PSI Health Impact Estimation Model: Use of Nevirapine for Prevention of Mother-to-Child Transmission of HIV

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PSI shares its models with all interested individuals or organizations. Please note that the models are updated periodically based on the latest available epidemiological, demographic, intervention effectiveness, and utilization data. As a result, numbers used in this document should be considered illustrative only. They show how the model works, but they are likely to have changed since the time of writing.

For more information or the latest model updates, contact Hongmei Yang at hyang@psi.org.

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Nevirapine DALY Model for Prevention of Mother-to-Child Transmission (PMTCT) of HIV

Background

Population Services International (PSI) is a social marketing organization that promotes healthy behaviors in low-income and vulnerable populations. PSI has programs in 65 countries (www.psi.org) and covers a wide range of health areas. PSI uses the disability-adjusted life year (DALY) as the metric for measuring the health impact of interventions in health areas. A DALY model has been developed for each of PSI’s products/services and behavior change communications (BCC) interventions. The DALY model presented here is the nevirapine DALY model for prevention of mother-to-child transmission (PMTCT) of HIV.

The nevirapine DALY model developed by PSI provides an estimate of DALYs averted per nevirapine treatment of HIV-positive pregnant women and their newborns (i.e., nevirapine DALY coefficient). It will be used to measure the impact of social marketing programs that provide nevirapine to prevent mother-to-child transmission of HIV in HIV-positive pregnant women. The purpose of this report is 1) to describe the principles and structure of a simple deterministic model (in Excel) that estimates the health impact of a nevirapine program on HIV-positive pregnant women and their newborns in DALYs averted per nevirapine treatment, and 2) to identify the parameters and assumptions used in the model.

Section 1: Principles and Structure of the Model

1.1 Principles of the math model

The nevirapine DALY model uses probability models to determine the impact of single-dose nevirapine given to HIV-positive pregnant women before the onset of labor and given to their newborns within 72 hours of birth. The probability of infection of a newborn through mother-to-child transmission of HIV is estimated as shown below:

\[ P = \text{Live Birth Rate} \times (1 - U5MR) \times \gamma \times (1 - PE) \]

Where,

- \( P \) refers to the probability of infection of a newborn through mother-to-child transmission of HIV,
- \( U5MR \) refers to the under-five mortality rate,
- \( \gamma \) refers to the probability of mother-to-child transmission of HIV when no antiretroviral therapy (ART) is present (including nevirapine), and
- \( PE \) refers to the protective efficacy of nevirapine in reducing the probability of mother-to-child transmission of HIV.

1.2 Structure of the DALY model

The DALY model is designed to estimate both the burden of disease (BOD) and the health impact of the use of nevirapine for prevention of mother-to-child transmission of HIV. Calculating the burden of disease (i.e., infants born HIV positive) tests the reliability of the model by comparing the BOD obtained with BODs reported by other organizations (e.g., UNAIDS) if such data are available. The BOD is measured by the number of infants born HIV positive to HIV-positive mothers and DALYs. The health impact of the PSI nevirapine program is measured by new infections averted and DALYs averted per dose of nevirapine administered to HIV-positive mothers and their newborns.
To measure the BOD and the health impact, the model is designed with two components: baseline (i.e., a scenario where the PSI nevirapine program is not present) and post-intervention (i.e., a scenario where the PSI nevirapine program is present). The baseline component assumes no incremental interventions and provides an estimate of the potential disease burden that would accrue in a given year in terms of number of the new infections resulting from mother-to-child transmission of HIV. This figure, in turn, is translated into an equivalent measure in DALYs, based on country-specific population and epidemic data on pregnant women. The post-intervention component of the model estimates the reduction in risk HIV infection of newborns of HIV-positive mothers as a result of implementation of the PSI nevirapine program.

Section 2: Estimating Disease Burden

Because the mortality rate for children under five is high in many countries, the first step in estimating the burden of disease (BOD) is to calculate the probability that an infant born alive will survive at least five years. This probability is then multiplied by the probability that the child of an HIV-positive mother will be born with HIV (in the absence of treatment). The likelihood of infection is then multiplied by the number of births in the country per year and HIV prevalence among pregnant women. The result is an estimate of the total number of new HIV infections due to mother-to-child transmission (MTCT) during the study period (one year).

The estimated number of new infections is then translated into an equivalent figure for disease burden measured in DALYs. The progression of vertically acquired HIV infection appears to have a bimodal distribution. In approximately 20% of children born with HIV the disease progresses rapidly (i.e., severe illness develops in the first year of life and child survives 23 months after the onset of severe illness); among the rest of the children, the infection follows a pattern similar to that of adults (i.e., asymptomatic HIV for an average of eight years, and AIDS lasting another two years).

Section 3: Estimating the Impact of Interventions

The second (post-intervention) component of the model estimates the health impact of the PSI nevirapine program on the population. A time period of one year is assumed because PSI measures health impact in terms of one full year. The outputs of the model are new HIV infections averted and DALYs averted per nevirapine treatment received by HIV-positive mothers and their newborns.

The PSI nevirapine program for prevention of mother-to-child transmission of HIV consists of treating HIV-positive pregnant women with single dose nevirapine before the onset of labor and treating their newborns with single dose nevirapine within 72 hours of birth. Programmers reported that sometimes only the HIV-positive mother received the single dose nevirapine treatment (i.e., the infant was not treated) because they could not follow up with the infant after the birth.

When both the HIV-positive mother and her newborn are treated with single doses of nevirapine, the reduction in mother-to-child transmission of HIV is reported to be approximately 50%. There is no information on the effect when only the HIV-positive mother receives the nevirapine treatment. For purposes of the model, this figure was estimated to be 20%. Finally, the model determines the number of MTC HIV infections averted and DALYs averted per nevirapine treatment of HIV-positive pregnant women and their newborns.

Section 4: Parameters and Data Sources

This section presents information on the determinants (i.e., data points) for the parameters used in the DALY model and their sources.
4.1 Biological information

Probability of mother-to-child transmission (MTCT) of HIV when no treatment is present: 35% (Connor et al., 1994; Giaquinto et al., 2006; Hare, 2006).

4.2 Disease-related information

Duration of HIV in adults: 10 years; YLD weight: 0.135 (DCPP)

Duration of AIDS in adults: 2 years; YLD weight: 0.505 (DCPP)

Percentage of HIV-infected newborns that developed severe illness in the first year of life: 20% (Blanche et al., 1997; http://www.webmd.com/hiv-aids/guide/hiv-in-children?page=3)

Median survival years of HIV-infected newborn after onset of severe illness: 23 months (Blanche et al., 1997)

Life span: 81.25

4.3 Efficacy of products/intervention

Nevirapine treatment/intervention reduces mother-to-child transmission (MTCT) of HIV by 50% when both HIV-positive mother and newborn receive single dose nevirapine treatment (Bardsley-Elliot and Perry, 2000; Giaquinto et al., 2006; Guay et al., 1999). The reduction in mother-to-child transmission of HIV is 20% when only the HIV-positive mother receives the nevirapine treatment. (Note: This is an assumption; no information was found in the literature.)

4.4 Epidemic data

Table 1: Epidemiologic information

<table>
<thead>
<tr>
<th>Country</th>
<th>U5MR (/1000)a</th>
<th>Annual number of birthsb</th>
<th>HIV prevalence (%) among women age 15-49 attending ANC clinics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haiti</td>
<td>120</td>
<td>255,000</td>
<td>3.1c</td>
</tr>
<tr>
<td>Mozambique</td>
<td>145</td>
<td>773,000</td>
<td>16.2d</td>
</tr>
<tr>
<td>Uganda</td>
<td>136</td>
<td>1,468,000</td>
<td>6.7e</td>
</tr>
</tbody>
</table>

a. The state of the world's children 2007: Women and Children The Double Dividend of Gender Equality, Table 1 http://www.unicef.org/sowc07/docs/sowc07.pdf

b. The state of the world's children 2007: Women and Children The Double Dividend of Gender Equality, Table 1 http://www.unicef.org/sowc07/docs/sowc07.pdf

c. Gaillard EM et al., Understanding the reasons for decline of HIV prevalence in Haiti. Sex. Transm. Inf. 2006;82;i14-i20


e. HIV among general pop. WHO/UNAIDS Epidemiological Fact Sheets on HIV/AIDS and STIs
References


Hare CB. HIV InSite Knowledge Base Chapter, January 2006. http://hivinsite.ucsf.edu/InSite?page=kb-03-01-01