SPREADSHEET MODELS FOR FOCUSING RESEARCH ON HIGH YIELD PREVENTION AND CONTROL STRATEGIES

I. OPERATIONS RESEARCH AND EPIDEMIOLOGY

A. Definition of operations research (OR)

1. The systematic study, by observation and experiment, of the workings of a system with a view to improvement
   a. System
      (1) A set of discrete, but interdependent, components designed to achieve a set of goals
   b. Improvement
      (1) Increase the cost-benefit or cost-effectiveness of the system

B. Objectives of operations research

1. To diagnose current state of the system and determine why program operations are either successful or unsuccessful
2. To test new modes of service delivery that are more efficient than existing approaches

C. Stages of operations research

1. Situation Analysis
   a. Define the problem
   b. Describe the various factors that contribute to the problem

2. Solution Analysis
   a. Identify various solutions to the problem
   b. Select what look to be the best solutions (theoretically best)
      (1) Focus research on a limited set of solutions

3. Solution Validation
   a. Implement the theoretically best solution
   b. Test the solution to determine if it is effective in the "real" world

D. Relationship between epidemiology and operations research

1. Definition of epidemiology
a. The study of the distribution and determinants of disease and related events in populations, and the application of this study to control of health problems

2. Epidemiology and operations research

a. Research on the workings of the health care delivery system and on optimum solutions to improve the health status of the population

II. SYSTEMS VIEW FOR EVALUATION OF A HEALTH PROGRAM

A. The general model

![General program evaluation model](Figure 18-1)

B. Cost-effectiveness measures based on the model

1. Of interest in *operations research* (OR) studies
   
a. **Input** versus **output**
      
      (1) Average cost per unit output
      
      (2) Volume of output for a given cost
   
b. Reasons for lack of **output**
   
c. Measures are relatively easy to obtain and can be done quickly by local personnel

2. Of interest in *Epidemiologic* studies

   a. **Input** versus **effect**
      
      (1) Average cost per change in recipient
         
         (a) Change in knowledge, attitude, practice (KAP)
         
         (b) Change in immune status
         
         (c) Change in physiological or pathological status
      
      (2) Measure...
         
         (a) in surveys of program participants
         
         (b) with spreadsheet models
b. **Input versus impact**
   (1) Average cost per prevented illness, death or disability
   (a) Average cost per year of health life gained (YHLG)
   (b) Average cost per disability-adjusted life year (DALY) gained
   (2) Measure...
      (a) in experimental or non-experimental epidemiologic studies
      (b) using spreadsheet models

III. SPREADSHEET MODELS

A. Steps for constructing spreadsheet models

   1. Specify variables of interest (often phrased as questions)
   2. Draw a flow chart with questions to be answered and consequences
   3. Convert to a spreadsheet program
   4. Experiment with the spreadsheet model
   5. Use results to decide on critical research elements for actual field investigations

B. Example One - Tetanus Toxoid

1. Objective
   a. Prevent the onset of tetanus in children during the first month of life

2. Disease
   a. Signs, symptoms and prognosis
      (1) Central nervous system disorder with rapid onset (usually stiffness of muscles in the jaw or neck) and convulsive spasms of various muscles
      (2) Prognosis is grave with 80-100 percent case-fatality during first few weeks of life
   b. Organism
      (1) Clostridium tetani
         (a) Anaerobic spore-forming bacterium which exists either in a vegetative or spore forms
         (b) Organism is found in soil, dust, water and intestinal tracts of man and animals
      (2) Enters the body and produces a toxin which harms nervous tissue
         (a) If the stump of the umbilical cord is exposed, the organism can enter
         (b) Since it does not require oxygen for survival (i.e., anaerobic), organism can grow in umbilical area and produce tetanospasmin, a neurotoxin
         (c) Tetanospasmin gains access to the central nervous system by either vascular or neural routes
         (d) Once bound to the central nervous tissue, tetanospasmin is unaffected by antitoxin
c. Incubation period
(1) Usually 5-12 days
d. Prevention
(1) Immunize mother with tetanus toxoid during pregnancy
   (a) two doses of tetanus toxoid one month apart with the second approximately
       one month prior to the birth date
   (b) creates increased titer of tetanus antitoxin
(2) Fetus obtains passive immunization from mother
   (a) antitoxin crosses the placenta from the mother to the fetus
(3) Antitoxin protects newborn child during the early days of life when the severed
    umbilical cord is exposed to potential contamination

3. Necessary steps for a successful tetanus toxoid immunization program

   a. Step 1: Woman becomes pregnant
   b. Step 2: Woman remains pregnant
      (1) Spontaneous or induced abortions
   c. Step 3: Woman is aware of pregnancy
      (1) Often does not occur until the 4th to 5th month of pregnancy

   d. Step 4: Woman seeks antenatal or other health care at local health facility
      (1) Five care visits
         (a) 10 opportunities to vaccinate pregnant women
            i) 1-2 (visit 1 - visit 2), 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5, 4-5
      (2) Four care visits
         (a) 6 opportunities to vaccinate pregnant women
            i) 1-2, 1-3, 1-4, 2-3, 2-4, 3-4
      (3) Three care visits
         (a) 3 opportunities to vaccinate pregnant women

\[\text{Figure 18-2. Opportunities for tetanus toxoid vaccination in}
\text{developing countries.}\]
i) 1-2, 1-3, 2-3

e. **Step 5**: Health workers recognize that a pregnant woman visiting the health clinic is eligible for tetanus toxoid immunization
   (1) Antenatal care on days other than those specially set aside for antenatal care
   (2) Postnatal care for other children
   (3) Care for other illness
   (4) Dental care
   (5) Visits to the pharmacy

f. **Step 6**: Tetanus toxoid is available in the health facility refrigerator
   (1) Adequate system for supplying toxoid on a regular basis
   (2) A working refrigerator is available to store the toxoid

g. **Step 7**: Health workers are willing to give tetanus toxoid to the pregnant woman
   (1) Not willing to open and use vial with maximum of 8 vaccine doses if there are only a few pregnant women
   (2) Concerned about contraindications

h. **Step 8**: Pregnant woman accepts tetanus toxoid
   (1) Woman may refuse injection out of fear of pain or concern over possible negative effects on the fetus

i. **Step 9**: Tetanus toxoid is biologically potent
   (1) No prior disruptions in the cold chain

4. Systems view of tetanus toxoid (TT) immunization program in a developing country

![Diagram]

- Personnel (vaccinators, nurses, health assistants, physicians, etc.), equipment (refrigerator, vaccine, syringes, cold boxes, posters, etc.) and financial budget (money allocated to TT program)
- Program for vaccinating pregnant women with two doses of TT to develop passive immunity against tetanus in the newborn
- Number of TT injections given to pregnant women
- Increased tetanus antitoxin titer in the blood of pregnant women and in their newborn off-springs
- Reduction of tetanus incidence among neonates and improvement in the rate of neonatal mortality

**Figure 18-3.** Evaluation model of TT program.

5. Cost-effectiveness measures based on the model

a. Of interest in *operations research* studies
   (1) **Input** versus **output**
      
      (a) Average cost per TT dose
      (b) Average cost per fully immunized pregnant woman
         i) Two doses one month apart, 3-4 weeks before birth
         
         **Note**: the commonly-used term "fully immunized" means only that the person has received the required number of injections. It does not mean
the person is immune.
(c) Number of vaccinated women during a given fiscal year with a fixed programmatic budget
   i) Usually the count is of administered doses rather than individual women
   ii) Comparison is made from one year to the next
(2) Reasons for lack of output
   (a) Does the health facility have TT in stock?
   (b) Are health workers willing to open a new vial of vaccine if only 1-2 women are to be immunized?
   (c) Are women afraid to be injected with TT?
b. Of interest in epidemiologic studies
(1) Input versus effect
   (a) Average cost per immune woman
      i) Measured in serological surveys
      ii) Estimate using spreadsheet models
(2) Input versus impact
   (a) Average cost per prevented case of tetanus
   (b) Average cost per prevented neonatal tetanus death
      i) Measured in experimental or non-experimental epidemiologic studies
      ii) Estimate using spreadsheet models

6. Steps for constructing spreadsheet model
a. Specify variables or questions of interest
   (1) How many pregnant women are there in the community?
   (2) How likely are they to attend the local health clinic?
   (3) Is TT offered only on certain days during antenatal care clinics?
   (4) Is TT available in the health facility?
   (5) Is the health worker willing to give TT to individual women or only to groups of women?
   (6) Do pregnant women accept getting an injection of TT or do they fear it may harm their unborn child?
   (7) Has the TT been kept sufficiently cold to preserve its biological potency?
b. Draw a flow chart with questions to be answered and consequences
FIGURE 18-4. Flow chart for TT program.
c. Convert to a spreadsheet program

(1) Two components
(a) Number of visits made by pregnant woman to health clinic
(b) Decisions made by mother and staff while at health clinic

(2) Decision Model with One Clinic Visit
(a) see Table 18-1 to the left
(b) All births in the population are classified at the decision points (or nodes) and flow along a path to a single end
   i) A single birth can only move along a single path
   ii) The probabilities along the path are conditional on having reached the prior decision point

(c) End of each row in spreadsheet shows the number of births that flowed along the individual path
   i) Tetanus and non-tetanus neonatal mortality values are set by the investigator based on estimates from other local studies or the literature
   ii) Births
      a) the highlighted values in the spreadsheet are shown in a flowchart on following page (Figure 18-5)

Table 18-1. TT decision model, one clinic visit.
iii) Tetanus neonatal deaths
   a) Formula for each row

<table>
<thead>
<tr>
<th>Derived by investigator</th>
<th>Calculated by Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Tetanus Neonatal Mortality</td>
<td>Number of deaths in row</td>
</tr>
<tr>
<td>1,000 Live Births</td>
<td>of births</td>
</tr>
</tbody>
</table>

Figure 18-5. Flow chart of TT administration, one clinic visit.
iv) non-tetanus neonatal deaths
   a) Formula for each row

\begin{tabular}{|c|c|}
\hline
Derived by investigator & Calculated by Program \\
\hline
Annual Non-tetanus Neonatal Mortality & Number of births \times \text{Number of non-tetanus neonatal deaths in row} \\
1,000 Live Births & \\
\hline
\end{tabular}

(3) Decision model with Two Clinic Visits

(a) See Appendix for full model
   i) This program is available on the class website
      a) Tetanus.xls
(b) Summary table of input data (see Table 18-2)

Table 18-2. Summary table of input data in Tetanus.xls.

\begin{tabular}{|c|c|c|}
\hline
Number of health care visits and doses of TT received by pregnant woman & Neonatal deaths per 1,000 births per year & \\
\hline
No health care visits & 25 & 50 \\
One health care visit & & \\
0 viable TT & 20 & 30 \\
1 viable TT & 10 & 30 \\
Two health care visits & & \\
0 viable TT & 20 & 20 \\
1 viable TT & 10 & 20 \\
2 viable TT & 0 & 20 \\
\hline
\end{tabular}

(c) Table with Program Output (see Table 18-3)

Table 18-3. Table with program output values of Tetanus.xls.

\begin{tabular}{|c|c|c|c|c|}
\hline
Neonatal mortality per 1,000 live births & Number of health care visits & Number of women & Missed opportunity@ \\
\hline
Tetanus & 13.7 & & \\
Non-tetanus & 26.8 & & \\
Total & 40.5 & & \\
\hline
\end{tabular}

\begin{tabular}{|c|c|c|c|}
\hline
Percent of women vaccinated with... & & & \\
Doses & TT & Viable TT & \\
\hline
One & 40.0 & 39.7 & \\
Two & 20.4 & 16.5 & \\
\hline
\end{tabular}

\@ 1) health worker does not recognize woman is eligible, or 
2) TT is not available in health facility, or 
3) health worker is not willing to give TT to woman, or 
4) woman will not accept TT

\[-10-\]
d. Experiment with the spreadsheet model
   (1) Table with summary of three policies (see Table 18-4)

**Table 18-4.** Table with program summary values in *Tetanus.xls.*

<table>
<thead>
<tr>
<th>Policy</th>
<th>Neonatal mortality per 1,000 live births per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetanus</td>
</tr>
<tr>
<td>No health care visits and no tetanus toxoid</td>
<td>25.0</td>
</tr>
<tr>
<td>Health care visits but no tetanus toxoid</td>
<td>21.0</td>
</tr>
<tr>
<td>Health care visits and tetanus toxoid</td>
<td>13.7</td>
</tr>
</tbody>
</table>

(2) Graph comparing three policies in above table (see Figure 18-6)

**Figure 18-6.** Graph of three TT policies in Table 18-4.

e. Use results from the model experiments to select field research studies
   (1) Model identifies high yield research studies
      (a) Focused research
      (b) Time and money are not wasted on unimportant studies
   (2) Field studies are used to set policy
      (a) Findings in field are also used to validate the model
         i) Can re-use model in different settings

7. Example Two - Tetanus Toxoid in Indonesia

   a. Spreadsheet - Before intervention (see *Table 18-5*)
Table 18-5. Estimated tetanus toxoid coverage among pregnant females in Indonesia

<table>
<thead>
<tr>
<th>Service Provider</th>
<th>Prop. ever going to service provider during preg.</th>
<th>Conditional Probability</th>
<th>Percent of pregnant women actually immunized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prop. ever going to service provider during preg.</td>
<td>TT is available in facility</td>
<td>Client gets TT-1</td>
</tr>
<tr>
<td>Posyandu</td>
<td>0.30</td>
<td>0.65</td>
<td>0.35</td>
</tr>
<tr>
<td>Puskesmas</td>
<td>0.60</td>
<td>0.90</td>
<td>0.35</td>
</tr>
<tr>
<td>Hospital</td>
<td>0.04</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>Private MD</td>
<td>0.03</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Private MW</td>
<td>0.20</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Spreadsheet after intervention (see Table 18-6)

Table 18-6. Estimated tetanus toxoid coverage among pregnant females in Indonesia with elimination of most missed opportunities in the puskesmas.

<table>
<thead>
<tr>
<th>Service Provider</th>
<th>Prop. ever going to service provider during preg.</th>
<th>Conditional Probability</th>
<th>Percent of pregnant women actually immunized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prop. ever going to service provider during preg.</td>
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<td>0.10</td>
</tr>
<tr>
<td>Private MW</td>
<td>0.20</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-12-
c. **Figure 18-7** compares TT-1 and TT-2 before and after policy changes

C. Example Three - Acute Respiratory Infections (ARI)

1. See Assigned Readings (Enarson, 2005 and Frerichs, 1989)

2. Prevention and Management of ARI

   a. Primary prevention (not the major topic of this lecture)

   (1) Immunization against measles, pertussis, diphtheria, and tuberculosis
       (a) May account for 25% of all ARI cases
       (b) Expanded Program on Immunization (EPI)

   (2) Vitamin A supplementation (if deficient)

   (3) Promotion of breastfeeding

   (4) Reduction of indoor air pollution
       (a) Indoor cooking fires

   b. Secondary prevention (case-management)

       (1) Intention is to identify disease cases at an early stage in order to reduce the rate of progression to either more severe forms or death

       (2) Use mothers and primary health care workers to identify mild, moderate, and severe ARI

       (a) Accurate diagnosis followed by appropriate management

       (3) Should ask three important questions...

       (a) Does the child have a mild illness that does not require antibiotics and can be managed at home with supportive measures?

           i) Mild ARI

           ii) Mother should treat as follows...

               a) Continue breastfeeding and/or small, frequent feedings

               b) If vomiting is occurring, frequently offer small amounts of fluid

               c) If dehydrated, give oral rehydration fluids

               d) Care should be taken not to over-clothed or tightly wrap children
since such measures may increase the fever and degree of respiratory distress
e) If high fever, give acetaminophen orally
f) To facilitate breathing (especially in young infants), clear the nose and upper respiratory passage
g) Use local inexpensive remedies that contain ginger, licorice, or mint and herbal teas to soothe the child
h) Give inexpensive cough mixtures

iii) Emphasis is on using the parents rather than health care personnel to treat mild cases
   a) No expense for consultations, antibiotic treatment or referrals
   b) Remedies are cited as cost-effectiveness for mild ARI

(b) Does the child have a moderate illness (with reasonable likelihood of bacterial pneumonia) that might benefit from treatment with antibiotics on an outpatient basis?
   i) Moderate ARI
   ii) Typically treated in puskesmas with first-line antibiotics
       a) Procaine penicillin
       b) Ampicillin
       c) Cotrimoxazole
   iii) Bronchodilators
   iv) Salbutamol for wheezing

(c) Does the child have a severe illness that requires referral for hospitalization?
   i) Severe ARI
   ii) Parent and child are sent to Provincial hospital
       a) Second-line antibiotics
           Chloramphenicol
           Oxacillin
           Gentamicin
           Ampicillin (high dose)
           Benzylpenicillin
       b) Oxygen for children respiratory distress

(4) Diagnostic algorithm mention by WHO (see Figure 18-8, used in Bohol, Philippines)
Figure 18-8. ARI algorithm of WHO (Bohol protocol).
3. Diagnostic accuracy of mothers and health workers

a. Recognition of illness

### DIAGNOSIS OF HEALTH WORKER AT PUSKESMAS

Child has an ARI requiring treatment

<table>
<thead>
<tr>
<th>PERCEPTION OF MOTHER</th>
<th>Child has a respiratory illness that requires treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Sick</td>
</tr>
<tr>
<td>No</td>
<td>Worried well</td>
</tr>
<tr>
<td></td>
<td>Non-perceived sick</td>
</tr>
</tbody>
</table>

(1) Sick
   (a) Appropriate perception of the mother
   (b) Child is available for treatment
   (c) Cost
       i) Consultation
       ii) Treatment
       iii) Referral (if necessary)
   (d) Expected outcome
       i) Decrease in case-fatality (greater proportion live)

(2) Worried well
   (a) Inappropriate perception of mother
   (b) The health care worker had to examine the child, but found the child did not require treatment
   (c) Cost
       i) Consultation
   (d) Expected outcome
       i) No change in case-fatality

(3) Non-perceived sick
   (a) Inappropriate perception of mother
   (b) The child was not brought to the puskesmas for treatment
   (c) Cost
       i) None
   (d) Expected outcome
       i) Increase in case-fatality (higher proportion die)

(4) Well
   (a) Appropriate perception of mother
   (b) The child remained at home with the mother
   (c) Cost
       i) None
   (d) Expected outcome
       i) No change in case-fatality

b. Viewed as a flow chart (see **Figure 18-9**)

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c. Viewed as a spreadsheet model

(1) Assumptions
(a) A child may have one or more ARI episode per year
(b) ARI episodes can be separated into three categories
i) Mild ARI
ii) Moderate ARI
iii) Severe ARI
(c) Children with ARI flow through the health care system to eventual recovery or death

(2) Knowledge and behavior of both parents and health care providers determine if the child with ARI moves through the system in a correct manner
(a) Correct diagnosis
   i) Is it really ARI?
(b) Correct behavior
   i) Were mild ARI treated with only simple supportive care?
      a) Viral etiology -- antibiotics have no effect
   ii) Were moderate and severe ARI treated with antibiotics?
   iii) Were severe ARI referred to a hospital for more intensive care?
      a) Did the parents take the child to the hospital?

(3) If the model explains the system, we can experiment with the model to
determine the probable outcome of intervention strategies

4. The Spreadsheet Model (decision tree)

a. Created using Excel

(1) Available at the class website
   (a) ARI.xls (see Appendix)
      i) This version of the ARI program has only the flowchart
   (b) ARI-INT.xls
      i) This version shows the flowchart, three tables, and two graphs of the major findings
      ii) The column width is set to show the Table 3 results
         a) Before printing Tables 1 and 2, you should adjust the column widths
         b) The formulas for Table 3 calculations are included only for row 188 (existing system)

b. Flowchart (see Appendix and Frerichs, 1989 reading assignment)

   (1) Conditional probabilities are termed "Prob." in the flowchart
      (a) Probability of movement to the next category given that the child is in the present category
   (2) Estimates of parameter values
      (a) Derived from earlier studies in Indonesia and various reference articles on ARI

c. Tables

   (1) Output data from model for comparison with real data (see Table 18-7 showing Table 1 in the spreadsheet)
Table 18-7. First table of ARI model encouraging comparison with real data.

Table 1. ARI cases in the community, taken to a health center or to a hospital

<table>
<thead>
<tr>
<th>ARI Category</th>
<th>Community</th>
<th></th>
<th>Health Center</th>
<th></th>
<th>Hospital</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ARI Cases per 100 children in community</td>
<td>Percent of all ARI cases in community</td>
<td>ARI Cases per 100 children in health center</td>
<td>Percent of all ARI cases in health center</td>
<td>ARI Cases per 100 children in hospital</td>
<td>Percent of all ARI cases in hospital</td>
</tr>
<tr>
<td>Mild</td>
<td>590.0</td>
<td>90.8</td>
<td>112.1</td>
<td>76.3</td>
<td>0.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>50.0</td>
<td>7.7</td>
<td>27.6</td>
<td>18.8</td>
<td>0.4</td>
<td>9.2</td>
</tr>
<tr>
<td>Severe</td>
<td>10.0</td>
<td>1.5</td>
<td>7.2</td>
<td>4.9</td>
<td>3.6</td>
<td>88.3</td>
</tr>
<tr>
<td>Total</td>
<td>650.0</td>
<td>100.0</td>
<td>146.9</td>
<td>100.0</td>
<td>4.1</td>
<td>100.0</td>
</tr>
</tbody>
</table>

(2) Input costs for the model (see Table 18-8 showing Table 2 in the spreadsheet)

Table 18-8. Second table of ARI model showing cost data.

Table 2. Total cost of ARI by source of care

<table>
<thead>
<tr>
<th>Source of Care and Funding</th>
<th>ARI cases receiving service per 100 children per year</th>
<th>Average cost per case ($US)</th>
<th>Total cost per 100 children ($US)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supportive care by parents</td>
<td>280.6</td>
<td>$0.11</td>
<td>$30.09</td>
</tr>
<tr>
<td>Puskesmas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultations</td>
<td>146.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paid by parents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>71.5</td>
<td>0.32</td>
<td>47.25</td>
</tr>
<tr>
<td>Paid by government</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild ARI</td>
<td>0.1</td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Paid by parents</td>
<td></td>
<td>0.32</td>
<td>0.03</td>
</tr>
<tr>
<td>Paid by government</td>
<td></td>
<td>1.98</td>
<td>0.20</td>
</tr>
<tr>
<td>Moderate ARI</td>
<td>0.4</td>
<td></td>
<td>2.42</td>
</tr>
<tr>
<td>Paid by parents</td>
<td></td>
<td>6.43</td>
<td></td>
</tr>
<tr>
<td>Paid by government</td>
<td></td>
<td>16.09</td>
<td>6.06</td>
</tr>
<tr>
<td>Severe ARI</td>
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<td>Paid by government</td>
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(3) Experiment with the model (see Table 18-9 showing Table 3 in the spreadsheet)
Table 18-9. Third table of ARI model with cost-effectiveness analyses.

<table>
<thead>
<tr>
<th>State of health care system</th>
<th>Cost in $US per 100 children</th>
<th>Annual ARI mortality rate per 100 children</th>
<th>Annual prevented ARI deaths per 100 children</th>
<th>Annual cost per prevented ARI death per 100 children</th>
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<td>Only supportive care by parents</td>
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<td>Existing system with limited supply of antibiotics</td>
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<td>POLICY A - enforcement of proper antibiotics use by health center staff</td>
<td>233</td>
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<td>POLICY B - education of parent as to diagnosis and case-management</td>
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<td>611</td>
<td>908</td>
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<tr>
<td>POLICY C - combination of proper antibiotic use and education of parents</td>
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<td>Perfect system with correct diagnosis and case-management by parents and provider</td>
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a Cost estimates do not include the cost of conducting the intervention program
b Clinic staff use antibiotics to treat 50% of mild ARI cases, 60% of moderate ARI cases and 70% of severe ARI cases
c POLICY A - use of antibiotics is reduced to 10% for diagnosed mild ARI cases, and changed to 90% for diagnosed moderate ARI and 95% for severe ARI.
d POLICY B - the same values as the existing system with three categories of exceptions:
1) the likelihood that the parent will make a correct diagnosis of ARI is increased to 80% for mild ARI cases, 90% for moderate ARI cases and 95% for severe ARI cases
2) once the diagnosis is made, the parent will use supportive care to initially treat 90% of the mild ARI cases, 95% of the moderate ARI cases and 95% for severe ARI cases
3) the parent will take to a health center 10% of the mild ARI cases, 95% of the moderate ARI cases and 97.5% of the severe ARI cases
e POLICY C - combination of POLICY A and B
f the mild, moderate and severe ARI cases are all diagnosed, managed and referred, and taken to the hospital in a 100% correct manner by parents and health center staff
g ARI mortality rate derived in Appendix for ARI.XLS

### d. Graphs

(1) Impact and cost of potential intervention strategies for ARI (see Figure 18-10)
(2) Cost-effectiveness and prevented ARI deaths with potential intervention strategies (see Figure 18-11)

Figure 18-10. Cost and impact of potential ARI intervention strategies.

Figure 18-11. Efficiency of potential ARI intervention strategies.
## APPENDIX

### Tetanus.xls (left side)

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<th>Number of anticipated births in the population during year</th>
<th>Pregnant woman seeks care at health clinic</th>
<th>Health worker recognizes woman as eligible for TT</th>
<th>TT is available in health facility</th>
<th>Health worker is willing to give TT</th>
<th>Woman accepts TT</th>
<th>TT cold chain was intact</th>
<th>Pregnant woman again seeks care at health clinic</th>
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</tbody>
</table>

Total 1,007.00 13,722 26,800
Example calculation for top row (shaded):

\[ 0.0425 \times 0.0016 = 0.00000679 \text{ per 100 children} \]

\[ 0.00000679 \times 1000 = 0.00679 \text{ line-specific deaths due to mild ARI per 1,000 children} \]