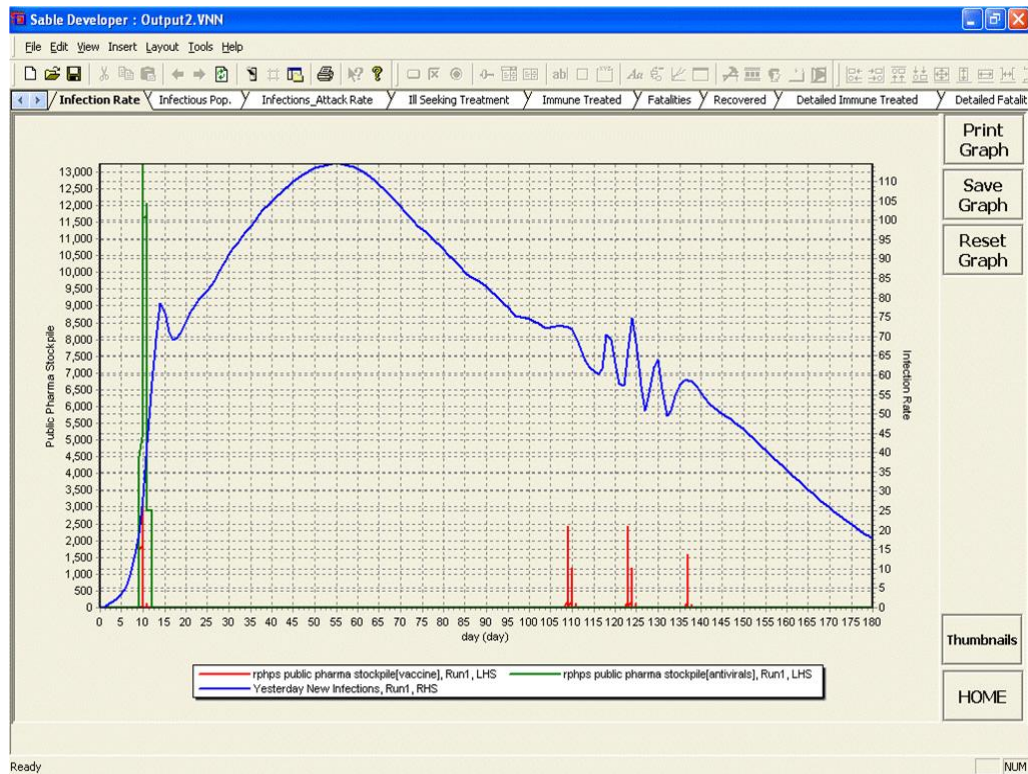
FIGURE 6-2 Example of Full-Size Graphics Screen

tabs navigate the user to tabs not visible on the screen. These full-size results graphs can be manipulated by zooming and dragging in the same way as explained for the dashboard graphs above.

6.2.3 Saving and Printing Results Graphs

Graphs can be saved and printed from the full-size graph view. To save a graph as a JPEG image, select the tab for the results graph to be saved and click on the Save Graph button. In the dialog box that appears, select the graphics file format to be used and then click on the Save button. Give the file a name in the Save As dialog box that appears, and click Save. Click on the Close button to close the Save Graph dialog box.

To print a results graph, select the tab for the graph to be printed and click on the Print Graph button. Select the desired options in the dialog box that appears and click on the Print button. Click on the Close button to close the Print Graph dialog box.

> *Testing has shown that the PDF file format displays all graph lines as black, eliminating the color differentiation necessary to distinguish one variable from another on multivariable charts. For this reason, saving graphs directly to a PDF*

format should be avoided. If a PDF format is needed, save the graph image in any of the other formats and then convert it to PDF.

The Reset Graph button returns the graph to its original zoom level and format. To return to the dashboard screen to display the results graphs thumbnails, click on the Thumbnails button. To jump to the Scenario Definition, or Home, screen, click on the Home button.

The following sections describe each of the four categories of results graphs available from *EpiPOD* simulation runs related to Process, Disease, Supply, and Personnel.

6.3 POD PROCESS RESULTS

The seven types of results graphs related to the POD Process are as follows:

Treatment Center Entry Queue (Figure 6-3). This graph shows the average number of persons standing in queue outside a vaccination center (POD) within the system. If the vaccination system has only a single center, then this graph shows that single center.

Departed Due to Queue Length (Figure 6-4). This graph shows the potential impact of long lines outside the treatment center. A portion of arriving customers chooses to depart and come back later to receive their medication. Default model settings have most patients waiting up to 2 hours; after that point an increasing fraction, depending on the wait time, depart and return. The value shown is the maximum hourly departures due to wait time on each day.

Departed Due to Supply Shortage (Figure 6-5). This graph shows the number of customers who were turned away because of a lack of pharmaceutical supplies. The value shown is the number of persons departing because of supply shortage on a given day.

Average Medical Triage Queue (Figure 6-6). This graph shows the number of persons, based on an *average* POD in the system, waiting to be seen by medical triage personnel.

Average Forms Completion Queue (Figure 6-7). This graph shows the average number of persons throughout the POD system waiting either to receive their forms or for a place to complete them.

Average Forms Evaluation Queue (Figure 6-8). This graph shows the average number of persons waiting to be served at the forms review station within the POD system.

Average Treatment Queue (Figure 6-9). This graph shows the average number of patients waiting to be seen at the vaccination stations within the POD system.
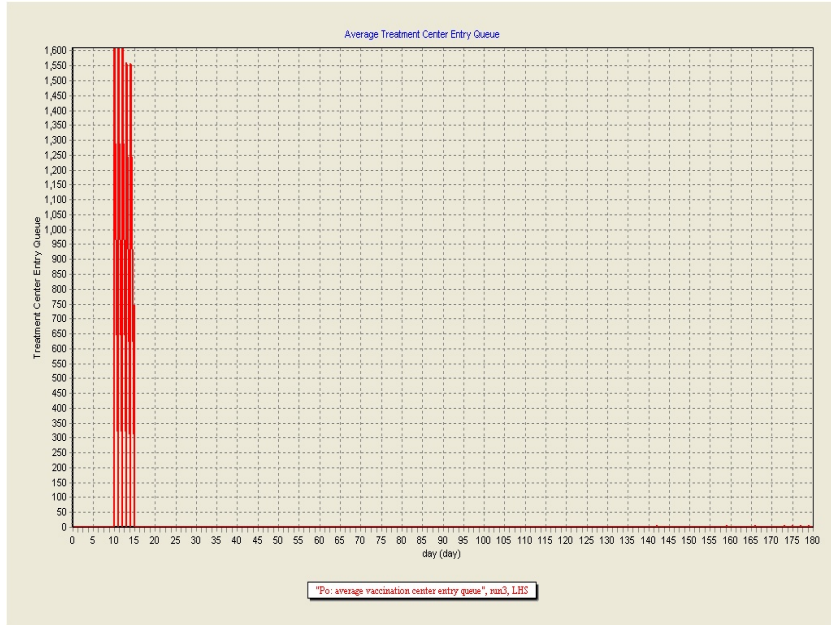
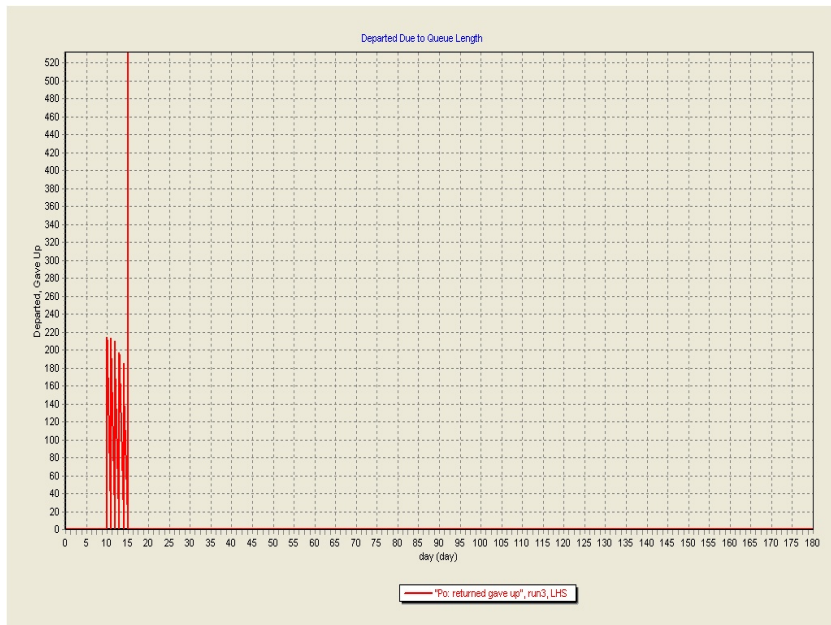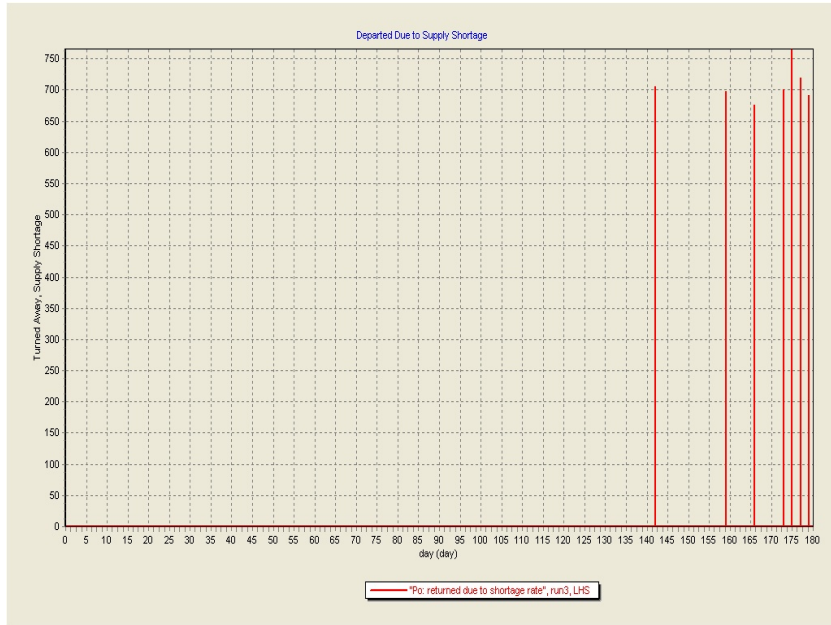**FIGURE 6-3 Treatment Center Entry Queue Results Graph**
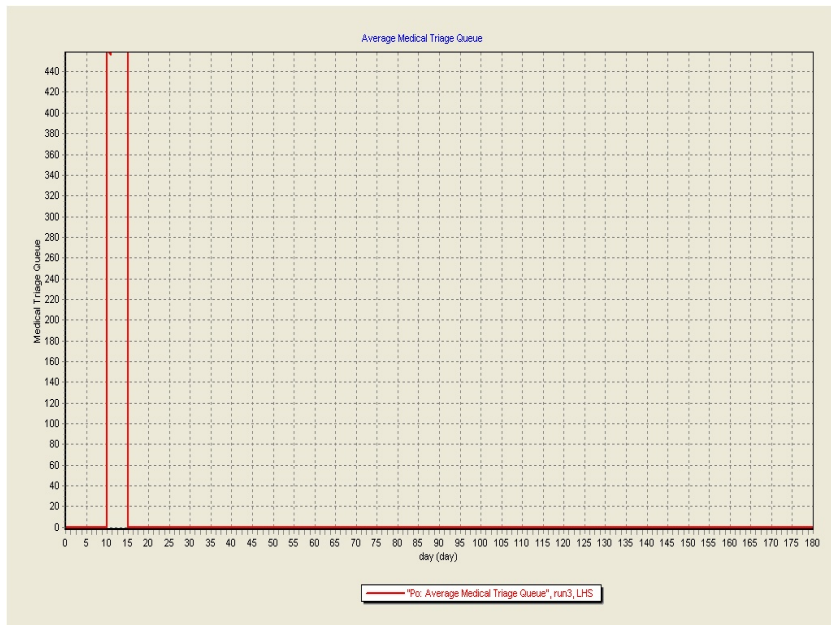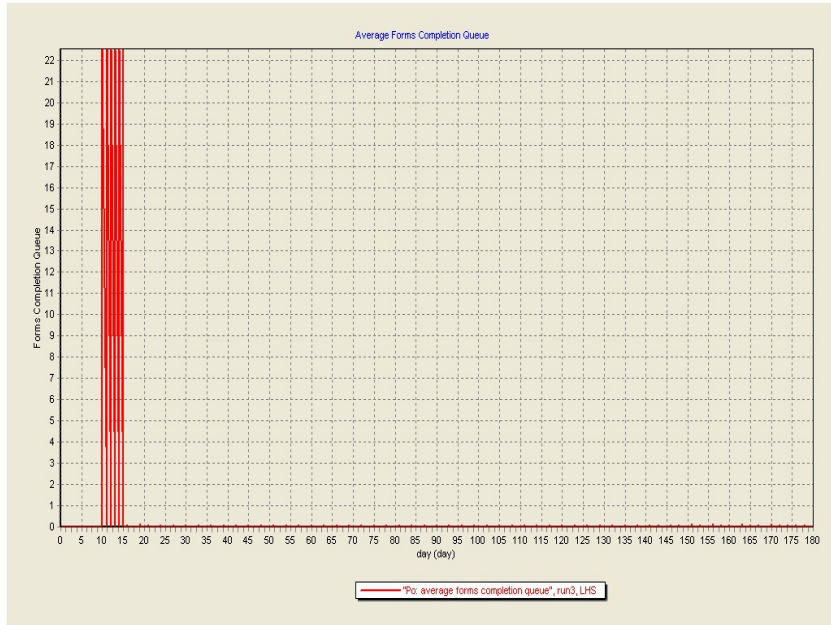

FIGURE 6-4 Departed Due to Queue Length Results Graph
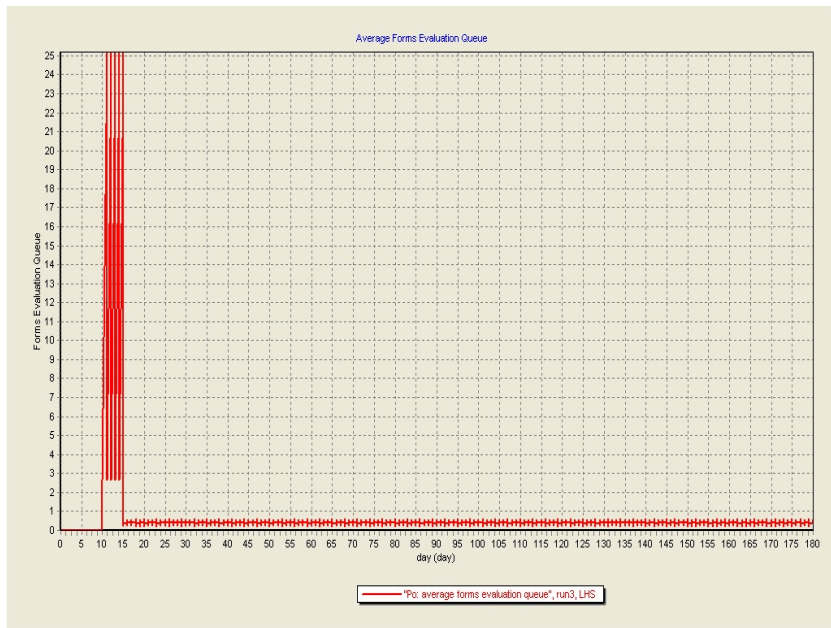
FIGURE 6-5 Departed Due to Supply Shortage Results Graph
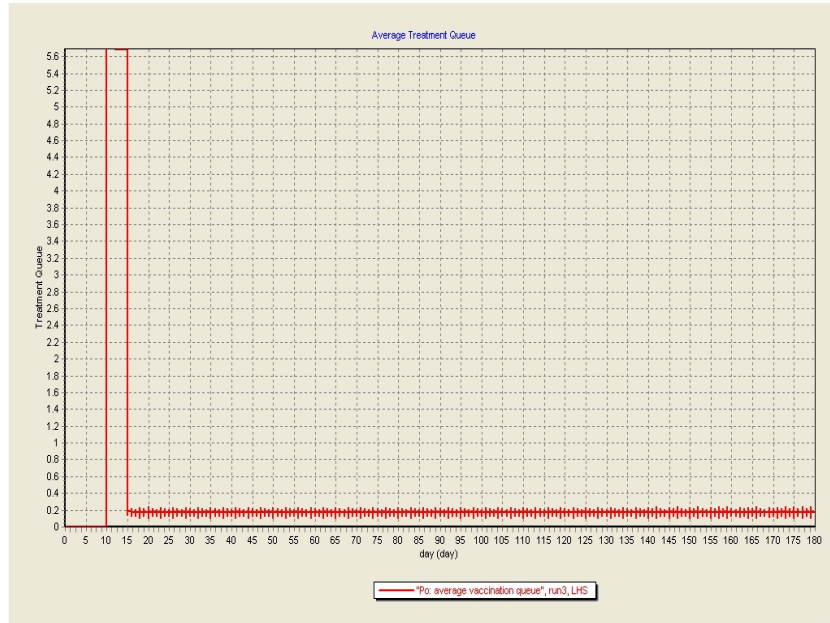

FIGURE 6-6 Average Medical Triage Queue Results Graph

FIGURE 6-7 Average Forms Completion Queue Results Graph

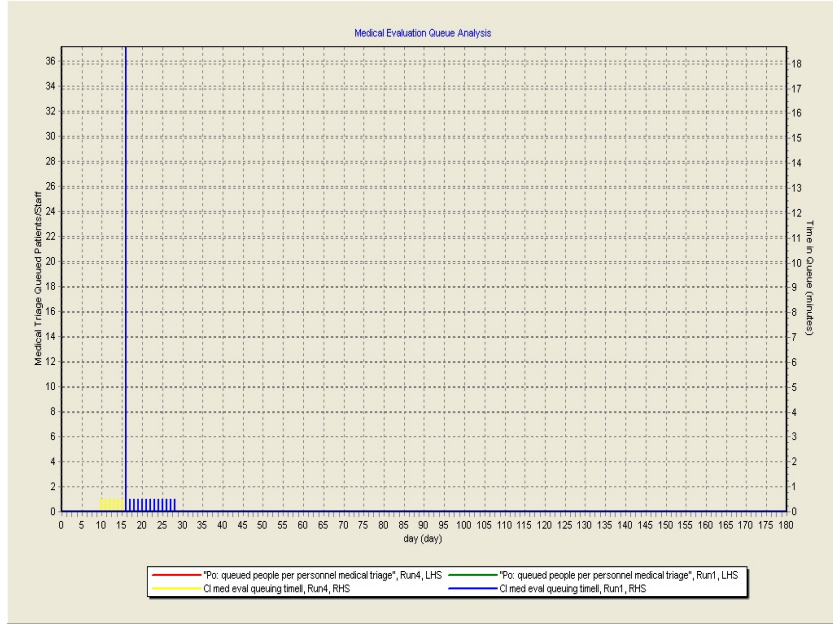**FIGURE 6-8 Average Forms Evaluation Queue Results Graph**

FIGURE 6-9 Average Treatment Queue Results Graph

The remaining three graphs in this section illustrate the capability to analyze and understand the queuing at points throughout the treatment center. In order to do so, two model runs are plotted on each graph. Run 1, shown in blue and green on the graphs, has an equal number of personnel assigned to each process step; Run 4, shown in yellow and red, has the same number of personnel, but they are assigned based on the amount of time each process takes according to study data.

> **Medical Evaluation Queue Analysis** (Figure 6-10). This graph is plotted on two Y-axes. The left Y-axis is the number of queued patients per staff person working, and the right Y-axis is the amount of time patients spend in queue prior to being seen by medical evaluation personnel.
>
> **Forms Evaluation Queue Analysis** (Figure 6-11). This graph is plotted on two Y-axes. The left Y-axis is the number of queued patients per staff person working, and the right Y-axis is the amount of time patients spend in queue prior to being seen by forms evaluation personnel.
>
> **Treatment Queue Analysis** (Figure 6-12). This graph is plotted on two Y-axes. The left Y-axis is the number of queued patients per staff person working, and the right Y-axis is the amount of time patients will spend in queue prior to being seen by forms evaluation personnel.
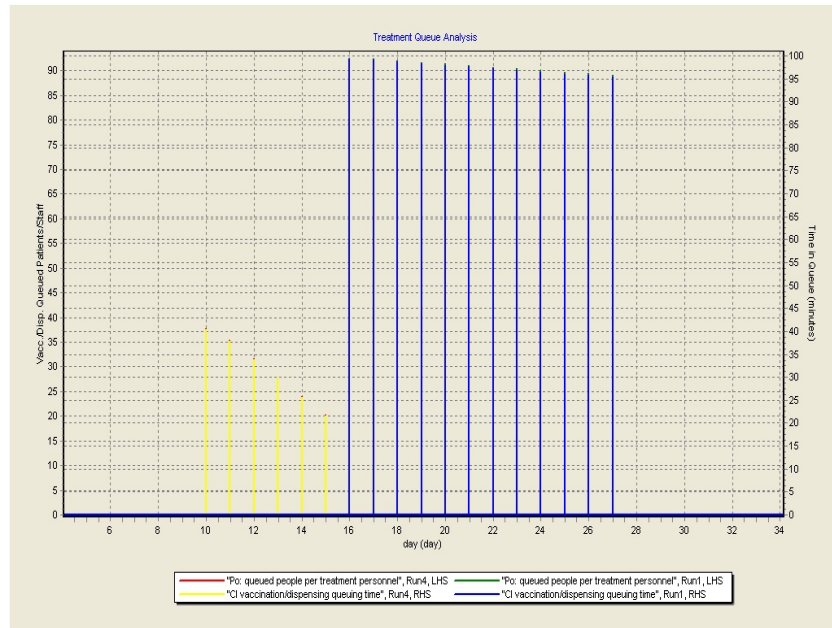
FIGURE 6-10 Medical Evaluation Queue Analysis Results Graph
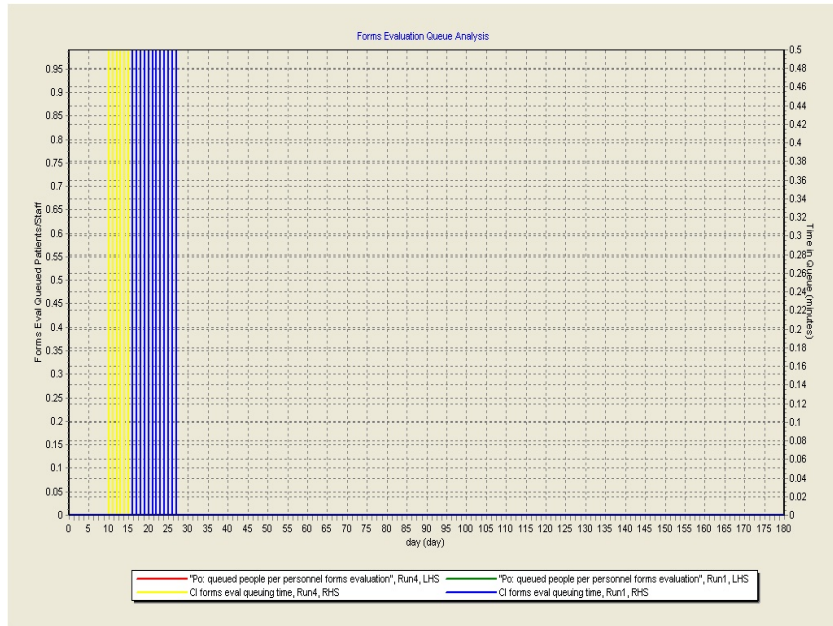
FIGURE 6-11 Forms Evaluation Queue Analysis Results Graph

FIGURE 6-12 Treatment Queue Analysis Results Graph

6.4 IMPACT OF THE DISEASE THROUGH THE POPULATION

The ten types of results graphs related to the Disease Process are as follows:

Public Pharmaceutical Stockpiles and New Infections (Figure 6-13). Variables related to the quantity of vaccine or antiviral drugs delivered and available for public distribution are graphed on the left Y-axis. The number of new infections from the previous day is graphed on the right Y-axis.

Current Infectious Population (Figure 6-14). This graph shows the number of persons in the population at large who are in the infectious stage of the disease; that is, they can transmit the disease to others.

Total Infected and Attack Rate (Figure 6-15). The total number of persons who have contracted the illness up to the current time is graphed on the left Y-axis. The clinical attack rate, that is, the percentage of the total population that has contracted the disease (total infections/total population), is graphed on the right Y-axis. The axes are scaled so these variables follow identical trajectories; thus, only a single line is visible.

Ill Population in Treatment (Figure 6-16). This graph shows the number of infected and symptomatic persons who have sought treatment at the local hospitals or at other health care providers. These persons *do not* present at the mass dispensing or vaccination centers.

Vaccinated/Treated Population (Figure 6-17). This graph shows the number of persons in the population at large who have been treated with either vaccine or antiviral/antibiotic medication at public health mass vaccination or dispensing centers.

Cumulative Fatalities (Figure 6-18).This graph shows the number of persons in the population who have become infected and died from the disease in the community.

Cumulative Recovered (Figure 6-19). This graph shows the number of persons in the community who have become infected and recovered from the disease in the community.

Treated Population by Age Cohort (Figure 6-20)**.** This graph shows the detailed breakdown by age cohort of the persons who have been treated with either vaccine or antiviral/antibiotic medication.

Fatalities by Age Cohort (Figure 6-21). This graph is the detailed breakdown of the number of persons in the population by age cohort who have become infected and died from the disease in the community.

Recovered by Age Cohort (Figure 6-22). This graph is a detailed breakdown of the number of persons in the population by age cohort who have become infected and recovered from the disease in the community.
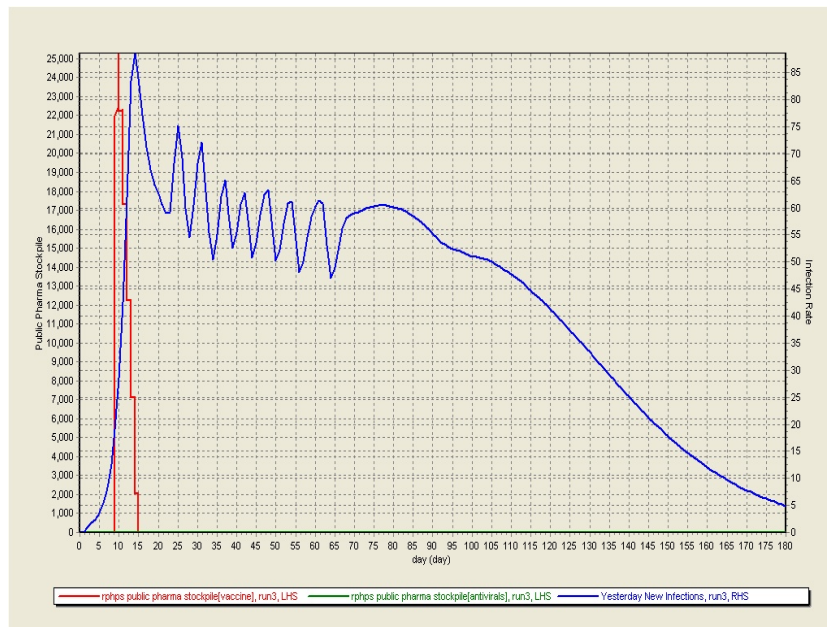
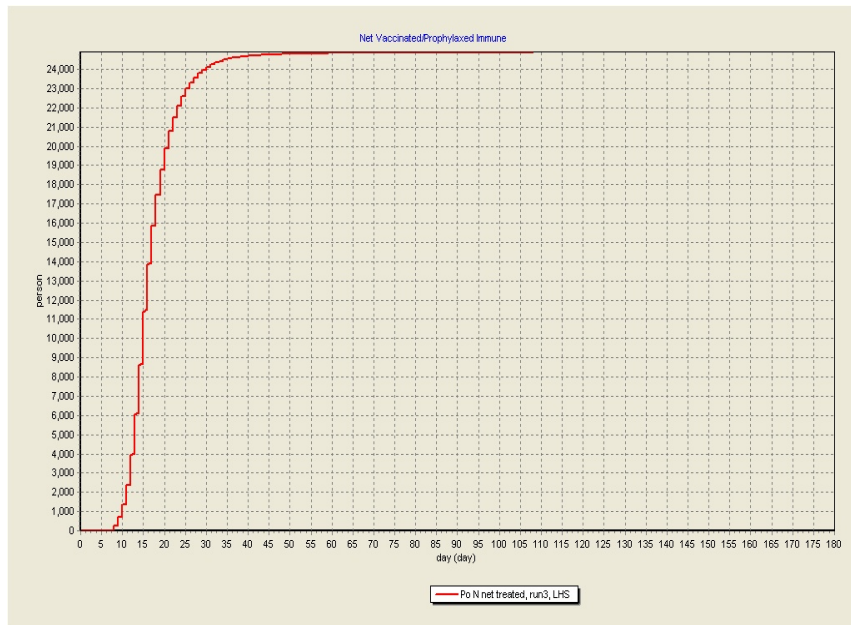**FIGURE 6-13 Public Pharmaceutical Stockpiles and New Infections Results Graph**
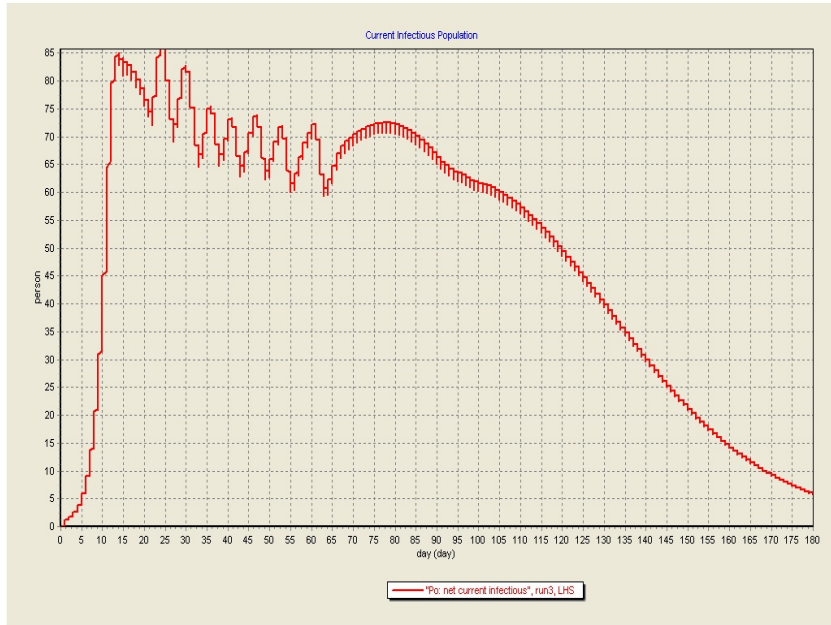
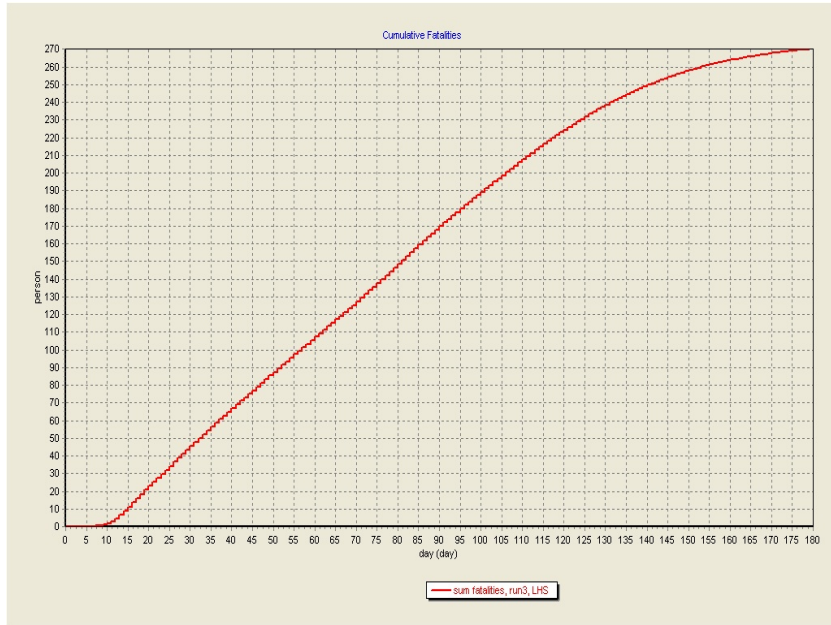**FIGURE 6-14 Current Infectious Population Results Graph**
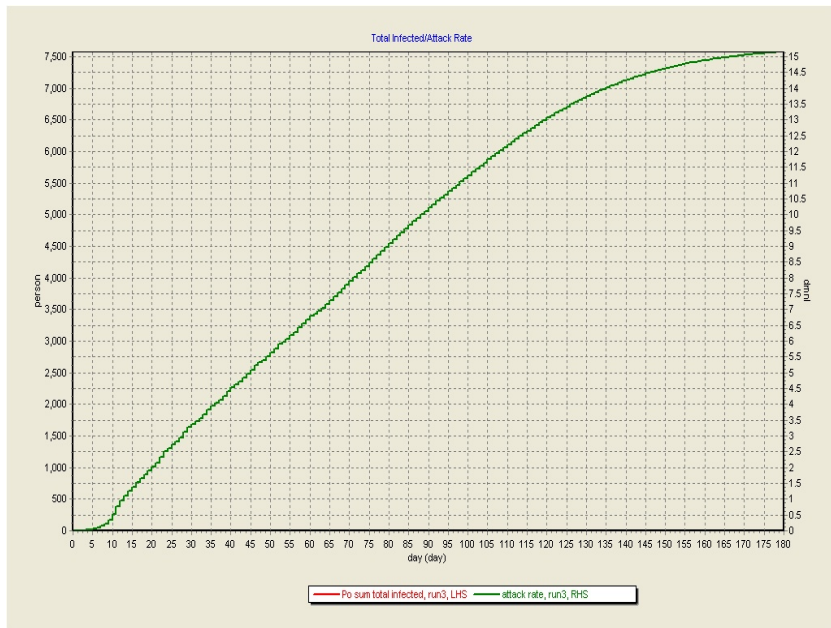
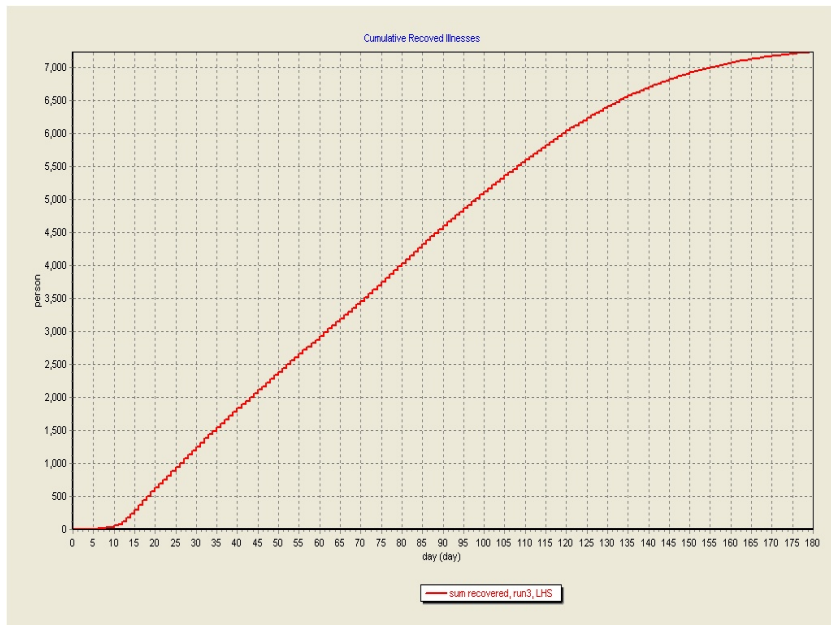**FIGURE 6-15 Total Infected and Attack Rate Results Graph**
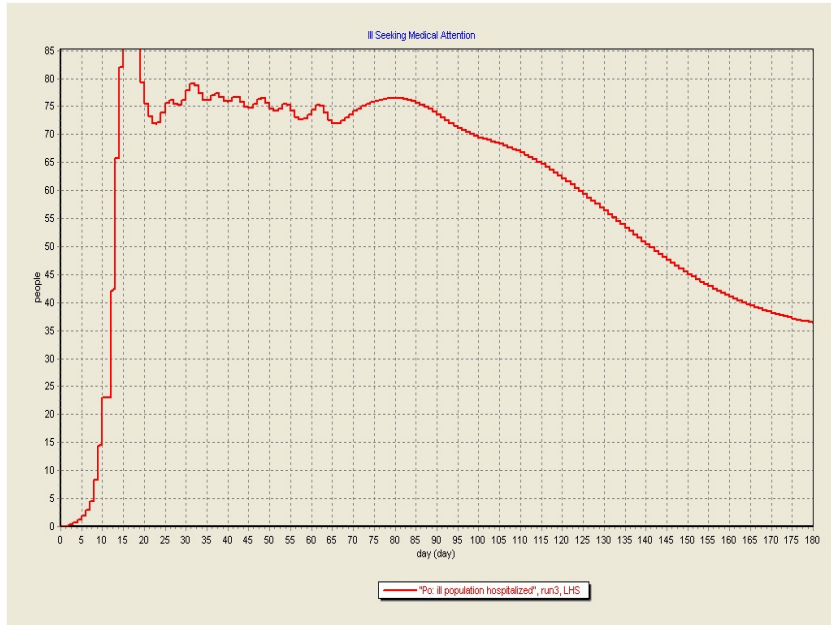
FIGURE 6-16 Ill Population in Treatment Results Graph
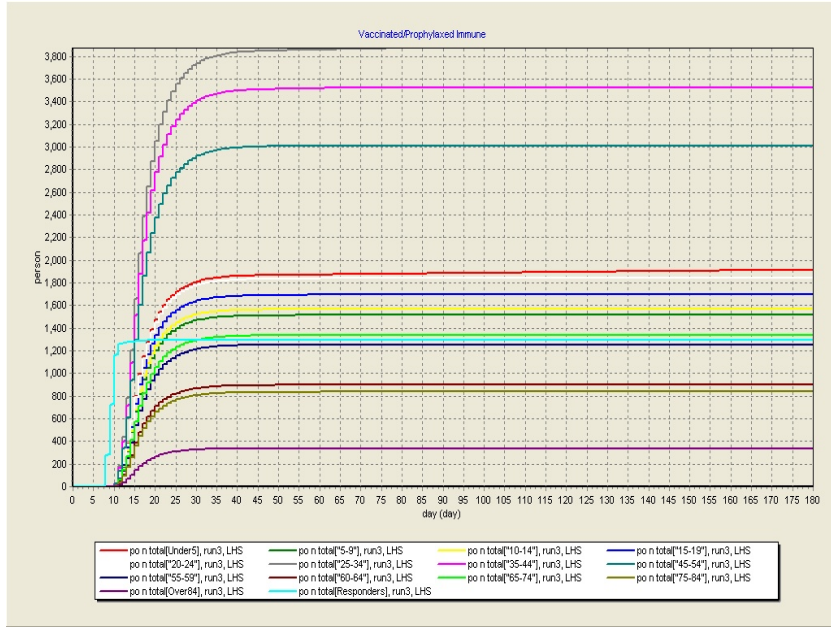

FIGURE 6-17 Vaccinated/Treated Population Results Graph
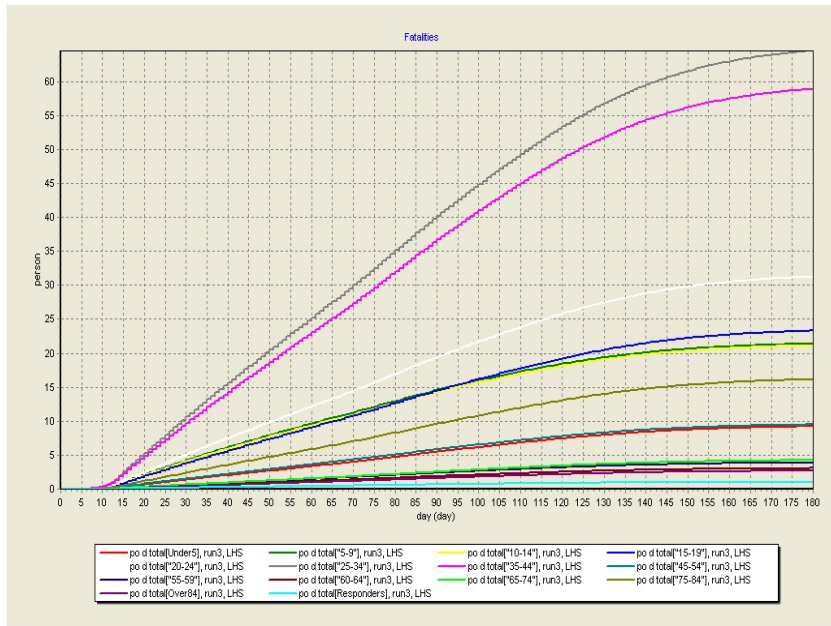
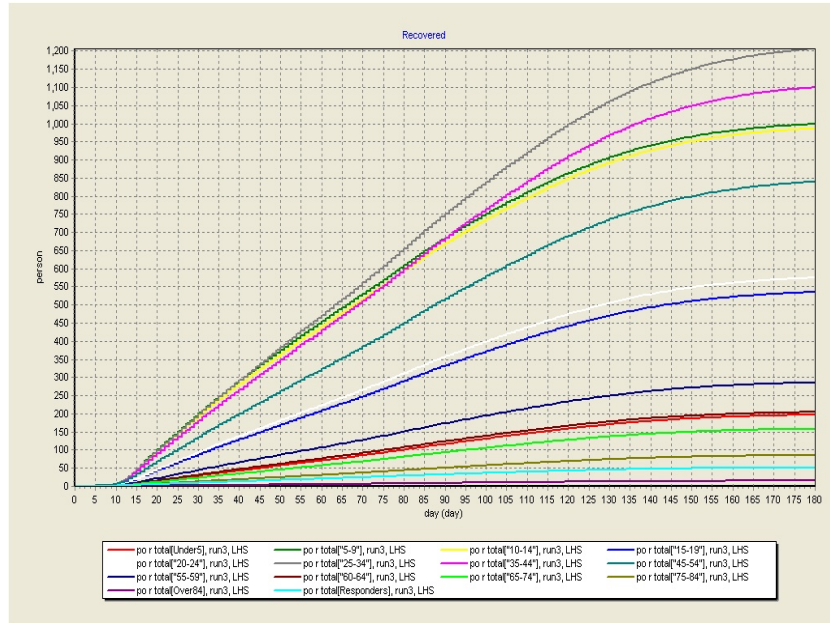**FIGURE 6-18 Cumulative Fatalities Results Graph**

FIGURE 6-19 Cumulative Recovered Results Graph

FIGURE 6-20 Treated Population by Age Cohort Results Graph

FIGURE 6-21 Fatalities by Age Cohort Results Graph

FIGURE 6-22 Recovered by Age Cohort Results Graph
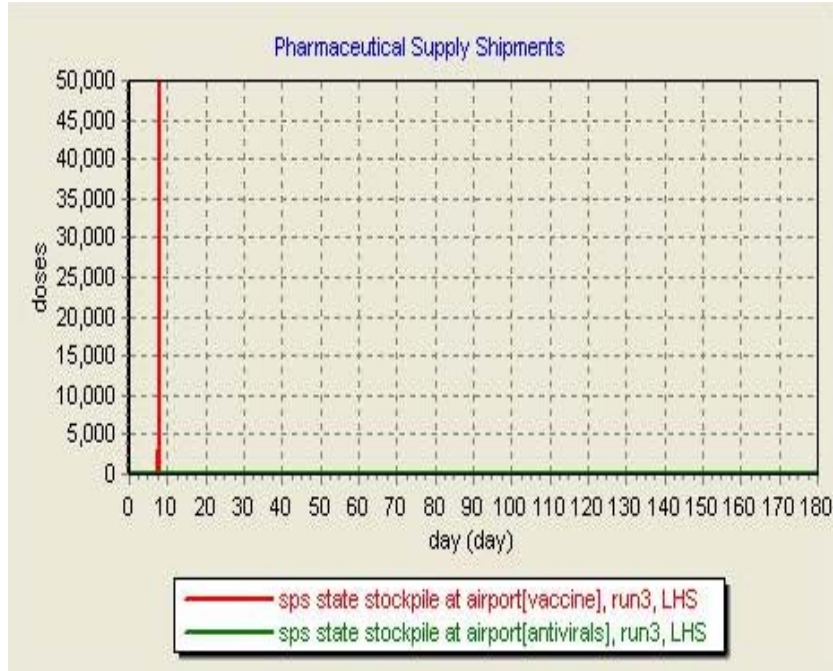
6.5 PHARMACEUTICAL SUPPLY ARRIVALS

The supply output pages track the shipment and arrival of pharmaceutical supplies throughout the campaign, complete with estimates of quantities for both vaccines and antiviral medications. There are four types of results graphs for this category, as follows:

Pharmaceutical Supply Shipments (Figure 6-23). This graph reports the occurrences and quantities of pharmaceutical supply arrivals in the jurisdiction, both vaccines and antiviral/antibiotic medications.
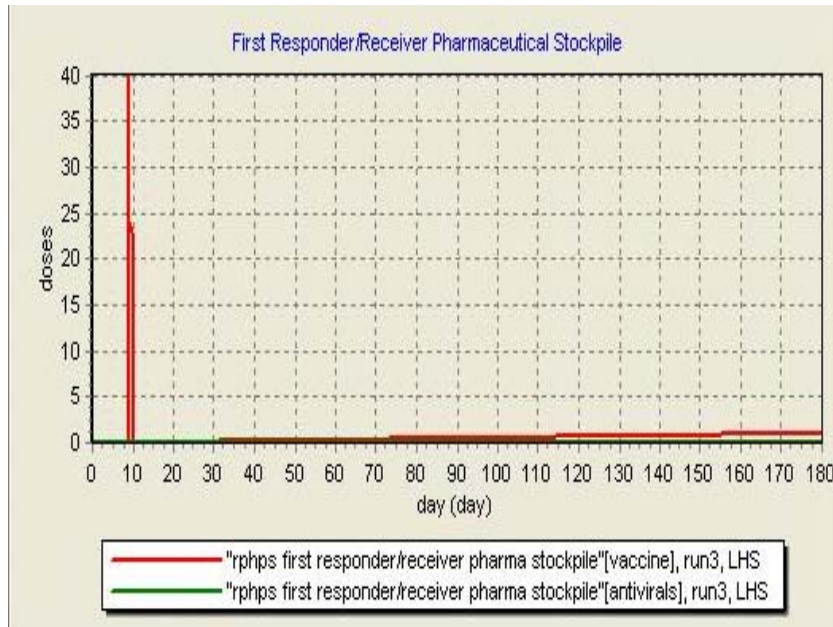
First-Responder/-Receiver Stockpile (Figure 6-24). This graph reports the quantity of vaccine and antiviral medications available for first- responders, first-receivers, and staff at the mass treatment centers.

Hospital Pharmaceutical Stockpile (Figure 6-25). This graph shows the quantity of vaccine and antiviral medications available for treatment of hospital patients and prophylaxis of hospital personnel.

POD Pharmaceutical Stockpile (Figure 6-26). This graph reports the quantity of vaccine and antiviral medications available for mass treatment/prophylaxis of the public.
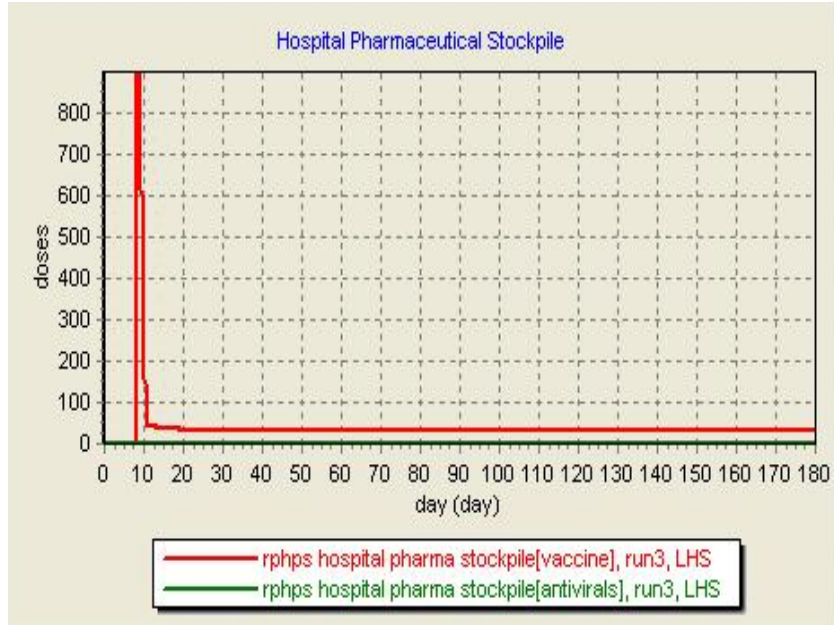
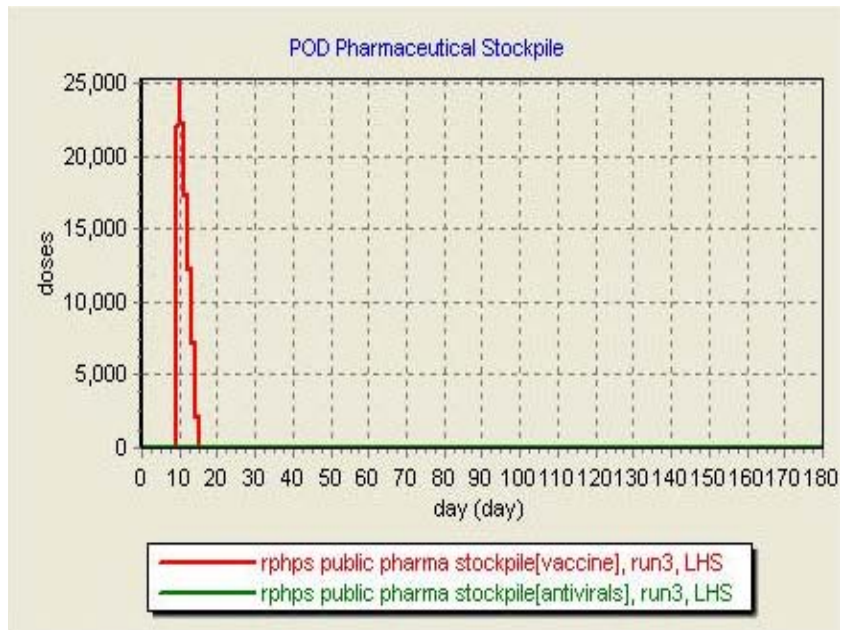**FIGURE 6-23 Pharmaceutical Supply Shipments Results Graph**

**FIGURE 6-24 First-Responder/-Receiver Pharmaceutical
Stockpile Results Graph**

FIGURE 6-25 Hospital Pharmaceutical Stockpile Results Graph

**FIGURE 6-26 POD Pharmaceutical Stockpile Results Graph**

6.6 AVAILABILITY OF HUMAN RESOURCES

Graphs in the personnel output screens allow the user to assess the availability of human resources on the basis of their treatment status. Three classes of workers are tracked, as follows:

Treated First-Responders/-Receivers and POD Personnel (Figure 6-27). The graph shows the number of personnel who have been treated and when treatment occurred.

T**reated Hospital Employees** (Figure 6-28). The graph shows the number of hospital staff who have been treated and with what form of prophylaxis, antiviral/antibiotic medication, or vaccine.
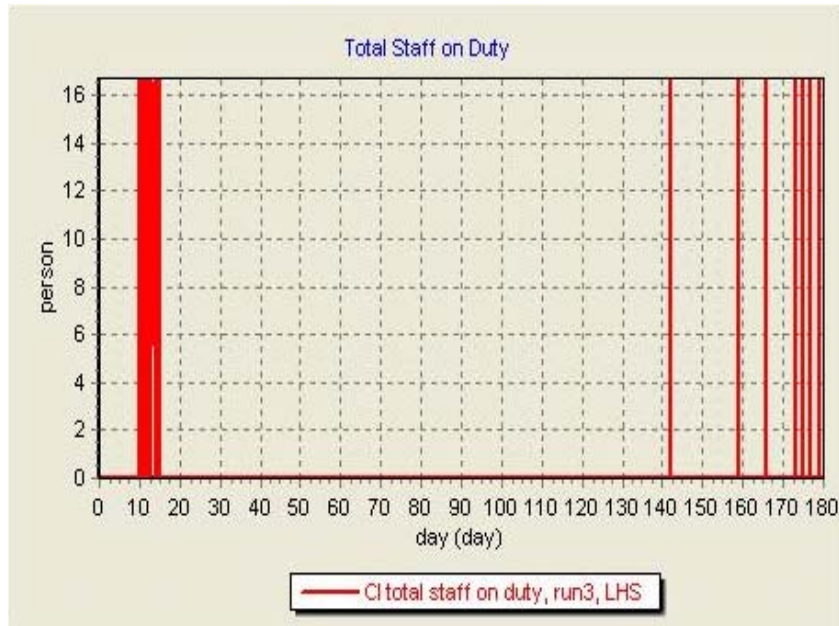
Total Staff on Duty (Figure 6-29). This graph shows the number of treated staff who have reported for and are working at the public health dispensing or vaccination centers or PODs.
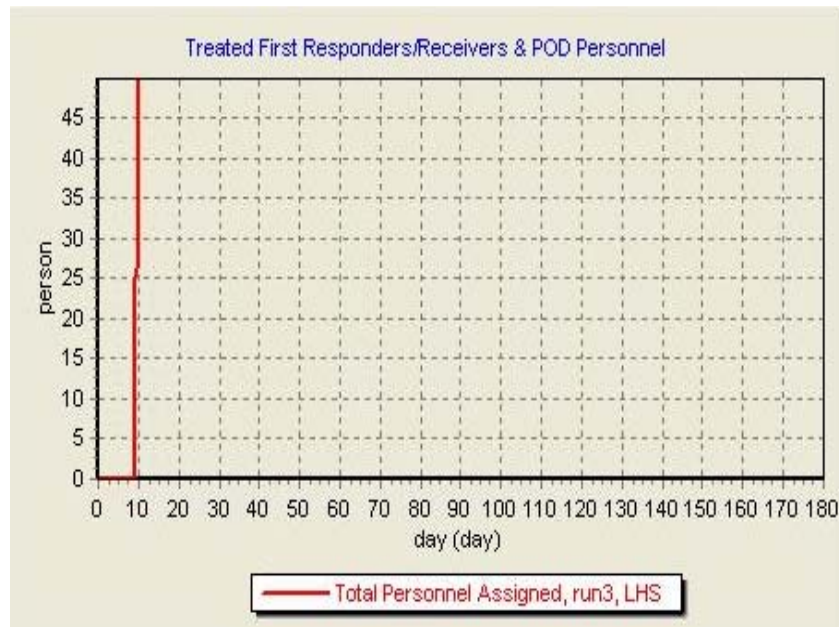
FIGURE 6-27 Treated First-Responders/-Receivers and POD Personnel Results Graph
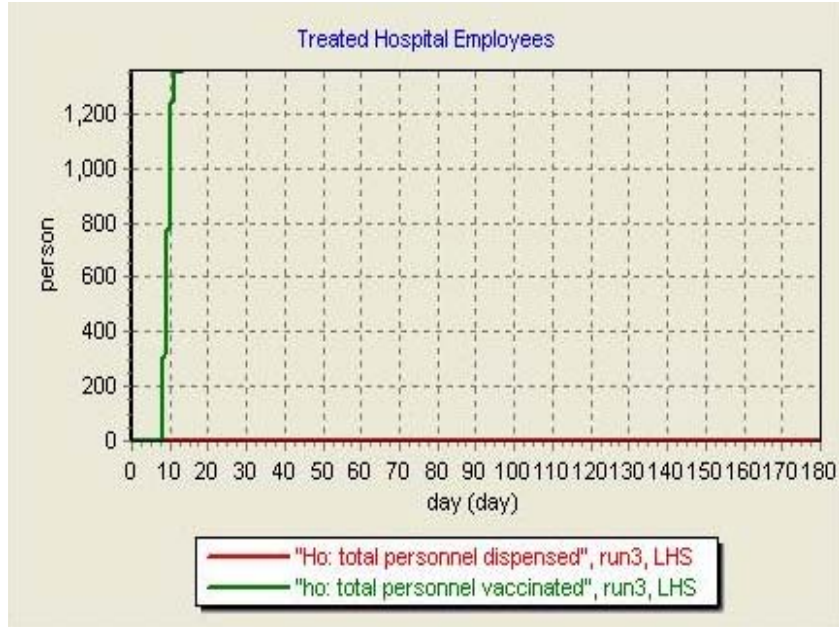
FIGURE 6-28 Treated Hospital Employees Results Graph

FIGURE 6-29 Total Staff on Duty Results Graph

7 *EpiPOD* ASSISTANCE

Please direct any questions or comments about the model to:

Matthew Berry   or   Michael Samsa
mberry@anl.gov   msamsa@anl.gov
(630) 252-8485   (630) 525-4961