Projecting the Potential Cost-Effectiveness of Universal Access to Modern Contraceptives in Uganda

ABSTRACT

Background: Over two thirds of women who need contraception in Uganda lack access to modern effective methods. This study was conducted to estimate the potential cost-effectiveness of achieving universal access to modern contraceptives in Uganda by implementing a hypothetical New Contraceptive Program (NCP) from both societal and governmental perspectives.

Methods: A Markov model was developed to compare the NCP to the status quo or Current Contraceptive Program (CCP). The model followed a hypothetical cohort of 15-year old girls over a lifetime horizon. Data were obtained from the Uganda National Demographic and Health Survey and from published and unpublished sources. Costs, life expectancy, disability-adjusted life expectancy, pregnancies, fertility and incremental cost-effectiveness measured as cost per life-year (LY) gained, cost per disability-adjusted life-year (DALY) averted, cost per pregnancy averted and cost per unit of fertility reduction were calculated. Univariate and probabilistic sensitivity analyses were performed to examine the robustness of results.

Results: Mean discounted life expectancy and disability-adjusted life expectancy (DALE) were higher under the NCP vs. CCP (28.74 vs. 28.65 years and 27.38 vs. 27.01 respectively). Mean pregnancies and live births per woman were lower for the NCP (9.51 vs. 7.90 and 6.92 vs. 5.79 respectively). Mean lifetime societal costs per woman were higher for the NCP from the societal perspective ($1,074 vs. $1,041) and the governmental perspective ($448 vs. $397). The incremental cost-effectiveness ratio comparing the NCP to the CCP was $88 per DALY averted (societal perspective) and $138 per DALY averted (governmental perspective). The results were robust to univariate and probabilistic sensitivity analysis.

Conclusion: Universal access to modern contraceptives in Uganda appears to be highly cost-effective. Increasing contraceptive coverage should be considered among Uganda's public health priorities.

INTRODUCTION

With a fertility rate of 6.7 births per woman and an annual population growth rate of 3.2%, Uganda has one of the fastest growing populations in the world.[1] This may be attributed to a variety of factors including individuals' desire for large families and a low level of contraceptive use. Based on DHS, among fecund married or unmarried, sexually active women in Uganda who have the desire to delay pregnancy or stop having children completely, only 31% use effective modern contraceptives – which include the pill, intra uterine device, injectable contraceptives, implants, male condoms, and male and female sterilization. Then, 69% percent lack access to effective modern contraception; and of those 8% use traditional contraception –which includes rhythm, withdrawal and folk methods of contraception – and 61% lack access completely.[2]The lack of access to modern contraceptives can be attributed to a poor public health system and individual poverty.

As a result, there are many unintended pregnancies and unplanned births. In fact, up to 45% of births in 2006 were unplanned and Ugandan women continue to have more children (6.7 per woman) than they want (5.1 children per women) according to the 2006 Uganda Demographic and Health Survey (UDHS).[1]The vast majority of these unintended pregnancies (88%) occur among those who do not use contraceptives; only 12% occur as a consequence of contraceptive failure.[2]

In addition to reducing total fertility and slowing the rate of population growth, increased access to contraception is associated with many potential benefits. Couples are able to achieve their desired family size, which has been shown to contribute to improved broad social, economic and developmental indicators such as improved child nutrition, increasing rates of school attendance and increasing family incomes.[3-5]Moreover, improving socioeconomic conditions are associated with a reduction in desired family size, thereby increasing the potential long-term impact of increased contraceptive coverage.

Given these potential benefits, policy makers and health planners should ensure that access to contraceptives is universal in Uganda are met. However, access to contraceptives has been decreasing, possibly due to families' desire for fewer children with unchanging supply of contraceptive services but also due to government apathy in providing services through the government healthcare system.[6] With a total per capita health expenditure of only US$24,[7] Uganda's government-run healthcare system must prioritize among many competing health needs of the population because of the extreme budget constraint. As a result, many healthcare interventions that could result in socioeconomic and health benefits may not be implemented.

Cost-effectiveness analysis considers both costs and health outcomes in evaluating the efficiency of interventions and allows policy makers to prioritize among competing uses of scarce healthcare resources. The objective of this study was to compare the incremental cost-effectiveness of a hypothetical New Contraceptive Program (NCP) that would achieve universal access to modern contraceptives in Uganda, to the Current Contraceptive Program (CCP), the status quo in which access to contraception is limited.

METHODS

Markov Model

A Markov cohort model was developed to compare the potential cost-effectiveness of a hypothetical NCP designed to achieve universal access to modern contraceptives in Uganda to the status quo which we will refer to as the CCP. The model projected the reproductive health experience of a hypothetical cohort of 15-year old girls, starting at their sexual debut, over a lifetime horizon. Figure 1 shows a schematic of the Markov model.

The Markov model is suited to women's reproductive experience because it spans many years and many events– pregnancies, miscarriages, abortions and births – can occur multiple times. The model had 7 states: (i) not sexually active (NSA); (ii) intentional non-contraception (INC); (iii) unintentional non-contraception (UNC); (iv) modern contraception (MOC); (v) traditional contraception (TRC); (vi) pregnant and (vii) dead.   The NSA state included unmarried women who had not had sex within the 3 months preceding the UDHS. The INC state included women who were looking to get pregnant. The UNC state included women lacked access to modern contraception and the MOC and TRC states included women using modern and traditional methods of contraception respectively. The cycle time was 9 months.

The model was validated by varying transition probabilities between 0 and 1to observe if responses were logical and setting costs and outcomes to 0 separately to examine if the expected values were identical. Additional validation was performed by comparing the predicted fertility to the published estimate from the UDHS.

The analysis was performed from both the governmental (the national healthcare payer) and the societal perspectives and included direct and indirect costs. Costs and outcomes were discounted at 3% per year (0 – 5% in sensitivity analyses) as recommended by the Panel on Cost-Effectiveness and Medicine of the US Public Health Service.[8]The NCP was compared to the CCP on the basis of costs, life expectancy and incremental cost-effectiveness analysis using cost per life-year (LY) saved and disability-adjusted life years (DALY) averted, which captures quality and quantity of life. The model was also used to compute other intermediate measures of cost-effectiveness: 1) cost per pregnancy averted; 2) cost per unit of fertility reduction; 3) cost per ectopic pregnancy averted; 4) cost per miscarriage averted; 5) cost per induced abortion averted; 6) cost per still birth averted 7) cost per neonatal death averted; 8) cost per infant death averted; and 9) cost per child death averted.

The WHO and others have suggested that, because of the lack of a universally accepted standard for a threshold for cost-effectiveness, researchers use a GDP-based approach. Suggested thresholds have ranged from 1 to 3 times per capita GDP per additional quality-adjusted life-year or DALY[9-11] and other studies have used this threshold in Uganda.[12] Uganda's GDP per capita was $474 at the real exchange rate.[13] Therefore the NCP was judged to be highly cost-effective if the incremental cost-effectiveness ratio (ICER) was less than $474 per DALY (1 times per capita GDP) and cost-effective if the ICER was less than $1,423 per DALY (3 times per capita GDP).

Starting distribution of the hypothetical cohort among Markov states

The 2006 UDHS[1] was the main source of data on transition probabilities between Markov states. This survey is performed regularly and is considered the best source of demographic and health data in the country. Sexual activity was defined as having at least one sexual encounter in the month prior to the survey. Sexually active women were divided among states according to their use of contraception—modern or traditional—and the lack of access to modern contraception. The proportion of women who lacked access was started in the UNC state. The proportion of sexually active women using either traditional or modern contraception was started in the MOC and TRC states. The remainder of the women were considered to want to conceive and started in the INC state. In the NCP, women who previously started in the TRC and UNC states were started in the MOC state which is akin to achieving universal access to modern contraception in Uganda.

According to the 2006 UDHS, at 15 years of age, 80.3% of women were not sexually active and were started in the NSA state and 19.7% were sexually active. Of those who were sexually active, 11.4% used contraception (9.1% modern (MOC state), and 1.8% traditional (TRC state)) while 6.6% lacked access (UNC state). This left 2.1% who were considered to intended to conceive (INC state). In the new national program, 17.6% started in the MOC state and 0%started in the INC and TRC states.

Transition between states of contraceptive use and pregnancy

We used the age-specific proportion of women in states of contraceptive use, based on the 2006 UDHS, as estimates for their rates of transition between the respective Markov states over the reproductive lifespan. The age-specific proportion of women who remain sexually inactive was used as the estimate for the probability of women staying in the NSA state. The age-specific proportion of women using traditional and modern contraception was used as an estimate for the probability of transition between the NSA and UNC states and MOC and TRC states respectively. The age-specific proportion of sexually active women lacking access to contraceptive was used as the estimate of the probability of transition between the NSA and UNC states while the calculated proportion of sexually active women who wish to conceive was used as the estimate of transition from the NSA state to the INC state. The age specific transition probabilities are shown in Table 1.

For transition from the UNC and INC states to the pregnant state, we applied the probability of pregnancy without contraception to the proportion of sexually active women who are not using any contraception. The probability of pregnancy in populations where contraception is not used, or in which women cease to use contraception to get pregnant, is 85%.[14] The probability of pregnancy was adjusted for menopause starting at age 35 according to the age-specific prevalence of menopause defined as last known menstrual period occurring 6 or more months preceding the 2006 UDHS among non-pregnant and non-amenorhoeic women, which increases from 2.4% between 30 and 34 years to 42.8% between 48 and 49 years of age.[1] The rate of transition from the TRC state and MOC state to the pregnant state was obtained from the study by Trussell et al. [14] This study, a systematic review, was chosen because it is the only published study we could find that estimated rates of contraceptive failure and pregnancy in the absence of contraception. The different rates for modern use were weighted by the frequency of use of different methods of modern contraception in Uganda according to the UDHS.[1]

Because of the lack of data from Uganda on the probability of contraceptive discontinuation, we used an average from a study performed in Kenya and Tanzania,[15] the two closest neighboring countries, as the estimate for the rate of transition between the MOC and TRC states to the INC and UNC states. This study, which was based on primary data collection, reported that the annual rate of discontinuation with intent to have children was 18.4% in Kenya and 15.0% in Tanzania; we modeled the average of 16.7%. The annual rate of discontinuation without intent (due to side effects and access problems) was 10.8% in Kenya and 13.8% in Tanzania; we modeled the average of 12.1%.

All women who had live births were assumed to join the MOC state because the probability of pregnancy during lactation amenorrhea is similar to that of other modern contraceptives.[16] Women who have non-live birth pregnancy outcomes were allowed to transition to other states at the same rate as women in the NSA state. The non-age-specific transition probabilities are shown in the table of parameters (Table 2).

The model disallowed movement between the MOC and TRC states in a single cycle as well as movement from contraceptive use states to the NSA state; women returned to the NSA state only after pregnancy. Pregnancy was a temporary state i.e. people did not spend more than a single cycle in this state.

Mortality

Age-specific mortality rates from all causes for women in Uganda, which represent the transition between all states and death, were obtained from country-specific life tables published by the WHO[17] and are shown in table 1. These were adjusted for the percentage of deaths due to maternal causes which was 13% in the 2006 UDHS.[1] Maternal mortality, which represents the transition from the pregnant to the dead state, was reported in the 2006 UDHS as 435 (345 – 524) deaths per 100,000 live births.[1] This estimate was adjusted for the proportion of pregnancies that result in live births. Neonatal, infant and child mortality estimates were obtained from the UDHS.[1] These estimates are cumulative i.e. infant mortality includes neonatal mortality and child mortality includes both neonatal and infant mortality.

Disability-Adjusted Life Years (DALYS)

An estimated total of 498,000 DALYs are lost annually by women aged 15 to 59 years from maternal conditions (pregnancy complications) in Uganda.[18] There are an estimated 1,830,000 pregnancies annually in Uganda.[19] The annual number of DALYs lost by the annual number of pregnancies to obtain an estimate of the average DALY loss due to pregnancy complications associated with a single pregnancy which is 0.27 DALYs.

Costs

Costs were estimated for the MOC state, the pregnant state, and the dead state. Costs were divided into direct medical and non-medical costs and indirect costs. The direct medical costs of modern contraception included the cost of contraceptive technology and healthcare personnel while the direct costs of pregnancy included the costs of healthcare personnel and other healthcare materials associated with normal delivery, complicated delivery (cesarean section, obstetric hemorrhage and eclampsia), ectopic pregnancy, miscarriage, induced abortion, and still births, weighted by the incidence of the different outcomes of pregnancy. The direct non-medical costs of contraception and pregnancy included capital costs, recurrent costs, and costs of transportation and upkeep while seeking healthcare. The indirect costs included productivity losses while seeking care and as a result of premature mortality.

The costs of modern contraception were obtained from the Uganda Safe Motherhood Program Costing Study the only study of contraception costs in Uganda that we could find.[20] In this study, the costs per year of protection for contraceptives were $2.6 to $5.7 for oral contraceptives, $3.6 for Depoprovera, $3.8 for condoms, $1.1 for intrauterine devices, $23.0 for Norplant, and$3.3 for sterilization. These costs were weighted by the contraceptive technology mix in Uganda which is 35% oral contraceptives, 45% depoprovera, 10% condoms, 4% intrauterine device, 1% Norplant, and 5% sterilization.[20]

The costs of healthcare personnel, materials, capital goods, and recurrent expenditure were obtained from a study of costs of maternal healthcare services in Uganda.[21] In this study, costs were estimated for antenatal care, normal delivery, and complicated delivery. The study measured both direct healthcare costs and indirect costs including user fees and transportation. The estimated costs from this study were as follows: antenatal care $6.4; normal delivery $23.5; cesarean section $82.5; obstetric hemorrhage $85.0; and eclampsia $123.3. These were weighted by the probability of these outcomes in pregnancy obtained from the literature: 95% of women attend at least 1 antenatal visit;[1]the percentage of pregnancies that are ectopic is 1.4%;[22]the percentage that are miscarried 4.9%;[23]the percentage that are aborted 19%;[19] that end in still births 1.7%;[24] and in live births 73% (calculated).

Productivity losses for antenatal care were assumed to equal those of regular out-patient visits for abortion care study. We assumed that pregnancy is associated with a productivity loss of 1 month starting in the immediate preterm period and going into the pueperium and estimated using Uganda's GDP per capita.[13] All costs are presented in United States dollars. A detailed representation of the calculation of the costs of the MOC and pregnant states is shown in Appendices D and E, respectively.

Sensitivity Analysis

Sensitivity analyses were performed to determine which variables had substantial impact on costs and outcomes. All parameters were assigned a range of plausible values using 95% confidence intervals when available or+/- 50% for costs and +/- 20% for other parameters.(see table 2). To further test the robustness of our results, we conducted a probabilistic sensitivity analysis. We created probability distributions for all of the parameters in the model. For the annual discount rate, a uniform distribution ranging from 0% to 5% was used. For all other parameters, the base-case value was used for the mean, and the standard error was estimated based on the approximation that the range used for one-way sensitivity analyses represented a 95% confidence interval, with the range approximately equal to four times the standard error.[25] A Beta distribution was used for probabilities and DALYs and a normal distribution for costs. Monte Carlo simulation was used to create 10,000 iterations for which the expected outcome values were calculated. The probability that either intervention was cost-effective was then calculated for various levels of willingness to pay. Data analysis was performed using TreeAge Pro.

RESULTS

Model validation

Varying transition probabilities between 0 and 1 resulted in logical responses and setting costs and outcomes to 0 separately resulted in identical expected values. Additionally, the model predicted the total fertility rate in Uganda fairly well (6.92 vs. 6.70).[26]

Cost-consequences analysis

Table 3 shows the results of a cost-consequences analysis for a hypothetical cohort of 100,000 women in Uganda. For this population of women, the NCP would result in $3.25 million in additional societal costs, $5.1 million in additional governmental costs, 160,000 less pregnancies and 113,000 fewer births. The NCP would also result in 9,000 additional life years, 37,000 additional DALEs, 2,200 fewer ectopic pregnancies, 29,000 fewer induced abortions, 7,000 fewer miscarriages, 2,000 fewer still births, 3,000 fewer neonatal deaths, 9,000 fewer infant deaths, and 16,000 fewer child deaths.

Base-case analysis

Mean discounted life expectancy was higher under the NCP (28.74 vs. 28.65 years and 27.38). The mean discounted disability-adjusted life expectancy was also higher under the NCP (27.38 vs. 27.01).The mean number of pregnancies per woman would be reduced from 9.51 under the CCP to 7.90 under the NCP: this also reduces the total fertility rate from 6.92 to 5.79.

Other maternal and child health outcomes were also more favorable under the NCP: 0.02 fewer ectopic pregnancies, 0.07 fewer miscarriages, 0.29 fewer abortions, 0.02 fewer still births, 0.03 fewer neonatal deaths, 0.09 fewer infant deaths, and 0.16 fewer child deaths per woman on average.

Mean lifetime societal costs per woman were higher for the NCP from the societal perspective ($1,074 vs. $1,041) and the governmental perspective ($448 vs. $397).

Table 4 shows the main results of the cost-effectiveness analysis. The incremental cost-effectiveness ratio (ICER) comparing the NCP to the CCP was $88 per DALY averted from the societal perspective and $138 per DALY averted from the governmental perspective.

From the societal perspective, the other ICERs comparing NCP to CCP $361 per life year saved, $20 per pregnancy averted, $29 per unit of fertility reduction, $1,477 per ectopic pregnancy averted, $464 per miscarriage averted $112 per abortion averted $1,625 per still birth averted $1,083 per neonatal death averted, $361 per infant death averted, and $203 per child death averted. From the governmental perspective, the ICERs comparing the NCP to the CCP, $51 per life year saved, $32 per pregnancy averted, $45 per unit of fertility reduction, $2,323 per ectopic pregnancy averted, $730 per miscarriage averted $176 per abortion averted $2,555 per still birth averted $1,703 per neonatal death averted, $567 per infant death averted, and $319 per child death averted. Table 4 presents the details of the incremental costs and outcomes as well as the ICERs comparing the NCP to the CCP**.**

Sensitivity analysis

Univariate sensitivity analyses (Figure 2) showed that the incremental societal cost was most sensitive to the uncertainty surrounding the costs of contraception and pregnancy. Incremental DALE were most sensitive to the uncertainty surrounding the discount rate and the probability of modern contraception discontinuation. Probabilistic sensitivity analysis (Figure 3) showed that all cost-effectiveness pairs obtained from probabilistic sensitivity analysis lie in the “northeast” and “southeast” quadrants indicating a great deal of certainty that the NCP is more effective than the CCP and that there is some uncertainty as to whether the NCP is more costly than the CCP. Figure 4 is a cost-effectiveness acceptability curve which shows that the probability that the NCP is cost-effective compared to the CCP is higher (approximately 70% vs. approximately 30%) for the range of values of willingness to pay constrained at three times Uganda's GDP per capita, a commonly used standard.[9]

DISCUSSION

Using a Markov model based on states of contraceptive use and pregnancy, this study assessed the cost-effectiveness of a hypothetical New Contraceptive Program (NCP) to achieve universal access to modern contraceptives in Uganda and found that it would be highly cost-effective. From the societal perspective, the ICER comparing the NCP to the CCP was $88 per DALY averted which can be interpreted as highly cost-effective based on the GDP threshold cited earlier. From the governmental perspective, the ICER comparing the NCP to the CCP was $138 per DALY averted which can also be interpreted as highly cost-effective. Additionally, all other measures of incremental cost-effectiveness, such as cost per pregnancy averted and cost per neonatal death averted resulted in favorable ICERs. And these findings were robust to univariate and probabilistic sensitivity analyses.

Contraception has a direct, positive impact on maternal and child health which are important aspects of general health and development in low income countries, accounting for two of the eight Millennium Development Goals. In a country with one of the highest levels of maternal mortality in the world,[1, 27] limiting unintended pregnancies to those caused by contraceptive failure, reduces the exposure of women to potential morbidity and mortality due to unsafe abortions, miscarriages and complicated pregnancies.

The potential impact of universal access to contraception in Uganda would be especially important on abortion-related morbidity and mortality because legal and religious proscriptions, as well as widespread stigma drive abortions underground where they are performed by undertrained individuals in unsanitary conditions and post-abortion care in the country is poor. The NCP would reduce the estimated 297,000 induced abortions performed annually in Uganda, the 85,000 complications requiring treatment in the health care system and the 1,200 abortion-related deaths.[19] Because post-abortion care is not illegal, improving post-abortion services might also result in improved health outcomes to complement the reduction in unwanted pregnancies due to improved contraceptive coverage. Increased contraception use could also reduce the number of unplanned births which could reduce child morbidity and mortality and increase the amount of resources that families and the healthcare system spend on the other, well planned children.

Because this study provides evidence that increasing access to modern contraception is a potentially good use of scarce healthcare resources, we believe that it has implications for policy development for the improvement in the health and socioeconomic condition of women and children in Uganda. And because the model is primarily based on demographic and health survey data, it may be modified to answer similar policy questions using data from the other countries with such surveys.

The model estimated that meeting the contraceptive needs of Ugandan women would be cost-saving from the societal perspective, and cost-effective from the healthcare system perspective. This finding is consistent with a previous study conducted in Uganda, which found that satisfying all the unmet need for modern methods of contraception would reduce maternal mortality by 40% and unplanned births and induced abortions by 84-85% while saving $3 for every dollar invested in reducing this unmet need.[2] The present study had the added advantage of making a formal value assessment including an incremental cost-effectiveness ratio for comparison with other healthcare interventions, incorporating parameter uncertainty in the modeling framework and modeling the entire reproductive and life experience of women.

Our findings may be attributed to relatively low cost of contraception, coupled with a substantial reduction in maternal and child morbidity and mortality. The incremental cost-effectiveness of meeting the contraceptive needs of women in Uganda ($88 per DALY averted from a societal perspective and $138 per DALY from a healthcare system perspective) compares favorably with the incremental cost-effectiveness of a number of health interventions that have been evaluated for cost-effectiveness in Uganda such as facility-based care for HIV ($1,396 per quality-adjusted life-year(QALY)),[12] group psychotherapy with reinforcement for depression ($1,150 per QALY),[28] home-based antiretroviral therapy compared to using septrin alone ($597 per DALY),[29] vitamin A fortification of oil ($18 per DALY) or sugar ($82 per DALY),[30] and traffic enforcement ($27 per life-year saved).[31] This would suggest that policy makers should consider increasing contraceptive coverage among the top public health priorities in Uganda.

Another argument for policy interventions to implement the NCP is affordability. The annual cost of modern contraception for all those who need it in Uganda has been estimated at $72 million[2] compared to say, provision of facility-based care for HIV which would cost $461 million.[12] While cost-effectiveness and affordability are not the only considerations for the allocation of the scarce healthcare resources in a low-income country like Uganda, – equity, fairness and political considerations often play a significant role – their combination is quite compelling and might lead to the most efficient use of a severely limited budget.

The trajectory of socioeconomic development is uncertain and it is unclear what the impact of universal contraceptive access would be on fertility intentions, ideal family size and preference for different methods of family planning. Empirical inquiry into these issues may be an area of potential future research to enable the setting of ongoing policy in response to the dynamic nature of the population and its maternal and child health needs. Another area of potential future research might be the improvement and adaptation of our modeling framework for use in other countries or settings as a tool to estimate the potential impact of contraceptive programs and to help in the allocation of scarce healthcare resources.

One limitation of the study was that it did not estimate the potential change in fertility preference over time. If we started with 15 year old girls today, their fertility intentions and ideal family size are likely to change with increasing socioeconomic development. Our modeling framework does not capture this but estimates the impact of universal access to modern contraception with constant fertility intentions and ideal family size. Future analyses could incorporate these effects by changing the proportion of women in the hypothetical cohort that start, transition to, and stay in the intentional non-contraception state.

Another limitation is that we modeled the current use distribution of modern contraception over the time horizon of the analysis i.e. we did not consider the potential for a gradual shift from less efficacious to more efficacious contraceptive methods or changing contraceptive preferences, which may have an impact on the estimate of cost-effectiveness. Future analyses might incorporate these.

The study was also limited because the main reason for contraception is not to improve health but to limit or regulate fertility. This has both health benefits and wider benefits to society and individuals. The study current study looked at the health benefits and health costs only.

The implementation of a universal contraceptive program is not only costly but a potentially difficult process involving many different activities and players. It would require willingness and action by donors, co-operation by government, and a well coordinated implementation plan. It would involve overcoming many prevailing implementation barriers such as contraceptive stock-outs, social marketing to overcome stigma and religious opposition, and reaching remote areas. The impact of these barriers on the success of a universal contraceptive program would need to be studied in detail and a plan to overcome them developed and implemented.

Universal access to modern contraception appears to represent an efficient use of scarce healthcare resources consistent with the need for constrained maximization in the face of extreme budget constraints. It would contribute directly to achieving millennium development goals (MDGs) number 4 (reduce child mortality) by reducing unwanted pregnancies and consequently child deaths and 5 (improve maternal health) by reducing deaths from pregnancy-related conditions. It would also contribute indirectly to MDG number 1 (eradicate extreme hunger and poverty) by reducing the socioeconomic consequences of too many poorly planned or poorly spaced children in families; MDG number 2 (achieve universal primary education) by controlling population and enabling scarce education resources to be spent on fewer children; and MDG 3 (promote gender equality and empower women) by allowing women to spend less time raising children and participating in economic activity and by reducing maternal morbidity. Policy makers in the national ministry of health and other stakeholders and development partners should consider urgent, concrete steps to increase access to modern contraceptives to women who need them.

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Table 1.Age-specific transition probabilities from different states of contraceptive use, pregnancy and death

Age group	**15 – 19**	**20 – 24**	**25 – 29**	**30 – 34**	**35 – 39**	**40 – 44**	**45 – 49**
NSA to INU	0.02	0.17	0.17	0.12	0.08	0.05	0.13
NSA to UNU	0.07	0.21	0.26	0.29	0.29	0.27	0.19
NSA/UNU to MOD	0.09	0.17	0.19	0.22	0.19	0.21	0.19
NSA/UNU to TRA	0.02	0.03	0.04	0.04	0.04	0.06	0.05
NSA to NSA	0.80	0.41	0.34	0.31	0.39	0.41	0.47
UNU/INU to PRE*	0.85	0.85	0.85	0.83	0.81	0.69	0.17
UNU to UNU	0.07	0.05	0.05	0.05	0.06	0.16	0.53
All states to Dead$^{\Psi}$	0.002	0.003	0.006	0.009	0.012	0.011	0.011

NSA – Not Sexually Active; INU – Intentional Non-Use of contraception; UNU – Unintentional Non-Use of contraception; MOD – Modern contraception; TRA – Traditional Contraception; PRE - Pregnant

*Initial estimate of 85% probability of pregnancy is adjusted for proportion of women who are menopausal by age

$^{\Psi}$Gender and age-specific mortality rate for Uganda converted to a nine-month transitional probability.

Table 2. Parameters of the Markov model

Parameter	Base case	Sensitivity range*	Reference
Transition probabilities			
MOD – PRE	0.03	0.02 – 0.03	[14]
TRA– PRE	0.20	0.16 – 0.24	[14]
MOD– INU	0.25	0.20 – 0.29	[15]
MOD– UNU	0.34	0.27 – 0.41	[15]
TRA – INU	0.26	0.21 – 0.31	[15]
TRA – UNU	0.36	0.27 – 0.41	[15]
PRE – NSA$^{\phi}$	0.73	0.58 – 0.88	[1, 19, 22-24]
PRE – INU	0.03	0.02 – 0.04	[1, 19, 22-24]
PRE – UNU	0.06	0.05 – 0.08	[1, 19, 22-24]
PRE – MOD	0.04	0.03 – 0.05	[1, 19, 22-24]
PRE – TRA	0.01	0.01 – 0.02	[1, 19, 22-24]
PRE – Dead$^{\Psi}$	0.0034	0.0028 – 0.0041	[1]
Pregnancy Complications			
Miscarriage	0.049	0.039 – 0.059	[23]
Ectopic pregnancy	0.014	0.011 – 0.017	[22]
Abortion	0.190	0.152 – 0.059	[19]
Still birth	0.017	0.014 – 0.020	[24]
Mortality			
Neonatal mortality	0.021	0.017 – 0.025	[1]
Infant mortality	0.055	0.044 – 0.067	[1]
Child mortality	0.049	0.080 – 0.120	[1]
Life expectancy (2.5 years)	51.7	--	[17]
DALYs lost			
Maternal conditions	0.272	0.218 – 0.327	[18]
Costs ($US)			
Contraception (MOH)	25.5	12.7 – 38.2	[20, 21]
Contraception (Societal)	39.0	19.5 – 58.5	[20, 21] Primary study
Pregnancy (MOH)	79.4	40.1 – 120.4	[20, 21]
Pregnancy (Societal)	142.2	71.1 – 213.4	[13, 20, 21] Primary study
Annual productivity loss	354.2	--	[13]

* Sensitivity ranges are based on 95% confidence intervals where available or represent +/- 50% for costs and +/- 20% for other parameters

$^{\phi}$Also probability of live birth. Calculated by subtracting ectopic pregancies, induced abortions, miscarriages and still births

$^{\Psi}$Maternal mortality

Table 3. Results of a cost-consequences analysis for a hypothetical cohort of 100,000 Ugandan women

	CCP	NCP	Difference
Societal costs	104,142,000	107,392,000	3,250,000
MOH costs	39,691,000	44,802,000	5,111,000
Pregnancies	950,000	790,000	-160,000
Life years	2,865,000	2,874,000	9,000
DALEs	2,701,000	2,738,000	37,000
Ectopic pregnancies	13,300	11,100	-2,200
Induced abortions	180,000	151,000	-29,000
Miscarriages	46,000	39,000	-7,000
Still births	16,000	14,000	-2,000
Live births	692,000	579,000	-113,000
Neonatal deaths	20,000	17,000	-3,000
Infant deaths	53,000	44,000	-9,000
Child deaths	95,000	79,000	-16,000

Table 4. Results of the baseline analysis showing the costs, incremental costs, DALE, incremrntal DALE and ICERs comparing NCP to the CCP

Program	**Societal cost**	**Inc. Societal Cost**	**Gov cost**	**Inc. Gov Cost**	**DALE**	**Inc. DALE**	**ICER Societal**	**ICER Gov**
CCP	1,041		397		27.01			
NCP	1,074	33	448	51	27.38	0.37	88	138

DALE – Disability-adjusted life expectancy; Inc. – Incremental; Gov – Government; CCP – Current Contraceptive Program; NCP – New Contraceptive Program

Table 5. Mean incremental costs and health outcomes, and incremental cost-effectiveness ratios (ICERs) comparing the new contraceptive program to the current contraceptive program in Uganda

	Societal perspective	**Governmental perspective**
Incremental cost ($)	32.5	51.1
Incremental life expectancy (LYs)	0.09	0.09
ICER ($/LY)	361	567
Reduction in pregnancies	1.60	1.60
ICER ($/pregnancy averted)	20	32
Reduction in fertility	1.13	1.13
ICER ($/unit of fertility reduction)	29	45
Reduction in ectopic pregnancies	0.02	0.02
ICER ($/Ectopic pregnancy averted)	1,477	2,323
Reduction in miscarriages	0.07	0.07
ICER ($/Miscarriage averted)	464	730
Reduction in abortions	0.29	0.29
ICER ($/Abortion averted)	112	176
Reduction in still births	0.02	0.02
ICER ($/Still birth averted)	1,625	2,555
Reduction in noenatal deaths	0.03	0.03
ICER ($/Neonatal death averted)	1,083	1,703
Infant deaths	0.09	0.09
ICER ($/Infant death averted)	361	567
Reduction in child deaths	0.16	0.16
ICER ($/Child death averted)	203	319

Figure 1.Markov model. The model illustrates the different states of contraception through which women between 15 and 49 years of age in Uganda transition. Each state is associated with a cost and a value of disability-adjusted life expectancy. All states may progress to dead.

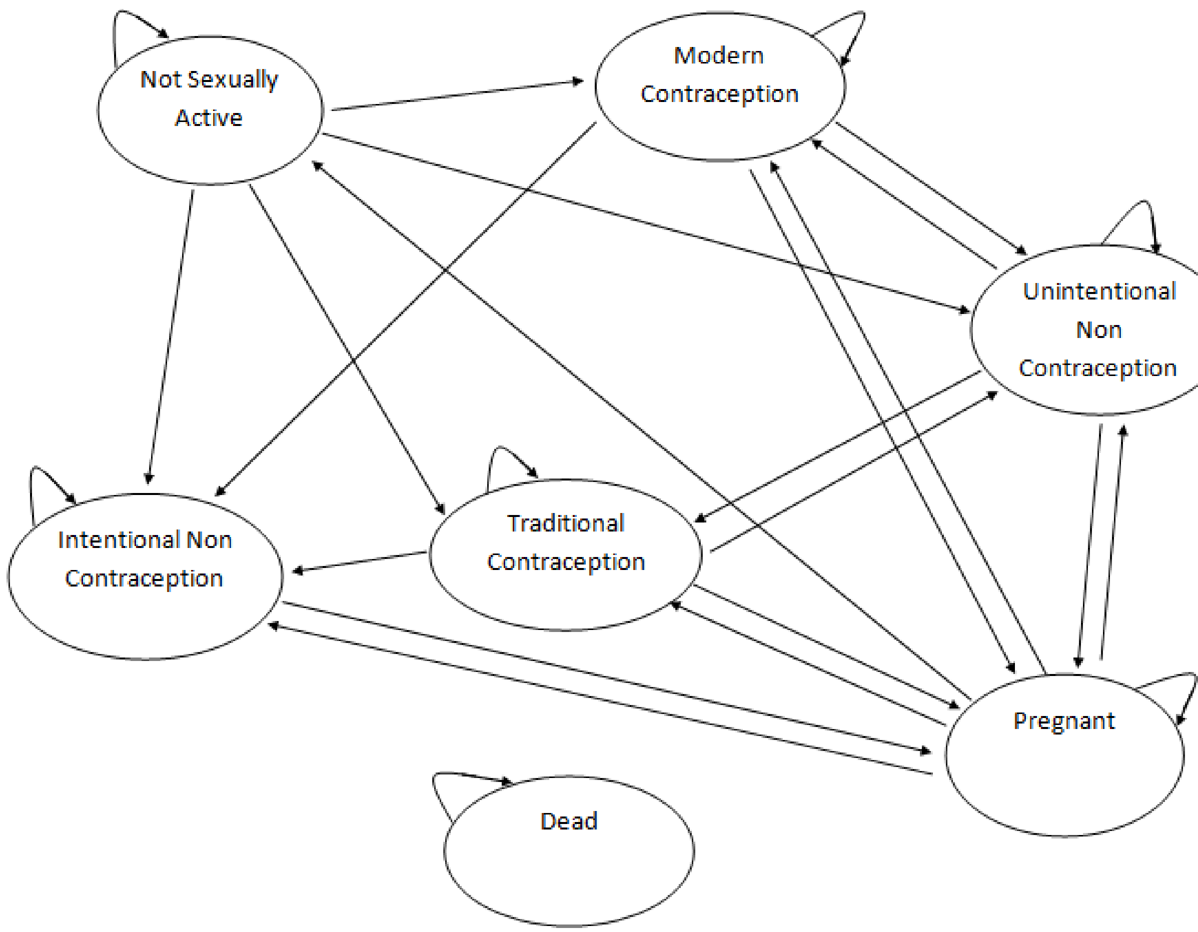
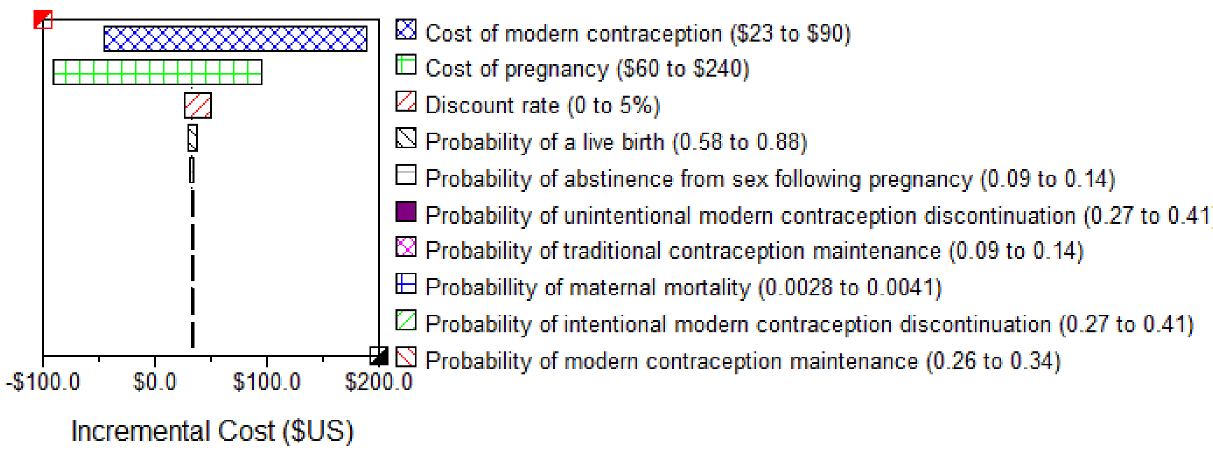


Figure 2.Tornado diagrams of univariate sensitivity analysis from the societal perspective. The diagram shows, for a comparison between the New Contraceptive Program and the Current Contraceptive Program, the impact of uncertainty surrounding different variables on incremental cost (a) and incremental DALE (b). The 10 most influential variables are shown.

a)



b)

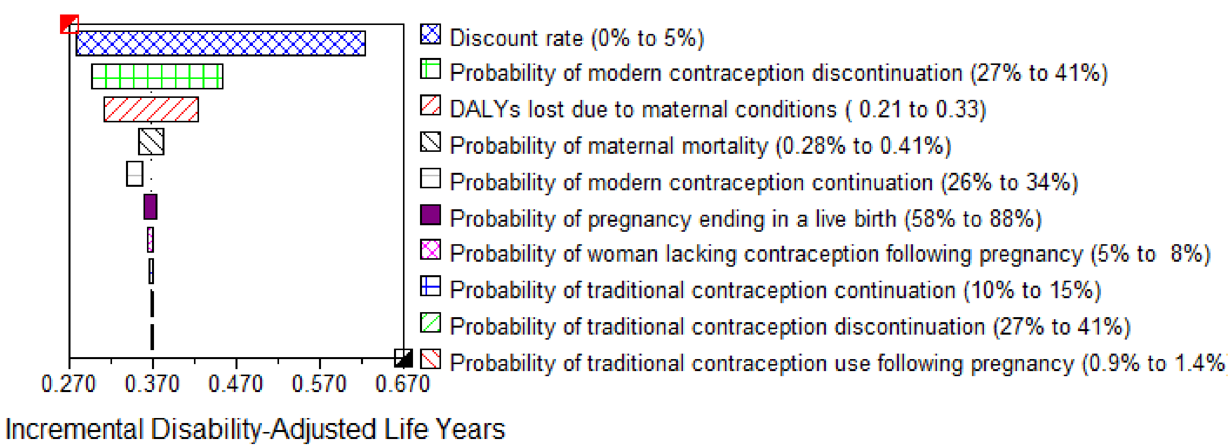


Figure 3. Incremental cost-effectiveness scatter plot obtained from probabilistic sensitivity analysis. The figure shows the distribution of cost-effectiveness pairs on the cost-effectiveness plane.

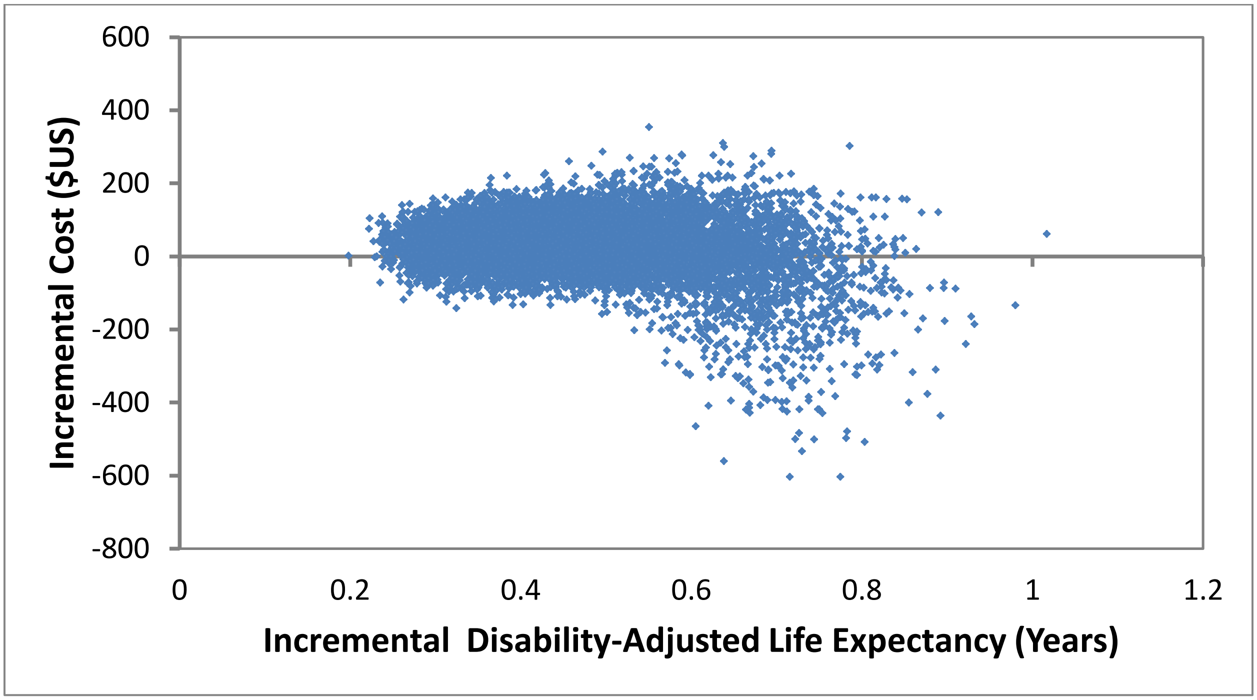


Figure 4.Cost-effectiveness acceptability curves obtained from probabilistic sensitivity analysis. The curves show, for 10,000 simulated samples, the probability that each contraception program is cost-effective compared to the comparator at varying levels of willingness to pay for an additional disability-adjusted life year (DALY).