Mathematical Modeling of Pregnancies Averted

Modeling Analysis and Report

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Acronyms

CEA	cost-effectiveness analysis
CEAC	cost-effectiveness acceptability curve
DALY	disability-adjusted life year
DHS	Demographic and Health Survey
GDP	gross domestic product
ICER	incremental cost-effectiveness ratio
ISP	Integrated Support Programme
IUD	intrauterine device
MOHCC	Ministry of Health and Child Care
MVC	model view controller
NGO	non-governmental organization
PSA	probabilistic sensitivity analysis
PSI	Population Services International
QA	quality assurance
SQL	structured query language
UNFPA	United Nations Population Fund
WHO	World Health Organization
WHO-CHOICE	WHO Choosing Interventions that are Cost–Effective
ZAP	Zimbabwe Averted Pregnancies
ZNFPC	Zimbabwe National Family Planning Council

1. BACKGROUND

The Zimbabwe Integrated Support Programme (ISP) on Sexual and Reproductive Health and HIV Prevention is a 4-year programme to support the Ministry of Health and Child Care (MOHCC) and the Ministry of Women's Affairs, Gender and Community Development in providing integrated reproductive health and gender-based violence prevention services aimed at contributing to the reduction of maternal morbidity and mortality, cervical cancer, gender-based violence, and HIV. The ISP is supported by the United Kingdom's Department for International Development, Irish Aid, and the Government of Sweden, and is guided by four primary pillars:

1. Delivery of social marketing of integrated services in private sector and non-governmental organization (NGO) sites. This pillar is being led by Population Services International (PSI).
2. Addressing public sector integration of services. This pillar is led by the United Nations Population Fund (UNFPA).
3. Procurement and nationwide distribution of commodities. This pillar is led by Crown Agents.
4. Independent impact evaluations, mathematical models, and provision of technical support. This pillar has three impact evaluation questions and is led by the World Bank:
    i. Does integrating HIV and SRH services save money, without decreasing the quality of patient care?
    ii. What is the impact of the combination HIV prevention strategy on HIV incidence in Zimbabwe?
    iii. How many unintended pregnancies have been averted?

To answer the third impact evaluation question under Pillar 4, the Zimbabwe Averted Pregnancies (ZAP) model was developed. The objective of this model is to estimate and compare key metrics of Zimbabwe's family planning services before implementation of the ISP and during the ISP period. Specifically, the ZAP model will estimate the number of new family planning users, the number of unplanned pregnancies averted, the cost per pregnancy averted, and several other related outcomes as a result of ISP-supported family planning activities.

With limited time and resources, mathematical models (henceforth "models") serve as critical decision and evaluation tools to assess the impact of interventions, identify bottlenecks in care, and make priority recommendations for health investments. Models allow for an immediate examination of the potential impact of a specific intervention, or packages of interventions, across care settings, equipping health decision makers with the real-time data to inform their decisions. Models can be used to evaluate health interventions that have been implemented, are in the process of being implemented, or may be implemented in the future.

A number of models have been developed to assess the impact of improved contraceptive use, assess the potential future health and/or economic impact of family planning services, or estimate the resources required to meet certain family planning goals. For example, Marie Stopes International developed the IMPACT 2 model to assess the impact of improved contraceptive service provision on health and demographic outcomes in developing countries. The Guttmacher Institute developed the Adding It Up model to illustrate the health and financial benefits of full contraceptive coverage in developing countries. The ImpactNow model was developed by the Futures Group to estimate the health and economic benefits of achieving contraceptive use goals as outlined in Family Planning 2020 (FP2020). EngenderHealth developed the Reality Check v.2 model as a planning and advocacy tool that can be used to estimate the resources required to meet contraceptive goals in developing countries. The FamPlan model was developed by the Futures Institute to estimate coverage and effectiveness rates of contraceptive interventions in developing countries, allowing users to assess the impact of scaling up these rates.

Although existing models serve a purpose, they have a number of limitations that make them inappropriate for evaluation of the impact of family planning commodities distributed through the ISP. In terms of data sources, previous models are not developed specifically for Zimbabwe or to evaluate the ISP. Most data used to populate these models are at the country or region level (primarily Demographic and Health Survey [DHS] and United Nations data). The models have not attempted to include comprehensive public and private sector data or to disaggregate the data by important variables, such as age. In addition, important intervention elements of the ISP, such as improving consistent and correct use of modern contraception, are not captured. Costing data, when available, have not been disaggregated by contraceptive method in previous models. In terms of model structure, previous models are deterministic linear models that do not take into account the joint uncertainty in inputs and are not built to perform sophisticated sensitivity and subgroup analyses.

The ZAP model addresses the following primary research question: "How many unplanned pregnancies are estimated to have been averted through implementation of ISP family planning services?" The ZAP model estimates the number of new family planning users as a result of ISP-financed family planning services, the number of unplanned pregnancies averted, the cost per pregnancy averted, and other related outcomes, through implementation of the ISP. RTI also assessed whether the ISP program is cost-effective compared with pre-ISP results and data.

In terms of model structure, the ZAP model differs from previous models by being a probabilistic cohort model and allowing several sensitivity and subgroup analyses to be run. Data sources differ from previous models by using data specific to Zimbabwe before and after implementation of the ISP. RTI collected all available locally relevant data from public and private sector sources on procurement, distribution, availability, and use, rather than relying solely on secondhand country-level data. RTI also collected local cost data by contraceptive method and for pre-ISP and ISP periods. Where possible, RTI collected data and presented results disaggregated by age groups: female adolescents (defined as 15-19 years) versus adult women (>19 years). RTI also disaggregated by wealth quintile where possible.

2. MODELING METHODOLOGY

The ZAP model is populated with data specific to Zimbabwe and uses estimates for pre-ISP and ISP implementation periods. Although the ISP was formally initiated in 2012, most ISP activities were not implemented until 2013; thus, the ISP period was defined as 2013–2015. In 2009, the Zimbabwe dollar was abandoned and the economy stabilized; therefore, the pre-ISP period was defined as 2009–2012.

2.1 Modeling Structure

The ZAP model is a probabilistic mathematical model. The model is run with pre-ISP and ISP parameter values to evaluate the impact of ISP intervention strategies on a variety of outcomes, including preventing unplanned pregnancies and the cost-effectiveness of the different family planning strategies implemented by the ISP.

2.1.1 Population and Setting

The initial population flowing into the model was all sexually active women of reproductive age (i.e., 15 to 49 years) in Zimbabwe in a 1-year time frame. This population was further disaggregated by female adolescents versus adult women. The number of sexually active women of reproductive age was used to estimate the number of women who are and are not planning a pregnancy (where the number of women not planning a pregnancy = number of sexually active women of reproductive age * [1 – percentage planning a pregnancy]). For women who are not planning a pregnancy, three constructs were evaluated that affect pregnancy prevention through strategies implemented during the pre-ISP baseline and ISP implementation periods: penetration (i.e., access to the contraceptive), utilization (i.e., consistently and correctly using the contraceptive), and effectiveness (i.e., the ability for the contraceptive to prevent pregnancy). Where possible, penetration and utilization were disaggregated by setting, including community, clinic, and hospital settings. This was important to capture because different settings may offer different forms of contraceptive interventions. For instance, condoms are widely available in the community setting, whereas a sterilization procedure is typically only available in the hospital setting.

2.1.2 Model Flow

The model follows a cohort simulation approach. The model flow comprises a series of probabilities and decisions around contraceptive access and use that affect the percentage of women who experience an unplanned pregnancy each year. Each contraceptive was assessed across the three constructs of penetration, utilization, and effectiveness. Penetration, utilization, and effectiveness were individually assessed on a percentage continuum between 0% and 100%. As an example, intrauterine devices (IUDs) had a pre-ISP penetration of 10%, likely due to a lack of trained clinicians and/or resources to properly insert an IUD. ISP penetration and utilization increased to nearly 25% as a result of ISP activities (e.g., improved training and supplies provided to clinic staff for proper IUD insertion). The IUD is a long-acting contraceptive with an effectiveness of >99%. Thus, a higher percentage of women successfully prevented a pregnancy following the successful implementation of this ISP strategy. The initial population was categorized into pregnancy successfully prevented or not successfully prevented. Of those not successfully prevented, a rate of pregnancy was applied to estimate the number of unplanned pregnancies in a given 1-year time frame.

2.1.3 Contraceptives and Interventions in the ZAP Model

The ZAP model evaluated the impact of ISP programming and interventions to support the uptake of correct and consistent contraceptive use in Zimbabwe. After consultation with ISP stakeholders, the following types of contraceptives were determined to be appropriate to examine in the ZAP model:

- Abstinence
- Sterilization
- Lactation amenorrhea method
- Natural family planning
- Diaphragm
- Male condom
- Female condom
- Spermicides
- Oral contraception/contraceptive pills
- Injectable contraception
- IUDs
- Transdermal contraceptives (the patch)
- Contraceptive implants
- Emergency contraception

Diaphragm, spermicides, and transdermal contraceptives were included, even though they are not currently procured in Zimbabwe, so that the capacity would be included in the model and scenarios, and the impact of these commodities could be analyzed to see the benefit of all common contraceptive methods. Each contraceptive type was assessed across the broad parameters of penetration, utilization, and effectiveness, measured annually at the pre-ISP and ISP time points for female adolescents versus adult women.

2.1.4 Model Outputs

The model provides the following primary output:

- Estimated number of new family planning users as a result of ISP-financed family planning services

It also provides the following secondary outputs:

- Estimated number of pregnancies that occurred annually from 2009 through 2012, before implementation of the ISP, including estimated number of unplanned pregnancies

- Estimated number of pregnancies that occurred annually from 2013 through 2015, after implementation of the ISP, including estimated number of unplanned pregnancies
- Estimated number of unplanned pregnancies averted annually from 2013 through 2015 compared with 2009 through 2012
- Estimated number of contraceptives used annually by type (e.g., condoms, hormonal contraceptive pills, injectables), before (2009–2012) and after (2013–2015) implementation of the ISP
- Estimated cost of each contraceptive, before (2009–2012) and after (2013–2015) implementation of the ISP
- Estimated total cost of ISP implementation (cost of contraceptives used added to ISP program costs)
- Estimated cost per averted pregnancy, before (2009–2012) and after (2013–2015) implementation of the ISP

Further, the ZAP model is linked to the MANDATE model (www.mnhtech.org), allowing for estimates of downstream averted maternal, fetal, and neonatal morbidity and mortality due to averted pregnancies. The following additional outputs were estimated:

- Estimated number of maternal deaths averted due to downstream maternal conditions, such as infection, hemorrhage, obstructed labor, and hypertensive diseases
- Estimated number of fetal deaths averted due to downstream fetal conditions, such as fetal distress
- Estimated number of fetal deaths averted due to downstream neonatal conditions, such as birth asphyxia, neonatal infection and respiratory distress syndrome
- Disability-adjusted life years (DALYs) averted due to maternal hemorrhage, maternal sepsis, hypertensive disorders of pregnancy, and obstructed labor
- DALYs averted due to preterm birth, birth neonatal encephalopathy/birth asphyxia/trauma, and neonatal sepsis

Where possible, output data were stratified by female adolescents or adult women and by wealth quintile. These outputs informed the cost-effectiveness of the ISP contraceptive strategies compared to pre-ISP strategies.

2.2 Data Collection

Data collection was carried out in two ways: (1) through locally available data sources, including those put in place as part of the ISP; and (2) through secondary data collection, including broader (i.e., regional) data and estimates from the literature, when other data sources were unavailable.

2.2.1 Local Data Collection

Data were collected from local entities responsible for routine collection of family planning data, in the years designated before and after ISP implementation, in order to populate the relevant parameters of the ZAP model as described above. Relevant data were requested from organizations directly involved with the ISP, including the MOHCC, Crown Agents, UNFPA, and PSI. In addition, Private sector distributors of family planning commodities, such as pharmacies and private clinics, were contacted for data that had not been otherwise captured. Finally, organizations that conduct routine monitoring of family planning statistics were contacted, such as ZIMSTAT (DHS); Zimbabwe National Family Planning Council (ZNFPC); and other parastatal, non-governmental, and private sector sources for additional data and information on contraceptive procurement, distribution, and use in Zimbabwe.

Data were collected systematically. A comprehensive list of possible data sources was compiled with the help of the World Bank, MOHCC, ZNFPC, PSI, and other local contacts directly involved in family planning and/or the ISP. Available data were collected from each organization listed and other potential data sources were identified, which were then added to the list. When there were gaps in the local data obtained, secondary sources of data collection were used.

In addition to capturing the data needed to parameterize the ZAP model, staff in Zimbabwe working with local partners helped to provide context for the data and the model. A number of factors may influence the values of parameters used in the ZAP model. The parameter of penetration may be influenced by cost, supply chain interruptions, policies, or demand. For example, supply chain implications were explored due to the contraceptive delivery system moving from a push system (e.g., local distributors monitor needs and supply contraceptives based on clinic needs) to a pull system (e.g., clinic staff request a certain number of contraceptives per month). Similarly, the parameter of utilization can be influenced by knowledge, cultural or health beliefs, timing of use, or degradation of products. For example, clinicians often recommended implants over IUDs because the procedure took less time and required less equipment and training to insert. Local staff provided context on these and other issues that may influence the values obtained for model parameters. This contextual information was recorded in extraction tables, giving the model a real-world backdrop against which to frame the outputs.

2.2.2 Secondary Data

The secondary data collection involved identifying gaps in the data required to inform the model and then identifying the most relevant and accurate secondary sources from which these data could be derived. Published and grey literature were reviewed, and subject area experts were contacted to provide further data to input into and validate the ZAP model. Literature reviews were conducted for a number of data parameters, using the Cochrane database of systematic reviews and PubMed for published literature. Google Scholar was searched to capture unpublished and grey literature, which provided data on model parameters. Finally, in-country surveys (e.g., DHS) were reviewed to assess population-level contraception use. Further, relevant data could not be identified from the published literature, discussions with local and regional governmental and non-governmental organizations also provided useful information.

2.2.3 Partnership, Collaboration, and Coordination

In addition to the data collection strategies described above, additional meetings were held to inform data collection, modeling, data validation, and presentation of results. RTI met with the ISP coordinators regularly throughout the project period. Attendees at stakeholder workshops provided feedback on the proposed data collection and modeling strategies. RTI met with ISP implementing partners and those leading other evaluation components of Pillar 4 and spoke with groups that have developed other relevant family planning models to inquire about their model specifications and the data used to inform their parameters in order to get additional information to inform the work. A webinar was held to present data inputs and findings to stakeholders. A 2-day workshop was held in Zimbabwe with local stakeholders to solicit feedback on and validate the model's data inputs and findings (see Section 3.6) and to train individuals on how to use the web-based model (described in Section 5).

2.2.4 Data Extraction

Standardized extraction tables were developed to capture all key data inputs needed to populate the model. The extraction tables were constructed for each parameter content area or construct. For example, they include parameters to define the population at risk of pregnancy and parameters to define contraceptive penetration, utilization, effectiveness, cost per unit used, and cost to maintain and grow the supply chain for each available contraceptive commodity. Each of these tables summarizes the data source by providing geographic, setting, and population context for the indicator reported. This context is crucial in identifying the generalizability of the data—for example, determining whether the data source is relevant to female adolescents or adult women and across care settings (home, public facilities, or private facilities). The data collected were then funneled into the appropriate data points in the ZAP model, which were used to parameterize the model. Descriptive statistics, including means, standard deviations, and minimum and maximum values, were stored for use in setting up the probabilistic model and conducting sensitivity analyses.

2.3 Model Inputs

The ZAP model contains three levels of model inputs: (1) population-level variables; (2) penetration, utilization, and effectiveness of contraceptives; and (3) cost inputs.

Population-level variables are used to structure the environment in the model (e.g., number of women of reproductive age, annual risk of pregnancy given unprotected sex). Penetration, utilization, and effectiveness of contraceptives capture trends in contraceptive use during a specific time frame (i.e., pre-ISP and ISP periods). Finally, cost inputs capture the unit cost of contraceptives, program costs, and costs per pregnancy averted.

2.3.1 Population Variables

Population-level variables generally stay constant during model scenarios. These estimates are primarily derived from secondary data sources. Table 2-1 shows the population variables, estimates, and source from which the data point was derived. Population variables were primarily populated through DHS data and in-country data from partners to capture population-specific trends. DHS data are a nationally representative survey of attitudes, beliefs, and practices primarily relying on self-report. The data provide insight on the pre-ISP landscape of contraceptive use and care seeking. Internal partner data, such as NatPharma, Crown Agents, MoHCC, ZNFPC, and PSI, were used to populate contraceptive care-seeking trends in the ISP time period. Multiple partner records were used, if possible, to confirm ISP data points to ensure that trends were captured appropriately.

Table 2-1. Population Variables

Variable	Baseline Estimate	Low Estimate	High Estimate	Source
Total number of women of reproductive age (ages 14–49) (pre-ISP 1-year estimate)	3,294,872	N/A	N/A	World Bank Population Projection Tables, 2009–2012
Total number of women of reproductive age (ages 14–49) (ISP annual estimate)	3,751,705	N/A	N/A	World Bank Population Projection Tables, 2013–2015
Percentage of women ages 14–19 among all women of reproductive age	22%	N/A	N/A	World Bank Population Projection Tables, 2009–2015
Percentage of women ages 20–49 among all women of reproductive age	78%	N/A	N/A	World Bank Population Projection Tables, 2009–2015
Probability of pregnancy given unprotected sex during one year (actively planning a pregnancy)	85%	80%	90%	Wang et al., 2003; Gnoth et al., 2003
Probability of pregnancy given unprotected sex during one year (not actively planning a pregnancy)	31%	21%	41%	Population Council, 2014 (Step Up Policy Brief (Family Planning Models Consensus Documents)
Percentage of women who were pregnant in last 6 months (age 14–19)	2.5%	2.0%	3.0%	Zimbabwe DHS, 2010–2011
Percentage of women who were pregnant in last 6 months (age 20–49)	10%	9.5%	10.5%	Zimbabwe DHS, 2010–2011
Percentage of women ages 14–19 trying to conceive	2%	0%	7%	Zimbabwe DHS, 2010–2011

(continued)

Table 2-1. Population Variables (continued)

Variable	Baseline Estimate	Low Estimate	High Estimate	Source
Percentage of women ages 14–19 currently pregnant via planned pregnancy	1%	0.5%	1.5%	Zimbabwe DHS, 2010–2011
Percentage of women ages 20–49 trying to conceive	10%	5%	15%	Zimbabwe DHS, 2010–2011
Percentage of women ages 20–49 currently pregnant via planned pregnancy	2%	1.5%	2.5%	Zimbabwe DHS, 2010–2011
Percentage of women ages 14–19 who seek contraceptives in the private sector (pre-ISP)	2%	2%	10%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2012; NatPharma, 2009–2012; PSI, 2009–2012
Percentage of women ages 14–19 who seek contraceptives in the public sector (pre-ISP)	23%	13%	25%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2012; NatPharma, 2009–2012; PSI, 2009–2012
Percentage of women ages 14–19 who do not seek contraceptives or seek contraceptives in the community (pre-ISP)	75%	65%	85%	Zimbabwe DHS, 2010–2011
Percentage of women ages 20–49 who seek contraceptives in the private sector (pre-ISP)	5%	2%	10%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2012; NatPharma, 2009–2012; PSI, 2009–2012
Percentage of women ages 20–49 who seek contraceptives in the public sector (pre-ISP)	40%	33%	45%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2012; NatPharma, 2009–2012; PSI, 2009–2012
Percentage of women ages 20–49 who do not seek contraceptives or seek contraceptives in the community (pre-ISP)	55%	45%	65%	Zimbabwe DHS, 2010–2011;
Percentage of women ages 14–19 who seek contraceptives in the private sector (ISP)	2%	2%	7%	ZNFPC, 2013–2014; NatPharma, 2013–2015; PSI, 2013–2014
Percentage of women ages 14–19 who seek contraceptives in the public sector (ISP)	28%	18%	33%	ZNFPC, 2013–2014; NatPharma, 2013–2015; PSI, 2013–2014
Percentage of women ages 14–19 who do not seek contraceptives or seek contraceptives in the community (ISP)	70%	60%	80%	ZNFPC, 2013–2014; NatPharma, 2013–2015; PSI, 2013–2014
Percentage of women ages 20–49 who seek contraceptives in the private sector (ISP)	5%	2%	10%	ZNFPC, 2013–2014; NatPharma, 2013–2015; PSI, 2013–2014
Percentage of women ages 20–49 who seek contraceptives in the public sector (ISP)	45%	38%	55%	ZNFPC, 2013–2014; NatPharma, 2013–2015; PSI, 2013–2014
Percentage of women ages 20–49 who do not seek contraceptives or seek contraceptives in the community (ISP)	50%	40%	60%	ZNFPC, 2013–2014; NatPharma, 2013–2015; PSI, 2013–2014

2.3.2 Penetration, Utilization, and Effectiveness of Contraceptives

Table 2-2 presents data on penetration, utilization, and effectiveness of contraceptive options across the community (i.e., seeking contraception outside of health care facilities), public, and private settings. Community setting includes distribution by community health workers or NGOs or contraceptive access through non-health–specific outlets. Currently, diaphragms, spermicide, and patches are not reported as available contraceptives in Zimbabwe. Of those using contraceptives, injectable, oral contraceptives, and implants are the most frequently reported contraceptive option.

Table 2-2. Penetration, Utilization, and Effectiveness of Contraceptives

Contraceptive	Variable	Setting	Pre-ISP Base–line	Pre-ISP Low	Pre-ISP High	ISP	ISP Low	ISP High	Source
Abstinence	Penetration	Community	100%	100.0%	100.0%	100%	100.0%	100.0%	Zimbabwe DHS, 2010–2011; Hatcher & Trussell, 2011
		Public	100%	100.0%	100.0%	100%	100.0%	100.0%	
		Private	100%	100.0%	100.0%	100%	100.0%	100.0%	
	Utilization	Community	75%	65.0%	85.0%	75%	65.0%	85.0%	
		Public	0%	0.0%	0.0%	0%	0.0%	0.0%	
		Private	0%	0.0%	0.0%	0%	0.0%	0.0%	
	Effectiveness	All settings	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	
Sterilization	Penetration	Community	0%	0.0%	0.0%	0%	0.0%	0.0%	Zimbabwe DHS, 2010–2011; Hatcher & Trussell, 2011
		Public	5%	1.0%	6.0%	10%	8.0%	12.0%	
		Private	5%	1.0%	6.0%	5%	13.0%	17.0%	
	Utilization	Community	0%	0.0%	0.0%	0%	0.0%	0.0%	
		Public	2%	1.0%	3.0%	2%	1.0%	3.0%	
		Private	0.5%	0.0%	1.0%	0.5%	0.0%	1.0%	
	Effectiveness	All settings	99.5%	99.5%	99.5%	99.5%	99.5%	99.5%	
Lactational amenorrhea method	Penetration	Community	95%	95.0%	95.0%	95%	95.0%	95.0%	Zimbabwe DHS, 2010–2011; Hatcher & Trussell, 2011
		Public	95%	95.0%	95.0%	95%	95.0%	95.0%	
		Private	95%	95.0%	95.0%	95%	95.0%	95.0%	
	Utilization	Community	50%	40.0%	60.0%	50%	40.0%	60.0%	
		Public	50%	40.0%	60.0%	50%	40.0%	60.0%	
		Private	50%	40.0%	60.0%	50%	40.0%	60.0%	
	Effectiveness	All settings	78%	78.0%	78.0%	78%	78.0%	78.0%	
Natural family planning	Penetration	Community	100%	100.0%	100.0%	100%	100.0%	100.0%	Zimbabwe DHS, 2010–2011; Hatcher & Trussell, 2011
		Public	100%	100.0%	100.0%	100%	100.0%	100.0%	
		Private	100%	100.0%	100.0%	100%	100.0%	100.0%	
	Utilization	Community	0.1%	0.0%	10.1%	0.1%	0.0%	10.1%	
		Public	0%	0.0%	0.0%	0%	0.0%	0.0%	
		Private	0%	0.0%	0.0%	0%	0.0%	0.0%	
	Effectiveness	All settings	76%	76.0%	76.0%	76%	76.0%	76.0%	

(continued)

Table 2-2. Penetration, Utilization, and Effectiveness of Contraceptives (continued)

Contraceptive	Variable	Setting	Pre-ISP Base–line	Pre-ISP Low	Pre-ISP High	ISP	ISP Low	ISP High	Source
Diaphragm	Penetration	Community	0%	0%	0%	0%	0%	0%	Zimbabwe DHS, 2010–2011; Hatcher & Trussell, 2011
		Public	0%	0%	0%	0%	0%	0%	
		Private	0%	0%	0%	0%	0%	0%	
	Utilization	Community	0%	0%	0%	0%	0%	0%	
		Public	0%	0%	0%	0%	0%	0%	
		Private	0%	0%	0%	0%	0%	0%	
	Effectiveness	All settings	88%	88%	88%	88%	88%	88%	
Male condom	Penetration	Community	50.0%	45.0%	55.0%	50.0%	45.0%	55.0%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2014; NatPharma, 2009-2015; PSI, 2009–2014; Hatcher & Trussell, 2011
		Public	99.0%	95.0%	100.0%	99.0%	95.0%	100.0%	
		Private	99.0%	95.0%	100.0%	99.0%	95.0%	100.0%	
	Utilization	Community	8.0%	4.0%	33.0%	9.0%	4.0%	34.0%	
		Public	7.0%	4.0%	32.0%	8.0%	4.0%	33.0%	
		Private	6.0%	4.0%	31.0%	7.0%	4.0%	32.0%	
	Effectiveness	All settings	82.0%	82.0%	82.0%	82.0%	82.0%	82.0%	
Female condom	Penetration	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2014; NatPharma, 2009–2015; PSI, 2009–2014; Hatcher & Trussell, 2011
		Public	98.0%	95.0%	100.0%	98.0%	95.0%	100.0%	
		Private	98.0%	95.0%	100.0%	98.0%	95.0%	100.0%	
	Utilization	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Public	0.3%	0.0%	5.3%	0.3%	0.0%	5.3%	
		Private	0.1%	0.0%	5.1%	0.1%	0.0%	5.1%	
	Effectiveness	All settings	79.0%	79.0%	79.0%	79.0%	79.0%	79.0%	
Spermicide	Penetration	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	Zimbabwe DHS, 2010–2011; Hatcher & Trussell, 2011
		Public	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Private	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Utilization	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Public	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Private	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Effectiveness	All settings	72.0%	72.0%	72.0%	72.0%	72.0%	72.0%	

(continued)

Table 2-2. Penetration, Utilization, and Effectiveness of Contraceptives (continued)

Contraceptive	Variable	Setting	Pre-ISP Base–line	Pre-ISP Low	Pre-ISP High	ISP	ISP Low	ISP High	Source
Oral contraceptives	Penetration	Community	5.0%	2.0%	8.0%	20.0%	15.0%	25.0%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2014; NatPharma, 2009-2015; PSI, 2009–2014; Hatcher & Trussell, 2011
		Public	97.0%	95.0%	100.0%	99.0%	95.0%	100.0%	
		Private	97.0%	95.0%	100.0%	99.0%	95.0%	100.0%	
	Utilization	Community	3.0%	0.0%	13.0%	10.0%	0.0%	20.0%	
		Public	47.0%	37.0%	57.0%	54.0%	44.0%	64.0%	
		Private	47.0%	37.0%	57.0%	54.0%	44.0%	64.0%	
	Effectiveness	All settings	91.0%	91.0%	91.0%	91.0%	91.0%	91.0%	
Injectables	Penetration	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009-2014; NatPharma, 2009–2015; PSI, 2009–2014; Hatcher & Trussell, 2011
		Public	95.0%	90.0%	100.0%	95.0%	90.0%	100.0%	
		Private	95.0%	90.0%	100.0%	95.0%	90.0%	100.0%	
	Utilization	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Public	40.0%	35.0%	45.0%	46.0%	41.0%	51.0%	
		Private	40.0%	35.0%	45.0%	46.0%	40.0%	51.0%	
	Effectiveness	All settings	94.0%	94.0%	94.0%	94.0%	94.0%	94.0%	
IUDs	Penetration	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2014; NatPharma, 2009–2015; PSI, 2009–2014; Hatcher & Trussell, 2011
		Public	10.0%	5.0%	15.0%	15.0%	10.0%	20.0%	
		Private	10.0%	5.0%	15.0%	25.0%	20.0%	30.0%	
	Utilization	Community	0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	
		Public	8.0%	3.0%	13.0%	12.0%	7.0%	17.0%	
		Private	15.0%	10.0%	20.0%	20.0%	15.0%	25.0%	
	Effectiveness	All settings	99.5%	99.5%	99.5%	99.5%	99.5%	99.5%	
Patches	Penetration	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	Zimbabwe DHS, 2010–2011; Hatcher & Trussell, 2011
		Public	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Private	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Utilization	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Public	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Private	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Effectiveness	All settings	91.0%	91.0%	91.0%	91.0%	91.0%	91.0%	

(continued)

Table 2-2. Penetration, Utilization, and Effectiveness of Contraceptives (continued)

Contraceptive	Variable	Setting	Pre-ISP Base–line	Pre-ISP Low	Pre-ISP High	ISP	ISP Low	ISP High	Source
Implants	Penetration	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	Zimbabwe DHS, 2010–2011; ZNFPC, 2009–2014; NatPharma, 2009–2015; PSI, 2009–2014; Hatcher & Trussell, 2011
		Public	15.0%	10.0%	20.0%	50.0%	45.0%	55.0%	
		Private	5.0%	1.0%	10.0%	40.0%	40.0%	45.0%	
	Utilization	Community	1.0%	0.0%	6.0%	1.0%	0.0%	6.0%	
		Public	5.0%	0.0%	10.0%	12.0%	7.0%	17.0%	
		Private	5.0%	0.0%	10.0%	12.0%	7.0%	17.0%	
	Effectiveness	All settings	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	
Emergency contraception	Penetration	Community	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	PSI, 2009–2014; Hatcher & Trussell, 2011
		Public	0.5%	0.0%	1.0%	0.5%	0.5%	5.0%	
		Private	1.0%	0.0%	5.0%	5.0%	0.5%	10.0%	
	Utilization	Community	0.5%	0.5%	5.5%	0.5%	0.5%	5.5%	
		Public	5.0%	0.0%	10.0%	2.0%	2.0%	12.0%	
		Private	15.0%	10.0%	20.0%	2.0%	15.0%	25.0%	
	Effectiveness	All settings	75.0%	75.0%	75.0%	75.0%	75.0%	75.0%	

Data in the pre-ISP time period relied heavily on DHS data, which provided a nationally representative sample of contraceptive access and use by adolescent and adult women, as well as on internal locally derived data. DHS data were not available for the ISP period. Data in the ISP time period relied heavily on internal, locally derived data from in-country partners, such as NatPharma, Crown Agents, MoHCC, ZNFPC, and PSI. Data used included records of procurement and distribution over time from pre-ISP and ISP periods. Data were available by contraceptive type and setting (such as private and public). As with population variables, multiple in-country sources were used to cross-compare trends. Most internal data did not break down contraceptive use by age group. Therefore, pre-ISP data generated primarily from DHS were used to provide information on female adolescents vs. adult women and wealth quintile trends during the ISP period.

Effectiveness data were obtained primarily from Hatcher and Trussell (2011), which is a well-cited source for effectiveness data in family planning models. Secondary literature sources for Zimbabwe-specific effectiveness estimates for contraceptives were also reviewed, but few representative studies have been done to examine effectiveness. Thus, Hatcher and Trussell (2011) were used to inform effectiveness estimates.

2.3.3 Cost Inputs

To conduct cost and cost-effectiveness analyses, data were collected on unit costs for each contraceptive, program costs during the pre-ISP and ISP time frames, and the estimated cost per pregnancy in Zimbabwe. Procurement data from Crown Agents, ZNFPC, and Family Care were used to estimate unit costs for contraceptives procured in Zimbabwe. For contraceptives that were not procured in Zimbabwe, market estimates were used from other African countries where available.

Unit costs were defined as the cost to produce an annual supply of the contraceptive. For instance, the unit cost for oral contraceptive pills would include a 12-month supply of pill packs, whereas injectable contraceptives would require four shots per year. When a contraceptive unit can be used for multiple years, such as sterilization or IUD, unit costs were averaged across the number of years a women typically receives benefit from this contraceptive method. The data for annual costs (Table 2-3) were derived primarily from in-country partners; however, secondary data were used to estimate costs for contraceptives not currently procured in Zimbabwe (e.g., patches). Of note, no unit costs are associated with abstinence, lactational amenorrhea method, and natural family planning, as these are behavioral family planning interventions.

Table 2-3. Contraceptive Unit Costs

Contraceptive	Annual Cost	High Estimate	Low Estimate	Source
Abstinence	N/A	N/A	N/A	N/A
Sterilization	$2.80	$1.40	$4.20	Adding it Up, 2012
Lactational amenorrhea method	N/A	N/A	N/A	N/A
Natural family planning	N/A	N/A	N/A	N/A
Diaphragm	$55	$27.50	$82.50	Lepine et al., 2015
Male condom	$30	$15	$45	ZNFPC, 2009–2014; Crown Agents, 2014
Female condom	$59	$29.50	$88.50	ZNFPC, 2009–2014; Crown Agents, 2014
Spermicide	$50	$25	$75	Estimate based on market value
Oral contraceptives	$4	$2	$6	ZNFPC, 2009–014; Crown Agents, 2014
Injectables	$6	$3	$9	ZNFPC, 2009–2014; Crown Agents, 2014
IUDs	$8	$4	$12	ZNFPC, 2009–2014; Crown Agents, 2014
Patches	$120	$60	$180	Estimate based on market value
Implants	$3.05	$1.53	$4.58	ZNFPC, 2009–2014; Crown Agents, 2014
Emergency contraception	$5.65	$2.83	$8.48	Family Care, 2012–2014

Program costs include training required and/or distribution and use of contraceptive methods. The cost of running the family planning interventions pre-ISP was estimated to be $2,100,000 (Sarley, Baruwa, & Tien, 2010). Pre-ISP program costs include training required and/or other activities that ensured contraceptive distribution and use in the pre-ISP period. Annual ISP program costs were estimated to be $3,580,000 and derived from budget estimates for Pillar 3 of the ISP program (Sexual and Reproductive Health and HIV Prevention in Zimbabwe, Annual Review, 2013, http://iati.dfid.gov.uk/iati_documents/4327296.odt).

To assess the cost per pregnancy averted, an estimated cost per pregnancy in Zimbabwe of $30 was used (Weinberger, Fry, & Hopkins, 2015). Impact 2 derived this estimate by assessing the average number of health services required during pregnancy and birth, including any complications, and the cost associated with each of these services in Zimbabwe. These numbers were multiplied to arrive at the average estimated cost per pregnancy.

3. MODELING ANALYSIS

3.1 Model Implementation

The ZAP model was implemented in Microsoft Excel with Visual Basic for Applications. The Excel model is composed of a series of linked tab worksheets. The model inputs are included in three tabs. One contains the model's population-level inputs, such as birth rates, number of women of reproductive age in Zimbabwe, and percentage of the population trying to conceive. Another tab captures penetration, utilization, and effectiveness of each contraceptive commodity. A third tab includes all cost inputs. The values of the model inputs were implemented with flexibility to run a deterministic or a probabilistic model (described in Section 3.7) and to conduct subgroup and sensitivity analyses (described in Section 3.8).

The model itself is in another tab, into which the previous three tabs of inputs feed. The model follows a cohort simulation approach and describes the population movement through the different contraceptive options. Additional tabs summarize the model outputs (described in Section 2.1.4).

3.2 Cost Calculation

The cost of each contraceptive type was calculated by multiplying the unit cost of the contraceptive by contraceptive coverage (where coverage is the multiplication of penetration and utilization rates) for the pre-ISP and ISP periods. The cost of ISP implementation was calculated by summing contraceptive costs with ISP program costs. By considering these programmatic costs in our analyses, the full costs of the ISP implementation could be compared to the potential benefits of unplanned pregnancies averted. The cost of pre-ISP implementation was calculated by summing contraceptive costs with pre-ISP program costs.

The cost savings of pregnancies averted were calculated by multiplying the number of pregnancies averted in each period by the cost of a pregnancy, which includes the costs of dealing with complications (as detailed in Section 2.3.3). Adding these savings to the cost of program implementation provides an estimate of the total cost pre-ISP and ISP that accounts for savings related to pregnancies averted.

The cost per pregnancy averted through the ISP was calculated by dividing the cost of ISP implementation, with and without cost savings, by the number of pregnancies averted.

3.3 Cost-Effectiveness Analysis

In a cost-effectiveness analysis (CEA), the costs and consequences of at least two strategies are compared. Where one strategy does not dominate (i.e., is not both more effective and less costly), costs and effects are combined in the form of incremental cost-effectiveness ratios (ICERs), defined as the difference in costs (C) divided by the difference in mean effectiveness (E), (Cj-Ci)/(Ej-Ei), where j is a more costly strategy than i. The ICER represents the additional cost required to achieve one additional unit of outcome. An optimal intervention is one with an ICER that is not more than the decision maker's intrinsic valuation for an additional unit of the outcome (Drummond et al., 2005). In the CEA, the outcome of interest is the number of pregnancies averted.

Two CEAs were performed. In one analysis, program implementation costs and effects (averted unplanned pregnancies) were compared between the pre-ISP and ISP periods. In another analysis, savings accrued with pregnancies averted were included in the estimation of total costs. Uncertainty in results was graphically depicted via cost-effectiveness acceptability curves (CEACs). CEACs represent the probability that the ISP program is cost-effective for different values of the decision maker's willingness to pay for one additional averted pregnancy.

3.4 Mortality and DALYs Due to Unplanned Pregnancies Averted

The number of deaths and DALYs avoided were calculated using the main health outcome, unplanned pregnancies averted, and secondary literature on mortality and morbidity rates and DALYs associated with pregnancy-related conditions. Mortality and morbidity rates for maternal, neonatal, and fetal conditions were taken from our previously developed Maternal and Neonatal Directed Assessment of Technology (MANDATE) model (www.mnhtech.org). DALYs were taken from the most recent Global Burden of Disease report (Murray et al., 2012–2013) for maternal and neonatal conditions (DALYs are not available for fetal conditions).

To calculate the number of deaths avoided in each period, mortality rates for each condition were multiplied by the number of unplanned pregnancies averted. Mortality rates are presented in Table 3-1.

Table 3-1. Mortality Rates Associated with Maternal, Fetal, and Neonatal Conditions

Mortality	Condition	Mortality Rate
Total mortality	Total maternal mortality	570 per 100,000
	Total fetal mortality	39 per 1,000
	Total neonatal mortality	39 per 1,000
Maternal condition specific mortality	Maternal hemorrhage	244.5 per 100,000
	Maternal sepsis	65.6 per 100,000
	Hypertensive diseases of pregnancy	59.9 per 100,000
Fetal condition specific mortality	Fetal complication due to antepartum or intrapartum hemorrhage	5.5 per 1,000
	Obstructed labor	5.9 per 1,000
	Syphilis	3.9 per 1,000
	Malaria	1.6 per 1,000
	Fetal complication due to hypertensive diseases of pregnancy	5.5 per 1,000
	Fetal distress	10.9 per 1,000
Neonatal condition specific mortality	Birth asphyxia	10.5 per 1,000
	Neonatal infection	11.3 per 1,000
	Preterm complications	12.9 per 1,000

To calculate the number of DALYs averted in each period, the number of unplanned pregnancies averted was multiplied by the incidence rate of each condition. This was then multiplied by the DALY associated with each condition. The incidence rates and DALY associated with maternal and neonatal conditions are reported in Table 3-2.

Table 3-2. Incidence and DALYs Associated with Maternal and Neonatal Conditions

Maternal and Neonatal DALYs	Condition	Incidence Rate	DALYs
Maternal condition specific DALYs	Maternal hemorrhage	14%	48
	Maternal sepsis	3%	19
	Hypertensive diseases of pregnancy	5%	41
Neonatal condition specific DALYs	Birth asphyxia	7%	728
	Neonatal infection	5%	642
	Preterm complications	4%	1,117

3.5 Disaggregation by Wealth Quintiles

Although there was interest in understanding how the ISP program influenced pregnancy rates for women across economic classes, it was not possible to stratify all modeled inputs by wealth quintile. At the program level, data are collected by where a women receives care, but information on wealth is not routinely collected. Therefore, a sub-analysis was conducted to understand women's fertility rates by wealth quintile (Knoema.com, Health Nutrition and Population Statistics by Wealth Quintile, 2014). Currently, data exist on total fertility rate for the years 2009, 2011, and 2013. However, the most recent data reported on fertility rate by wealth quintile in Zimbabwe are reported for 2009 and 2011, and more recent data for fertility rates by wealth quintile are not anticipated until mid-2016. Therefore, two techniques were used to estimate the potential change in fertility rate by wealth quintile in the ISP period:

1. Assume a proportionate reduction in fertility rate for each wealth quintile based on the overall decline in total fertility rate observed between 2011 and 2013.
2. Assume the maximum change in fertility rate between any wealth quintile noted in the 2009 to 2011 (i.e., the years in which fertility rate by wealth quintiles is reported) is similar to the maximum change between 2012 and 2015 to provide both conservative and aggressive outputs by wealth quintile.

Beginning with the known data on fertility rate (Table 3-3), the percentage reduction in the total fertility rate between 2009, 2011, and 2013 was calculated. Of note, the total fertility rate did not decline from 2009 to 2011, but declined by 13% from 2011 to 2013. Currently, no data exist on total fertility rate for 2015, the last year of the ISP program, so similar fertility rates were assumed between 2013 and 2015. To derive fertility rates for 2015, the same proportionate distribution of fertility rate was maintained among wealth quintiles in 2011, but fertility rates in each wealth quintile were adjusted down to reflect the 13% decline in total fertility rate (Table 3-4). Because there could be wide variation in the fertility rates by each wealth quintile, conservative and aggressive estimates were calculated (i.e., ±0.6). Therefore, both conservative and aggressive estimates were included on the possible change in fertility rate. These conservative and aggressive fertility rate estimates are also noted in Table 3-4. Finally, the distribution of pregnancy rates were assumed to be similar to the distribution of fertility rates, and these results are described in Section 4.8.

Table 3-3. Known Fertility Rates by Wealth Quintile in Zimbabwe

Wealth Quintile	2009	2011	2013
Poorest	5.6	5.3	NA
Poor	4.5	5.1	NA
Middle	3.8	4.4	NA
Wealthy	3.3	3.8	NA
Wealthiest	2.4	2.6	NA
Total fertility rate	**4.04**	**4.04**	**3.56**

Table 3-4. Stratification of Fertility Rate by Wealth Quintile

Wealth Quintile	2011 Fertility Rate	2015 Fertility Rate (Moderate Estimate)	2015 Fertility Rate (Aggressive Estimate)	2015 Fertility Rate (Conservative Estimate)
Poorest	5.3	4.9	5.3	4.1
Poor	5.1	4.7	5.1	3.9
Middle	4.4	4.1	4.5	3.3
Wealthy	3.8	3.5	3.9	2.7
Wealthiest	2.6	2.4	2.9	1.7

3.6 Model Calibration and Validation

Calibration ensures that the inputs and outputs are consistent with available data, and validation ensures that the model reproduces reality (Eddy et al., 2012). For parameters that were unobservable—for example, any pre-ISP baseline inputs—the calibration target was the number of pregnancies pre-ISP. Since the number of pregnancies is an estimate that is not readily available, the birth rate in Zimbabwe was multiplied by the number of women of reproductive age in Zimbabwe to derive the number of live births in Zimbabwe. Next, the number of live births was adjusted to account for fetal loss (McClure, Nalubamba-Phiri, & Goldenberg, 2006). Then, pre-ISP baseline inputs on population and contraceptive commodity specifications were calibrated to ensure that the annual number of pregnancies was within a plausible range of actual number of pregnancies for Zimbabwe in the pre-ISP period (Table 3-5). Model inputs were manually selected so that model outputs (which are functionally dependent on the unidentifiable parameters) were as close as possible to empirically observable data. Goodness of fit was assessed by calculating the distance of model-produced results from the calibration target. Goodness of fit was assessed by calculating difference rather than defining likelihood functions. Although likelihood functions incorporate precision of endpoint data, they are more difficult to implement and require sample size and distribution information. Finally, this process was repeated to calibrate the pregnancies modelled during the ISP period.

Table 3-5. Variation between Target Estimates and Modelled Estimates

Estimate for Zimbabwe	Pre-ISP	ISP
Number of women of reproductive age	3,294,872	3,751,705
Number of live births	418,197	440,078
Number of pregnancies in (Target)	460,017	484,086
Modeled estimate of number of pregnancies in Zimbabwe (modeled output)	456,236	486,118
Variation	**−0.8%**	**0.4%**

To ensure that the model was internally valid and behaved as expected, the accuracy of all coding was checked. For example, extreme parameter values were used to assess whether the model generated predictable effects on model outputs. To ensure external validity of the model results, model outputs were compared to empirical observations of those outputs. For cross-model validation, model outputs were compared to outputs of other models, such as the FamPlan model, in Spectrum. Specific outputs that were compared include total pregnancies averted, fertility rate, and contraceptive prevalence.

In addition to these internal quality assurance measures, a workshop was held in Zimbabwe with local stakeholders to validate the data inputs and findings. During this 2-day workshop, local stakeholders reviewed and provided feedback on the data inputs. Stakeholders included participants from the Ministry of Health (MoH), University of Zimbabwe, United Nations Population Fund (UNFPA), World Bank, PSI, ZNFPC as well as private sector stakeholders.

3.7 Parameter Uncertainty

Some model inputs cannot be known with certainty. Parameter uncertainty was represented via probabilistic sensitivity analysis (PSA). In the PSA, all parameters were varied simultaneously, with values being sampled from a priori-defined probability distributions, in which less information was represented by assigning a more diffuse distribution to reflect their full uncertainty (Bilcke et al., 2011; Briggs et al., 2012). Monte Carlo simulation randomly selected values of the parameters from the assigned distributions and propagated these distributions through the model (Doubilet et al., 1985), allowing results to be presented in the form of CEACs (Fenwick et al., 2001; Briggs et al., 2012).

3.8 Heterogeneity and Subgroup Analysis

Heterogeneity refers to the extent to which between-individual variability can be explained by individuals' characteristics (e.g., age-specific mortality). The term is not related to parameter uncertainty. Its relevance lies in the identification of subgroups for whom separate CEAs should be undertaken. The model was set to run several subgroup analyses that produced results for different age groups. Results were produced for all women of reproductive age, adult women only (aged 20 to 49 years), and adolescent women only (aged 14 to 19 years). In addition, Outputs were stratified by wealth quintile to estimate the impact of the ISP program on pregnancies for each wealth quintile.

3.9 Scenario Analysis

By changing several input parameters at a time (multi-way sensitivity analysis), several scenarios could be run. A no-contraceptive intervention scenario was analyzed by setting all contraceptive penetration and utilization at zero, thus simulating birth rates before modern contraception was introduced. Outcomes from this scenario were compared to the pre-ISP and ISP outcomes to assess whether the model calculations were working as anticipated, ensuring that complete removal of contraception resulted in a substantially higher number of unplanned pregnancies per 1,000 women of reproductive age than the numbers from pre-ISP and ISP scenarios.

Another scenario was analyzed that used values for penetration and utilization of contraception in the United States (high-resource country). Birth rates from this scenario were compared to birth rates in the United States to determine whether the ZAP model outputs were within a plausible range of the high-resource country values.

Finally, a hypothetical scenario was analyzed of near perfect utilization of IUD and male condoms among women who are not planning a pregnancy. This scenario ensured that the model was operating appropriately, even under extreme conditions.

3.10 Quality Assurance Plan

Quality assurance (QA) procedures were implemented at each step of the work performed to ensure that accurate and high quality data were collected, entered into the model, and ultimately disseminated. The model was built using good modeling practices (Gold et al., 1996; Drummond et al., 2005) and appropriate statistical methodology, such as selecting distributions for input parameters based on agreed statistical methods (Briggs et al., 2006, 2012). QA checks were performed on the data entered into the Excel spreadsheets through double data entry. In addition, a second person who did not build the original model checked the structure and mathematical formulas to ensure that no errors occurred.

4. RESULTS

4.1 Program Reach and Pregnancy Outcomes

The yearly number of family planning users (i.e., program reach), unplanned pregnancies, total pregnancies, and unplanned pregnancies averted are shown in Table 4-1 for the pre-ISP period, ISP period, and the difference between pre-ISP and ISP periods. The number of family planning users increased after implementation of the ISP for all age groups. Comparing pre-ISP and ISP periods, the number of unplanned pregnancies averted increased for women of reproductive age and adult women. The number of unplanned pregnancies averted increased after ISP implementation for all age groups. For female adolescents, the results were less clear and interpretable, because of small sample sizes and very large credible intervals. All results concerning female adolescents should therefore be interpreted with caution throughout the report. The wide credible intervals reflect the uncertainty of model inputs, as reflected in Tables 2-1 through 2-3 in Section 2.3. However, Table 4-1 presents absolute numbers that do not account for the difference in the number of women of reproductive age in both periods. Figures 4-1 through 4-4 account for these differences.

Figures 4-1 through 4-3 present reach and pregnancy outcomes as a percentage of all women of reproductive age, for pre-ISP and ISP periods for all women of reproductive age, adult women, and female adolescents, respectively. Figure 4-4 presents the percentage change in key family planning metrics. The number of family planning users increased by 13% for all women of reproductive age, 15% for adult women, and 10% for female adolescents in the pre-ISP period compared with the ISP period. The number of unplanned pregnancies decreased by 9% for all women of reproductive age, 9% for adult women, and 12% for female adolescents. Similarly, the total number of pregnancies decreased by 6% for all women of reproductive age, 7% for adult women, and 12% for female adolescents. The number of unplanned pregnancies averted increased by 5% for all women of reproductive age and 6% for adult women. However, for female adolescents, the number of unplanned pregnancies averted decreased by 11% from the pre-ISP period to the ISP period. Again, this result should be interpreted with caution due to the small sample size and large credible intervals noted in Table 4-1.

Table 4-1. Program Reach and Pregnancy Outcomes for All Women of Reproductive Age, Adult Women, and Female Adolescents, in the Pre-ISP and ISP Periods (Per Year)

	All Women			Adults			Adolescents		
Estimate for Zimbabwe	**Pre-ISP**	**ISP**	**ISP − Pre-ISP**	**Pre-ISP**	**ISP**	**ISP − Pre-ISP**	**Pre-ISP**	**ISP**	**ISP − Pre-ISP**
Family planning users	887,469 [733,838, 1,058,097]	1,144,092 [915,274, 1,372,910]	256,623 [205,298, 307,948]	704,774 [565,555, 860,947]	919,768 [768,321, 1,103,967]	214,994 [104,205, 330,952]	144,024 [105,006, 196,043]	180,978 [136,177, 237,035]	36,954 [−33,253, 104,643]
Pregnancies									
Unplanned pregnancies	320,322 [247,606, 405,535]	331,360 [267,061, 403,587]	11,038 [−82,625, 98,405]	275,009 [218,216, 343,377]	283,713 [225,422, 356,788]	8,704 [−52,375, 73,453]	60,270 [39,378, 87,310]	60,259 [40,740, 85,166]	−11 [−26,821, 23,976]
Total pregnancies	456,236 [374,726, 553,633]	486,118 [414,190, 564,903]	29,882 [−74,732, 125,371]	381,021 [316,519, 457,339]	404,424 [336,945, 480,430]	23,403 [−44,314, 83,342]	70,600 [47,086, 97,664]	70,681 [49,807, 96,292]	81 [−11,341, 12,441]
Unplanned pregnancies averted	205,628 [174,142, 240,167]	246,779 [222,829, 267,993]	41,150 [5,783, 75,914]	153,512 [127,803, 179,388]	185,903 [157,735, 214,522]	32,391 [11,993, 53,353]	53,977 [45,342, 62,471]	54,682 [46,037, 63,382]	705 [−11,341, 12,441]

Note: Numbers in brackets are 95% credible intervals.

Figure 4-1. Percentage of Family Planning Users, Unplanned Pregnancies, Total Pregnancies, and Pregnancies Averted for Pre-ISP and ISP Periods among All Women of Reproductive Age

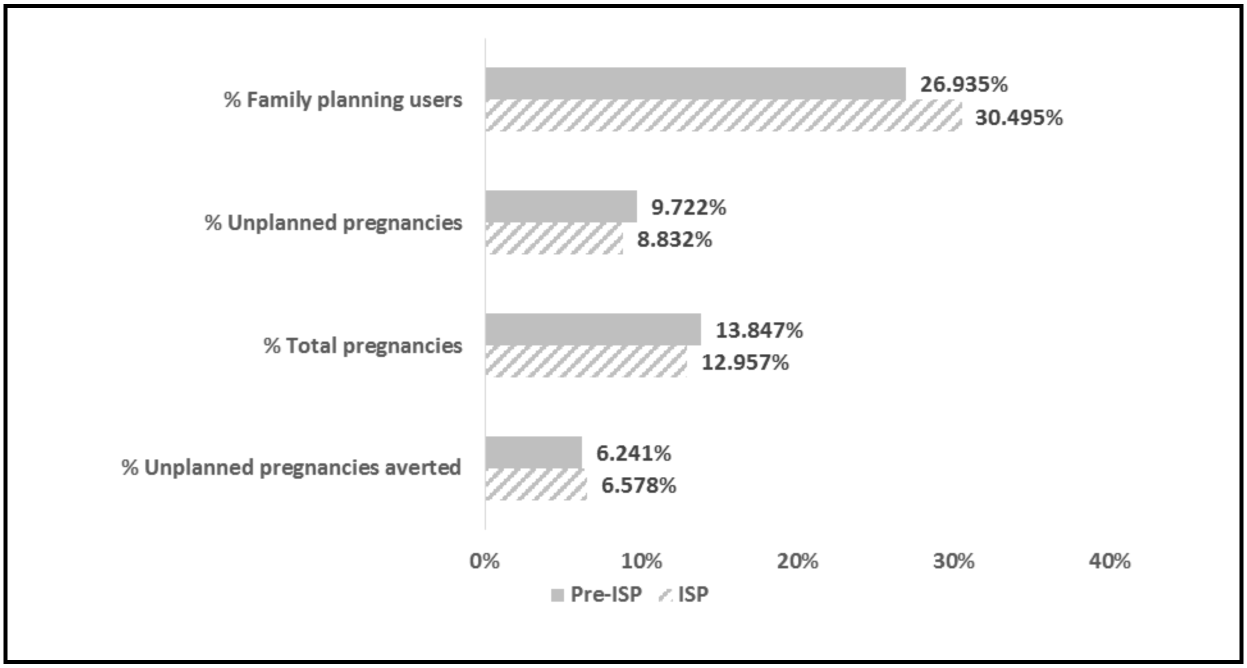


Figure 4-2. Percentage of Family Planning Users, Unplanned Pregnancies, Total Pregnancies, and Pregnancies Averted for Pre-ISP and ISP Periods among Adult Women

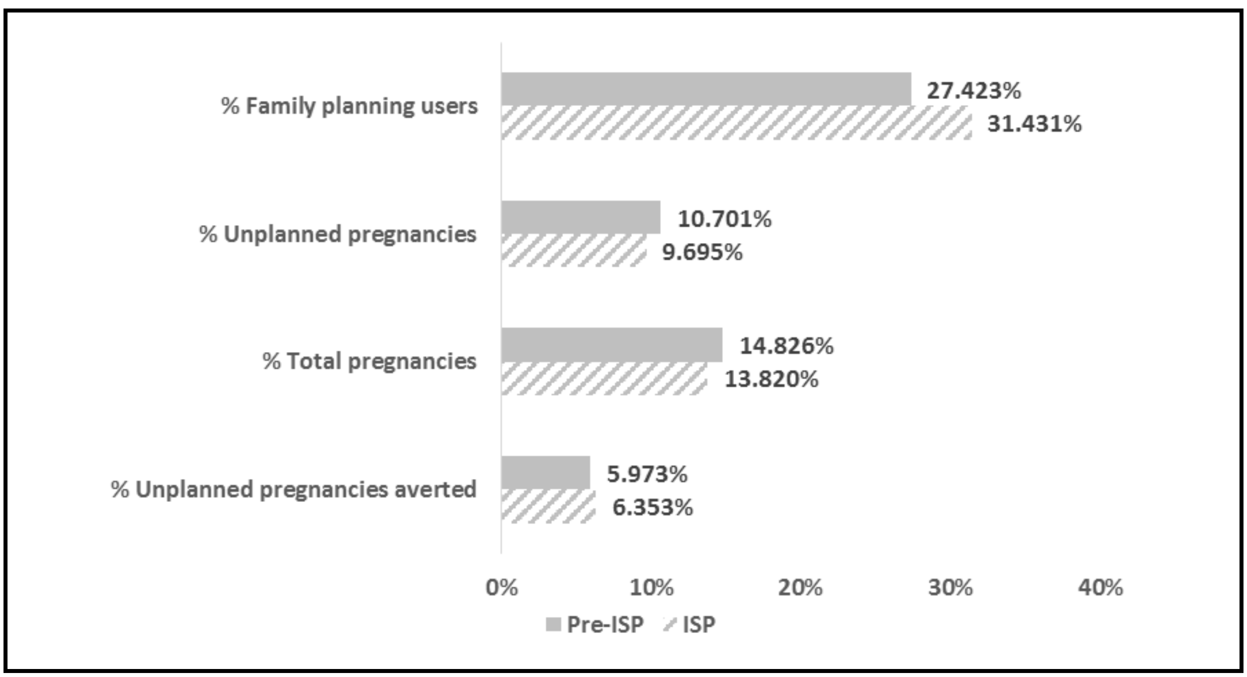


Figure 4-3. Percentage of Family Planning Users, Unplanned Pregnancies, Total Pregnancies, and Pregnancies Averted for Pre-ISP and ISP Periods among Female Adolescents

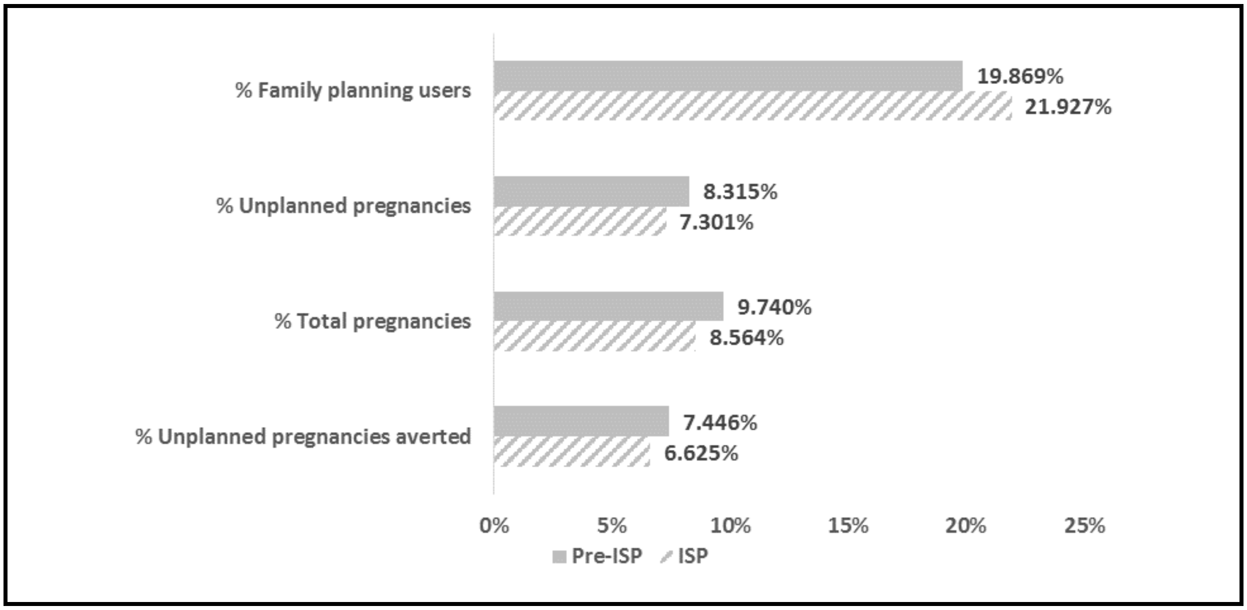
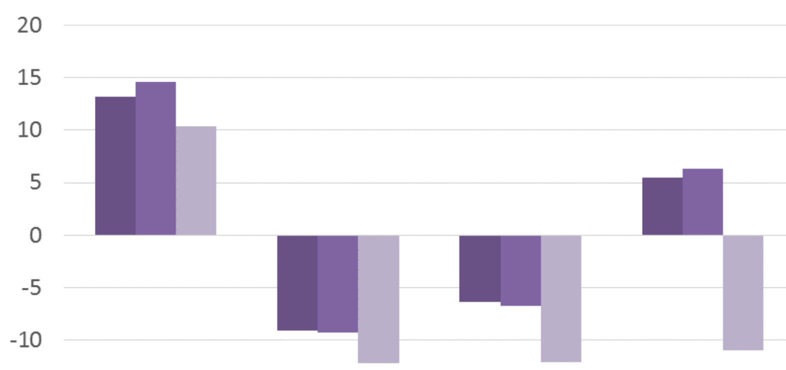


Figure 4-4. Percentage Change for Family Planning Users, Unplanned Pregnancies, Total Pregnancies, and Pregnancies Averted for Pre-ISP and ISP Periods among All Women of Reproductive Age (i.e., All Population), Adult Women, and Female Adolescents



	% Change Family Planning Users	% Change in Unplanned Pregnancies	% Change in Total Pregnancies	% Change in Unplanned Pregnancies Averted
All Population	13	-9	-6	5
Adults	15	-9	-7	6
Adolescents	10	-12	-12	-11

[a] Adolescent data should be interpreted with caution due to small sample size.

4.2 Contraceptive Usage

Table 4-2 shows the yearly number of women using each type of modern contraceptive method during the pre-ISP and ISP periods for all women of reproductive age, adult women, and female adolescents. Compared with the pre-ISP period, use of all contraceptives increased for all age groups after ISP implementation. However, Table 4-2 shows absolute numbers that do not account for the increase in the number of women of reproductive age between pre-ISP and ISP periods. Figures 4-5 through 4-8 account for these differences.

Table 4-2. Contraceptive Use for All Women of Reproductive Age, Adult Women, and Female Adolescents, Pre-ISP and ISP (Per Year)

	All Women			Adults			Adolescents		
Contraceptive	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**
Male condoms	101,348 [11,805, 343,600]	131,692 [18,747, 396,482]	30,343 [−239,162, 321,606]	93,215 [13,906, 261,113]	119,188 [20,869, 406,154]	25,973 [−175,661, 239,134]	6,218 [1, 43,342]	9,096 [7, 47,768]	2,878 [−35,332, 45,834]
Female condoms	3,194 [57, 42,444]	3,595 [118, 36,953]	401 [−40,960, 35,086]	3,304 [83, 29,503]	3,718 [94, 39,862]	414 [−28,735, 37,523]	—	—	—
Oral contraceptives	575,116 [438,265, 724,657]	775,173 [646,628, 901,028]	200,057 [1,477, 396,445]	423,136 [319,896, 551,832]	586,972 [459,589, 731,992]	163,835 [−68,143, 133,007]	138,456 [100,782, 189,677]	174,450 [132,033, 229,837]	35,995 [−33,174, 100,825]
Injectables	260,563 [202,227, 333,639]	291,566 [234,356, 359,795]	31,003 [−57,849, 113,781]	233,306 [167,518, 314,627]	263,658 [182,672, 357,111]	30,353 [−68,143, 133,07]	3,376 [1,409, 6,386]	4,001 [1,607, 7,688]	625 [−3,234, 4,815]
IUD	3,810 [1,666, 7,184]	8,199 [4,937, 12,384]	4,389 [−133, 9,393]	3,166 [1,421, 5,662]	7,097 [3,882, 11,439]	3,931 [98, 8,534]	—	—	—
Implants	2,927 [804, 6,269]	21,570 [13,403, 31,734]	18,643 [9,945, 29,798]	2,579 [10,221, 29,938]	18,561 [10,221, 29,938]	15,982 [7,427, 27,200]	69 [2, 275]	234 [10, 1,006]	165 [−170, 959]
Emergency contraception	468 [75, 1,288]	1,927 [510, 5,306]	1,459 [−116, 4,654]	320 [27, 1,048]	1,682 [308, 5.190]	1,362 [−160, 5,045]	7 [0, 36]	32 [1, 219]	25 [−25, 219]

Note: Numbers in brackets are 95% credible intervals; female condoms and IUDs were not used by adolescents.

Figures 4-5 through 4-7 present the percentage using each contraceptive method for pre-ISP and ISP periods for all women of reproductive age, adult women, and female adolescents, respectively. Figure 4-8 presents the percentage change in use of contraceptive methods. The use of male condoms increased by 14% for all women of reproductive age, 12% for adult women, and 28%for female adolescents. The use of female condoms decreased slightly by 1% and 2%, respectively, for all women of reproductive age and adult women. Female condoms were not used by adolescents before and during ISP implementation. The largest increase in contraceptive use was for oral contraceptives. The number of oral contraceptive packs increased by 18% for all women of reproductive age, 22% for adult women, and 11% for female adolescents. Injectables use decreased modestly by 2% and 1%, respectively, among all women of reproductive age and adult women, and increased by 4% among female adolescents. IUD use increased by 89% for all women of reproductive age and 98% for adult women. IUDs were not used by female adolescents before and during ISP implementation. Implants use increased by 546% for all women of reproductive age and 534% for adult women. Emergency contraceptives use increased by 264% and 375% for all women of reproductive age and adult women, respectively. Implants and emergency contraception were used by <0.05% of female adolescents in both the pre-ISP and ISP periods. Still, their use increased by 180% and 300% during ISP implementation, respectively.

Figure 4-5. Percentage of All Women of Reproductive Age Using Each Contraceptive Method for Pre-ISP and ISP Periods among All Women of Reproductive Age

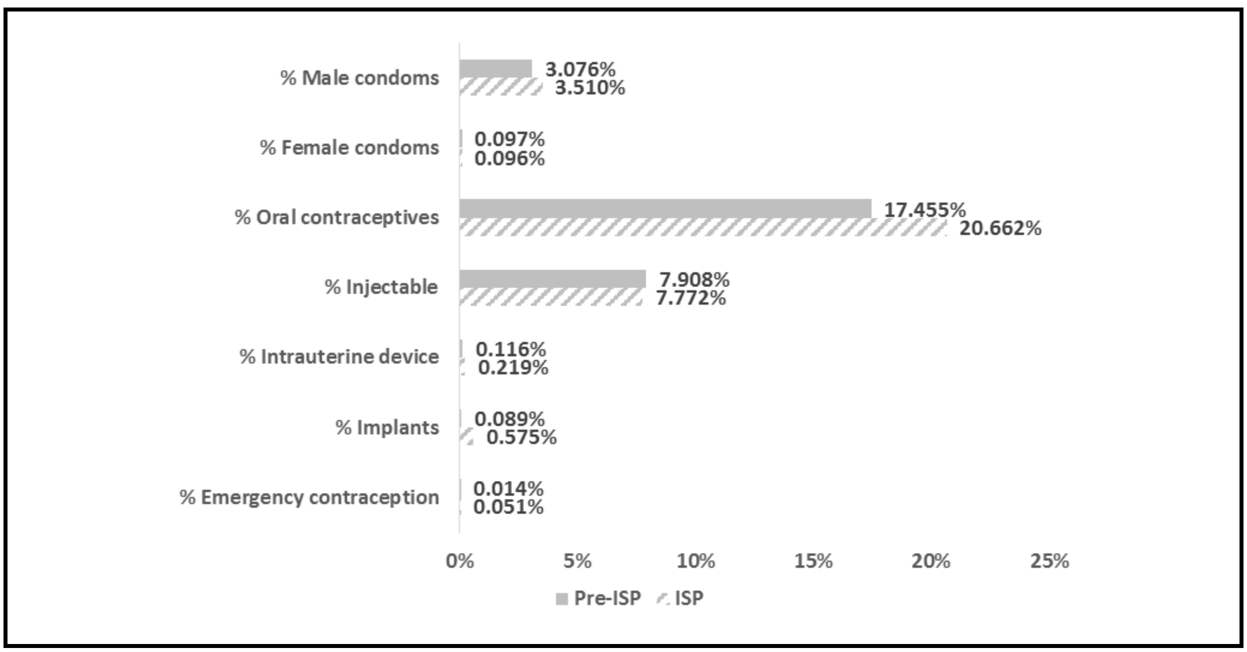


Figure 4-6. Percentage of All Women of Reproductive Age Using Each Contraceptive Method for Pre-ISP and ISP Periods among Adult Women

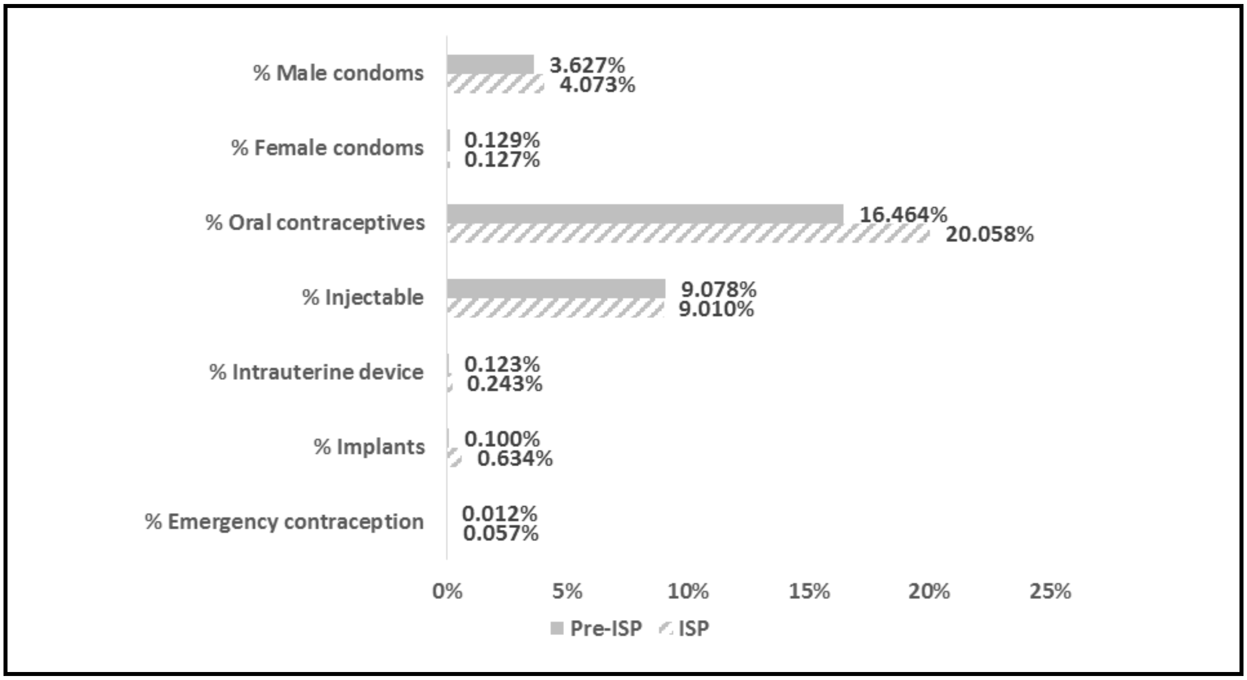


Figure 4-7. Percentage of All Women of Reproductive Age Using Each Contraceptive Method for Pre-ISP and ISP Periods among Female Adolescents

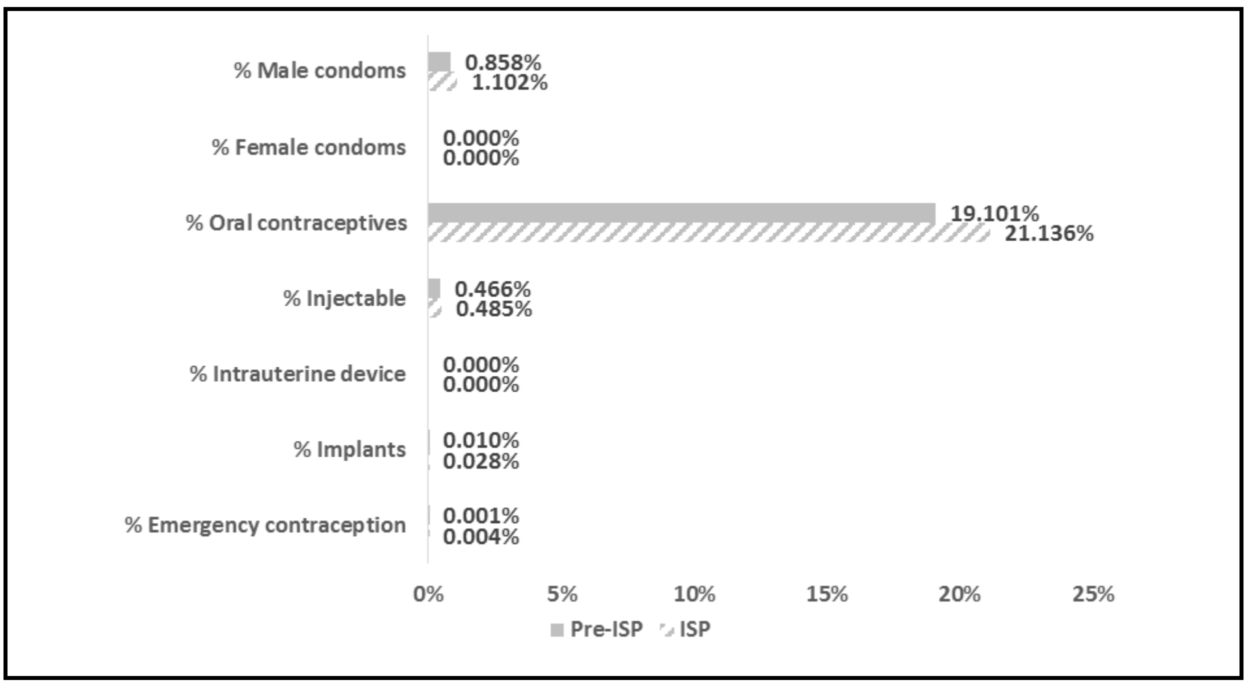
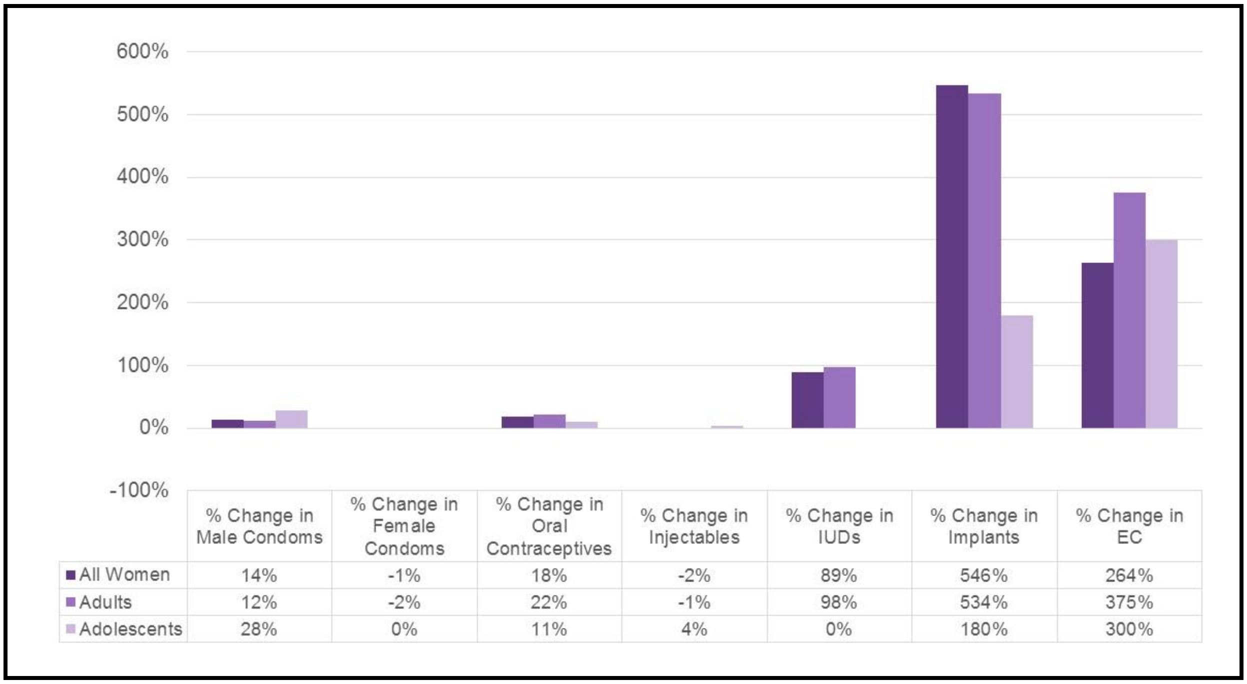


Figure 4-8. Percentage Change in Contraceptive Use for Pre-ISP and ISP Periods among All Women of Reproductive Age (i.e., All Population), Adult Women, and Female Adolescents



[a] Adolescent data should be interpreted with caution due to small sample size.

4.3 Contraceptive Cost

Table 4-3 presents the overall yearly cost of each contraceptive method pre-ISP and during the ISP period for all women of reproductive age, adult women, and female adolescents. The cost of each contraceptive method was calculated by multiplying the unit cost of each contraceptive by the total number of contraceptives used. Compared with the pre-ISP period, after ISP implementation, the cost of each contraceptive method increased for all groups. This is due to the increased use of all contraceptives, as described in Table 4-2 above.

4.4 Total Cost of All Contraceptives, Program Costs, and Cost Savings

Table 4-4 shows the total yearly cost of all contraceptives, program costs, and cost savings for all women of reproductive age, adult women, and female adolescents, pre-ISP and during the ISP period. The cost of all contraceptives is the sum of the cost of each contraceptive method, presented in Table 4-3. Pre-ISP and ISP program costs were derived from the literature as described in Section 2.3.3. Savings from pregnancies averted were calculated by multiplying the number of pregnancies averted described in Table 4-1 above by the cost of a pregnancy ($30), as described in Section 2.3.3. Using those three cost estimates, and as detailed in Section 3.2, pre-ISP and ISP implementation costs are the sum of the cost of all contraceptives and the program cost. Total costs are the sum of implementation costs and savings with pregnancies averted.

For all groups, program implementation costs increased during the ISP period. This increase is $4.58 million for all women of reproductive age, $3.74 million for adult women, and $738,763 for adolescents. When taking into account savings related to pregnancies averted (i.e., total cost), the increase in cost is slightly less: $3.34 million for all women of reproductive age, $2.77 million for adult women, and $717,620 for female adolescents. As for all estimates, the wide credible intervals are related to uncertainty in model inputs.

4.5 Cost per Unplanned Pregnancy Averted

The average cost per pregnancy averted through implementation of the ISP was calculated by dividing the cost of ISP implementation by the number of pregnancies averted. This resulted in an average cost per unplanned pregnancy averted of $56 for all women of reproductive age, $62 for adult women, and $36 for female adolescents. When the savings from pregnancies averted are included, the average costs per unplanned pregnancy averted are $26for all women of reproductive age, $32 for adult women, and $6 for female adolescents. These are average cost-effectiveness estimates, however, and do not compare the incremental costs and outcomes of the ISP program with the pre-ISP program. ICERs, where the incremental costs and effects are taken into account, are more informative regarding the additional cost related to the additional effect incurred by the ISP. ICERs are presented in Section 4.6.

4.6 Cost-Effectiveness Results: Unplanned Pregnancies Averted

ICERs are the difference in cost between the two time periods, divided by the difference in their effect, and represents the average incremental cost associated with 1 additional unit of the measure of effect. An optimal intervention is one with an ICER that is not more than the decision maker's intrinsic valuation for an additional unit of the outcome (Drummond et al., 2005). In the CEA, the outcome of interest is the number of pregnancies averted.

Table 4-3. Contraceptive Cost for All Women of Reproductive Age, Adult Women, and Female Adolescents, Pre-ISP and ISP (Per Year)

	All Women			Adults			Adolescents		
Contraceptive	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**
Male condoms	$3,040,447 [$313,914, $10,964,856]	$3,950,752 [$506,220, $11,582,050]	$910,304 [−$7,271,097, $9,577,115]	$2,796,449 [$384,932, $7,987,553]	$3,575,642 [$575,503, $10,287,907]	$779,193 [−$5,938,926, $8,455,945]	$186,553 [$18, $1,227,808]	$272,888 [$204, $1,413,521]	$86,335 [−$1,132,470, $1,279,340]
Female condoms	$188,450 [$2,881, $2,366,227]	$212,089 [$4,774, $2,019,522]	$23,639 [−$2.360,706, $1.980,170]	$194,909 [$4,246, $2,041,207]	$219,336 [$4,713, $2,221,526]	$24,426 [−$1,926,029, $2,12,110]	—	—	—
Oral contraceptives	$2,300,465 [$1,189,965, $3,756,002]	$3,875,864 [$2,170,222, $6,054,517]	$1,575,400 [−$708,770, $4,289,778]	$1,692,545 [$871,700, $2,881,749]	$2,934,858 [$1,632,731, $4,724,256]	$1,242,313 [−$459,516, $3,217,230]	$553,822 [$289,444, $917,434]	$872,251 [$480,307, $1,446,967]	$318,429 [−$246,236, $975,662]
Injectables	$1,563,375 [$835,742, $2,665,059]	$2,040,962 [$1,153,769, $3,259,036]	$477,587 [−$921,160, $1,921,944]	$1,399,833 [$744,197, $2,267,851]	$1,845,609 [$911,515, $3,124,407]	$445,776 [−$785,999, $1,875,944]	$20,257 [$7,321, $41,445]	$28,010 [$9,791, $63,281]	$7,753 [−$22,885, $43,475]
IUD	$30,480 [$11,129, $66,553]	$73,789 [$35,791, $130,656]	$43,309 [−$11,930, $107,339]	$25,329 [$9,213, $52,036]	$63,877 [$26,286, $119,235]	$38,549 [−$5,336, $98,851]	—	—	—
Implants	$8,928 [$2,049, $21,460]	$65,788 [$31,788, $118,553]	$56,860 [$23,306, $109,872]	$7,865 [$2,024, $19,407]	$56,610 [$25,812, $104,308]	$48,745 [$14,628, $97,407]	$211 [$6, $954]	$715 [$28, $3,170]	$504 [−$580, $2,991]
Emergency contraception	$2,646 [$373, $8,000]	$10,890 [$2,520, $29,272]	$8,244 [−$1,320, $26,989]	$1,810 [$139, $5,898]	$9,503 [$1,418, $29,467]	$7,693 [−$1,363, $27,941]	$42 [$0, $207]	$183 [$3, $1,253]	$142 [−$131, $1,199]

Note: Numbers in brackets are 95% credible intervals; female condoms and IUDs were not used by adolescents.

Table 4-4. Total Cost of All Contraceptive, Program Costs, and Cost Savings, for All Women of Reproductive Age, Adult Women, and Female Adolescents, Pre-ISP and ISP (Per Year)

	All Women			Adults			Adolescents		
Cost	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**	**Pre-ISP**	**ISP**	**ISP – Pre-ISP**
a. Cost of all contraceptives	$7,134,790 [$3,50,457, $15,034,581]	$10,230,133 [$5,790,048, $18,345,450]	$3,095,343 [−$6,064,763, $11,730,118]	$6,118,740 [$3,078,352, $11,627,117]	$8,705,436 [$4,739,821, $15,753,621]	$2,586,696 [−$4,451,845, $10,871,825]	$760,885 [$340,642, $1,910,942]	$1,174,047 [$579,469, $2,415,830]	$413,163 [−$813,523, $1,807,424]
b. Program cost	$2,100,000 [$1,185,474, $3,258,960]	$3,580,000 [$1,967,956, $5,476,785]	$1,480,000 [−$370,156, $3,666,756]	$1,638,000 [$911,345, $2,468,645]	$2,792,400 [$1,648,630, $4,305,962]	$1,154,400 [−$190,343, $2,802,053]	$462,000 [$260,720, $712,051]	$787,600 [$449,569, $1,223,513]	$325,600 [−$97,343, $798,842]
c. Savings from pregnancies averted	$6,168,854 [$3,433,920, $10,273,332]	$7,403,364 [$4,182,414, $11,848,080]	$1,234,510 [$164,703, $2,644,508]	$4,605,358 [$2,480,574, $7,280,853]	$5,557,088 [$3,080,431, $8,794,784]	$971,730 [$315,095, $1,926,985]	$1,619,310 [$906,683, $2,554,085]	$1,640,453 [$911,034, $2,616,563]	$21,143 [−$354,050, $400,384]
Cost of program implementation (a+b)	$9,234,790 [$5,365,309, $17,228,920]	$13,810,133 [$8,868,131, $22,515,242]	$4,575,343 [−$4,368,019, $13,339,610]	$7,756,740 [$4,478,616, $13,397,215]	$11,497,836 [$7,294,520, $18,686,901]	$3,741,096 [−$3,568,232, $11,913,765]	$1,222,885 [$748,290, $2,412,242]	$1,961,647 [$1,243,316, $3,214,027]	$738,763 [−$531,844, $2,201,295]
Total costs (a+b+c)	$3,065,937 [-$2,170,860, $10,985,786]	$6,406,769 [−$371,619, $14,861,193]	$3,340,832 [−$5,486,093, $12,079,857]	$3,151,382 [−$834,318, $9,117,798]	$5,920,747 [$608,366 $13,569,559]	$2,769,366 [−$4,538,308, $10,808,238]	-$396,426 [−$1,461,825, $886,088]	$321,194 [−$819,00, $1,736,516]	$717,620 [−$551,352, $2,122,869]

Note: Numbers in brackets are 95% credible intervals.

Two CEAs were performed. In one analysis, program implementation costs and effects (unplanned pregnancies averted) were compared from pre-ISP and ISP periods. In another analysis, the savings accrued with pregnancies averted were included in the estimation of total costs. Table 4-5 shows the ICER for each analysis by group. The ICER using implementation costs only is $111 per unplanned pregnancy averted for all women of reproductive age, $115 for adult women, and $1,048 for female adolescents. Therefore, for example, for all women of reproductive age, the ISP averts one additional unplanned pregnancy than the pre-ISP program at an additional cost of $111. The ICER is higher for adolescents, reflecting the lower impact of the program on this subgroup, where an additional $1,048 would have to be spent to avert one additional adolescent pregnancy. When the savings related to averting unplanned pregnancies are included, the ICER decreases as the program is "less expensive." In this analysis, the additional cost to avert one additional unplanned pregnancy is $81 for all women of reproductive age, $85 for adult women, and $1,018 for female adolescents. Figures 4-9 through 4-11 show the base-case results for each age group in the form of a CEAC using total costs (contraceptive cost, program cost, and savings for pregnancies averted). The CEAC shows the probability that the ISP program is preferred to pre-ISP, for different maximum willingness to pay amounts for an additional averted pregnancy. As decision makers are willing to pay more for an additional pregnancy averted, the more costly and cost-effective strategy is preferred.

Table 4-5. Incremental Cost-Effectiveness Ratios of Pregnancies Averted for Different Cost Assumptions in Pre-ISP and ISP Periods

Numerator in ICER	All Women	Adults	Female Adolescents
a. Cost of contraceptives and program	111	115	1,048
b. Total cost (a + cost savings)	81	85	1,018

Figure 4-9 for all women of reproductive age and Figure 4-10 for adult women show that when the decision maker is not willing to pay anything for an additional unit of outcome, the probability that the ISP program is more cost-effective than pre-ISP is only about 0.20. As the decision maker is willing to pay more for an additional unplanned pregnancy averted, the probability that the ISP is cost-effective increases, reaching 0.5 at the value of the ICER ($81 per additional pregnancy averted in Figure 4-9 and $85 in Figure 4-10). If the decision maker is willing to pay more than the value of the ICER, the ISP is more cost-effective than pre-ISP and is cost-effective about 99% of the time for willingness to pay values above approximately $1,000 per additional unplanned pregnancy averted.

Figure 4-9. Cost-Effectiveness Acceptability Curve of ISP vs. Pre-ISP for All Women of Reproductive Age

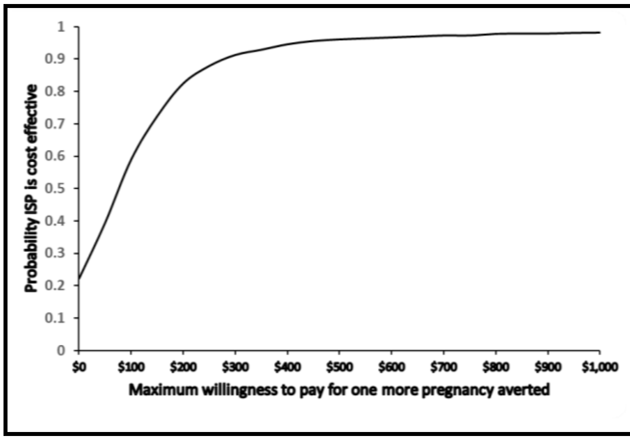
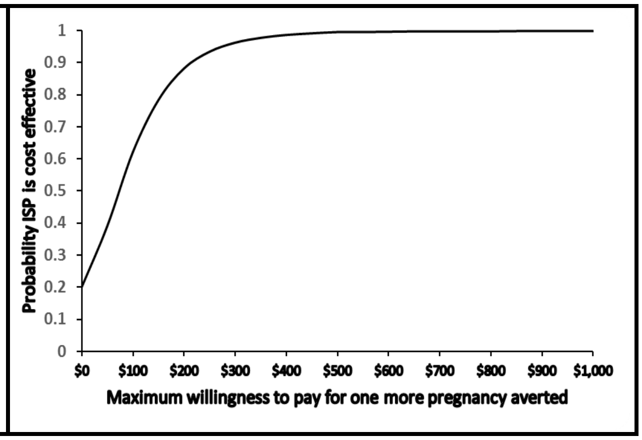
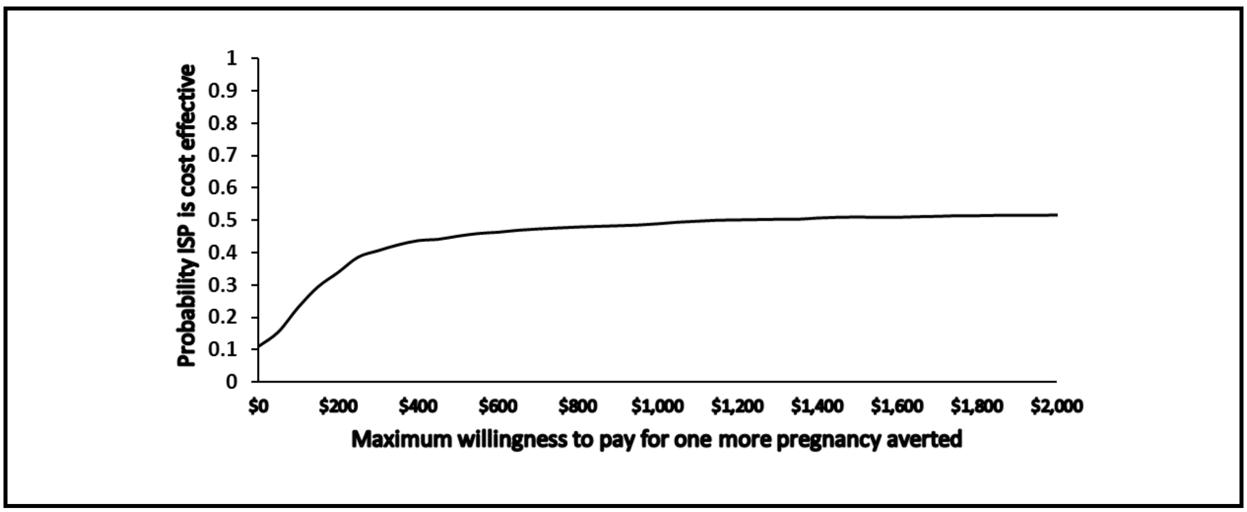


Figure 4-10. Cost-Effectiveness Acceptability Curve of ISP vs. Pre-ISP for Adult Women



When the decision maker is not willing to pay anything for an additional unit of outcome, the probability that the ISP program is more cost-effective than pre-ISP for adolescents is only about 0.1 (Figure 4-11). As the decision maker is willing to pay more for an additional unplanned pregnancy averted, the probability that the ISP is cost-effective increases, reaching 0.5 at the value of the ICER ($1,018 per additional pregnancy averted). However, the probability that the ISP program is cost-effective for adolescents is never above 0.52, indicating that there is still a chance that 48% of the time pre-ISP is more cost-effective for this age group.

Figure 4-11. Cost-Effectiveness Acceptability Curve of ISP vs. Pre-ISP for Female Adolescents



4.7 Mortality and DALYs Associated with Unplanned Pregnancies Averted

The estimated number of deaths avoided before and during ISP implementation and the incremental number of deaths avoided with the ISP were calculated by applying condition-specific mortality rates to the number of pregnancies averted in each period. Before implementation of the ISP, 14,744 deaths were avoided per year due to averted unplanned pregnancies. During implementation of the ISP, this number increased to 17,694. By averting 41,150 more pregnancies per year, the ISP avoided an additional 2,950 maternal, fetal, and neonatal deaths (Table 4-6).

Table 4-6. Maternal, Fetal, and Neonatal Deaths Avoided Due to Averted Unplanned Pregnancies

Mortality	Condition	Pre-ISP	ISP	ISP – Pre-ISP
Maternal condition specific mortality	Maternal hemorrhage	502.76	603.37	101
	Maternal sepsis	134.89	161.89	27
	Hypertensive diseases of pregnancy	123.17	147.82	25
Fetal condition specific mortality	Fetal complication due to antepartum or intrapartum hemorrhage	1,131	1,357	226
	Obstructed labor	1,213	1,456	243
	Syphilis	802	962	160
	Malaria	329	395	66
	Fetal complication due to hypertensive diseases of pregnancy	1,131	1,357	226
	Fetal distress	2,241	2,690	449
Neonatal condition specific mortality	Birth asphyxia	2,159.10	2,591.18	432
	Neonatal infection	2,323.60	2,788.60	465
	Preterm complications	2,652.61	3,183.45	531
Total deaths averted		14,744	17,694	2,950

The number of DALYs avoided by averting the three leading causes of maternal and neonatal disability are presented in Table 4-7. Before implementation of the ISP, approximately 28 million DALYs were avoided due to unplanned pregnancies averted. This number increased to almost 34 million during the ISP period. The ISP was associated with an increase in DALYs avoided of around 5.6 million.

Table 4-7. Maternal and Neonatal DALYs Avoided Due to Averted Unplanned Pregnancies

DALYs	Condition	Pre-ISP	ISP	ISP − Pre-ISP
Maternal condition specific mortality	Maternal hemorrhage	1,381,823.19	1,658,353.51	276,530
	Maternal sepsis	117,208.22	140,663.91	23,456
	Hypertensive diseases of pregnancy	421,538.32	505,896.53	84,358
Neonatal condition specific mortality	Birth asphyxia	10,478,825.84	12,575,847.46	2,097,022
	Neonatal infection	6,600,673.26	7,921,599.36	1,320,926
	Preterm complications	9,187,479.17	11,026,076.62	1,838,597
Total DALYs averted		28,187,548.00	33,828,437.39	5,640,889.39

4.8 Cost-Effectiveness Results: DALYs Avoided

The incremental cost of the ISP, taking into account the implementation costs of the ISP and savings due to pregnancies averted, was $3,340,832 (see Table 4-4); and the incremental number of DALYs avoided was 5,640,889 (see Table 4-7). This results in an ICER of $0.6 per additional DALY averted.

4.9 Stratification by Wealth Quintile

In Table 4-8, pregnancies in the pre-ISP and ISP periods and pregnancies averted were distributed by wealth quintile. In addition, a range of pregnancies was included per wealth quintile for an exemplar year in the ISP period (i.e., 2014) and for the pregnancies averted annually between the pre-ISP period and the ISP period.

Table 4-8. Stratification of Fertility Rate by Wealth Quintile

Wealth Quintile	2011 Pregnancies Distributed by Fertility Rates	2014 Pregnancies Distributed by Fertility Rates	Pregnancies Averted Distributed by Fertility Rates
Poorest	114,059	121,529 (118,166–126,179)	10,288 (10,003–10,681)
Poor	109,755	118,166 (114,215–120,716)	9,899 (9,668–10,219)
Middle	94,690	100,892 (100,385–101,594)	8,541 (8,798–8,600)
Wealthy	81,778	87,134 (85,204–88,530)	7,376 (7,213–7,494)
Wealthiest	55,953	59,618 (52,424–64,822)	5,047 (4,438–5,487)

4.10 Scenario Analysis

Three scenario analyses were used to ensure the accuracy of the model results and that the model is behaving as expected:

1. No contraceptive intervention scenario
   - No contraceptive methods used (i.e., penetration and utilization of all contraceptives are zero)
2. High resource country contraceptive use
   - Rates for contraceptive penetration and utilization in the United States
3. Aggressive estimate scenario
   - IUD and male condoms set to 98% penetration and 98% utilization

The pregnancy rates resulting from these scenarios are presented in Table 4-9.

Table 4-9. Scenario Analyses

Scenario	Model Results for Pregnancy Rate (per 1,000 Women of Reproductive Age)	Expected Pregnancy Rate (per 1,000 Women of Reproductive Age)
1. No intervention	357.59	>279
2. U.S. estimate	103.47	102.1
3. Aggressive estimate	53.94	<80

4.10.1 Analysis of Scenario 1: No Intervention Scenario

Countries in Middle Africa have the highest pregnancy rates in the world, averaging about 279 pregnancies per 1,000 women of reproductive age (Sedgh, Singh, & Hussain, 2014). Some contraceptive methods, even if not modern methods, are used in Middle Africa, and therefore a higher pregnancy rate is expected under a scenario of no intervention. The pregnancy rate obtained with the model under this scenario was 358, which is higher than the highest pregnancy rate reported and reassures us that the model is behaving as expected.

4.10.2 Analysis of Scenario 2: High Resource Country Scenario

Penetration and utilization rates were modified to reflect contraceptive use rates in the United States. In addition, contraceptive care seeking behavior was modified to reflect the higher number of women in the United States who have access to and seek contraceptive care compared with women in Zimbabwe. The number of women currently pregnant was adjusted to reflect the lower number of women currently pregnant in the United States. The model resulted in a pregnancy rate of 103. The reported pregnancy rate in the United States is 102 (CDC, 2013). This is a variation of 1.01%, which reassures us that the model is working accurately.

4.10.3 Analysis of Scenario 3: Aggressive Estimate Scenario

The final scenario is hypothetical since no country has perfect use of IUD and male condoms. Some of the lowest pregnancy rates in the world are around 80 pregnancies per 1,000 women (Sedgh, Singh, & Hussain, 2014). Thus, the model should produce a slightly lower pregnancy rate when near perfect penetration and utilization (98%) of IUD and male condoms are used by women not planning a pregnancy. Under this scenario, the model produces 54 pregnancies per 1,000 women of reproductive age, which is a result in the correct direction, thus ensuring that the model is behaving as expected.

5. WEB-BASED MODEL

5.1 Specifications of the Web Model

The deterministic Excel-based ZAP model was converted into a web-based platform that is freely available to all users. This web-based model is available at www.zap4contraceptives.org. The web-based model uses the .NET MVC (model view controller) framework 3, utilizing code developed in .NET 4/C#. It relies on a Structured Query Language (SQL) Server 2005 back-end database and employs Javascript, jQuery, and jQueryUI libraries for the user interface. This web model is compatible with most updated browser versions. The web model allows users to create a scenario by altering input parameters of the model. After the user runs a scenario, the web model produces a report page that provides a comprehensive summary report of the scenario, with output tables and/or graphs. This summary report can then be downloaded as a pdf.

5.2 Quality Assurance of the Web Model

QA checks of the web-based model were conducted to ensure optimal performance. First, the Excel-based model was rigorously calibrated. That model was then used as the benchmark for the programming of the web model. Each mathematical line of the web-based model has been tested against the Excel-based model to ensure quality, accuracy, and completeness. Every contraceptive commodity has been tested online to confirm that the web-based model produces the same outputs as the deterministic results of the Excel-based model. This series of QA checks ensures that the models are free from error and that the Excel- and web-based models are functioning in sync.

5.3 Using the Web Model

The online web model can be used to review contraceptive use estimates in the pre-ISP and ISP periods. It can also be used to create customizable, hypothetical scenarios that reflect future goals or improvements in contraceptive access or use, or to compare and contrast scenarios to inform programming and policy decisions. To access the model, go to www.zap4contraceptives.org and then click the "start" button. Using the model entails three steps: (1) determining your input parameters; (2) modifying contraceptive penetration, utilization, and effectiveness rates (as needed); and (3) interpreting the results.

In Step 1, the user will be prompted to determine which input parameters (i.e., population, output estimations, and time frame) they would like to use for their modeling scenarios. Populations in the model can be all women of reproductive age, adult women, or female adolescents. Output estimation calibrates the model to report aggressive, moderate, or conservative estimates of pregnancies averted. The time frame selection allows the user to compare contraceptive use and pregnancies averted from two of the following three time frames: the pre-ISP period, the ISP period, or users may input their own custom future time frame.

After selecting the input parameters, the model will walk the user through each type of contraceptive in the model and report the penetration, utilization, and effectiveness of each contraceptive. The categories of contraceptives include non-commodity behavioral methods (i.e., abstinence, sterilization, lactational amenorrhea method, natural family planning), barrier methods (i.e., diaphragm, male condom, female condom, spermicide), long-acting methods (i.e., IUD and implants), and hormonal methods (i.e., oral contraceptives, injectable, patches, and emergency contraceptives). Users are discouraged from modifying the pre-populated baseline estimates for the pre-ISP and ISP periods, as these have been built off the best available estimates. However, a user can modify the baseline estimates if necessary. Any modifications to the baseline estimates must be disclosed when reporting ZAP estimates and supported with references. The disclosures only apply to modifications of the calibrated pre-ISP and ISP baselines. On the other hand, users are encouraged to create hypothetical future scenarios. The model allows the user to create any futuristic or hypothetical scenario without any additional disclosures.

To interpret the results, the user will be given a summary report of the results of their chosen scenarios. The report includes the following sections: pregnancies, mortality, cost, contraception, condition map, assumptions, references, and save. The pregnancies report calculates the unplanned pregnancies averted in each of the two time frames selected and the pregnancy rate stratified by health care setting, and provides a graphic display of the pregnancies averted. The mortality report gives the mortality due to the pregnancies averted. Difference in mortality is reported by maternal, fetal, and neonatal populations and is striated by the major causes of mortality for each population. The cost report calculates the average annual amount of money spent (in 2014 U.S. dollars) to procure the total number of contraceptives used during the first and second time frames selected. The contraception tab denotes average annual number of commodities used in the first and second time frame selected. The condition map visually depicts which contraceptives are available to the user in the model. The assumptions page displays every number that contributed to the model’s outputs. The references page highlights key references used to calibrate the model. Finally, the save page allows a user to download a pdf of their modeled scenario.

The intended purpose of the web model is to highlight pregnancies averted due to the ISP program. However, adding the capacity for users to model futuristic scenarios allows stakeholders in Zimbabwe to compare the relative costs and benefits of a range of contraceptive scenarios in Zimbabwe.

5.4 Similarities and Differences between Excel and Web Model

The Excel and web models operate using the same mathematical structure, contraceptive interventions, and parameters. Both models provide yearly estimates for unplanned pregnancies averted, mortality averted, DALYs averted, and contraceptive costs.

However, each format of the model also provides users with slightly different capabilities. For example, the Excel model can provide users with both probabilistic and deterministic outputs, whereas the web model provides only deterministic outputs. The Excel model allows a user to change every potential parameter in the model, whereas the web model only allows users to change penetration, utilization, and effectiveness. The Excel model uses the number of women of reproductive age in year 2014 for the IPS period and year 2011 for the pre-ISP period, while the web model uses an average of the number of women of reproductive age across all years of each period as the starting population to model. Both the Excel and web models report annual estimates. Another difference is the ease of use. The web model is designed to be easy to use after minimal training, but the Excel model requires extensive training. Ultimately, the web model is slightly less flexible because some of the features that are more prone to error or would impact model performance are not modifiable on the web model. However, it has the advantage that any user can easily interface with the web model and plan for future contraceptive program planning.

6. CONCLUSIONS

The ZAP model was developed to estimate the number of new family planning users, the number of unplanned pregnancies averted, cost-effectiveness, and a range of related outcomes as a result of implementation of the ISP in Zimbabwe. Although a number of family planning models exist, none are appropriate for evaluating the impact of ISP intervention strategies. The ZAP model specifically compares the designated pre-ISP (2009–2012) and ISP implementation (2013–2015) periods, using all available locally relevant data from public and private sector sources on procurement, distribution, availability, and use. This allows for more accurate parameter value estimates than other models, which have relied solely on secondhand country-level, public sector data. The model is a probabilistic cohort model, allowing for sensitivity and subgroup analyses to be run. Extensive QA checks were conducted to ensure the highest level of model parameter quality, accuracy, and completeness.

6.1 Summary of Results

The ISP attained the objective of increasing the numbers of family planning users and unplanned pregnancies averted. During the ISP period, a total of 1,144,092 (95% CI 915,274-1,372,910) (30.5%) women had access to family planning commodities. Compared with the pre-ISP period, 256,623 (95% CI 205,298-307,948) more women of reproductive age had access to family planning commodities during ISP implementation, representing an increase of 13%. In addition, 41,150 (95% CI 5,783–75,914) more pregnancies were averted in the ISP period than in the pre-ISP period. This represents an increase of 5%, after adjusting for the number of women of reproductive age. The positive impact of the ISP was observed for all women of reproductive age and for adult women, but not for female adolescents. In fact, the number of unplanned pregnancies averted decreased by 11% among female adolescents during the ISP, which might indicate that the program did not reach this population to the same extent that it reached adults. However, these results among female adolescents must be interpreted with caution due to the small sample size and large credible intervals for data inputs.

Overall, there was an increasing trend in the use of most modern contraceptives. The largest increase was for oral contraceptives, which increased by 18% for all women of reproductive age, 22% for adult women, and 11% for female adolescents. Implants and emergency contraception were rarely used by female adolescents in either the pre-ISP or ISP period. IUDs and female condoms were not used by female adolescents, either before or during implementation of the ISP. The use of female condoms remained fairly stable for all women of reproductive age and for adult women.

The overall cost of contraceptives increased during the ISP, as a result of increased usage. Taking into account contraceptive and program costs, the cost of the family planning portion of the ISP was around $13.8 million, an increase of $4.6 million. When accounting for savings related to avoiding unplanned pregnancies, the total cost of the ISP was $6.4 million, an increase of $3.3 million compared with the pre-ISP period.

The cost-effectiveness results show that the ISP is a highly cost-effective strategy for preventing unplanned pregnancies for all women of reproductive age and adult women, if decision makers are willing to pay approximately $81 to $84 per unplanned pregnancy averted. However, for female adolescents, there is a high level of uncertainty around whether the ISP was cost-effective.

6.2 Challenges

The interpretation of these results should take into consideration that a model is always a simplification of reality. It should also be emphasized that a model is only as good as the data that feed into it. Although the model was populated using data derived from local entities responsible for routine collection of family planning data for each year of the pre-ISP and ISP periods, data were not uniformly available. As such, at times it was necessary to incorporate data from secondary data sources. These included nationally representative surveys, which are high-level data generally conducted at approximately 3- to 5-year intervals in Zimbabwe rather than annually. It was also necessary to incorporate data from published literature, which were not always specific to Zimbabwe. These secondary data sources led to less precision in the estimates of model parameters. An important secondary data source is the DHS survey, for which select data parameters were obtained for the pre-ISP period. However, although a DHS survey was conducted in 2014–2015, those results have not yet been published, and thus comparable data were not available for the ISP period.

For certain variables, data were absent or imprecise. This was addressed by assuming higher uncertainty in input values, which was reflected in the wide confidence intervals of several of the model outputs. For example, the cost of the programs pre-ISP and during the ISP period were associated with high uncertainty because the estimates were informed by budgets that were not specifically reporting cost data for the family planning component of each program. Data on wealth quintiles were not available during the ISP period. To compare program impact by wealth quintile, it was necessary to make assumptions about trends in pregnancy and fertility rates by wealth based on data from earlier time periods prior to ISP implementation. This is a distinct limitation, particularly given the dynamic economic environment in Zimbabwe, and these results should be interpreted with caution. The majority of data used to populate the ZAP model were derived from programmatic data and local partner data, with the incorporation of data from national surveys where appropriate. Ideally, these data would be compared with data reported in the peer-reviewed literature as a quality control measure; however, the limited literature base specific to

Zimbabwe precluded this comparison in most instances. Although data are likely more representative than if DHS or other survey data alone were used, the model relies heavily on the quality of the data collection processes and reporting of these sources. There is often uncertainty around this. In addition, few data sources disaggregated values by age of contraceptive user (female adolescents vs. adult women) and by wealth quintile, thus making it challenging to cross-check the sources.

Data on contraceptive usage pre-ISP and post-ISP were not available on an annual basis. Only aggregate contraceptive usage was available for each period. Data were also not available from communities that did not receive the ISP intervention in Zimbabwe, to serve as comparison groups. For that reason, trends in contraceptive usage could not be examined within each period or forecast per-ISP usage to the ISP period; the pre-ISP rate was assumed to be the same during the ISP period had the ISP not be present. This pre-post comparison represents a study limitation, as it lacks a counterfactual and therefore all change identified is attributable to the ISP.

6.3 Model Cross-comparison

Model inputs and outputs were compared with those from Spectrum's FamPlan model and Impact2 during select years of the pre-ISP and ISP time periods (2011 and 2014, respectively). Key inputs included number of sexually active women, annual risk of pregnancy among sexually active women, and effectiveness of contraceptives. Key outputs compared were the number of family planning users, number of pregnancies, and the percentage of women of reproductive age using each contraceptive method. Inputs were within the range of values used in FamPlan and Impact2 (Table 6-1).

Table 6-1. Standard Inputs between ZAP, FamPlan, and Impact2

Contraceptive	Variable	ZAP	FamPlan	Impact2
Male Condoms	Coverage	3.50%	3.10%	3.5%
	Effectiveness	82%	81%	82%
Female Condoms	Coverage	0.10%	0.10%	0.0%
	Effectiveness	79%	81%	79%
Oral Contraceptives	Coverage	20.67%	40.95%	27.2%
	Effectiveness	91%	92%	91%
Injectables	Coverage	7.80%	8.30%	6.1%
	Effectiveness	94%	100%	94%
IUDs	Coverage	0.20%	1.80%	0.2%
	Effectiveness	99.5%	96%	99.8%
Implants	Coverage	0.60%	1.80%	2.2%
	Effectiveness	99.9%	100%	99.9%

Comparisons with Impact2 are not appropriate, because those estimates were regional, whereas ZAP estimates are specific to Zimbabwe. FamPlan model outputs are higher than ZAP outputs in terms of number of family planning users and number of pregnancies in Zimbabwe. Furthermore, the proportion of family planning users using each contraceptive varied among some contraceptive methods. For instance, FamPlan estimates that the majority of contraceptive users relied on oral contraceptives. While oral contraceptive use was high as per the ZAP estimates, data from the ZAP model also suggest that women in Zimbabwe are more often using long-acting methods, such as injectable, implants, and IUDs. FamPlan does not provide information on the sources of their data, and it appears that aggregate data from several countries are used to inform country-level estimates. In contrast, Zimbabwe national surveys, such as DHS, along with local data sources were used to arrive at the ZAP estimates. This is likely to be the reason for any discrepancies and gives us confidence in the ZAP results and their specificity to Zimbabwe.

6.4 Implications for Zimbabwe

The ISP is a multi-component program with the overall objective of reducing maternal morbidity and mortality, cervical cancer, gender-based violence, and HIV through the provision of integrated reproductive health and gender-based violence prevention services. This study only evaluated components of the program that directly affect the use of family planning commodities in Zimbabwe. The following are key findings:

First, the research has demonstrated that **ISP efforts to increase access to and use of modern contraceptive methods were effective among women of reproductive age** in terms of increasing the percentage of women accessing contraception and decreasing the percentage of women experiencing an unplanned pregnancy. Data also demonstrate that the ISP is a relatively cost-effective strategy for reducing unplanned pregnancies.

Second, the research showed **large uncertainty and conflicting results concerning contraceptive use by female adolescents.** Exploring reasons for this finding is important, but outside the scope of this research. Follow-up research could focus on looking at the reasons for this, which may include a lack of knowledge about contraceptives and/or how to access them, stigma around contraceptive access and use, differential attendance at health facilities due to financial or logistical barriers, lack of adolescent-friendly services, or other reasons. Alternate and/or more targeted strategies may be required to cost-effectively reduce unplanned pregnancies in the adolescent population.

Third, approximately twice as many pregnancies were averted for women in the poorest wealth quintile compared with the wealthiest wealth quintile. Although unplanned pregnancies decreased substantially across all wealth quintiles, these results suggest that the ISP had the greatest impact on women in the poorest wealth quintile, providing contraceptive care to some of the most vulnerable women in Zimbabwe.

Fourth, some family planning commodities remain not readily available in Zimbabwe. In terms of modern contraceptive use, certain commodities such as patches and the diaphragm remain unavailable in Zimbabwe, and expanding access to all effective contraceptive methods may be a consideration for future programming. Although the use of long-acting reversible methods, such as IUDs and implants, demonstrably increased, their use overall was still modest. Furthermore, a number of effective modern methods, including IUDs and female condoms, were not accessed at all by adolescents. These represent important areas for further investigation when considering the way forward in family planning services in Zimbabwe. Programming that focuses on continuing to increase access and use of effective methods, particularly of long-acting reversible contraception, may be a promising strategy going forward. Determining cost-effective ways to reach adolescents with these commodities will also be an important consideration in future family planning programming and policy in Zimbabwe.

Fifth, the ISP family planning commodity distribution was cost-effective. These results indicate an estimated ICER of US$ 0.6 per DALY avoided. There are varying approaches for governments to determine whether an intervention represents good use of money for their national health care system. The World Health Organization (WHO) promotes an approach to this decision making that involves the use of thresholds based on per capita gross domestic product (GDP), known as the WHO Choosing Interventions that are Cost–Effective (WHO-CHOICE) project (WHO, 2014). WHO-CHOICE stipulates that an intervention that, per DALY avoided, costs less than three times the national annual gross domestic product (GDP) per capita is considered cost-effective, whereas one that costs less than one time the national annual GDP per capita is considered highly cost-effective. The GDP per capita in Zimbabwe in 2014 was US$931.20 (The World Bank, 2016). Following the threshold outlined in WHO-CHOICE, the family planning interventions implemented as part of the ISP would be considered highly cost-effective and should therefore be considered for integration into the national health care system.

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