P4O
planning for outcomes

Planning for Outcomes (P_4O) Model

FORMULAE USED IN MODEL

2018 version

Contraceptive and Maternal Health Measures

Assume that there are N_{WRA} women of reproductive age, and that P_{INJ} is the proportion using injectable contraception. We wish to estimate how many more (or fewer) pregnancies there would be per year if a proportion Y of the $N_{WRA} \cdot P_{INJ}$ injectable users stopped using the method, when further assuming a proportion X of those who stop take up a replacement modern method.

> *Note: P_4O allows three options for how women replace injectables: 1) in proportion to the existing, country-specific distribution of other modern methods after excluding injectables; 2) in proportion to the existing distribution of other modern methods after excluding injectables or permanent methods; 3) according to a user-specified mixture of methods besides injectables. For simplicity, only the math for option 1 is described here.*

Among previous injectable users shifting to a new method, the proportion switching into each type is

$$Q_i = P_i / \left(P_{FS} + P_{MS} + P_{OC} + P_{IUD} + P_{MC} + P_{VB} + P_{IMP} + P_{OTH}\right), i \in \{FS, MS, OC, IUD, MC, VB, IMP, OTH\},$$

where P_{FS} (etc.) is the current proportion using Female Sterilization (FS), Male Sterilization (MS), OCs, IUD, Male Condoms (MC), Vaginal Barriers (VB), Implants (IMP), or Other modern methods (OTH).

Next let PP_j for j in {*NM, FS, MS, INJ, OC, IUD, MC, VB, IMP, OTH*} denote the yearly-probability of pregnancy when using No Method (NM), etc. Then the change in the expected number of pregnancies per year, if a proportion Y of injectable users stop using the method and a proportion X of those who stop adopt a new method is given by

$$\begin{aligned} NP_{diff} = {} & N_{WRA} P_{INJ} Y (1 - X) PP_{NM} \\ & + N_{WRA} P_{INJ} YX (PP_{FS} Q_{FS} + PP_{MS} Q_{MS} + PP_{OC} Q_{OC} + PP_{IUD} Q_{IUD} + PP_{MC} Q_{MC} + PP_{VB} Q_{VB} + PP_{IMP} Q_{IMP} + PP_{OTH} Q_{OTH}) \\ & - N_{WRA} P_{INJ} Y PP_{INJ}, \end{aligned}$$

USAID Envision FP fhi360 THE SCIENCE OF IMPROVING LIVES where the first line is the expected number of pregnancies among women switching to no method, the second line is the expected number of pregnancies among women switching to the existing method mix, and the last line is the expected number of pregnancies that would have occurred among injectable users had they not stopped using the method. This can be simplified as

$$
\begin{aligned}
NP_{diff} &= N_{WRA} P_{INJ} Y \times \\
&\quad (X\{PP_{FS}Q_{FS} + PP_{MS}Q_{MS} + PP_{OC}Q_{OC} + PP_{IUD}Q_{IUD} + PP_{MC}Q_{MC} + PP_{VB}Q_{VB} + PP_{IMP}Q_{IMP} + PP_{OTH}Q_{OTH} - PP_{NM}\} \\
&\quad + PP_{NM} - PP_{INJ}).
\end{aligned}
$$

All other pregnancy-related indicators are obtained by multiplying NP_{diff} by the appropriate factor (i.e., the chance that an unintended pregnancy leads to a live birth, abortion, unsafe abortion, maternal death, or additional maternal and neonatal health care costs/year).

Note: we assume that a woman who is either using a modern method or who has an unmeet need after ceasing injectable use has at most one unintended pregnancy per year

For a given Y, the 'break-even' replacement level X* (for which $NP_{diff} = 0$) is given by

$$
\begin{aligned}
X^* &= (PP_{INJ} - PP_{NM}) \\
&\quad /(PP_{FS}Q_{FS} + PP_{MS}Q_{MS} + PP_{OC}Q_{OC} + PP_{IUD}Q_{IUD} + PP_{MC}Q_{MC} + PP_{VB}Q_{VB} + PP_{IMP}Q_{IMP} + PP_{OTH}Q_{OTH} - PP_{NM}).
\end{aligned}
$$

To obtain the break-even level across a set of C countries (indexed by 'c'), we solve for

$$
\begin{aligned}
X^* &= (PP_{INJ} - PP_{NM}) \sum_{c=1}^{C} N_{WRA,c} P_{INJ,c} \,/ \\
&\quad \sum_{c=1}^{C} \{N_{WRA,c} P_{INJ,c} (PP_{FS}Q_{FS,c} + PP_{MS}Q_{MS,c} + PP_{OC}Q_{OC,c} + PP_{IUD}Q_{IUD,c} + \\
&\quad PP_{MC}Q_{MC,c} + PP_{VB}Q_{VB,c} + PP_{IMP}Q_{IMP,c} + PP_{OTH}Q_{OTH,c} - PP_{NM})\}
\end{aligned}
$$

Note: there may not be a solution for X ≤ 100% reallocated if women are assumed to switch to methods which are, on average, less effective than injectables. P_4O simply reports '>100%' if there is no break-even replacement level.*

If injectable use increases risk of HIV acquisition, then withdrawing injectables may lead to fewer new HIV infections. This could be counter-balanced, however, if women who stop using injectables are more likely to become pregnant, and if pregnancy increases the risk of HIV. There could also be an increase in the number of children born with HIV or acquiring HIV in infancy, if HIV-positive women who stop using injectables take up less effective methods.

The user must first input an assumption about the overall incidence of HIV among non-pregnant women who are using modern contraception (denoted I_{HIV}).

> *Note: In P_4O, the incidence assumption is specified as a fraction of the prevalence of HIV among all WRA in each country (i.e., incidence = Z% of prevalence, where 'Z' is based on current UNAIDS data).*

Once I_{HIV} is specified, an estimate of HIV incidence is separately obtained for condom users, injectable users, and users of methods besides condoms or injectables. Denote the hazard ratio (HR) for Injectable use versus any method besides condoms as HR_{INJ}, and the HR for condoms versus any method besides injectables as HR_{MC}. Then the incidence of HIV among users of any method besides condoms or injectables can be approximated as

$$I_{HIV}^{0} = \frac{I_{HIV}}{\{(1 - Q_{INJ} - Q_{MC}) + HR_{MC}Q_{MC} + HR_{INJ}Q_{INJ}\}},$$

where Q_{INJ} is the proportion of the existing method mix which is injectables and Q_{MC} is the proportion of the method mix which is male condoms. Then the incidence of HIV among injectable users is

$$I_{HIV}^{INJ} = I_{HIV}^{0} \cdot HR_{INJ}$$

and the incidence of HIV among condom users is

$$I_{HIV}^{MC} = I_{HIV}^{0} \cdot HR_{MC}.$$

(HIV related Measures, continued)

To compute the yearly change in the number of women becoming infected with HIV, if a proportion Y of current injectable users are withdrawn from the method and a proportion X of those who stop adopt a new method, we also need to know: the prevalence of HIV ($PREV_{HIV}$) (since only those not already infected can become newly infected); the HR for HIV when a woman is pregnant or in the first few months post-partum (HR_{PREG}) (since we want to allow for the possibility that HIV acquisition risk changes during this period); and the chance that an unintended pregnancy results in a live birth (F_T) (since how long a pregnant woman is at differential risk of HIV will depend on whether or not she carries to term and has a live birth).

We make the simplifying assumption that women who become pregnant and carry the pregnancy to term contribute up to 1 year of HIV risk while pregnant; women who become pregnant but don't carry to term contribute 6 months of risk while pregnant and 6 months while not pregnant; women stop using their method (including condoms) while pregnant; and women who do not become pregnant contribute 1 year of HIV risk using their contraceptive method.

We then compute the expected change in the yearly number of women becoming infected with HIV as

$$
\begin{aligned}
&N_{WRA}P_{INJ}Y(1-PREV_{HIV})\times \\
&\{(1-X)((1-PP_{NM})(1-\exp(-I^0_{HIV}))+PP_{NM}(F_T(1-\exp(-I^0_{HIV}HR_{PREG}))+(1-F_T)(1-\exp(-0.5\cdot I^0_{HIV}(1+HR_{PREG})))))\\
&+X\sum_i Q_i((1-PP_i)(1-\exp(-I^0_{HIV}))+PP_i(F_T(1-\exp(-I^0_{HIV}HR_{PREG}))+(1-F_T)(1-\exp(-0.5\cdot I^0_{HIV}(1+HR_{PREG})))))\\
&+XQ_{MC}((1-PP_{MC})(1-\exp(-I^0_{HIV}HR_{MC}))+PP_{MC}(F_T(1-\exp(-I^0_{HIV}HR_{PREG}))+(1-F_T)(1-\exp(-0.5\cdot I^0_{HIV}(HR_{MC}+HR_{PREG}))))))\\
&-((1-PP_{INJ})(1-\exp(-I^0_{HIV}HR_{INJ}))+PP_{INJ}(F_T(1-\exp(-I^0_{HIV}HR_{PREG}))+(1-F_T)(1-\exp(-0.5\cdot I^0_{HIV}(HR_{INJ}+HR_{PREG})))))\},
\end{aligned}
$$

where the sum in the third-row indexes women adopting {*FS, MS, OC, IUD, VB, IML, OTH*} (with or without becoming pregnant), and the last row captures the number of new infections that would have occurred among the $N_{WRA}P_{INJ}Y(1\text{-}PREV_{HIV})$ women had they not stopped using injectables.

To estimate the number of additional children born with HIV if injectable use is reduced, we need to determine what percentage of the extra live births were to HIV-infected women, what percentage of women become HIV-infected while pregnant, and the probability that infection is transmitted to the child. For the latter, we must consider the percentage of HIV-infected women who are on ART ($PREV_{ART}$), the risk of transmitting HIV to a child when on daily ART (P_T^{ART}), and the risk of transmitting HIV to the child when not on ART (P_T^0). Then the excess number of children born with HIV is given by:

$$
\begin{aligned}
&NP_{diff}\cdot P_{LB}\cdot\{PREV_{HIV}[PREV_{ART}\cdot P_T^{ART}+(1-PREV_{ART})\cdot P_T^0]+\\
&(1-PREV_{HIV})(1\text{-}\exp(\text{-}I^0_{HIV}HR_{PREG}))[PREV_{ART}\cdot P_T^{ART}+(1-PREV_{ART})\cdot P_T^0]\}.
\end{aligned}
$$

Note: we assume the risk of transmitting HIV to an infant is not influenced by when infection occurred in the mother.

Questions?

Should you have additional questions, please feel free to contact:

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