VaCRO User Manual

Vaccination Clinic Reconstitution Optimizer

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2015

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# 1. Introduction

## 1.1 Purpose and Overview

The purpose of VaCRO is to help clinicians minimize open vial waste from multi-dose vials while maximizing immunization coverage. This objective is achieved by determining optimal cut-off times to stop vial reconstitution for a single type of vaccine. Optimal cut-off times are generated for each session (i.e., each clinic work-day) as a function of:

* Total number of vaccination sessions remaining before replenishment (i.e., the next shipment of vaccines)
* Number of vials remaining
* Doses per vial
* Average daily demand (i.e., expected number of patients per session)
* Total number of hours each session

The results are listed in *Recommended Actions Today* under the “Today” worksheet*.*

The optimal policy is generated by a Markov Decision Process model developed by Mofrad et al. (2014)[[1]](#footnote-1). In this framework, the following assumptions are made:

* Vaccines are stored within their manufacturer-recommended ranges at all times
* The shelf life of an open vial is equal to the duration of the session in which it was opened
* All vials have the same vial size

This tool was developed in C++ and Visual Basic for Applications within Microsoft Excel.

## 1.2 Rationale – Why use VaCRO?

To maximize the number of children who receive vaccinations, clinicians must consider efficient ways to operate a vaccination clinic so that they can reduce vaccine waste. The World Health Organization (WHO) estimates that 50% of vaccines are wasted globally, most of which is caused by open vial waste2. Open vial waste occurs when a multi-dose vial is reconstituted but its remaining doses are unused before vaccine expiration. One way to reduce open vial waste is to change the vaccine administration policy – the decision rules that dictate when vials are reconstituted. Instead of reconstituting vials whenever patients arrive (regardless of long-term consequences), VaCRO determines optimal cut-off times each session for which it is optimal to stop reconstituting vials so remaining inventory is preserved for future demand. The superior performance of this policy is described in Mofrad et al. (2014)1.

# 2. Using VaCRO

Use VaCRO for each available vaccine type at the start of each immunization session for the most accurate results. However, if this frequency of use is inconvenient, use VaCRO at the beginning of a set of immunization sessions and use the policies described in the “All Results” worksheet until the next replenishment. See [Section 3.3.1.](#_3.3.1_Don’t_Open)

## 2.1 System Requirements

* Operating System: Windows 2003 or higher
* Software: Microsoft Excel (MS-Excel) 2003 or higher
* WinZIP, WinRAR, 7-ZIP, or any other unzipping software.

## 2.2 Unzipping VaCRO

To unzip VaCRO, find the folder in which the Pitt VaCRO ZIP archive was saved after it was downloaded. Right-click the Pitt VaCRO ZIP archive and click “Extract to Pitt VaCRO\” as shown in red in Figure 1. A folder entitled “Pitt VaCRO” should appear. See Figure 2.

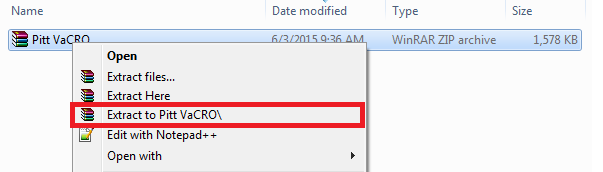


Figure Unzipping Pitt VaCRO using WinRAR

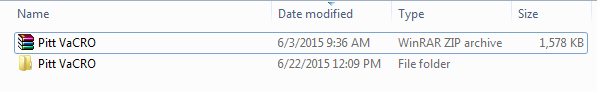


Figure 2 Pitt VaCRO Folder

The “Pitt VaCRO” folder contains two folders entitled “Debug” and “Output”, the User Manual, and two MS-Excel workbooks entitled “Average Daily Demand Tool” and “VaCRO”. See **Error! Reference source not found.**. Refer to [Section 4](#_4._Average_Daily) for instructions on using the Average Daily Demand Tool. Sections [2.3](#_2.3_Launching_VaCRO) and [2.4](#_2.4_Description_of) provide instructions for using VaCRO while [Section 3](#_3._Interpreting_Results) provides instructions for interpreting the output from VaCRO.

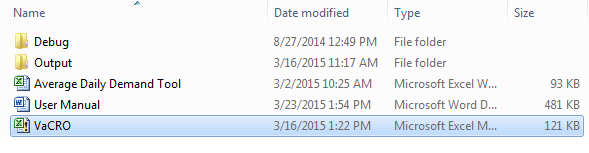


Figure . Pitt VaCRO folder and files

The “Debug” folder contains the executable file, “DServiceTimeVaringModel.exe,” which VaCRO calls upon to compute optimal cut-off times. These calculations are saved in the “Output” folder as comma-separated value (.CSV) files. The data from these output files are read and printed nicely on MS-Excel spreadsheets by VaCRO. **Since VaCRO automatically coordinates these functions, it is unnecessary to manually use any of the files in the “Debug” or “Output” folders. It is important that the names of these folders and the contents of the “Debug” folder are unchanged. Otherwise, VaCRO will not run. Furthermore, these folders MUST remain in the “Pitt VaCRO” folder for VaCRO to run properly**.

## 2.3 Launching VaCRO

First, unzip the “Pitt VaCRO” folder. See [Section 2.2](#_2.2_Unzipping_VaCRO) for instructions on unzipping Pitt VaCRO.

To launch VaCRO, double-click the MS-Excel file entitled “VaCRO.” **Make sure that ”VaCRO” is not removed from the “Pitt VaCRO” folder. “VaCRO” must be in this folder to run properly.**

An MS-Excel spreadsheet will open. For first-time VaCRO users, a message saying “SECURITY WARNING Macros have been disabled” will appear. If so, click the “Enable Content” button. See Figure 4.

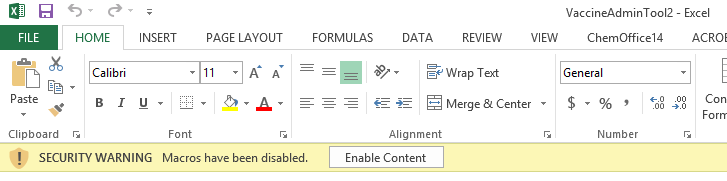


Figure Enable Macros

Once macros are enabled, click the “Launch VaCRO” button on the right-hand side of the console. See Figure 5. The VaCRO application will load with default parameters. See Figure 6.

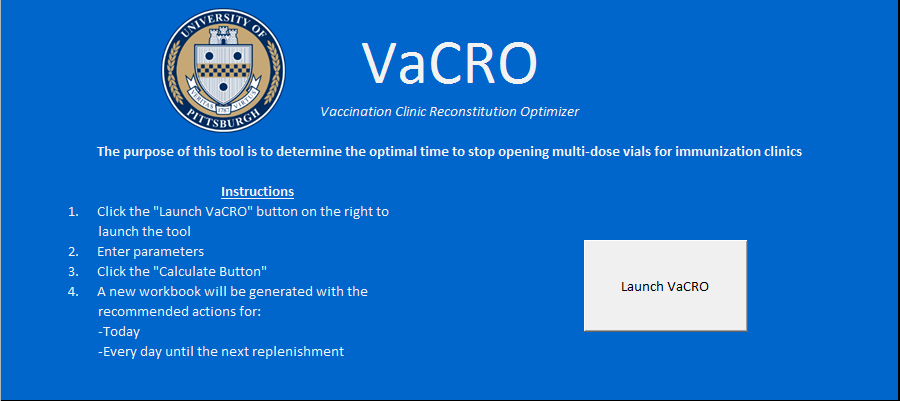


Figure Launch VaCRO Button

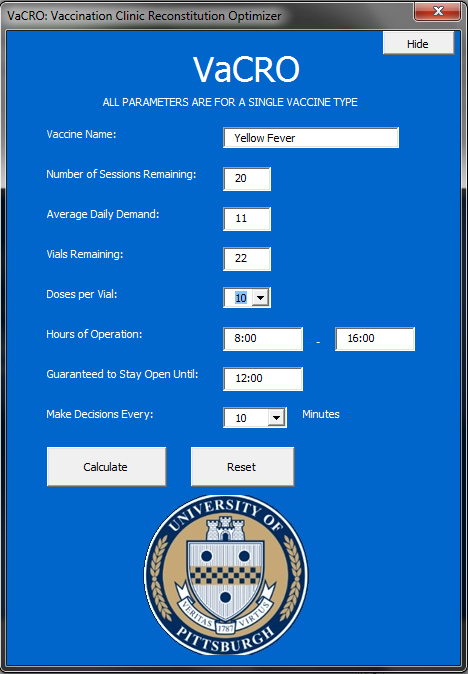


Figure VaCRO Application

## 2.4 Description of Input Parameters

In order to determine optimal reconstitution stopping times, the following parameter values must be entered:

1. **Vaccine Name**
   1. This parameter describes the name of the vaccine for which VaCRO is being used, since VaCRO can only compute optimal cut off times for one vaccine at a time. Entering a vaccine name is optional, but recommended so different results can be organized by vaccine type.
2. **Number of Sessions Remaining**

This parameter describes the number of immunization sessions (i.e., work days) before the next replenishment (i.e., shipment) of vaccines. This parameter must be entered as a positive *integer* (e.g., 15).

1. **Average Daily Demand**

This parameter describes the average number of vaccination requests each day. This parameter can either be an *integer* (e.g., 1, 2, 3, 4) or a *decimal* value (e.g., 23.56).

If the *Average Daily Demand* is unknown, use the “Average Daily Demand Tool” included in this package. See [Section 4](#_4._Average_Daily) for instructions on using this tool.

1. **Vials Remaining**

This parameter describes the number of vaccine vials currently in the clinic’s inventory. This parameter must be entered as a positive *integer.*

1. **Doses per Vial**

This parameter describes the number of vaccine doses in each vial before any reconstitution. It is assumed that all of the vials have the same number of doses. This parameter must be selected from the drop-down list.

1. **Hours of Operation**

These parameters describe the times at which the immunization session begins and ends. These times must be entered in a 24-hour time format (e.g., 13:00 instead of 1:00 PM).

1. **Guaranteed to Stay Open Until**

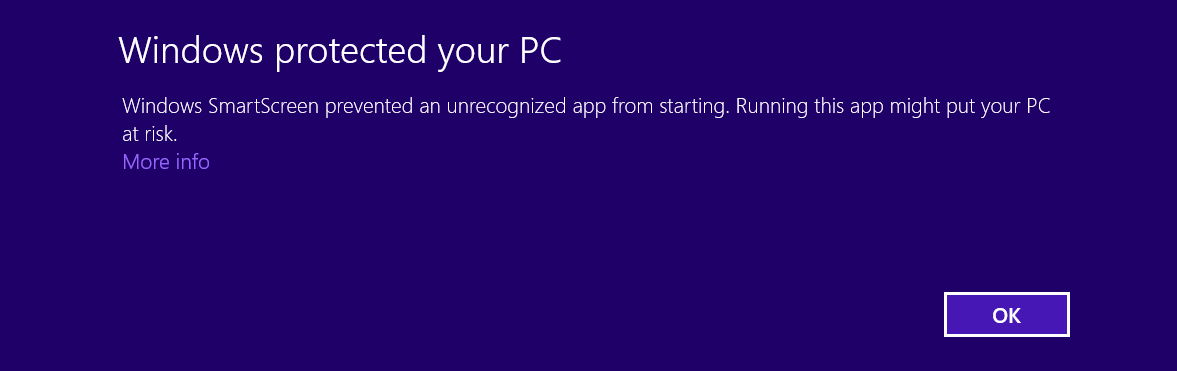
This parameter describes the time until which the clinic is guaranteed to serve patients, regardless of remaining inventory and sessions remaining until replenishment. This parameter must be entered in a 24-hour time format. Additionally, this time must be within the times listed under the *Hours of Operation*.

1. **Make Decisions Every \_ Minutes**

This parameter describes the level of detail at which the calculations are performed. Choosing to make a decision every 1 minute instead of 10 minutes will result a more exact policy, but will take longer to calculate. It is recommended to select a value of 10 or 15 minutes for this parameter in order to balance computational effort and practicality. This parameter must be selected from the drop-down list.

To reset the input parameters to the default parameters, click the “Reset” button. Once the parameters have been entered, click “Calculate” to determine the optimal cut-off times for vial reconstitution. Depending on parameter inputs and computer specifications, run time may range from seconds to several minutes. Once the calculations are complete, a new Microsoft Excel Workbook with the results will be generated.

Note that for Windows 8 or higher, a warning message may appear due to Windows SmartScreen. In order to use VaCRO, bypass this warning by clicking “More Info” and then “Run Anyway”. See Figure 7.



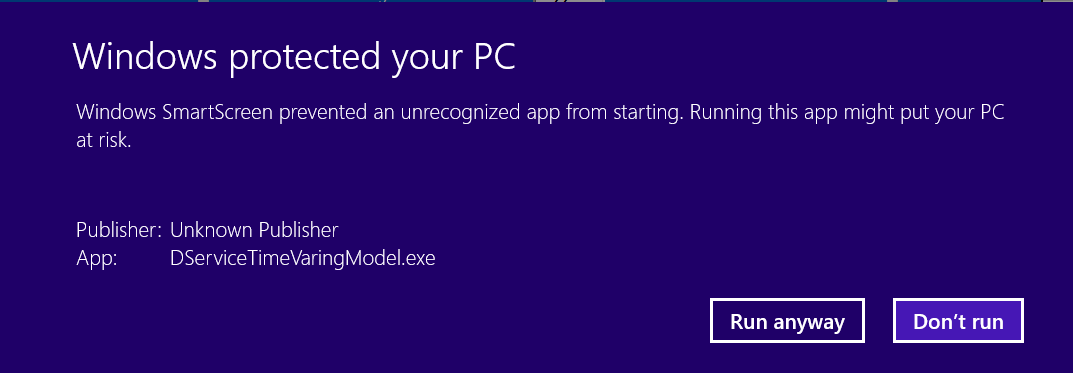


Figure Windows SmartScreen (Windows 8 and higher)

# 3. Interpreting Results

Once the results have been generated, VaCRO can be hidden or closed to better view the results. To hide VaCRO, click the “Hide” button in the upper-right corner of the application. VaCRO will shrink into a small window with a “Show” button. To unhide VaCRO, click the “Show” button. To close VaCRO instead, click the “X” above the “Hide” button. See Figure 8.



Figure Hide and Show buttons

At the bottom of the generated workbook, there are three different tabs (worksheets). These worksheets are labeled “Today,” “Policy Visualization,” and “All Results”. See Figure 9.

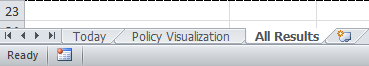


Figure "Today", "Graphs", and "All Results" Tabs

At the top-left corner of each worksheet, a table contains all of the input parameters used for the calculations. See Figure 10. The remainder of this section will detail how to interpret the results of each worksheet.

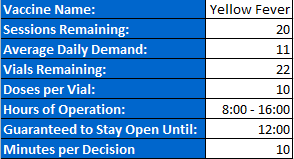


Figure Parameters Table

## 3.1 Today WORKSHEET

This worksheet contains the *Recommended Actions* *Today* and its corresponding visualization.

### 3.1.1 Reading the Recommended Actions Today

The *Recommended Actions Today* are displayed in chronological order. See Figure 11. At each time listed, look over the remaining inventory and determine whether to stop opening vials. If the policy indicates that vials should not be opened, administer the remaining doses from any vial currently open (assuming that the remaining doses have not yet expired). No more vials should be reconstituted during the current vaccination session. **These recommended actions are only recommended for today.**

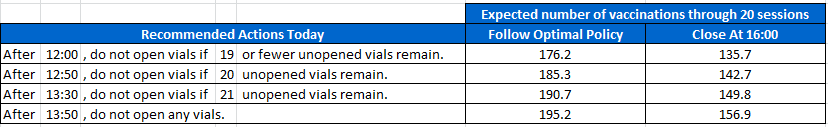


Figure Recommended Actions Today

As an example, the first recommendation in Figure 9 states:

*At 12:00, do not open vials if 19 or fewer unopened vials remain.*

So at 12:00, check the remaining inventory. If 19 or fewer vials remain, then administer any remaining doses from an open vial, but do not reconstitute any additional vials in this session. However, if 20 or more unopened vials remain, then continue to operate as normal until 12:50. At 12:50, survey the inventory and determine whether to continue or not. Proceed with this process until the policy dictates a cease in vial reconstitution or the clinic closes, whichever comes first.

The next two columns under “Expected number of vaccinations through *N* sessions”, with N being the number of sessions remaining, describe the number of vaccination administrations expected by following either the optimal policy or by continuing to open vials until the clinic closes. As an example, the first row can be read as “*If the recommended actions are followed, there is an expected 176.2 vaccinations in the next 20 sessions. Otherwise, there is only an expected 135.7 vaccinations.”* This output is meant to aid users (clinicians, inventory managers, etc.) in quantifying the impact of following the optimal policy.

### 3.1.2 Reading the Recommended Actions Graph

This graph (Figure 12) is a supplemental visual aid for the *Recommended Actions Today*. The y-axis (vertical axis) shows the “Time” and the x-axis (horizontal axis) shows the number of “Unopened Vials Remaining.” The graph shows the time at which a clinician should stop reconstituting vials based on the number of unopened vials remaining in the inventory. For example, the highlighted point in Figure 10 can be interpreted to say “*If 21 unopened vials remain at 13:30, stop reconstituting vials.”*

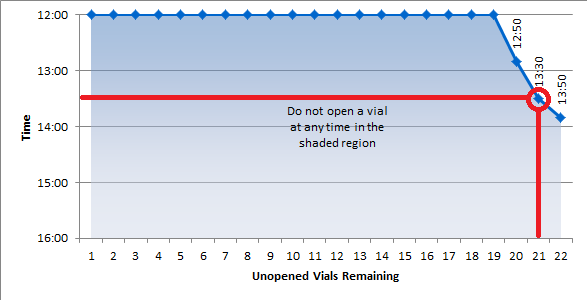


Figure Recommended Actions Graph

### 3.1.3. Printing the Recommended Actions Today

To print the Recommended Actions Today, click the “file” button in the top-left corner of MS-Excel as shown in red in Figure 13.

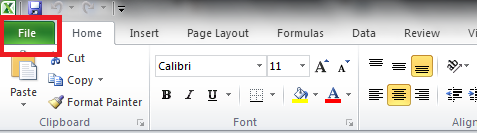


Figure File Button in MS-Excel

A menu will appear along the left-hand side of MS-Excel. Click the “Print” tab shown in green in Figure 14. VaCRO has already set the Print Area to include the user-chosen parameters and the “Recommended Actions Today” table. Select the desired printer and click the “Print” button shown in red in Figure 14.

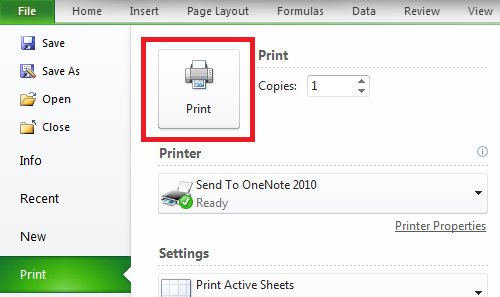


Figure Print Tab and Print Button

## 3.2 Policy Visualization WORKSHEET

This worksheet presents a graphical interface to preview the recommended actions for *each remaining session* until inventory is replenished. The y-axis (vertical axis) shows the “Time” and the x-axis (horizontal axis) shows the number of “Unopened Vials Remaining.” Figure 15 shows how the interface would appear under the parameters used in Figure 8.

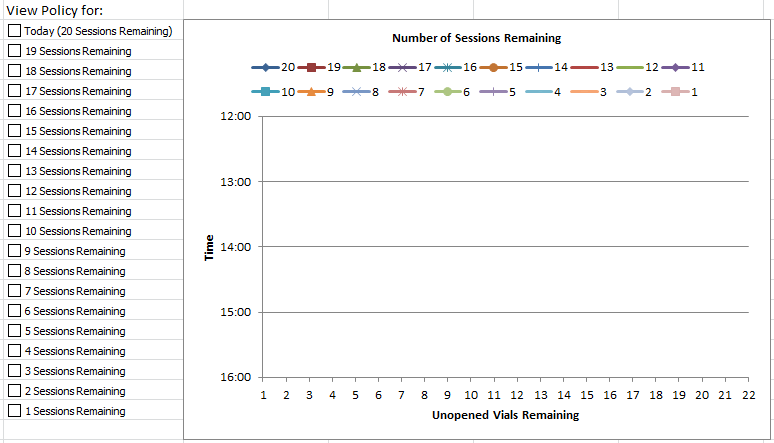


Figure 15 Graphical Interface for Policy Visualization

To use this worksheet, click on the checkbox next to the desired policy. Figure 16 shows what the recommended actions would look like for “19 Sessions Remaining” and “18 Sessions Remaining.” The red squares represent “19 Sessions Remaining” whereas the green triangles represent “18 Sessions Remaining.” The points corresponding to each policy can be determined by checking the key above the graph, highlighted in red in Figure 16.

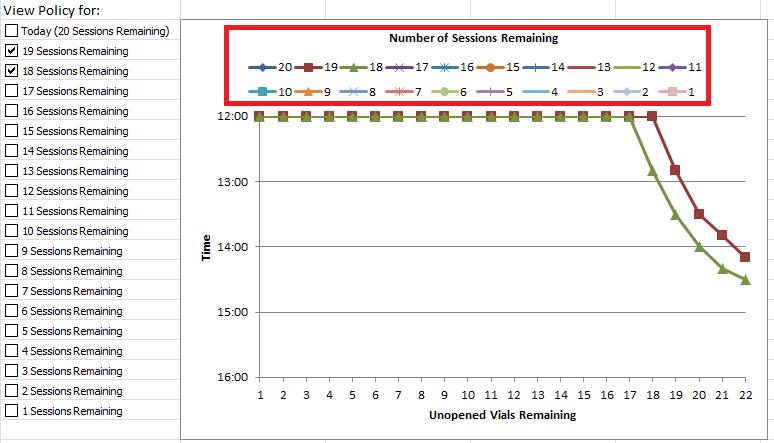


Figure 19 Sessions Remaining and 18 Sessions Remaining

This worksheet can be used to anticipate potential closing times in the future for operational purposes. This graph can be read like the graph in the “Today” worksheet is read. Refer to [Section 3.1.2](#_3.1.2_Reading_the).

## 3.3 All Results WORKSHEET

This section details the calculated results for each session until inventory replenishment. These results are presented in a tabular format with the number of sessions remaining as rows and the number of unopened vials as columns. The parameters used for the examples below are the same parameters used in Figure 10.

### 3.3.1 Don’t Open A Vial After…

This table displays the recommended times at which vials should not be opened. Figure 17 shows a portion of the table with the time 14:20 highlighted. This can be interpreted as “When 17 sessions remain until replenishment and there are 20 unopened vials remaining, stop opening vials after 14:20.” Any time highlighted in yellow is a recommended time to stop opening vials before the clinic’s actual closing time.



Figure 17 Snapshot of “Don't Open A Vial After…” Table

To print this table, refer to the instructions provided in [Section 3.1.3](#_3.1.3._Printing_the). By default, the Parameters table and the “Don’t Open A Vial After…” table have been selected as the objects to be printed.

### 3.3.2 Expected Number of Vaccinations

The values in this table report the number of patients that a clinic can expect to vaccinate under the recommended actions based on the number of sessions remaining, unopened vials remaining, and average daily demand. In Figure 18, the highlighted point can be interpreted to say “If there are 18 sessions remaining before inventory replenishment, 20 unopened vials remaining, and an average daily demand of 11 patients per day, then an expected 176.4 people will be vaccinated before replenishment.”

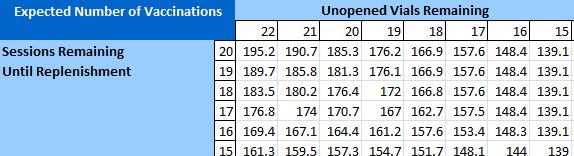


Figure Expected Number of Vaccinations

# 4. Average Daily Demand Tool

The “Average Daily Demand Tool” is intended to be a supplemental tool for users who do not have patient demand data. To launch this tool, click the MS-Excel file entitled “Average Daily Demand Tool”. See Figure 19.

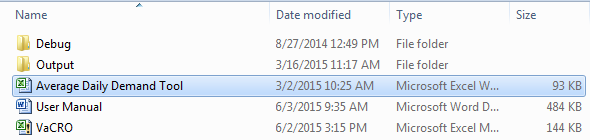


Figure Launch the Average Daily Demand Tool

Upon launching the “Average Daily Demand Tool”, three different tabs will appear at the bottom of the spreadsheet (Figure 20). The “Instructions” tab contains detailed instructions for how to use the “Average Daily Demand Tool” (Figure 21). The “EXAMPLE Calculator Log Sheet” shows a complete and labeled example of the “Calculator Log Sheet”, which is used to determine average daily demand.



Figure Average Daily Demand Tool Tabs

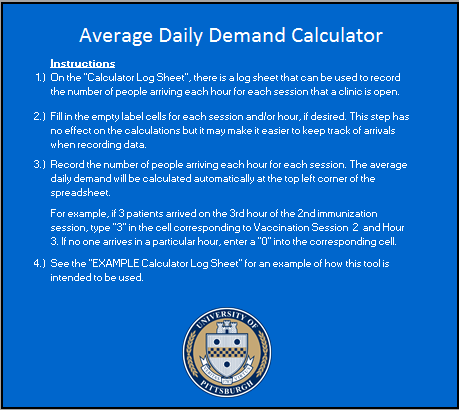


Figure Average Daily Demand Calculator Instructions

The “Calculator Log Sheet” contains a tabular log sheet that can be used to record patient arrivals. Once these arrivals have been recorded in the “Calculator Log Sheet”, the average daily demand will be calculated in the upper-left-hand corner of the “Calculator Log Sheet” (Figure 22).

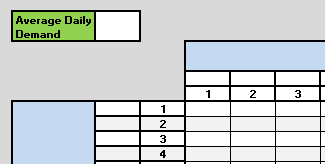


Figure 22 Average Daily Demand

# 5. VaCRO Easy-Use Checklist

The following checklist outlines the steps needed to use VaCRO. The steps listed below are in sequential order (so the first item must be done first, the second item done second, etc.). Steps that are only for first-time users will be **bolded***.*

* **Locate and unzip the “Pitt VaCRO” folder (**[**Section 2.2**](#_2.2_Unzipping_VaCRO)**)**
* **If average daily demand for a vaccine type is unknown, record and calculate the average daily demand using the “Average Daily Demand Tool” (**[**Section 4**](#_4._Average_Daily)**)**
* Open the MS-Excel file VaCRO.xlsx ([Section 2.3](#_2.3_Launching_VaCRO))
* **Click “Enable Content” (**[**Section 2.3**](#_2.3_Launching_VaCRO)**)**
* **For Windows 8 Users, disable Windows SmartScreen (**[**Section 2.3**](#_2.3_Launching_VaCRO)**)**
* Click “Launch VaCRO” ([Section 2.3](#_2.3_Launching_VaCRO))
* Enter parameters ([Section 2.4](#_2.4_Description_of))
* Click “Calculate” ([Section 2.4](#_2.4_Description_of))
* If VaCRO is being used at the start of each clinic session, print results from “Today.” Otherwise, print results from “Today” and “All Results.” (Sections [3.1](#_3.1_Today_WORKSHEET) and [3.3](#_3.3_All_Results))
* Use VaCRO results to determine optimal cut-off times for each immunization session ([Section 3](#_3._Interpreting_Results))

1. Maryam H. Mofrad, Lisa M. Maillart, Bryan A. Norman & Jayant Rajgopal (2014) Dynamically optimizing the administration of vaccines from multi-dose vials, IIE Transactions, 46:7, 623-635, DOI: 10.1080/0740817X.2013.849834

   2World Health Organization. (2005) Monitoring vaccine wastage at country level: Guidelines for programme managers. Available from <http://whqlibdoc.who.int/hq/2005/WHO_V&B_03.18.Rev.1_eng.pdf>, accessed May 27, 2015. [↑](#footnote-ref-1)