

Revised on: 03/30/2009



Beta Test Version 1.0

**A Tool to Estimate the Potential Impacts for Stockpiling
Vaccines for Vaccine-Preventable Diseases of Children**

Sundar S. Shrestha, MS, PhD

Martin I. Meltzer, MS, PhD

Gregory S. Wallace, MD, MS, MPH

Centers for Disease Control and Prevention

Atlanta, Georgia, USA



AUTHORS

Sundar S. Shrestha,¹ Martin I. Meltzer,² and Gregory S. Wallace³
Centers for Disease Control and Prevention,
U.S. Department of Health and Human Services
Atlanta, GA.

AUTHOR AFFILIATIONS

¹Coordinating Office for Terrorism Preparedness and Emergency Response (COTPER);

²National Center for Preparedness, Detection, and Control of Infectious Diseases (NCPDCID),
Division of Emerging Infections and Surveillance Services (DEISS);

³National Center for Immunization and Respiratory Diseases (NCIRD).

CONTACT

For additional help or feedback, please e-mail your comments or questions to the authors: Sundar S. Shrestha (SShrestha@cdc.gov), Martin I. Meltzer (MMeltzer@cdc.gov), or Gregory S. Wallace (GWallace@cdc.gov)

SUGGESTED CITATION

Shrestha SS, Meltzer MI, Wallace GS. *VacStockpile* V1.0: A manual to aid users in estimating the potential impacts of stockpiling vaccines for vaccine-preventable diseases of children (Beta test version). Atlanta: Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services; 2008.

ACKNOWLEDGMENTS

CDC Stockpile Work Group Members

John Fitzsimmons, Global Immunization Division, NCIRD, CDC
Lauri Markowitz, Division of Sexually Transmitted Disease Prevention, National Center for HIV, Viral Hepatitis, STD, and TB Prevention (NCHHSTP), CDC
Martin Meltzer, Division of Emerging Infections and Surveillance Services, NCPDCID, CDC
Nancy Messonnier, Division of Bacterial Diseases, NCIRD, CDC
Jane Seward, Division of Viral Diseases, NCIRD, CDC
Angela Shen, National Vaccine Program Office, U.S. Department of Health and Human Services, (HHS)
Sundar Shrestha, Office of the Director, COTPER, CDC
Evern Thompson, Immunization Services Division, NCIRD, CDC
Nicola Thompson, Division of Viral Hepatitis, NCHHSTP, CDC
Gregory Wallace, Immunization Services Division, NCIRD, CDC
Melinda Wharton, Office of the Director, NCIRD, CDC

CDC Subject Matter Experts for Technical Inputs

Gregory Armstrong, Division of Viral Diseases, NCIRD, CDC
Harrell Chesson, Division of Sexually Transmitted Disease Prevention, NCHHSTP, CDC
Thomas Clark, Division of Bacterial Diseases, NCIRD, CDC
Amanda Cohn, Division of Bacterial Diseases, NCIRD, CDC
Fatima Coronado, Division of Bacterial Diseases, NCIRD, CDC
Margaret Cortese, Division of Viral Diseases, NCIRD, CDC
Kathleen Gallagher, Division of Viral Diseases, NCIRD, CDC
Scott Holmberg, Division of Viral Hepatitis, NCHHSTP, CDC
Dale Hu, Division of Viral Hepatitis, NCHHSTP, CDC
Aisha Jumaan, Division of Viral Diseases, NCIRD, CDC
Jennifer Liang, Division of Bacterial Diseases, NCIRD, CDC
Pekka Nuorti, Division of Bacterial Diseases, NCIRD, CDC
Umesh Parashar, Division of Viral Diseases, NCIRD, CDC
Amy Parker, Division of Viral Diseases, NCIRD, CDC
Tami Skoff, Division of Bacterial Diseases, NCIRD, CDC

National Vaccine Advisory Committee for external peer review.

DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

SYSTEM REQUIREMENTS

VacStockpile uses the Microsoft Windows¹ operating system (Microsoft Windows 2000 or higher) and Excel (Microsoft Office 2000 or higher). We recommend using a computer with at least a 486 Pentium processor and at least 128MB RAM. *VacStockpile* requires up to 2 megabytes of storage space on the computer's hard drive.

¹Microsoft Windows and Microsoft Office are copyrighted products produced by Microsoft Corporation, Redmond, Washington. Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services.

TABLE OF CONTENTS

ACKNOWLEDGMENTS	iii
DISCLAIMER	iv
SYSTEM REQUIREMENTS	v
1. INTRODUCTION	1
1.1 Background	1
1.2 Purpose and intended audience	1
2. DATA AND METHODS	3
2.1 Data need and sources	3
2.2 Specifying the stockpile scenario	4
2.3 Specifying the demand for vaccine	4
2.4 Specifying the vaccine shortage scenario	5
2.5 Estimating the number of doses available by shortage scenario	5
2.6 Estimating the scenario-specific shortage in vaccine production	5
2.7 Estimating the weighted average shortage in vaccine production	5
2.8 Estimating potential vaccine shortages	5
2.9 Estimating vaccine available for rotation and wastages	6
2.10 Estimating unmet needs	7
2.11 Estimating cost consequences	7
2.12 Estimating the health impacts of vaccine shortage	8
3. USING VacStockpile	10
3.1 Setting Microsoft Excel security level	10
3.2 Loading and starting <i>VacStockpile</i>	10
3.3 Main menu	11
3.3.1 Using <i>VacStockpile</i> for non-combination vaccines	12
Input Worksheet-II: Example using Rotavirus	17
Outputs: Example using Rotavirus Vaccine	19
3.3.2 Using <i>VacStockpile</i> for combination vaccines	23
Input Worksheet-I: Example using Hib Vaccine	25
Input Worksheet-II: Example using Hib Vaccine	28
Outputs-I: Example using Hib Vaccine	29
Outputs-II: Example using Hib Vaccine	32
3.4 Summary Outputs	33
Summary Outputs-I	33
Summary Outputs-II	37
4. PRINTING RESULTS AND EXITING VacStockpile	39

1. INTRODUCTION

1.1 Background

The Centers for Disease Control and Prevention and the U.S. Department of Health and Human Services is congressionally mandated to maintain a stockpile of routinely recommended vaccines for the United States in the event of vaccine shortages or other unanticipated supply problems. The national pediatric vaccines stockpile currently maintains 14 pediatric vaccines that protect infants, children, and adolescents from 15 vaccine-preventable diseases excluding influenza. Vaccine stockpile administrators and policy makers face the challenge of determining the number of doses of each type of vaccine to be stockpiled. To date, there is no tool to help policy makers evaluate the potential effects of decisions they make regarding the number of doses stockpiled or doses to be stockpiled for each type of vaccine.

1.2 Purpose and intended audience

The *VacStockpile* has been designed to help planners and policy makers evaluate the potential health and cost impacts of stockpile decisions for each type of pediatric vaccine for an array of scenarios regarding possible vaccine shortages. The consequences of a vaccine shortage evaluated include potential doses of vaccine shortage, replenishment costs to replace stockpile doses that are used for shortages or discarded because of expiry of shelf life, and a number of potential health consequences (e.g., number of cases, hospitalizations and deaths) that may occur under various vaccine shortage scenarios. Although *VacStockpile* has been designed for use in the United States, it can be applied to other situations or locations where vaccine stockpiles are being maintained or considered.

1.3 Model overview

The *VacStockpile* is a spreadsheet-based (Excel 2003, Microsoft[§], WA) model. For the purposes of the model, recommended pediatric vaccines are grouped into two groups; 1) Non-combination vaccines that prevent one specific disease. These includes, HepB, Rota, Hib, PCV7, HepA, IPV,

[§] Microsoft Windows and Office are copyrighted products produced by Microsoft Corporation, WA. Use of trade names and commercial sources is for information only and does not imply endorsement by the Centers for Disease Control and Prevention.

VAR, HPV, and MCV4, and 2) Combination vaccines that prevent multiple diseases.

Combination vaccines are further grouped into two groups; a) Vaccines that prevents multiple diseases, but vaccines in this group, such as the measles, mumps, and rubella vaccine (MMR), DTaP (Pediatrics) and Tdap (Adoloescent), do not have any non-combination alternative that are routinely recommended, and b) Vaccines that prevents multiple diseases but vaccines in this group, such as DTaP-HepB-IPV and HepB-Hib, have alternative non-combination vaccines.

For diseases with a single recommended vaccine, *VacStockpile* has two worksheets for data inputs and one worksheet for outputs. For diseases with more than one recommended vaccine, *VacStockpile* has two worksheets for data inputs and two worksheets for outputs. For each vaccine, *Vacstockpile* has total 12 input steps. The *Vacstockpile* also includes worksheets, one for a low stockpile target and one for a high stockpile target summarizing the results from all the vaccines. These aggregate tables allow the user to see the net total health and cost impacts of unmet needs for all stockpiled vaccines, after stockpiles have been used.

In the first input worksheet (Input Worksheet-I), *VacStockpile* allows users to alter the number of scheduled doses, stockpile target scenarios (high and low targets), demand for vaccine, and probability of scenario-specific shortages. The second input worksheet (Input Worksheet-II) allows users to input a range of estimates of incidence, morbidity, and mortality rates of disease, vaccine efficacy, and the price of vaccine.

The *VacStockpile* produces three major sets of outputs. The first set includes the unmet need of vaccine after drawdown from the stockpile and the number of doses of vaccine available for rotation after drawdown. The second set includes the cost to replace vaccine drawn from the stockpile, the cost of vaccine wastage because of expiry, and sum of both as total. The third set includes health consequences of vaccine shortages after intervention from stockpile, including the number of children not covered with vaccine, infected with disease, or hospitalized (or other measure of morbidity) and deaths.

To allow direct comparisons between stockpile scenarios, *VacStockpile* essentially assumes that all vaccine shortages occur in a single year. In reality, shortages may occur over several years.

Since *VacStockpile* uses annual weighted risks, and estimates of a single year of health impact if shortages were to occur. That is, *VacStockpile* does not discount any results. As the purpose of the stockpile is to prevent shortages, and thus cases of disease, *VacStockpile* does not place a dollar value on benefits or health outcomes.

The numbers generated with *VacStockpile* should not be considered predictions of the *actual* consequences of vaccine stockpiles but should be considered estimates of what *could be* anticipated on the basis of input assumptions.

2. DATA AND METHODS

2.1 Data need and sources

The data inputs needed to run *VacStockpile* are the size of the current birth cohort, scheduled number of doses of vaccine per child, range of targeted number of doses of vaccine to be stockpiled, demand for vaccine, per unit cost of vaccine (U.S. \$ per dose), disease incidence rate among children not vaccinated, morbidity among children who are ill, mortality rate among children who are ill, and the vaccine efficacy against disease outcomes. Table 1 provides the sources of default data used in the model.

Table 1: Data needed and sources of data used in the model

Data	Sources
Birth cohort size	U.S. Census Bureau (http://www.census.gov/compendia/statab/tables/09s0077.xls). Accessed on August 1, 2008
Scheduled doses of vaccine	2008 Harmonized childhood and adolescent schedule.
Current (high) target for stockpile	As determined by cohort methodology.
Low target for stockpiled	Minimum of current stockpile delivered or 50% of high target.
Vaccine demand defined as either– a) Number of doses distributed b) Number of doses to vaccinate one age cohort	a) Reported annually by vaccine manufacturers. b) Number of persons × Number of recommended doses.
Probability and degree of vaccine shortages	Expert opinion. An addendum explaining data sources for each vaccine is in the Appendix.
Incidence rate of diseases among vaccinated/not vaccinated cohort	Literature and expert opinion. An addendum explaining data sources for each vaccine is in the Appendix.
Morbidity rate (e.g., rate of hospitalization among ill)	Literature and expert opinion. An addendum explaining data sources for each vaccine is in the Appendix.

Mortality rate among ill	Literature and expert opinion. An addendum explaining data sources for each vaccine is in the Appendix.
Efficacy of vaccine against incidence	Literature and expert opinion. An addendum explaining data sources for each vaccine is in the Appendix.
Efficacy of vaccine against hospitalization	Literature and expert opinion. An addendum explaining data sources for each vaccine is in the Appendix.
Efficacy of vaccine against death	Literature and expert opinion. An addendum explaining data sources for each vaccine is in the Appendix.
Cost of vaccines (U.S. \$/dose)	The cost included is CDC contract rate: http://www.cdc.gov/vaccines/programs/vfc/cdc-vac-price-list.htm). Accessed on August 1, 2008.

2.2 Specifying the stockpile scenario

Low and high stockpile scenarios are input to provide a range of stockpile targets for evaluation.

The high stockpile scenario represents the current stockpile target in the United States. The low stockpile scenario represents the minimum of the current stockpile delivered in the United States or 50% of the current target. The current target for the stockpile for each of childhood and adolescent vaccines for a 6-month national need is calculated as follows.

Current target for vaccine stockpile (No.)= [the U.S. birth cohort size (estimated as 4 million) × the number of recommended scheduled doses of vaccine per child]/ 2.

2.3 Specifying the demand for vaccine

For vaccines recommended for children aged 0–6 years, the demand for each vaccine is based on the doses distributed in the previous year. For vaccines recommended for children aged 7–18 years, the vaccine demand is based on the doses needed to vaccinate one age cohort with the recommended number of doses in the series. In estimating health impacts because of vaccine shortages, it is assumed that each dose of vaccine distributed has a protective effect, i.e. all vaccine doses distributed are administered, all administered doses are stored and handled properly, and all dose schedules are followed properly.

2.4 Specifying the vaccine shortage scenario

The potential supply of each type of vaccine is subject to uncertainty due to number of manufactures, unanticipated production problems, and the dynamic nature of the vaccine market. To account for this uncertainty, the magnitude of shortages of vaccines is modeled by five scenarios labeled A through E. We have specified default rates of vaccine shortages in increments of 25%, starting with scenario A with 0% shortage (Best Case) through Scenario E with 100% shortages (Worst Case). Each scenario is assigned a probability of occurrence. The default assigned probabilities and assumptions are provided below (please refer to Box 1) and in the addendum provided separately.

2.5 Estimating the number of doses available by shortage scenario

For each shortage scenario, the number of doses of vaccine available is calculated as follows.

Scenario-specific No. of doses of vaccine available = demand for vaccine × [1- (% shortage in the distribution of vaccine ÷ 100)]

2.6 Estimating the scenario-specific shortage in vaccine production

For each vaccine, the scenario-specific shortage of vaccine is estimated as follows.

Scenario-specific vaccine shortage (No.) = demand for vaccine – Scenario-specific No. of doses available.

2.7 Estimating the weighted average shortage in vaccine production

The weighted average of unmet vaccine needs is the sum of the scenario-specific vaccine shortages multiplied by their respective probability of occurrence.

2.8 Estimating potential vaccine shortages

Potential vaccine shortages (i.e., the demand for vaccine drawdown from stockpile) is estimated as the weighted average stockpile drawdown due to shortages (No. of doses) as;

For each vaccine, the annual vaccine shortage is estimated as follows.

Estimated annual vaccine shortage = Sum of all shortage scenarios (a scenario of % shortage of current distribution × current distribution × probability of shortage of that size)

For situations where more than one type of vaccine exists, such as a single antigen vaccine and a combination vaccine, e.g., HepB vaccine and HepB-Hib combination vaccine, we calculated the potential shortage as follows:

Estimated annual vaccine shortage = [(For vaccine 1: Sum of all shortage scenarios for Vaccine 1 (a scenario of % shortage of current distribution × probability of shortage of that size × percentage of vaccine 1 as part of total annual distribution) + (For vaccine 2: Sum of all shortage scenarios for Vaccine 2 (a scenario of % shortage of current distribution × probability of shortage of that size × percentage of vaccine 2 as part of total annual distribution))]

If there are more than two vaccines, (e.g., also have for hepatitis B combination HepB-DTaP-IPV vaccine), then the equation is expanded to include these other vaccines.

2.9 Estimating vaccine available for rotation and wastages

When there is no unmet need, the difference between doses in the stockpile and doses needed provides doses available for either rotation or wastages due to expiry of shelf life of vaccines. We calculated the doses of vaccine requiring rotation as follows. When number of doses of stockpile is greater than the estimated need, then:

Rotation (No. of doses) = the number of doses of vaccine in the stockpile – estimated need for doses from the stockpile

When estimated need is greater than doses stockpiled, then there are no doses of vaccine available for rotation and it is denoted by Nil (i.e., negative or zero value).

We calculated, for each vaccine, the number of doses of wastage as follows. When number of doses available for rotation is greater than the annual distribution of vaccine, then:

Wastage (No. of doses) = the number of doses of vaccines available for rotation – current annual national distribution of vaccine.

2.10 Estimating unmet needs

The differences between the estimated shortages and stockpiles become the estimated unmet needs, i.e., the number of vaccine doses still needed after stockpile has been completely used. For each vaccine, the unmet dose of vaccine is estimated as follows. When estimated shortage is greater than the size of stockpile, then:

Unmet need (No.) = Estimated shortage – size of stockpile

When stockpile size greater than estimated shortages, then there is no unmet need, and it denoted as Nil.

2.11 Estimating cost consequences

The *VacStockpile* estimates three types of budgetary impacts of vaccine stockpile decisions: replenishment costs, cost of wastage and total cost.

Estimating the replenishment cost for stockpiling

The replenishment cost is defined as the cost required for maintaining the same level of stockpile after drawdown because of shortage responses. For each vaccine, the replenishment cost is calculated as follows.

Replenishment cost (\$) = the number of doses of vaccine drawn from stockpile × current CDC's contract price (\$/dose) of vaccine

The doses of vaccine to be replenished is equal to the stockpile if it is less than the demand for drawdown or is equal to the demand for drawdown if it is less than the stockpile.

Estimating the cost of vaccine wastage

The cost of wastage is calculated as follows.

Cost of wastage (\$) = number of doses of vaccine in wastage × current CDC' contract price (\$/dose) of vaccine.

Estimating the total cost to replace the stockpile vaccines

For each vaccine, the total cost incurred for stockpile target is calculated as follows.

Total cost of (\$) = Replenishment cost (\$) + Cost of wastage (\$)

2.12 Estimating the health impacts of vaccine shortage

The potential health impact of vaccine shortages is estimated as incidence of disease, morbidity, and mortality from disease. To estimate these impacts, first, the number of children in the cohort not covered (Children not vaccinated because of vaccine shortages) after the intervention from stockpile is calculated.

Number of children in the birth cohort not covered

The number of children in the birth cohort not covered from vaccination is as follows.

Number of children not covered= Total unmet doses of vaccine ÷ scheduled number of doses per child

Estimating incidence of diseases because of vaccine shortages

The number of children with clinical illness due to vaccine shortage is calculated as follows.

Number of cases = Number of children not covered × disease incidence among those unvaccinated × efficacy of vaccine against disease incidence

Estimating the morbidity of children because of vaccine shortage

For DTaP (pediatric), DTaP-HepB-IPV, Hib, HepB-Hib, PCV7, IPV, MMR, VAR, Tdap(adolescent), and MCV4 vaccines, the morbidity of children is defined as the rate of hospitalization of patients among those ill resulting from vaccine shortages. The morbidity of children among those ill because of vaccine shortage is estimated as follows.

Morbidity (No.) = Number of cases × the hospitalization rate among those ill × efficacy of vaccine against hospitalization

For HepA, the morbidity rate is defined as cases of acute clinical illness; for HepB morbidity is defined as the cases of chronic hepatitis; and, for HPV morbidity is defined as cancer cases attributable to HPV 16/18.

For Rotavirus vaccine, the morbidity of children is defined as the rate of hospitalization among those unvaccinated, as follows.

Morbidity (No.) = Number of children not covered × the hospitalization rate among those unvaccinated × efficacy of vaccine against morbidity

Estimating the mortality of children because of vaccine shortage

The mortality of children among those ill due to HepB, DTaP (pediatric), DTaP-HepB-IPV, Hib, HepB-Hib, PCV7, IPV, MMR, VAR, HepA, Tdap(adolescent), HPV, and MCV4, vaccine shortage is estimated as follows.

Mortality (No.) = Number of children not covered × mortality rate among ill × efficacy of vaccine against death

The mortality of children associated with Rotavirus vaccine shortage is estimated as follows.

$Mortality (No.) = Number\ of\ children\ not\ covered \times morality\ rate\ among\ those\ unvaccinated \times efficacy\ of\ vaccine\ against\ death$

3. USING *VacStockpile*

The tasks required to utilize *VacStockpile* are setting the Microsoft Excel security level, loading *VacStockpile*, inputting data, viewing outputs that include potential shortage of vaccines and its health and cost consequences, printing results, saving inputs and results, and exiting *VacStockpile*.

3.1 Setting Microsoft Excel security level

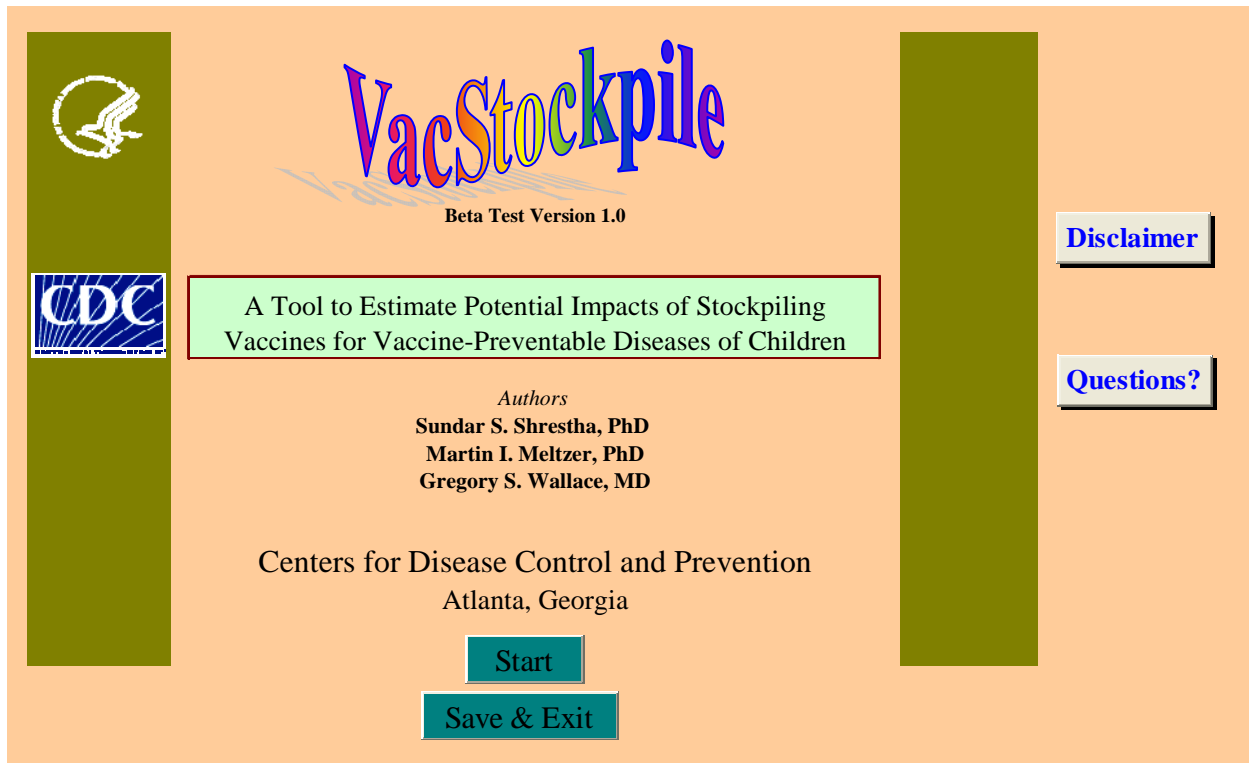
The Microsoft Excel security level should be set to “medium” by opening a blank Excel spreadsheet and setting the security level. Changing the security level after opening *VacStockpile* will not set the security level. Follow the steps below to set the security level.

- 1) Open a blank Excel spreadsheet.
- 2) Go to **Tools**.
- 3) Under **Tools**, click **Macro** and then choose **Security**.
- 4) A **Security** window will open. Set security level to **Medium**.
- 5) Click **OK**.

3.2 Loading and starting *VacStockpile*

- 1) Select the *VacStockpile* file from the appropriate folder. Double click the file to open it.
- 2) You will be asked to “Disable Macros” or “Enable Macros.” Click **Enable Macros**, and the program will take you to the **Front Page** as shown in Figure 1.

Figure 1.

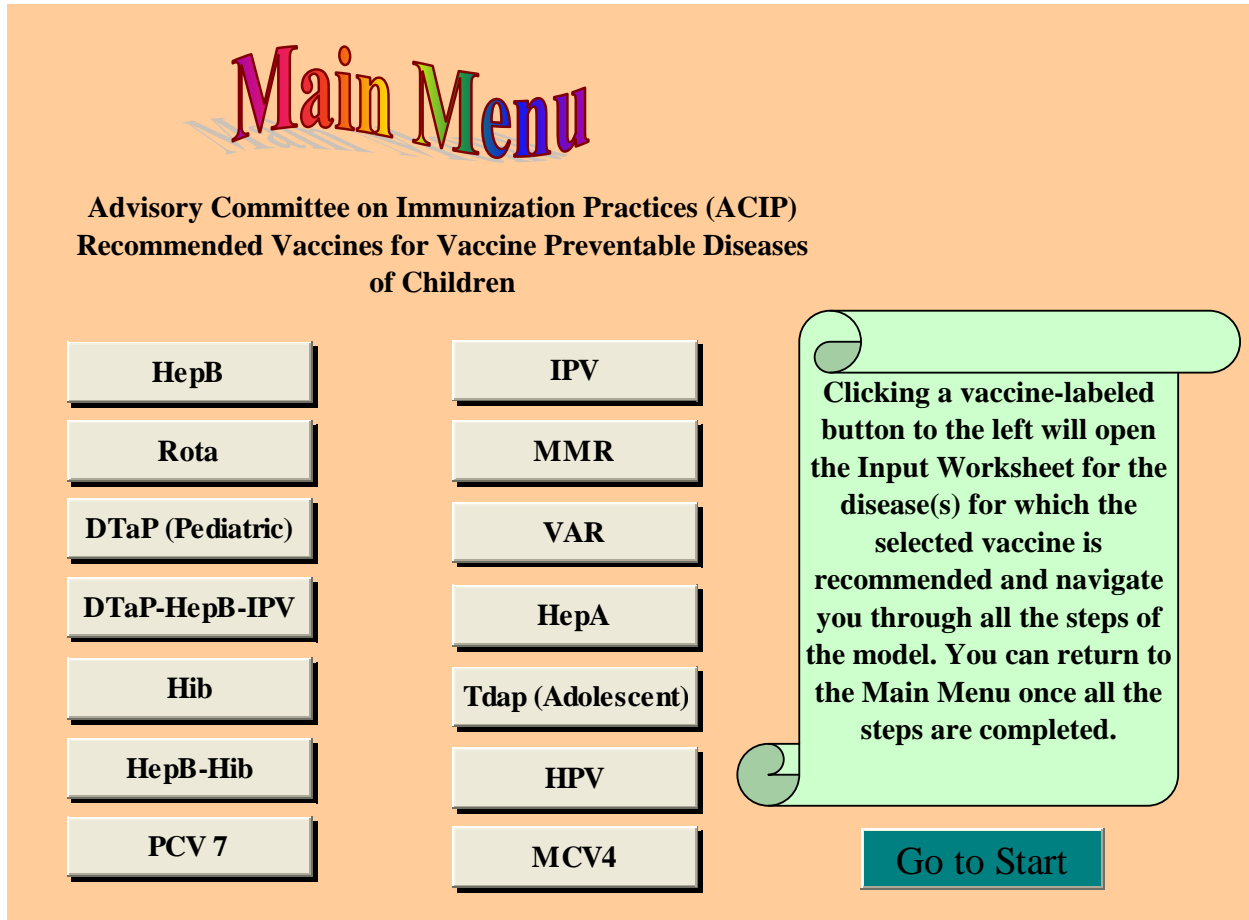


Now you are ready to begin *VacStockpile*. Click [Start](#) to go to the **Main Menu**.

3.3 Main menu

The Main Menu lists the routine pediatric vaccines as shown in Figure 2. Each button is labeled with the name of a vaccine. Clicking any of the buttons with a vaccine name will open the Input Worksheet-I for the disease for which the selected vaccine is recommended. The model will then navigate you through all 12 steps to complete the estimation of model from data entry to results for the selected vaccine. Once the model for the selected vaccine is complete, you can return to the Main Menu to start the program again with the same vaccine, or another vaccine listed. Only one vaccine can be selected at a time.

Figure 2.



Clicking **Go to Start** will take you to the **Front Page** where you can save your work and exit the program or restart the model.

3.3.1 Using *VacStockpile* for non-combination vaccines

For non-combination vaccines, such as HepB, Rota, Hib, PCV7, IPV, VAR, HepA, HPV, and MCV4, the basic structure of the model is the same. To illustrate the steps for using *VacStockpile* for these vaccines, Rotavirus vaccine has been used as an example.

Input Worksheet-I: Example using Rotavirus vaccine

On the **Main Menu**, click  to go to Rotavirus: **Input Worksheet-I**.

Rotavirus: Input Worksheet-I, Steps 1 through 4

In steps 1 through 4, you will enter the background information for the Rota vaccine as shown below in Figure 3. The *VacStockpile* allows you to enter, or alter data in the white cells only.

Figure 3.

Step 1: Determine the children cohort size for vaccination	4,269,000
Step 2: Dose schedule per child (No.)	3
Step 3: Determine the target dose for stockpile:	
Minimum of current stockpile or 50% of current target [Low]	2,500,000
Current target [High]	6,000,000
Step 4: Number of doses distributed (in 2007)	9,008,041

Step 1. Enter the size of the current birth cohort. The default value is the size of the birth cohort for the United States in 2006 (<http://www.census.gov/compendia/statab/tables/09s0077.xls>; Accessed on January 23, 2008). The size of the birth cohort is used to estimate the current target doses of vaccines to be stockpiled to vaccinate the current birth cohort size for 6 months. The current estimated target number is based on a birth cohort size of 4 million children. The size of the birth cohort you enter will not affect the current target for vaccine unless you use it for a substitute calculation for the current target, which is entered in step 3.

To estimate the current target by using the current birth cohort size, use the following formula.

$$\text{Current stockpile target} = (\text{No. of doses of vaccine scheduled per child} \times \text{Size of the birth cohort } B) / 2$$

If a birth cohort size of 4,269,000 children were used in the above formula, the current target (High) for stockpiling of the Rota vaccine would be 6,403,500 doses.

Step 2. The default value entered here represents the recommended number of doses of Rota vaccine per child (see Addendum provided separately). However, alternate schedules could be modeled if vaccine efficacy inputs were updated appropriately.

Step 3. Enter the target dose for stockpiling of the Rota vaccine. The default low target dose represents the minimum of current stockpile or half of the current target. The default high stockpile target represents the current target i.e., the number of doses of Rota vaccine required to cover the birth cohort of 4 million children for 6 months given the number of recommended doses of vaccine per child.

Step 4. Enter the potential number of doses of Rota vaccine that may be required (i.e., assumed demand) for the current year. The default number of doses entered here is the doses of Rota vaccines distributed in 2007, assuming that under normal conditions (i.e., no disease outbreak) the demand for doses of vaccine in the current year will be equal to the doses of vaccines distributed in the previous year. You may change this assumption to accommodate other scenarios, such as the worst-case scenario of disease outbreak.

Rotavirus: Input Worksheet-I, Steps 4a through 7

In steps 4a through 7 (Figure 4), you will determine the scenario of vaccine shortages and probability of shortages to estimate the scenario-specific shortages in production of vaccine. By default, *VacStockpile* has five specified scenarios of shortages in distribution (supply) of vaccines. They are scenario A, B, C, D, and E.

Step 4a. You do not need to enter data here. The number of doses distributed is copied from the data used in step 4, the potential demand for vaccine, and is the same for each scenario.

Figure 4.

	Demand, Production and Shortage Scenarios				
	A	B	C	D	E
Step 4a: No. of doses distributed [Copied from Step 4]	9,008,041	9,008,041	9,008,041	9,008,041	9,008,041
Step 5: Determine the scenario of shortages in distribution (%)	0%	25%	50%	75%	100%
Step 6: Probability of scenario-specific shortages during the year	0.2000	0.2000	0.2000	0.3000	0.1000
Step 6a: RESULTS: Number of doses available by shortage scenario per year	9,008,041	6,756,031	4,504,021	2,252,010	0
Step 7: Resultant shortage in production during the year (No. of doses)	0	2,252,010	4,504,021	6,756,031	9,008,041

Step 5. Determine the scenario of shortages with reference to distribution. By default, *VacStockpile* model has five specified shortage scenarios starting from 0% shortage (Scenario A) and increasing in increments of 25% to 100% shortage (Scenario E) as shown in Figure 4 above. Scenario A represents the best-case scenario and shows no shortages in supply of vaccine to meet the demand. Scenario E represents the worst-case scenario and shows no vaccine available.

Probability Scenario

Clicking **Probability Scenario** will show you the rationale for default probability scenarios as shown in Box 1 on the next page.

Step 6. Enter the probability of scenario-specific shortages during the year. *Important:* The sum of the probability must be 1. The default probabilities of shortages are distributed across the scenarios. You may consider any number of scenarios between 1 and 5. If you chose to limit the shortage scenarios to less than five, the sum of the probability across the scenarios you have chosen should still be 1 and the probability for the scenario(s) you did not chose must be zero. For instance, if you select scenarios A and B, then the sum of the probabilities entered in scenarios A and B must be 1, and the probabilities under scenarios C, D, and E must be zero.

Step 6a. You do not need to enter any data here. The values in the cells represent the number of doses of vaccine available for each scenario. For a discussion of how *VacStockpile* model calculates this value, refer to section 2, Data and Methods, which begins on page 3 of this document.

Box 1: Criteria for Shortage Probability

Scenario 1: Two manufacturers, a relatively stable market, no recent history of production problems, and no projected changes vaccine type or recommendations in the near future.

Scenario 2: Two manufacturers, but a slightly higher potential of production problems due to either new or changing market, recent history of manufacturing problems, projected changes in the vaccine type in the near future, or relative complexity of production process.

Scenario 3: One manufacturer, a relatively stable market, no recent history of production problems, and no projected changes vaccine type or recommendations in the near future.

Scenario 4: One manufacturer, but a slightly higher potential of production problems due to either new or changing market, recent history of manufacturing problems, projected changes in the vaccine type in the near future, or relative complexity of production process.

0% Shortage Probability: Vaccine types with a relatively stable market and production are given a probability of 0.3 while those vaccine types with a slightly higher potential of production problems have a lower probability of a 0% shortage of 0.2.

25% and 50% Shortage Probability: Vaccine types with two manufacturers are given a probability of 0.2 while those vaccine types with one manufacturer have a slightly lower probability of 0.15.

75% Shortage Probability: Vaccine types with a relatively stable market and production are given a probability of 0.2 while those vaccine types with a slightly higher potential of production problems have a higher probability of a 0% shortage of 0.3.

100 % Shortage Probability: Vaccine types with two manufacturers are given a probability of 0.1 while those vaccine types with one manufacturer have a slightly higher probability of 0.2.

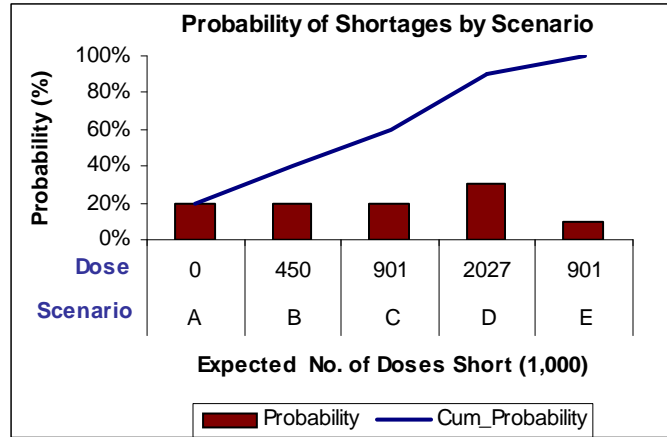
Scenario	0% Short. Prob.	25% Short. Prob.	50% Short. Prob.	75% Short. Prob.	100% Short. Prob.	Total
Scenario 1	0.3	0.2	0.2	0.2	0.1	1
Scenario 2	0.2	0.2	0.2	0.3	0.1	1
Scenario 3	0.3	0.15	0.15	0.2	0.2	1
Scenario 4	0.2	0.15	0.15	0.3	0.2	1

Step 7. You do not need to enter data here. The values in the cells represent the scenario-specific shortages in distribution of vaccine during the year, given the shortage scenarios.

The chart (Figure 5) in Input Worksheet-I provides the scenario-specific probability for shortages A through E and their corresponding expected doses of vaccine shortage expressed in thousands. The chart illustrates the implications on the expected shortages of doses of vaccine when any of

the values entered in steps 4, 5, or 6 are altered. For a discussion of how the *VacStockpile* model calculates the expected shortage of doses of vaccine, refer to section 2, Data and Methods, which begins on page 3 of this.

Figure 5.



Input Worksheet-II: Example using Rotavirus

In **Rotavirus: Input Worksheet-I**, click [Go to Main Menu](#) to go to **Main Menu** and click [Next](#) to go to **Rotavirus: Input Worksheet-II**

Rotavirus: Input Worksheet-II, Steps 8 through 12

In steps 8 through 10 (Figure 6), you will enter the potential health impacts of shortages of vaccine before intervention from the stockpile. The default rates entered in these steps are based on literature review and the inputs obtained from subject matter experts. For detailed information about the inputs received from subject matter experts, refer to the Addendum, which is provided separately.

Figure 6.

	Low	Most Likely	High
Step 8: Determine the incidence rate among unvaccinated cohort	0.650000	0.750000	0.850000
Step 9: Determine the rate of hospitalization among unvaccinated cohort	0.018000	0.022000	0.027600
Step 10: Determine the fatality rate [death rate] among unvaccinated cohort	0.000008	0.000010	0.000011

Step 8. Enter the incidence of disease among an unvaccinated cohort in the white cells. The range of rates may be based on current rates, rates expected to occur quickly during a shortage, rates prior to the availability of vaccine, or rates that are based on other scenarios. You may enter data into three value categories—Low, Most Likely, and High—to capture the variation in the rates. For types of assumptions that may be considered, refer to Addendum provided separately.

Step 9. Enter the morbidity rate among an unvaccinated cohort. For other vaccines, morbidity rates entered are the rates among children who are ill. For Rota vaccine, morbidity rates (rate of hospitalization) entered are among those unvaccinated. Again, you may enter data into three value categories—Low, Most Likely, and High—to capture the variation in morbidity rates under different scenarios.

Step 10. Enter the mortality rate among unvaccinated cohort. For several vaccines, mortality rates entered should be the rates among children who are ill. Again, you may enter data into three value categories—Low, Most Likely, and High—to capture the variation in mortality rates under different scenarios.

Step 11. Enter the efficacy of vaccine against incidence, morbidity, and death from the disease as shown in Figure 7. The range of rates may consider efficacy or effectiveness from clinical trials, surveillance, or assumptions in non-ideal scenarios. For types of assumption that may be considered, refer to Addendum provided separately.

Figure 7.

Step 11: Determine the efficacy of Rota Virus vaccine	Low	Most Likely	High
Against incidence	0.600000	0.700000	0.800000
Against hospitalization	0.800000	0.900000	0.980000
Against death	0.800000	0.900000	0.980000

The information entered in steps 8 through 11 are linked with information in other worksheets to estimate the potential health impacts after the intervention of stockpile.

Step 12. Enter the price per dose of vaccine (Figure 8). The default rate is the CDC contract price as of August 1, 2008.

Figure 8.

Step 12: Price of vaccine (\$/Dose)	\$57.20
--	---------

The price information is linked with other information to estimate the cost of replenishment of stockpile, the cost of vaccine wastage, and the total cost of maintaining the stockpile.

Outputs: Example using Rotavirus Vaccine

In **Input Worksheet-II**, click [Go to Main Menu](#) to return to the **Main Menu**.

Click [Back](#) to go to **Input Worksheet-I**, and click [Go to Outputs](#) to go to **Outputs**.

The outputs are grouped into five sections. The first section of outputs provides scenario-specific shortages of vaccines, unmet need with low and high stockpile target scenarios, and probability of shortages as shown in Figure 9.

Figure 9.

		Shortage Scenarios				
		A	B	C	D	E
Shortages [No. of doses]		0	2,252,010	4,504,021	6,756,031	9,008,041
Unmet need: Low stockpile scenario with stockpile dose of	2,500,000	-2,500,000	-247,990	2,004,021	4,256,031	6,508,041
Unmet need: High stockpile scenario with stockpile dose of	6,000,000	-6,000,000	-3,747,990	-1,495,980	756,031	3,008,041
Probability of scenario-specific shortages		0.200	0.200	0.200	0.300	0.100

Under both low and high stockpile target scenarios (Figure 9), the unmet needs are positive for shortage scenarios of 75% and above (columns D and E) i.e., the number of doses of vaccine shortage exceeds the number of doses of vaccine in stockpile. Shortage scenarios of 25% or less (columns A and B) have no unmet needs, but a shortage scenario of 50% (column C) has positive unmet need under the low stockpile scenario but not under the high stockpile scenario.

The second section of results, as shown in Figure 10, provides the expected positive unmet needs after intervention from stockpile and the weighted average of the assumed shortage probabilities. The expected number of doses of unmet need under low stockpile target scenario is 2,328,417 with 60% probability of shortage. Under the high target stockpile scenario, it is 527,613 doses of vaccines with 40% probability of shortage. However, under the high stockpile scenario, the overall expected value of unmet need is nil (negative or zero) and the probability that the stock available is not sufficient to meet the demand is 40%.

Figure 10.

	Low	High
Weighted average of scenarios with positive unmet needs after stockpile [No. of doses]	2,328,417	527,613
Probability of number of doses short exceeds the stockpile	0.60	0.40

The third section of results, as shown below in Figure 11, provides the estimates of the weighted average demand for drawdown from stockpile, the number of stockpile doses not drawn down and available for rotation, and the unmet needs given the assumed shortage probabilities.

Figure 11.

	Stockpile Scenarios					
	Low			High		
	<i>Low</i>	<i>Most Likely</i>	<i>High</i>	<i>Low</i>	<i>Most Likely</i>	<i>High</i>
Weighted average stockpile drawdown due to shortages (No. of doses)	4,278,819			4,278,819		
Maximum available vaccine doses from stockpile (No.)	2,500,000			6,000,000		
No. of stockpile doses not drawdown available for rotation	Nil			1,721,181		
Unmet need (No. of doses)	1,778,819			Nil		

The estimated demand for drawdown is 4,278,819 doses of Rota vaccines. Under the low stockpile target scenario, the demand for drawdown exceeds the stockpile, therefore no vaccine is available for rotation. Instead, the stockpile is estimated to be short by 1,778,819 doses of vaccine to meet the demand. In the case of high stockpile target scenario, the stockpile exceeds the demand for drawdown resulting in unmet need being nil, but 1,721,181 doses of vaccine would be available for rotation.

The fourth section of results, as shown in Figure 12, provides the potential health impact given the assumed shortage probabilities and assumed range of disease rates and vaccine efficacy measured in terms of the number of children in the cohort not covered after the intervention of stockpile. The fourth section also provides the number of children infected with disease, hospitalized (or other stated morbidity measure), and the number of deaths among children and adolescents not covered.

Figure 12.

Health Consequences (No. of Children)	Stockpile Scenarios					
	Low			High		
	<i>Low</i>	<i>Most Likely</i>	<i>High</i>	<i>Low</i>	<i>Most Likely</i>	<i>High</i>
No. of children in the cohort uncovered	592,940			Nil		
No. of children uncovered would be infected due to vaccine shortages	231,247	311,293	403,199	Nil	Nil	Nil
No. of children uncovered would be hospitalized due to vaccine shortages	8,538	11,740	16,038	Nil	Nil	Nil
Mortality [No.] due to vaccine shortages	4	5	7	Nil	Nil	Nil

Under the low stockpile target scenario, even after the intervention of stockpile, 592,940 children would potentially be unvaccinated. As a result, 231,247 to 403,199 children may be infected with disease, 8,538 to 16,038 children may be hospitalized, and 4 to 7 children may die because of vaccine shortages. Under the high stockpile target scenario, the demand for drawdown is less

than the stockpile, therefore no children would be expected to be left unvaccinated. As a result, the incidence of disease, morbidity, and mortality is nil.

The last section of results (Figure 13) provides the cost consequences of policy decisions on vaccine stockpile targets. The first part of the results shows the one time cost of increasing stockpile from low target doses to and high target doses. The second part provides the potential annual cost consequences of replenishing the stockpile after intervention, the cost of wastage because of expiry, and the total cost to replace the vaccines in stockpile given the assumed shortage probabilities.

Figure 13.

One time vaccine cost increasing Low stockpile target to High target	\$200,200,000
---	----------------------

Replenishment cost for replacing stockpile drawdown doses	\$143,000,000	\$244,748,474
Cost of vaccine wastage due to expiry	Nil	Nil
Total cost to replace stockpile vaccine (Replenishment + Wastage)	\$143,000,000	\$244,748,474

Under the low stockpile target scenario, the vaccine stockpiled is less than the demand for drawdown given the assumed shortage probabilities. Therefore, the replenishment cost is equal to the cost of replacing the used stockpile vaccine, i.e., \$143,000,000. The replenishment cost and the total cost of maintaining stockpile are the same because there is no wastage cost. Under the high stockpile target scenario, replenishment cost is \$244,748,474. Because the number of doses of vaccine available for rotation is less than the number of doses vaccine distributed, there would be no wastage of vaccine. Hence, the cost of wastage is nil. The total cost for maintaining the same level of stockpile would be equal to the cost of replenishment, which is \$244,748,474.

In **Output Worksheet**, click [Go to Main Menu](#) to return to the **Main Menu**

Click [Back](#) to go to **Input Worksheet-II** and click [Go to Summary Outputs-I](#) to go to summary outputs for all vaccines.

Summary Outputs for all vaccines

Summary outputs for all vaccines are described in section 3.4 on page 33. The next section, 3.3.2, describes an example of *VacStockpile* results using a combination vaccine.

3.3.2 Using *VacStockpile* for combination vaccines

Combination vaccines that do not have substitute non-combination vaccines

When the button labeled with combination vaccine that do not have substitute non-combination vaccine, such as MMR, DTaP (Pediatric) and Tdap (Adolescent) is clicked, *VacStockpile* takes you to one of the diseases for which the vaccine is recommended. The disease chosen to represent the combination vaccine is based on assumptions of which disease drives the potential impact because of shortages of that vaccine. For the measles, mumps, and rubella (MMR) vaccine, the model is based on the assumption that the measles disease drives the potential impact of MMR shortages (refer to Addendum provided separately). Similarly, for the combined diphtheria, tetanus, and pertussis ([DTaP, Pediatric] and [Tdap, Adolescent]) vaccines, pediatric and adolescent pertussis have been chosen.

All the steps required to follow for MMR, DTaP (Pediatric) and Tdap (Adolescent) vaccines are same as the instruction described in example with Rotavirus vaccine. Therefore, the steps required to follow for these vaccines are not described here.

Combination vaccines that do have substitute non-combination vaccines

For the combination vaccines that do have substitute non-combination vaccines, such as DTaP-HepB-IPV and HepB-IPV, when you click the button labeled with these vaccines, *VacStockpile* model will, first, take you to the input worksheet with background information on combination vaccines, such as the target dose, the number of doses distributed last year, and the price of the vaccines. The model then allows you to select the alternative non-combination vaccines one at a time. For example, if you click button labeled with DTaP-HepB-IPV vaccine in input worksheet, *Vacstockpile* allows you to select DTaP (Pediatric), HepB, or IPV one at a time. If you click the button labeled with IPV vaccine, the model will take you to Polio disease and allow you to

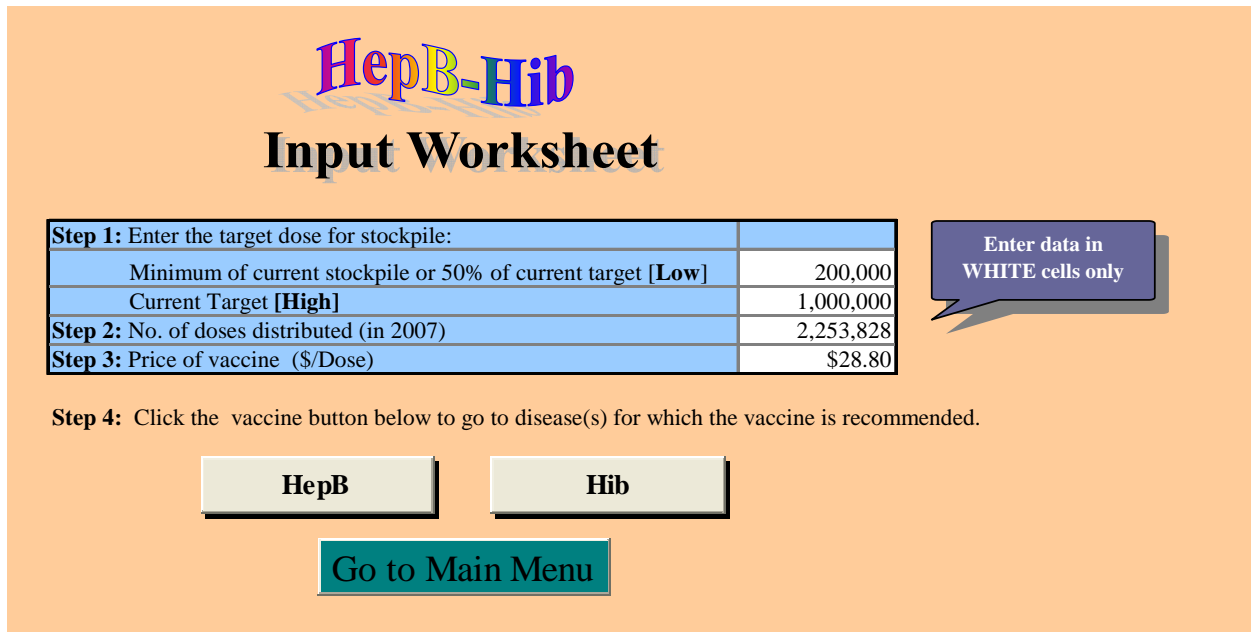
estimate the consequences of vaccine stockpile target with consideration of both IPV and DTaP-HepB-IPV vaccines. Aside from this, the basic structure and input requirements for the estimating model are the same for all routine vaccines.

To illustrate the steps for using *VacStockpile* for combination vaccines that do have substitute non-combination vaccines, we use HepB-Hib vaccine and focus on Heb as an example.

HepB-Hib: Input Worksheet

Click  to go to the **Input Worksheet** for HepB-Hib as shown in Figure 14.

Figure 14.



HepB-Hib
Input Worksheet

Step 1: Enter the target dose for stockpile:	
Minimum of current stockpile or 50% of current target [Low]	200,000
Current Target [High]	1,000,000
Step 2: No. of doses distributed (in 2007)	2,253,828
Step 3: Price of vaccine (\$/Dose)	\$28.80

Enter data in
WHITE cells only

Step 4: Click the vaccine button below to go to disease(s) for which the vaccine is recommended.

HepB

Hib

Go to Main Menu

In steps 1 through 3 of the HepB-Hib Input Worksheet, you will enter the stockpile targets for HepB-Hib vaccine, number of doses of HepB-Hib vaccine distributed last year, and the price of the vaccine.

In step 4, you will click one of the non-combination vaccines. As an example, we focus on the Hib vaccine.

Unlike the Input Worksheet-I for non-combination vaccines, the Haemophilus Input Worksheet-I has both non-combination and combination vaccines recommended for children against Haemophilus disease.

Input Worksheet-I: Example using Hib Vaccine

In **HepB-Hib Input-Worksheet**, click  to go to **Haemophilus: Input Worksheet-I**.

Haemophilus: Input Worksheet-I Steps 1 through 4

Figure 15.

Step 1: Determine the children cohort size for vaccination ¹	4,269,000		
Step 2: Dose schedule per child (No.)	4		
Step 3: Determine the target dose for stockpile:	<i>Total</i>	<i>Hib</i>	<i>HepB-Hib</i>
Minimum of current stockpile or 50% of current target [Low]	580,000	66%	34%
Current Target [High]	8,000,000	88%	13%
Step 4: No. of doses distributed (in 2007)	14,456,907	84%	16%

Step 1. See page 12. Same as the instructions described in Step 1 of *Rotavirus: Input Worksheet-I* under section 3.3.1 Using VacStockpile with non-combination vaccines and routinely recommended combination vaccines without non-combination substitutes.

Step 2. See page 13. Same as the instructions described in Step 2 of *Rotavirus: Input Worksheet-I* under section 3.3.1.

Step 3. Enter the total target dose (sum of the target dose of Hib and HepB-Hib). In the Hib column, enter the percentage of total target contributed by Hib vaccine. Similarly, you will enter

the percentage of total target dose contributed by HepB-Hip in the HepB-Hib column. The sum of the percentages for all vaccine columns must be 100%.

Step 4. As in step 3, enter the total number of doses of vaccines (sum of both vaccines) distributed last year in the total column and percentage share in the respective vaccine’s column.

Haemophilus: Input Worksheet-I, Steps 4a through 7

As shown in steps 4a through 7 of the *Rotavirus: Input Worksheet-I* example (section 3.3.1, pages 14–16 of this document), you will determine the scenario of vaccine shortages and probability of shortages to estimate the scenario-specific shortages in production of vaccine in Steps 4a through 7 of the *Haemophilus: Input Worksheet-I* as shown in Figure 16.

Figure 16.

	Demand, Production and Shortage Scenarios				
	A	B	C	D	E
Step 4a: No. of doses distributed [Copied from Step 4]	14,456,907	14,456,907	14,456,907	14,456,907	14,456,907
No. of doses of Hib	12,203,079	12,203,079	12,203,079	12,203,079	12,203,079
No. of doses of HepB-Hib	2,253,828	2,253,828	2,253,828	2,253,828	2,253,828
Step 5: Determine the scenario of shortages in distribution (%)	0%	25%	50%	75%	100%
Step 6: Probability of scenario-specific shortages during the year					
Hib	0.20	0.20	0.20	0.30	0.10
HepB-Hib	0.20	0.15	0.15	0.30	0.20
Step 6a: RESULTS: Number of doses available by shortage scenario per year	14,456,907	10,842,680	7,228,454	3,614,227	0
Step 7: Resultant shortage in production during the year (No. of doses)	0	3,614,227	7,228,454	10,842,680	14,456,907

Step 4a. You do not need to enter any data here. The first row of data is the same as that described in Figure 4 of the *Rotavirus: Input Worksheet-I* example on page 14. The second and third rows distribute the total number of doses of vaccine distributed last year between Hib and HepB-Hib on the basis of their percentage contribution of each vaccine to the total doses.

Step 5. See page 14. Same as the instructions described in Step 5 of the *Rotavirus: Input Worksheet-II* example in section 3.3.1. Data is required here.

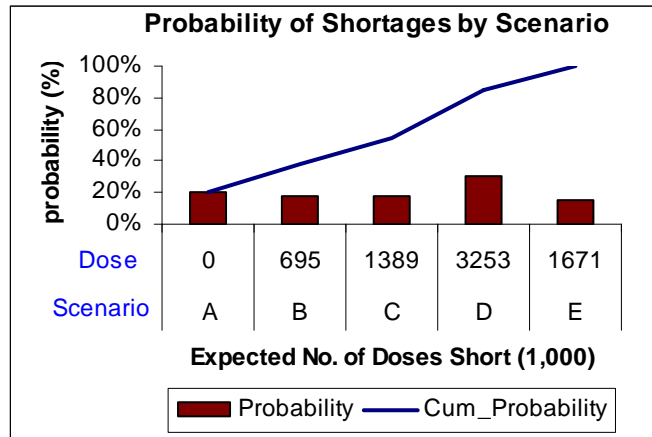
Step 6. See page 15. Same as the instructions described in Step 6 of the *Rotavirus: Input Worksheet-II* example in section 3.3.1, but you must enter the probability of shortages for each vaccine separately.

Step 6a. See page 16. Same as the instructions described in Step 6a of the *Rotavirus: Input Worksheet-II* example in section 3.3.1.

Step 7: See page 16. Same as the instructions described in Step 7 of the *Rotavirus: Input Worksheet-II* example in section 3.3.1.

As shown in *Rotavirus: Input Worksheet-I* on page 16 (Figure 5), the chart below (Figure 17) provides the scenario-specific probability of shortages and their corresponding expected doses of vaccine shortage expressed in thousands. Here, the probability in the y-axis is the scenario-specific average probabilities of Hib and HepB-Hib vaccines.

Figure 17.



Input Worksheet-II: Example using Hib Vaccine

Click [Go to Main Menu](#) to return to the **Main Menu**, and then click [Next](#) to go to **Haemophilus: Input Worksheet-II**.

Haemophilus: Input Worksheet-II, Steps 8 through 10

In steps 8 through 10 (Figure 18), you will enter the potential health impacts of shortages of vaccine before intervention from stockpile. The default rates entered in these steps are based on the inputs obtained from subject matter experts. For detailed information, please refer to the Addendum provided separately.

Figure 18.

	Low	Most Likely	High
Step 8: Determine the incidence rate among unvaccinated cohort	0.000040	0.000080	0.000396
Step 9: Determine the rate of hospitalization among those ill	0.900000	0.950000	0.100000
Step 10: Determine the fatality rate [death rate] among ill	0.020000	0.050000	0.070000

Step 8. See page 17. Same as the instructions described in Step 8 of the *Rotavirus: Input Worksheet-II* example in section 3.3.1.

Step 9. Unlike in the *Rotavirus: Input Worksheet-II* example, the morbidity rates entered here are rates among children and adolescents who are ill. As mentioned in section 2, Data and Methods, the formula used to calculate morbidity because of vaccine shortages depends on the specific rates that are entered. Therefore, users must use the same rate as specified in the model.

Step 10. See page 18. Same as the instructions described in Step 10 of the *Rotavirus: Input Worksheet-II* example in section 3.3.1.

In step 11, you will enter the efficiency of vaccines against disease, morbidity, and mortality.

Step 11: See page 18. Same as the instructions described in Step 11 of the *Rotavirus: Input Worksheet-II* example in section 3.3.1. Here we assume that the efficacy of a combination vaccine is at par to its substitute non-combination vaccine. Therefore, the efficacy rates are same for both vaccines (Figure 19).

Figure 19.

Step 11: Determine the efficacy of vaccine	Low	Most Likely	High
Against incidence	0.900000	0.950000	1.000000
Against hospitalization	0.900000	0.950000	1.000000
Against death	0.900000	0.950000	1.000000

Step 12: Enter the price of both vaccines separately (Figure 20). This information is used to estimate the vaccine-specific cost consequences.

Figure 20.

	Hib	HepB-Hib
Step 12: Price of vaccine (\$/Dose)	\$8.64	\$28.80

Outputs-I: Example using Hib Vaccine

In **Haemophilus Input Worksheet-II**, click **Go to Main Menu** to return tot the **Main Menu**. Click **Back** to go back to **Haemophilus Input Worksheet-I**, and click **Go to Output** to go to **Haemophilus: Outputs-I**.

Haemophilus: Outputs-I

The Haemophilus Outputs-I contains four sets of results. The section shown below (Figure 21) is the same as the *Rotavirus Outputs* example shown in Figure 9 on page 19. In the last row of the

Figure 21, the probability of scenario-specific shortages is calculated as the average of Hib and HepB-Hib vaccines.

Figure 21.

		Shortage Scenarios				
		A	B	C	D	E
Shortages [No. of doses]		0	3,614,227	7,228,454	10,842,680	14,456,907
Unmet need: Low stockpile scenario with stockpile dose of	580,000	-580,000	3,034,227	6,648,454	10,262,680	13,876,907
Unmet need: High stockpile scenario with stockpile dose of	8,000,000	-8,000,000	-4,385,773	-771,547	2,842,680	6,456,907
Probability of scenario-specific shortages (Average of vaccines)		0.200	0.175	0.175	0.300	0.150

Under the low stockpile target scenario, except for the 0% shortage scenario (column A), the unmet needs are positive for all other shortage scenarios. Under the high stockpile target scenario, positive unmet need occurs only in shortage scenarios of 75% or higher (columns D and E).

The second set of results, shown in Figure 22, is the same as the results in the *Rotavirus Outputs* example in Figure 10 on page 20. Under the low stockpile target scenario, the probability of positive unmet need of 6,854,809 doses of vaccines for the two vaccines together is 80%. However, under the high stockpile scenario, the probability of positive unmet need of 1,821,340 doses of vaccines is 45%.

Figure 22.

	Low	High
Weighted average of scenarios with positive unmet needs after stockpile [No. of doses]	6,854,809	1,821,340
Probability of number of doses short exceeds the stockpile	0.80	0.45

The third set of results, as shown in Figure 23, presents the overall demand for drawdown from stockpile, the number of doses of vaccine available for rotation, and unmet need both in total and by vaccine according to stockpile target scenarios, given the assumed shortage probabilities.

Figure 23.

	Stockpile Scenarios					
	Low			High		
	Total	Hib	HepB-Hib	Total	Hib	HepB-Hib
Weighted average stockpile drawdown due to shortages (No. of doses)	7,007,895	4,591,380	2,416,516	7,007,895	6,131,908	875,987
Maximum available vaccine doses from stockpile (No.)	580,000	380,000	200,000	8,000,000	7,000,000	1,000,000
No. of stockpile doses not drawdown available for rotation	Nil	Nil	Nil	992,105	868,092	124,013
Unmet need (No. of doses)	6,427,895	4,211,380	2,216,516	Nil	Nil	Nil

The estimated demand for drawdown is 7,007,895 doses of vaccines. Under the low stockpile target scenario, the total estimated demand for drawdown is comprised of 4,591,380 doses of Hib vaccine and 2,416,516 doses of HepB-Hib vaccine. Under the high stockpile target scenario, the total is composed of 6,131,908 doses of Hib and 875,987 doses of HepB-Hib vaccines. Under the low stockpile target scenario, doses of vaccine in stockpile is lower than the demand for drawdown in both total and by vaccine type, thus the vaccine available for rotation is nil but total unmet need is 6,427,895 doses of vaccines. On the basis of the stockpiled doses of vaccines, unmet need is 4,211,380 doses of Hib and 2,216,516 doses of HepB-Hib vaccines. Under the high stockpile target scenario, the demand for drawdown is less than the doses of vaccines in stockpile, therefore the unmet need is nil, but the doses of vaccine available for rotation is 992,105 and consists of 868,092 doses of Hib vaccine and the remaining 124,013 doses of Hep-Hib vaccine.

The fourth section of results, as shown in Figures 24 and 25, provides the cost consequences of policy decisions on stockpile targets. The first part of the results (Figure 24) shows the one time cost required to increase the low target doses to the high target doses. The total budget required to fill the gap between high and low stockpile targets is \$80,236,800, of which \$57,196,800 will be spent on Hib vaccine and \$23,040,000 on HepB-Hib vaccine.

Figure 24.

	Total	Hib	HepB-Hib
One time vaccine cost increasing Low stockpile target to High target	\$80,236,800	\$57,196,800	\$23,040,000

The second part of the cost results (Figure 25) shows the potential annual cost consequences of stockpile decisions given the assumed shortage probabilities. Under the low stockpile target

scenario, the doses of vaccine available for rotation is nil, thus there is no wastage and the cost of wastage is nil. The replenishment cost is \$9,043,200. Of this replenishment cost, \$3,283,200 is required for stockpiling Hib and \$5,760,000 is required for stockpiling the HepB-Hib vaccine. Under the high stockpile target scenario, doses of vaccine available for rotation is less than the doses distributed, thus the cost of wastage is nil. Therefore, the total cost required to replace the vaccines in stockpile is equal to the cost of replenishment. The total cost for replacing the vaccines drawn from stockpile is \$109,265,167, and \$95,607,021 of this cost is required for Hib and \$13,658,146 is required for the HepB-Hib vaccine.

Figure 25.

Replenishment cost for replacing stockpile drawdown doses	\$9,043,200	\$3,283,200	\$5,760,000	\$109,265,167	\$95,607,021	\$13,658,146
Cost of vaccine wastage due to expiry	Nil	Nil	Nil	Nil	Nil	Nil
Total cost to replace stockpile vaccine (Replenishment + Wastage)	\$9,043,200	\$3,283,200	\$5,760,000	\$109,265,167	\$95,607,021	\$13,658,146

Outputs-II: Example using Hib Vaccine

In **Haemophilus: Outputs-I** worksheet, click [Back](#) to go to **Haemophilus Input Worksheet-II**, and click [Go to Health Consequences](#) to go to **Haemophilus: Outputs-II** worksheet.

The **Haemophilus Outputs-II** worksheet, as shown in Figure 26, provides results on potential health consequences given the assumed shortage probabilities and assumed range of disease rates and vaccine efficacy under the low and high stockpile target scenarios. The difference between this outputs worksheet and the outputs worksheet described in the section Outputs: Example using Rotavirus on page 19 is that, the health impact is presented in total in the Outputs II worksheet, which includes the health impacts when both vaccines are in short supply.

Under the low target stockpile scenario, the total number of children not vaccinated against haemophilus disease because of a vaccine shortage is 1,606,974. Of this total, 1,052,848 children

are not vaccinated because of shortages of the Hib vaccine, and the remaining 554,129 children who are not vaccinated is due to shortages of the HepB-Hib vaccine.

Figure 26.

Haemophilus
Outputs-II

Low Stockpile Scenario Nil ?

Health Consequences	Total			Hib			HepB-Hib		
	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
No. of children in the cohort uncovered	1,606,974			1,052,845			554,129		
No. of children uncovered infected due to vaccine shortages	58	122	636	38	80	417	20	42	219
No. of children uncovered hospitalized due to vaccine shortages	47	110	636	31	72	417	16	38	219
Mortality [No.] due to vaccine shortages	1	6	45	1	4	29	0	2	15

High Stockpile Scenario

Health Consequences	Total			Hib			HepB-Hib		
	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
No. of children in the cohort uncovered	Nil			Nil			Nil		
No. of children uncovered infected due to vaccine shortages	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
No. of children uncovered hospitalized due to vaccine shortages	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Mortality [No.] due to vaccine shortages	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

The incidence of haemophilus disease, because of vaccine shortage, ranges between 58 and 636. Morbidity of children ranges between 47 and 636, and mortality of children ranges between 1 and 45. Under the high target stockpile scenario, the unmet need for vaccination is nil, thus the incidence of diseases, morbidity, and mortality is nil.

3.4 Summary Outputs

Summary Outputs-I

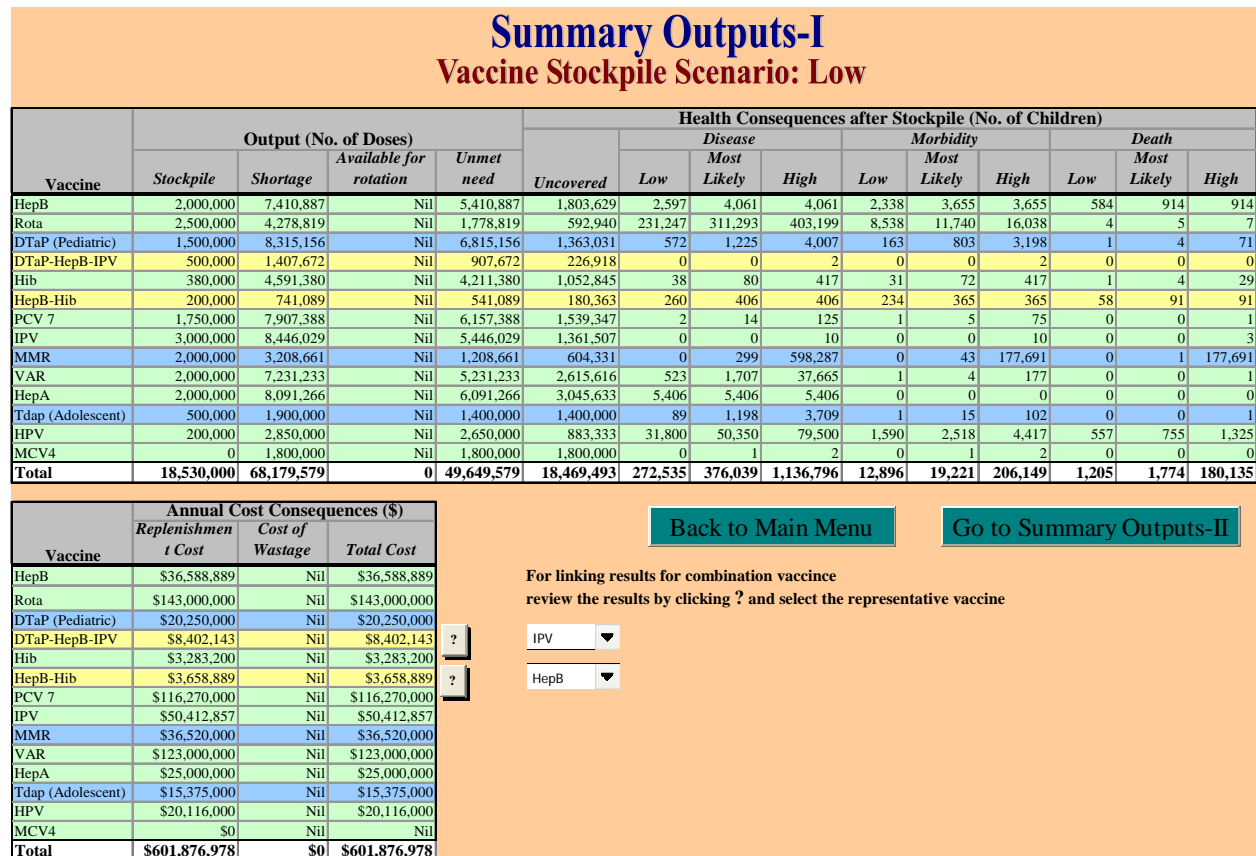
In **Haemophilus Output-II Worksheet**, click [Go to Main Menu](#) to return to the

Main Menu. Click [Back](#) to go to **Haemophilus Outputs-I**. Click

[Go to Summary Outputs-I](#) to go to **Summary Outputs-I**.



The summary outputs provide the results from all the vaccines in one worksheet. Results are grouped by stockpile target scenarios (Low and High). The way the vaccines-specific results are linked to summary outputs differs by vaccine type. For non-combination vaccines, vaccine-specific results are directly linked to summary outputs. For combination vaccines that do not have a routine non-combination alternate, such as MMR, DTaP(Pediatric), and Tdap(Adolescent), the outputs are linked to the representative disease (e.g. measles for MMR). For combination vaccines that have a routine non-combination alternative, such as DTaP-HepB-IPV and HepB-Hib, the results from only one of the substitute vaccines or diseases are linked. This is discussed in more detail later in this section.

Figure 27.



The Summary Outputs-I worksheet provides a one page summary of results from all the vaccines under the low stockpile target scenario. The results are grouped into three sections: physical

output in doses, health consequences after the use of the stockpile, and the annual cost consequences in U.S. dollars as shown in Figure 27.

For combination vaccines, such as DTaP-HepB-IPV and HepB-Hib, which can be substituted for routinely available non-combination vaccines such as DTaP, HepB, IPV and Hib, a representative vaccine must be chosen. To decide for which substitute vaccine the combination vaccine to be considered in summary results, click the  button next to a combination vaccine to review the results of the combination vaccine when it is substituted for a non-combination vaccines. Then from the drop down menu provided next to the combination vaccine, select the non combination vaccine that you would like to use as a substitute (e.g. for DTap-HepB-IPV, select ).

The summary outputs for DTaP-HepB-IPV and Hepb-Hib vaccines when they are substituted for non-combination vaccines are shown in Figures 28 and 29.

Figure 28.

Summary Outputs: DTap-HepB-IPV																	
Vaccine	Output (No. of Doses)				Health Consequences after Stockpile (No. of Children)										Annual Cost Consequences (\$)		
	Stockpile	Shortage	Available for rotation	Unmet needs	Uncovered	Disease			Morbidity			Death			Replenishment Cost	Cost of Wastage	Total Costs
						Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High			
Vaccine Stockpile Scenario: Low																	
DTaP-HepB-IPV	500,000	1,407,672	Nil	907,672	226,918	0	0	2	0	0	2	0	0	0	\$8,402,143	Nil	\$8,402,143
DTaP(Pediatric)	500,000	2,771,719	Nil	2,271,719	454,344	191	408	1,336	54	268	1,066	0	3	24	\$24,375,000	Nil	\$24,375,000
HepB	500,000	1,852,722	Nil	1,352,722	450,907	649	1,015	1,015	584	914	914	146	228	228	\$9,147,222	Nil	\$9,147,222
IPV	500,000	1,407,672	Nil	907,672	226,918	0	0	2	0	0	2	0	0	0	\$8,402,143	Nil	\$8,402,143
Vaccine Stockpile Scenario: High																	
DTaP-HepB-IPV	2,000,000	2,858,485	Nil	858,485	286,162	412	644	644	371	580	580	93	145	145	\$36,588,889	Nil	\$36,588,889
DTaP (Pediatric)	2,000,000	2,217,375	Nil	217,375	43,475	18	39	128	5	26	102	0	0	2	\$97,500,000	Nil	\$97,500,000
HepB	2,000,000	2,858,485	Nil	858,485	286,162	412	644	644	371	580	580	93	145	145	\$36,588,889	Nil	\$36,588,889
IPV	2,000,000	2,463,425	Nil	463,425	115,856	0	0	1	0	0	1	0	0	0	\$33,608,571	Nil	\$33,608,571
One time cost (\$): Going from Low to High Target Stockpile																	
DTaP-HepB-IPV	\$87,750,000																
DTaP (Pediatric)	\$73,125,000																
HepB	\$87,750,000																
IPV	\$73,125,000																

[Go to Summary Outputs-I](#)

[Go to Summary Outputs-II](#)

Figure 29.

Summary Outputs: HepB-Hib																		
Vaccine	Output (No. of Doses)				Health Consequences after Stockpile (No. of Children)										Annual Cost Consequences (\$)			
	Stockpile	Shortage	Wastage	Unmet needs	Uncovered	Disease			Morbidity			Death				Replenishment Cost	Cost of Wastage	Total Costs
						Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High				
Vaccine Stockpile Scenario: Low																		
HepB-Hib	200,000	741,089	Nil	541,089	180,363	260	406	406	234	365	365	58	91	91	\$3,658,889	Nil	\$3,658,889	
HepB	200,000	741,089	Nil	541,089	180,363	260	406	406	234	365	365	58	91	91	\$3,658,889	Nil	\$3,658,889	
Hib	200,000	2,416,516	Nil	2,216,516	554,129	20	42	219	16	38	219	0	2	15	\$3,283,200	Nil	\$5,760,000	
Vaccine Stockpile Scenario: High																		
HepB-Hib	1,000,000	1,429,242	Nil	429,242	143,081	206	322	322	185	290	290	46	72	72	\$18,294,444	Nil	\$18,294,444	
HepB	1,000,000	1,429,242	Nil	429,242	143,081	206	322	322	185	290	290	46	72	72	\$18,294,444	Nil	\$18,294,444	
Hib	1,000,000	875,987	124,013	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	\$13,658,146	Nil	\$13,658,146	

One time cost (\$): Going from Low to High Target Stockpile		Go to Summary Outputs-I	Go to Summary Outputs-II
HepB-Hib	\$23,040,000		
HepB	\$23,040,000		
Hib	\$23,040,000		

The default vaccine chosen for combination vaccines are based on the unmet need results of the combination vaccine. Under the low stockpile scenario, the routine non-combination vaccine that yields the minimum unmet needs when it is submitted with the combination vaccine is selected from among the diseases for which the combination vaccine is recommended. Then the results to summary outputs are linked only from the disease with minimum unmet need. For example, for DTaP-HepB-IPV vaccine, under the low stockpile scenario, the unmet need of the combination vaccine is minimum when it is substituted for IPV. Therefore, the results corresponding to IPV are linked to summary outputs of DTaP-HepB-IPV (the white rows in Figures 28 and 29). The same criteria have been used to select the substitute vaccine for HepB-Hib vaccine.

The stockpile target for a combination vaccines is the same for all routine non-combination vaccines that can be substituted with it. The target shows the doses of combination vaccine available for substituting any one or combination of vaccines. For instance, the low stockpile target for DTaP-HepB-IPV is 500,000 doses, which can be used to fulfill the demand for DTaP (Pediatrics), HepB or IPV, or a combination of these vaccines. For simplicity, the model allows you to choose any one vaccine from the list of vaccines that can be substituted.

For the low vaccine target scenario, a total 18,530,000 doses of vaccines are in the stockpile. On the basis of the assumed shortage scenarios and probability of shortages, the demand for drawdown of vaccines from stockpile is 68,179,579 doses. The demand for drawdown exceeds

the stockpile, therefore no vaccines are available for rotation. However, the unmet need of doses of vaccines is 49,649,579.

The potential number of children deprived of routine immunization because of the vaccine shortages is 18,469,493. Among those not covered, between 272,535 and 1,136,796 children and adolescents would be infected with diseases, 12,896 to 206,149 would become ill, and 1,205 to 180,135 would die.

The results also provide the annual cost consequences of replacing the vaccine drawn from the stockpile. Because no vaccines are available for rotation, there will be no wastage of vaccines and hence no wastage costs. The annual cost required to replace the vaccine drawn from the stockpile would be equal to the replenishment cost, i.e., \$601,876,978.

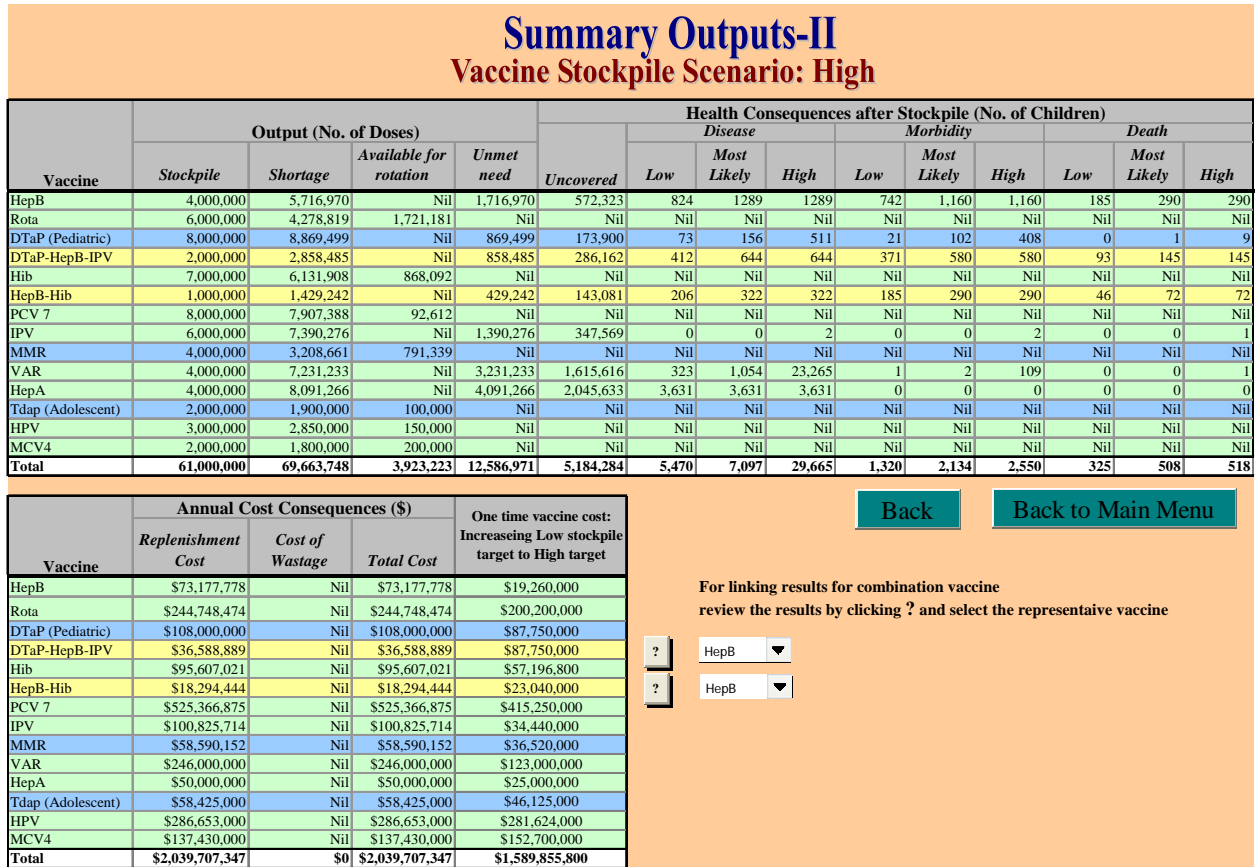
Summary Outputs-II

In **Summary Outputs-I**, click [Go to Summary Outputs-II](#) to go to Summary Outputs under the high stockpile scenario, as shown in Figure 30.

The Summary Outputs-II worksheet provides a one page summary of results for all the vaccines under the high stockpile target scenario. The results are grouped into three sections: physical outputs in doses, health consequences after the use of the stockpile, and the cost consequences in U.S. dollars, including both annual cost and one time cost as shown below in Figure 30.

Like in the low stockpile target scenario, a representative vaccine must be chosen for combination vaccines such as DTaP-HepB-IPV and HepB-Hib for which alternate vaccines containing some of the components are routinely available. Under the high stockpile scenario, the routine non-combination vaccine that yields the maximum unmet needs when it is submitted with the combination vaccine is selected from among the diseases for which the combination vaccine is recommended. The unmet need of DTaP-HepB-IPV is “Maximum” when it is substituted for HepB, therefore the results from HepB is linked to the summary outputs for

Figure 30.



stockpiling of DTaP-HepB-IPV. The same criteria have been used to select the substitute vaccine for the HepB-Hib vaccine.

Under the high stockpile target scenario, 61,000,000 doses of pediatric vaccines will be in the stockpile. On the basis of the assumed shortage scenarios and probability of shortages, the demand for drawdown of vaccines from stockpile is 69,663,748 doses, which is slightly larger than the estimated demand under the low stockpile scenario. The demand for drawdown normally is expected to be the same under both high and low stockpile scenarios. The difference is mainly attributed to variation in the criteria of combining combination vaccines with a non-combination vaccine for the disease in question. For vaccines that have no substitute combination vaccines, the demand from drawdown is the same under both low and high stockpile scenarios, but among vaccines that have substitute combination vaccines, the demand is not the same under two stockpile target scenarios.

Although the total demand for drawdown of vaccines exceeds the total doses of vaccines available in stockpile, 3,923,223 doses of vaccines will be available for rotation. Half of the listed vaccines contribute to doses of vaccine available for rotation. Even with a high stockpile target, 12,586,971 doses of vaccines will be in short supply resulting in 5,184,284 children not being vaccinated. Consequently, 5,470 to 29,665 children and adolescents would be infected with diseases, 1,320 to 2,550 would become ill, and 325 to 518 would die.

The doses of vaccines available for rotation is less than the demand from drawdown, therefore, the cost for wastage because of expiry of vaccine is nil. The annual cost required to replace the vaccines drawn from the stockpile would be \$2,039,707,347. The one time cost that will be required to purchase the difference between the low stockpile target and the high stockpile target of vaccines would be \$1,589,855,800.


In **Summary Outputs-II**, click  to go to **Summary Outputs** under low stockpile scenario, and then click  to return to the **Main Menu**.

4. PRINTING RESULTS AND EXITING *VacStockpile*

For any Excel worksheet, set your printing orientation to “Landscape” format to print your results on a single page.

- 1) Click **File** and choose **Page Set-up**.
- 2) Select **Landscape** under the orientation section of the Page tab.
- 3) Click **OK**.

To exit *VacStockpile* ,

- 1) Click  in the Summary Result worksheet to return to the **Main Menu**.

- 2) On the **Main Menu**, click **Go to Start** to go to the **Front Page**.
- 3) To save the data and results and exit *VacStockpile*, click **Save & Exit**.
- 4) To save the data and results without exiting *VacStockpile*, just close Microsoft Excel.