THE COST-EFFFECTIVENESS OF IMPROVED COMMUNICATION OF PREGNANCY RISK AND CONTRACEPTIVE INFORMATION

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ABSTRACT

Seri Anderson: The Cost-Efffectiveness of Improved Communication of Pregnancy Risk and Contraceptive Information
(Under the direction of Kristen Hassmiller Lich)

To prevent unplanned pregnancies, the Centers for Disease Control and Prevention (CDC) recommends that women receive contraceptive counseling and suggests a contraceptive poster that it designed as one tool to accomplish this goal. However, the CDC poster has not been evaluated to determine whether it improves contraceptive knowledge or intentions. Furthermore, it was not developed with the input of patients. This project's *overall objective* was to fill these gaps in the literature by creating and evaluating a patient-centered poster designed to better communicate information about pregnancy risk and contraceptive effectiveness. My *central hypothesis* was that the patient-centered poster would be a more cost-effective and acceptable method of preventing unplanned pregnancies among women of reproductive age than the CDC poster. This project is *innovative* because it draws on women's insights to develop the poster.

This project's *first aim* compared the comprehension, relevance, and acceptability of the two posters through cognitive interviews with N=26 women. The *second aim* compared how effectively the two posters changed: women's contraceptive knowledge, the accuracy of women's perceived pregnancy risk, and the effectiveness of the contraceptive methods women were most likely to use in the following year. We did this by conducting a randomized control trial of the posters in an Amazon Mechanical Turk sample of N=990 women. The *third aim*

compared the cost-effectiveness of the two posters in comparison to the status quo. To do this, we created two Markov models using a private payer perspective.

In the ***first aim***, we found that the final version of the patient-centered poster was preferred overall and in terms of comprehension and relevance by the majority of women. It generated few remaining acceptability issues. In the ***second aim***, we found that the patient-centered poster improved contraceptive knowledge significantly more than the CDC poster, and both posters significantly improved the effectiveness of women's most likely contraceptive method. In the ***third aim***, we found that both the patient-centered and the CDC poster reduced costs and improved health outcomes relative to the status quo. This project helps advance the CDC counseling recommendation and the Healthy People 2020 goal of reducing unplanned pregnancies.

Dedicated to my Grandmother, who started me on this path.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
NSFG	National Survey of Family Growth
OPA	Office of Population Affairs

CHAPTER 1: INTRODUCTION AND OVERVIEW

Specific Aims

In the US, unplanned pregnancies cost the public $21 billion annually [2] while harming the health of women and children [3]. Despite representing only 14% and 18% of the women at risk of an unplanned pregnancy, 54% and 41% of unplanned pregnancies occur among women who do not use contraception or who use it inconsistently, respectively [4]. Two key reasons [5, 6] for inconsistent or non-use of contraception are that 40% of women greatly overestimate contraceptive failure rates [7], and 24% of women greatly underestimate the long-term risk of pregnancy associated with unprotected sex [8]. The Centers for Disease Control and Prevention (CDC) has a poster that is designed to educate women about contraceptive effectiveness, but its effectiveness has not been evaluated, and it does not provide information about women's baseline pregnancy risk. Furthermore, it was not designed with the input of patients. An innovative, evidence-based new contraceptive poster is needed to prevent costly and harmful unplanned pregnancies.

This project's objective was to create and evaluate a patient-centered poster designed to better communicate information about pregnancy risk and contraceptive effectiveness. *My central hypothesis was that the patient-centered poster would be a more cost-effective and acceptable method of preventing unplanned pregnancies among women of reproductive age than the CDC poster.* This work had three specific aims:

Aim 1: Compare the comprehension, relevance, and acceptability of the CDC poster and the patient-centered poster among women of reproductive age.

Aim 2: Compare the effect of the CDC poster to the patient-centered poster on changes in women's contraceptive knowledge, the accuracy of women's perceived pregnancy risk, and the effectiveness of the contraceptive methods women were most likely to use in the following year.

> **Hypothesis 1:** In an online randomized control trial, women shown the patient-centered poster will increase their contraceptive knowledge, express an intention to use more effective contraceptive options, and increase the accuracy of their perceived risk of pregnancy compared to women shown the CDC poster.
>
> **Hypothesis 1a-c:** Hypothesis 2 holds for women with past pregnancy scares, low numeracy, and no current contraceptive method.

Aim 3: Compare the cost-effectiveness for preventing unplanned pregnancies of the CDC poster and the patient-centered poster compared to the status quo, which is the current distribution of contraceptive methods observed in the US population.

> **Hypothesis 2:** Using two Markov models, exposure to the patient-centered poster will cost-effectively prevent unintended pregnancies compared to the status quo.

This project's expected outcome is the estimated cost-effectiveness for preventing unplanned pregnancies of both posters. This project helps advance the CDC recommendation to provide contraceptive education during reproductive counseling [9] and the Healthy People 2020 goal of reducing unplanned pregnancies [10].

Significance

A. Unintended pregnancies are common and harm the health of mothers and infants.

Unintended pregnancies comprised 45% of pregnancies in the United States in 2011 [11]. This means that nearly 5% of reproductive age women (aged 15-44) will experience an unintended pregnancy each year [11]. Unintended pregnancies are associated with poor outcomes for mothers [3]: delayed prenatal care [12], reduced economic stability [13], and

worsened mental health [14]. Unintended pregnancies are also associated with poor outcomes for infants [3]: premature birth [15], worsened relationships with parents [16], and reduced economic investment in children [13].

B. The current approach to communicating contraceptive effectiveness encourages misinterpretation.

The CDC poster focuses on statistical and relative contraceptive effectiveness [17], as do most paper posters. This approach has two weaknesses. First, it does not report a pregnancy rate for unprotected sex. As a result, the CDC sheet may not educate the 1 in 4 women who underestimate the annual probability of pregnancy for unprotected sex by >15 percentage points [8]. Second, the sheet presents contraceptive effectiveness using one-year failure probabilities, which people rarely interpret accurately [18]. Consequently, the CDC poster may correct few of the 4 in 10 women who greatly overestimate contraceptive failure rates [7, 18]. The limitations of the CDC poster have real consequences: when women overestimate the likelihood of pregnancy with protected sex or underestimate the likelihood of pregnancy with unprotected sex, they are less likely to use contraception [6, 19-21]. Communication research suggests that when teaching people about risk, we should avoid statistical jargon and help people realize their behavior puts them at risk [22]. We pilot tested a poster that avoided jargon in its presentation of the effectiveness of each contraceptive method and no method (Aims 1-3).

C. Research on the cost-effectiveness of contraceptive posters has significant implications for policy and practice.

Reducing unintended pregnancies to 44% is a Healthy People 2020 goal [10]. Because of this, CDC recommends reproductive counseling at every patient contact and suggests using the CDC poster to educate people about contraception [9]. However, it is unknown whether this recommendation is cost-effective, because the effectiveness of the CDC poster has not previously been evaluated. This project is ***significant*** because it will 1) pilot several novel

methods of communicating risk that could be applied to other prevention goals, 2) test the cost-effectiveness of the CDC poster, and 3) pilot test a new poster for preventing unplanned pregnancies (Aims 1-3).

Innovation

When women have more contraceptive knowledge they tend to use more effective contraception [23], but researchers do not know whether contraceptive posters are a cost-effective educational intervention. Regardless of the outcome of this project, the results will influence clinical practice by providing evidence to improve CDC's recommendations regarding contraceptive posters.

Furthermore, this project is innovative because it tests several novel measures of probabilistic risk that could both help women rank contraceptive methods by effectiveness while also correcting misconceptions that increase contraceptive non-use. Finding a method of communicating risk that is intuitive and understandable for less numerate people would be advantageous for public health work in reproductive health and other preventable conditions. It is also innovative because it draws on the expertise of average patients to design a poster that meets the average woman's communication and informational needs.

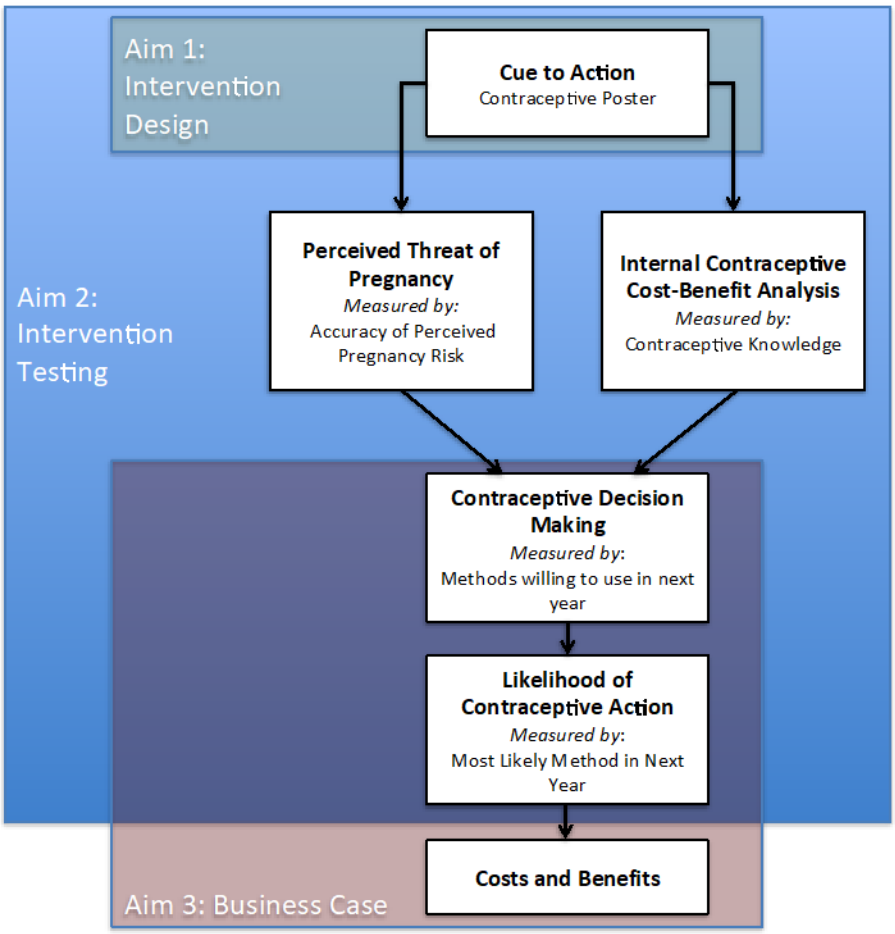


Figure 1.1 Contraceptive Health Belief Model

Conceptual Model

The conceptual model for this study is Hall's Contraceptive Health Belief Model [24] (Figure 1.1). This model posits that the likelihood of contraceptive behavior is dependent on individual decision making, which is determined by a number of factors: the perceived threat of pregnancy, a contraceptive-cost-benefit analysis, and modifying and enabling factors (not shown). Hall demonstrates that evidence consistently supports the links between each of the domains in this model [24].

In the context of this model, Aim 1 refines the cue-to-action intervention, which is the patient-centered contraceptive poster. Aim 2 tests how this cue affects contraceptive decision-making and likelihood of contraceptive behavior by changing the perceived threat of pregnancy

and a woman's contraceptive cost-benefit analysis. Aim 3 makes a business case by testing how the posters influence costs and benefits by changing individuals' contraceptive decision-making and likelihood of contraceptive behavior.

Approach

I will describe my approach to each aim individually. Throughout, I study women of reproductive age, defined as women age 18-44.

Aim 1

Introduction. This aim's *objective* was to compare the comprehension, relevance, and acceptability for the two posters. My planned *approach* was to conduct cognitive interviews with approximately 20 women about the posters (Figure 1.2). The interviews occurred in several waves, with revisions to the patient-centered poster after each wave. The *rationale* was to refine the patient-centered poster and provide feedback to the CDC on its poster. The *expected outcomes* were: 1) a refined patient-centered poster that was comprehensible, relevant, and acceptable to the majority of women, 2) suggested revisions to the CDC poster to improve comprehension, relevance, and acceptability, and 3) a qualitative understanding of how the patient-centered poster compares to the CDC poster in terms of comprehension, relevance, and acceptability.

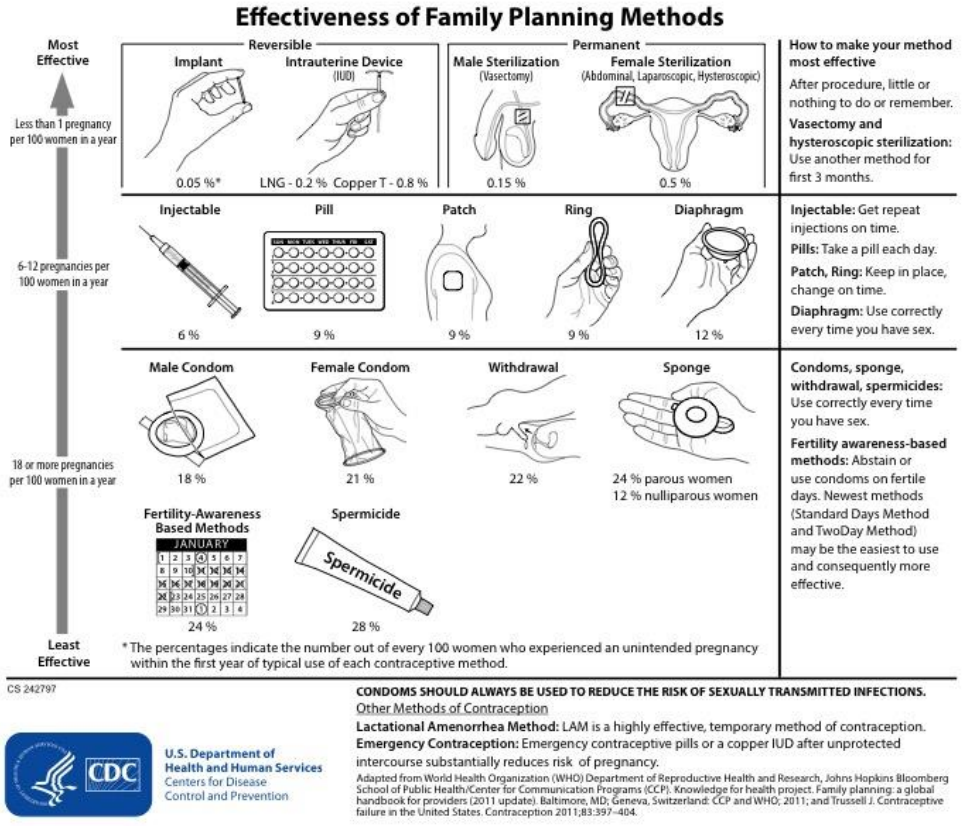
Procedures. I conducted cognitive interviews with 26 women age 18-44 living in North Carolina who spoke and read English and who had ever had sex. These women were recruited from a University email list, a women's health research center, and a Family Medicine practice. We purposively sampled women to have a range of characteristics that might influence their perspectives. Cognitive interviewing explores breakdowns in the process of understanding and responding to outside information [25], and has previously been used to test comprehension of contraception education materials [26]. It requires an iterative cycle of revisions and

interviewing. I used the "think-aloud" method with semi-structured interviews to elicit responses to the posters [27].

Analyses. We conducted interviews in unequal-sized waves until saturation was reached within the wave; we continued adding waves until we reached a wave where there were no suggestions warranting major revisions to the patient-centered poster. The interviews were audio recorded, transcribed, and coded for themes. A second researcher coded half of the interviews. Using the thematic codes and transcriptions, after each wave I created a structured report for each poster documenting issues that arose, the number of women mentioning an issue, and the number of mentions [25]. The summaries were used to decide what revisions to the patient-centered poster were needed [25].

Limitations. The primary limitation of this study is that it only includes women who live in North Carolina, which limits the generalizability of the results.

Aim 2



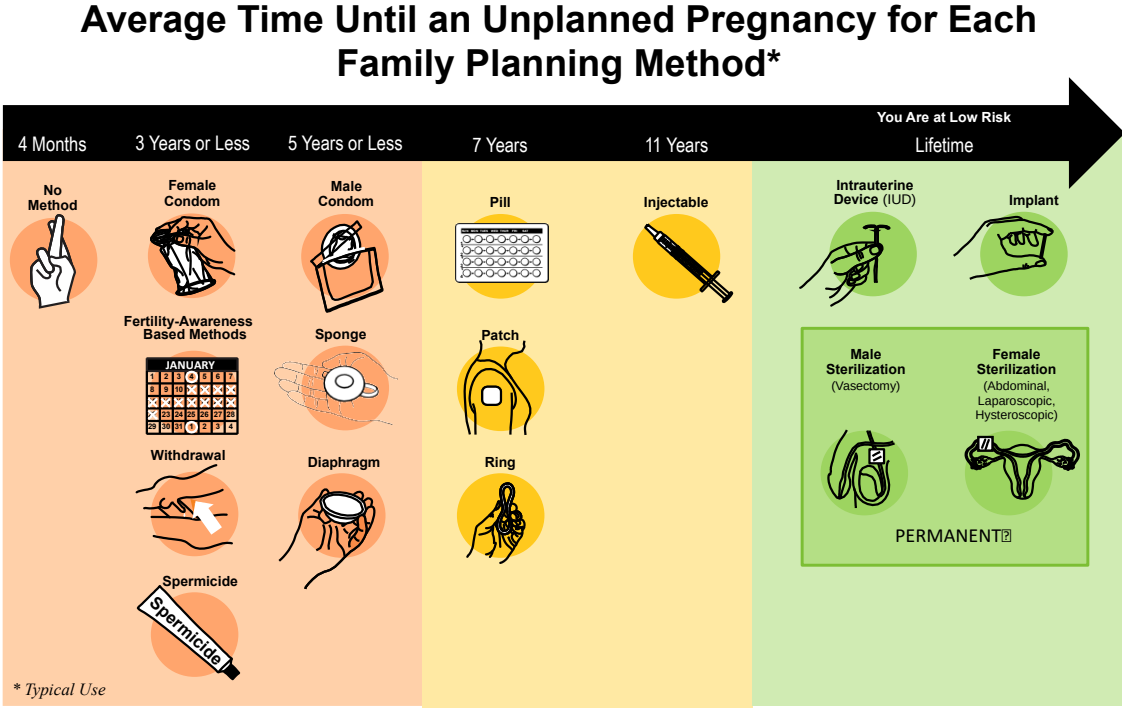


Figure 1.2 CDC and Initial Version of Patient-Centered Posters

Introduction. This aim's *objective* is to compare the effect of the CDC poster to the patient-centered poster on changes in women's contraceptive knowledge, the accuracy of women's perceived pregnancy risk, and the effectiveness of the contraceptive methods women were most likely to use in the following year. I tested the *working hypothesis* that the patient-centered poster would significantly improve all of these outcomes compared to the CDC poster, with subgroup analyses of this hypothesis among women with a previous pregnancy scare, low numeracy, or no current contraceptive method. My *approach* was to conduct a randomized control trial using an online national sample of approximately 1,000 women aged 18-44 who were sexually active with a man in the past three months, not seeking pregnancy, not pregnant, and who spoke and read English. The *expected outcomes* were pilot results on: 1) whether the CDC or patient-centered posters improve risk factors for unintended pregnancy, 2) whether these results hold for particularly vulnerable subgroups of women, and 3) whether either poster performs significantly better than the other.

Data Sources. I collected primary data on N = 990 women for this aim using Amazon Mechanical Turk. Amazon Mechanical Turk data are generalizable to American internet users and have been found to be as reliable as data from other sources [28, 29].

Key Variables and Measures. The survey will have screening questions, a "before exposure" section, exposure to one of two posters, and an "after exposure" section.

I measured current contraceptive use by asking women before exposure to a poster what method they used in the past three months. All other outcome variables are measured before and after exposure. Contraceptive knowledge was measured using the validated, 25-question Contraceptive Knowledge Assessment [30]. We measured contraceptive intentions by asking whether they 1) intend to continue using their current method and 2) rank which methods they

would be willing to use if they had to switch methods in the next year. To measure accuracy of pregnancy risk perception, women were asked whether their chances of getting pregnant this year were very high to very low, and this response was compared to their true risk based on their current contraceptive method.

Before exposure I asked whether the woman had ever had a pregnancy scare and I measured numeracy using the Berlin Single-Item Numeracy scale [31]. I used standard questions from the National Survey of Family Growth and the National Longitudinal Study of Adolescent to Adult Health to measure potentially confounding variables (see Chapter 4).

Analysis. First, we used two-sample t-tests and likelihood-ratio tests to test whether the confounding variables were balanced between the two randomized groups. Because there were no significant differences between the groups, we did not control for these variables. We also presented information on the distribution of similar covariates in a nationally representative sample: the 2013-2015 National Survey of Family Growth. We then tested whether each poster improved the three outcomes relative to baseline and relative to the other poster using two-sample t-tests on the change in the mean score for each outcome. Finally, we tested the same hypotheses in the three subgroups: women with prior pregnancy scares, low numeracy, or no current contraceptive method.

Limitations. A limitation of this study is the lack of follow-up data on women's contraceptive usage. However, this project is intended as a pilot study to assess the potential of these posters; future research should evaluate their performance in a clinical setting.

Aim 3

Introduction This aim's *objective* was to estimate the cost-effectiveness of using the CDC and patient-centered posters to prevent unplanned pregnancies compared to the status quo. I tested the *working hypothesis* that exposure to the patient-centered poster would cost-effectively prevent unintended pregnancies compared to the CDC poster and the status quo. My *approach* was to use two Markov models comparing the costs and benefits associated with contraceptive choices made after exposure to either poster or the status quo. The first Markov model did not simulate contraceptive switching and discontinuation, making the assumption that the population-level contraceptive mix is relatively stable. The second model did simulate contraceptive switching and discontinuation. The *rationale* for this study was to produce a business case for using these contraceptive education posters. The *expected outcome* was cost-effectiveness estimates for each poster.

Procedures. I built two Markov models in TreeAge Pro Healthcare that simulated the behavior of a hypothetical cohort of women who do not intend to conceive and are of reproductive age. Input probabilities and costs for this model were sourced from a literature review and Aim 2 primary data.

Key Variables and Measures. The health outcomes for this model were number of unplanned pregnancies averted and quality-adjusted life years. Women chose a contraceptive method using the distribution in preferences observed after being exposed to each poster or at baseline (for the status quo) in Aim 2. After choosing a method, women could experience one of four possible method failures or no failure that year. In the switching model, women could choose to switch to a new contraceptive method at the end of the year. This cycle repeated for five years. We chose this time horizon because long-acting contraceptive methods have high up-front costs, but are effective for a long period of time [1]. Costs were measured in 2017 US

dollars. I incorporated costs associated with method failures, contraceptive methods, and visit(s) for obtaining the method.

Analysis. I calculated incremental cost-effectiveness ratios for unplanned pregnancies averted and quality-adjusted life years, as well as a cost-effectiveness acceptability curve [32-34]. I will quantify uncertainty using a probabilistic sensitivity analysis [33] and a bivariate sensitivity analysis varying the implementation costs and effectiveness of the posters.

Limitations. Because Aim 2 only collected contraceptive intentions rather than behavior, this study assumes that women's intentions are acted on perfectly. The results are also only generalizable to the same population that the Aim 2 results are generalizable to; this likely means the internet-using population of women aged 18-44.

Summary of Contributions

The findings from this research provide evidence to enhance CDC's 2014 Quality Family Planning recommendations regarding contraceptive counseling using contraceptive posters. This project also tested several novel ways of communicating probabilistic risk. This research is important because to achieve the Healthy People 2020 goal of reducing the number of unplanned pregnancies in the US, every aspect of our contraceptive counseling must help women choose contraception that is in accordance with their reproductive goals. We can educate women while preserving their right to choose the contraceptive method of their choice using simple, inexpensive posters like the posters tested here.

CHAPTER 2: LITERATURE REVIEW

Overview

The goal of this dissertation is to refine and pilot test a new, patient-centered contraceptive effectiveness educational poster and compare it to a poster created by the CDC. This dissertation is needed because the CDC poster does not include information to address common misconceptions about pregnancy risk and contraceptive effectiveness. These misconceptions increase the likelihood that women will have unprotected sex [19, 23, 35-38]. This chapter will review the literature on the prevalence, sources, and consequences of these misconceptions about pregnancy risk and contraceptive effectiveness. It will also give an overview of the currently available contraceptive posters and decision aids, as well as previous studies of the posters' ability to change women's misconceptions and improve women's contraceptive behavior.

Prevalence of Pregnancy Risk Misconceptions

I define a pregnancy risk misconception to mean underestimating the risk of pregnancy with unprotected sex. A subtype of this misconception is perceived infertility: when a person wrongly thinks they cannot conceive. CDC reports that in 2013 about 6.1% of married women in the United States are infertile, meaning they are unable get pregnant after at least 12 months of unprotected sex [39]. However, many more than 6% of women believe that they might be infertile or underestimate the risk of pregnancy with unprotected sex. Between 14.6%-21.5% of women aged 15-29 have reported thinking that it is very likely that they are infertile on both large nationally representative surveys [40, 41] and single-state surveys [35, 36]. A small study

that I conducted using an Amazon Mechanical Turk survey of N = 242 women aged 18-44 found that 55% of these women thought that it was at least slightly likely that they were infertile.

Misconceptions about the general likelihood of conceiving with unprotected sex are similarly common. In a national survey of 1,392 women with no history of abortion recruited at family planning clinics, 91% inaccurately estimated the risk of conception from having unprotected sex once, and 25% underestimated the probability of pregnancy associated with a year of unprotected sex by >15 percentage points [8]. A second study conducted through the Contraceptive CHOICE project found that 14% of women thought that the annual chance of pregnancy without contraception was <10% (an underestimate of at least 75 percentage points) [42]. Finally, public and private health care providers rank "underestimating pregnancy risk" as the second most prevalent problem among contraceptive clients [43]. *In summary, at least twice as many women believe they are infertile as actually are infertile, and 14-25% of women dramatically underestimate the risk of pregnancy associated with a year of unprotected sex.*

Prevalence of Contraceptive Effectiveness Misconceptions

I define contraceptive effectiveness misconception to mean underestimating the effectiveness of contraception. For reference, the CDC categorizes contraceptive methods into three categories based on effectiveness: very effective methods have an annual risk of pregnancy 0-1%, effective methods have an annual risk of 2-9%, and somewhat effective methods have an annual risk of 10-30% [7]. Very effective methods include IUDs, implants, the hormonal shot, and surgical sterilization. Effective methods include birth control pills, the patch, and the ring. Somewhat effective methods include condoms, spermicide, and natural methods like withdrawal and fertility awareness.

Many studies have shown that US women know very little about the effectiveness of contraception. In the "Fog Zone" national survey of 1,800 unmarried men and women aged 18-

29, 40% of women believe that the chance of getting pregnant within a year while using the birth control pill is 50% or greater (true probability: 2-9%) [41]. This lack of knowledge does not translate into a lack of confidence: in the same study, 90% of these young adults felt that they had all of the information they needed to protect themselves from pregnancy [41]. In a national survey of 1,392 women with no history of abortion recruited at family planning clinics, only 26% of women correctly assessed the effectiveness of condoms, 61% for the effectiveness of OCs, and 56% for IUDs [8]. In a study of 433 reproductive-age US women, 70% of participants overestimated the risk of pregnancy with a very effective method by five percentage points, and 40% and 41% overestimated the risk of pregnancy with very effective and effective methods (respectively) by 15 percentage points or more [7]. Finally, a nationally representative survey of 623 unmarried 18-29 year old women who were at risk of unintended pregnancy found that only 50% of them received a grade of "A or B" on a contraceptive knowledge quiz, and 60% of them underestimated the effectiveness of the pill [23]. *In summary, these studies suggest that at most half of women can accurately estimate the effectiveness of various contraceptive methods, despite the fact that more than 99% of sexually active women of reproductive age have used at least one method of contraception [44]*.

Sources of Misconceptions

Studies have identified several sources of misconceptions about pregnancy risk and contraceptive effectiveness: a history of unprotected sex without pregnancy, alarmist sex education, poor communication with doctors, personal experience with contraceptive failures, and contraceptive failures among friends or family.

The first reason that a woman might believe she is infertile or has a low risk of pregnancy is having a history of unprotected sex without conception. In a sample of 300 teen girls aged 14-18 from an urban population, 18% of girls who ever had a negative pregnancy test

result ever thought they were infertile, compared to 6% of girls who had never had a pregnancy test (OR 3.23, 95% CI: 1.14-9.19) [37]. A second study of 32 women split into 4 focus groups found that women cited a history of unprotected sex without pregnancy to justify misconceptions about pregnancy risk [6]. Finally, qualitative interviews with 51 unmarried from two Bay Area community colleges found that when a woman had a history of unprotected sex without pregnancy, she believed that meant that she was unlikely to ever get pregnant [5]. In particular, women attributed this reasoning to sex education messages warning that pregnancy is the inevitable result of even one unprotected sexual encounter [5].

The second source of misconceptions about pregnancy risk is miscommunication with a doctor. The Fog Zone study found that 25% of the young women who believed they were infertile said that a doctor had told them so [41]. In a large qualitative study of women who received abortions at one California clinic, one researcher found that two-thirds of the women she interviewed said that a doctor had told them they could not get pregnant or would have trouble getting pregnant [45]. Since all of these women had received abortions, and thus were not infertile, further questioning often revealed that doctors had either told women with reproductive organs that vary from the norm that they "may have trouble conceiving", or had taken women off of their hormonal contraceptive methods in order to test their fertility [45]. Miscommunication by doctors resulting in increased risk of unplanned pregnancy did not end in the 1970s: 49% of abortion patients in a 2003 study reported undesirable provider behaviors like being taken off of oral contraceptives without being given a backup method [46]. *Providers who unduly worry women about potential infertility, or put women at risk of an unplanned pregnancy to test a woman's fertility, increase the chances that women will suffer from misconceptions about her pregnancy risk.*

Finally, misconceptions about contraceptive effectiveness can be attributed to how memorable method failures are. In a study of 32 women split into 4 focus groups, women cited anecdotal or personal experience with method failures to justify their misconceptions about contraceptive effectiveness [6].

In conclusion, misconceptions about pregnancy risk are likely attributable to a history of unprotected sex without pregnancy, alarmist sex education, and poor communication with doctors. Misconceptions about contraceptive effectiveness are attributable to personal experience with contraceptive failures or similar anecdotes from friends.

Consequences of Misconceptions

Misconceptions about pregnancy risk and contraception affect women's behavior. *Many studies confirm that when women are unlikely to use contraception if they think they are unlikely to get pregnant from engaging in unprotected sex.* Women who think they are unlikely to get pregnant are 1.5-3 times as likely as other women to have unprotected sex, even when controlling for baseline unprotected sex, demographic factors, and psychological factors [19, 35-38]. Women report in qualitative studies that one reason they choose to have unprotected sex is because of perceived infertility [6, 45]. Finally, one of the most frequently cited (40-44% of cases) reasons for having unprotected sex in both pregnant teens [47-50] and adult women with unplanned pregnancies [21, 50, 51] is perceived infertility. Furthermore, one study using Pregnancy Risk Assessment Monitoring System data from 7,856 women found that 66% of women only endorse one reason for having unprotected sex, and latent class analysis confirmed this finding. *This suggests that misconceptions about pregnancy risk are all that is needed for a woman to engage in unprotected sex* [51].

Women who underestimate the effectiveness of contraception are also less likely to use contraception; however, the evidence for this relationship is less strong. A national survey of

623 unmarried 18-29 year old women who were at risk of unintended pregnancy found that as their objectively-assessed contraceptive knowledge increased, the women were significantly more likely to use effective or highly effective birth control methods (17% increase in likelihood for each correct answer, $p<0.01$) [23]. These authors found the same association between knowledge and reported likelihood of having unprotected sex in the next three months (9% reduction in odds for each correct response, $p<0.05$) [23]. Finally, a study of unmarried women found that those who know less about the relative effectiveness of different contraceptive methods are less likely to use contraception [52]. However, one study which predicted previous unprotected intercourse found that the effect of underestimating the effectiveness of contraception was no longer significant after controlling for underestimating the risk of pregnancy, age, race, education, and perceived ease of access to birth control [19].

In conclusion, women who underestimate the risk of pregnancy with unprotected sex are much less likely to use contraception and there is some evidence that women who underestimate the effectiveness of contraception are also less likely to use contraception.

Contraceptive Effectiveness Posters

Because of the connection between contraceptive knowledge and pregnancy prevention behavior, the public health community has long tried to educate women about contraception. The CDC has recommended that every contact between women and a health care provider become an opportunity for education and reproductive life planning [9]. The CDC also recommends using contraceptive effectiveness educational tools, such as the CDC poster, during these contacts [9]. However, while posters explaining the effectiveness of contraception are available online, we were not able to identify any scientific evaluations of the effectiveness of these posters, nor were we able to find explanations of how they were developed.

On the other hand, several charts designed to communicate the relative effectiveness of different contraceptive methods, including a chart that seems to be the basis for the CDC poster, were evaluated in a previous study [7]. These charts include the FDA chart [53], the "categories" chart created by a group of contraceptive effectiveness researchers [7], and a chart similar to the CDC poster [54]. The FDA chart presents typical and perfect use rates for each method of contraception and no method in a table without any graphics. The "categories" chart [7] does not include typical or perfect use rates, but instead categorizes each method using the WHO categories of effectiveness and whether the method provides protection against STIs. The chart similar to the CDC poster combines the typical and perfect use rates with more general information about the broader effectiveness category that each contraceptive method falls into. It does not include the risk of pregnancy without a contraceptive method.

Previous Studies on Effectiveness of Counseling Posters

Each of these charts has strengths and weaknesses in terms of the information they include and the misconceptions they perpetuate. The three charts discussed previously (FDA, "categories", and CDC) do not provide all of the information that a woman might need to make a decision about which contraceptive method to use; instead, they complement the information that a practitioner can provide in response to a woman's needs and questions. A randomized trial conducted by Steiner et al. compared the side-by-side performances of these three charts in a sample of 433 women (age 18-44) recruited at five shopping malls around the US (2003). This trial found that the posters presenting pregnancy risk information numerically (FDA, CDC) increased the percent of participants who could correctly rank the pill and condoms or pill and hormone shot in terms of effectiveness by 14-20 percentage points [7]. On the other hand, the "categories" sheet poster did an even better job of improving participants' ability to rank methods by effectiveness, increasing the percent with a correct response by 27-37 percentage

points [7]. However, while the FDA and CDC charts appear to have improved women's ability to report failure rates for the contraceptive pill from 59 to 67%, the authors do not report whether the improvement was significant [7]. Furthermore, the "categories" chart demonstrated no improvement in misconceptions about contraceptive effectiveness [7]. *In conclusion, all three charts improved women's ability to rank methods in terms of effectiveness. However, if we want to educate women about actual contraceptive failure rates, then we cannot use "categories of effectiveness" alone, but must also provide numerical estimates of effectiveness.*

These results are supported by more general research on communicating risk information numerically. Humans, even those with some statistical training, have a number of biases when presented with probabilistic risk information. Cumulative probabilities are particularly problematic: when people are presented with a one-year probability of failure (as is the case in the FDA and CDC posters), they are unable to accurately predict how this translates to failure probabilities over longer periods of time [18]. Almost half of us do not predict that cumulative failure probabilities will increase over time [18]. The rest predict failure rates over time that increase too slowly and do not show large enough differences between contraceptive methods of different failure rates [18]. *In short, even if women could accurately estimate the one-year failure rates for different methods of contraception, they would still be overly optimistic about contraceptive failure rates over multiple years and pessimistic about them over the very short term.*

All contraceptive posters have to fight against women's widespread misconceptions about the baseline probability of pregnancy. Only the FDA chart includes the estimated risk of pregnancy with no method over the course of a year. *However, a Cochrane review found that no study has tested a poster's ability to improve women's knowledge on pregnancy risk [55], which*

is a clearer risk factor for contraceptive non-use than contraceptive effectiveness misconceptions.

Current research suggests many ways to improve counseling posters:

- The poster should present risk information non-probabilistically [18, 56].
- The poster should include the risk of pregnancy with no contraceptive method.
- The poster should also use visual cues to indicate the relative effectiveness of methods, since people tend to remember visual cues, not numbers [57, 58].
- The poster should include categories of effectiveness, but not rely on only categories to communicate contraceptive failure rates [7].
- The poster should present failure rates over longer lengths of time, since most women will use contraception for decades of their lives [18].
- Finally, the poster should help a woman place herself into the "high risk of pregnancy" category or the "low risk of pregnancy" category; people's preventive behavior is linked to whether they perceive themselves to be at low or high risk relative to other people [22, 58].

Contraceptive counseling posters should be redesigned using the wealth of evidence available about how to best communication risk information.

Finally, it is not a lost cause to rely on simple interventions like a poster to educate women about contraception and pregnancy. A systematic review of contraceptive education interventions found 21 interventions, of which nine used written materials/decision aids in either provider independent or enhanced settings [56]. Of these, six had a positive impact on knowledge [7, 59-62] and one found no impact. One of two that assessed the impact of written

education materials on actual contraceptive behavior found that compliance with oral contraceptive pill taking was increased [59]. *In conclusion, written educational materials can improve knowledge and promote pregnancy prevention behavior.*

CHAPTER 3: COGNITIVE INTERVIEWS TO IMPROVE A PATIENT-CENTERED CONTRACEPTIVE EFFECTIVENESS POSTER

Overview

Objectives: To refine by qualitatively comparing a patient-centered contraceptive effectiveness poster to a Centers for Disease Control and Prevention (CDC) poster based on comprehension, relevance, acceptability, design, and overall preference.

Study Design: We conducted cognitive interviews with 26 women aged 18-44 living in North Carolina who spoke and read English and had ever had sex. We interviewed women about both a CDC and a patient-centered poster in alternating order. Participants were contraceptive users and non-users that we selected purposively to have a range of characteristics that might influence their perspective: age, race/ethnicity, previous births and pregnancies, contraceptive method(s) used in the past three months, pregnancy intentions, and numeracy. The initial response rate for participants was 55%. We coded the interviews for comprehension, relevance, and acceptability as defined in cognitive theory, as well as design and overall preference. We structured the 26 interviews into four rounds and revised the patient-centered poster after each round to improve these measures.

Results: By the final round, 83% of women preferred the patient-centered poster overall, and it was preferred by the majority of women in terms of comprehension (86%), relevance (86%), and design (100%). Women raised few concerns about the acceptability of the final version of the patient-centered poster. Women identified many issues with both posters that the researchers did not anticipate, highlighting the value of patient-centered design approaches to educational materials.

Conclusions: This study refined a patient-centered poster so that its language is clear and it addresses the informational needs of its target audience.

Implications: The Centers for Disease Control and Prevention and the Office of Population Affairs recommend that clinicians educate women about contraception. This study developed a poster that could help clinicians follow this recommendation. Before widespread implementation, more research is needed to evaluate the poster's impact on contraceptive knowledge and behaviors.

Introduction

A Cochrane review of the effect of decision aids on helping people make health treatment and screening decisions found that decision aids like posters can improve knowledge and decision-making [9, 63]. A second systematic review of contraceptive education interventions, such as written materials, found that the majority improve contraceptive knowledge, and many can also significantly increase comfort with the decision making process and improve contraceptive intentions [56]. Some interventions have also demonstrated impacts on contraceptive use and pregnancy outcomes [56]. The Centers for Disease Control and Prevention (CDC) adapted an existing [7] contraceptive education poster (Figure 3.1) to help providers adhere to the CDC/Office of Population Affairs (OPA) recommendation that reproductive health counseling include contraceptive education [9]. However, while posters such as the CDC's are thoughtfully developed and scientifically accurate, they may not be designed with patients' input, as is recommended by the CDC and OPA [17]. When we involve patients in design, it helps make educational materials understandable [64], especially for the half of Americans with low health literacy [65]. Making health materials understandable is both a national priority, according to the Institute of Medicine [65], and important in sexual education specifically [17] because low literacy/numeracy have been associated with poor contraceptive knowledge and use [66]. We

used cognitive interviews to design a patient-centered poster that educates women about contraceptive effectiveness and their risk of pregnancy with unprotected sex; we tested this poster against the CDC's contraceptive effectiveness poster.

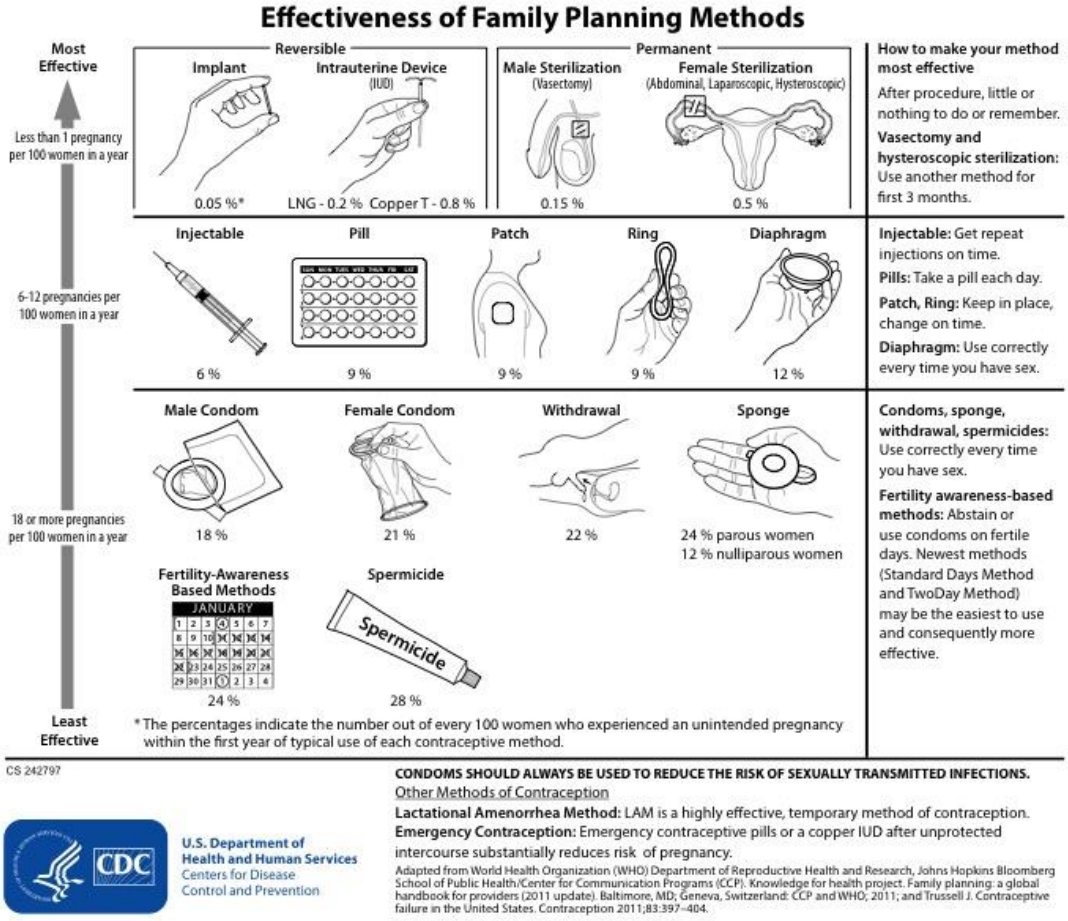


Figure 3.1 CDC-adapted Contraceptive Effectiveness Poster

Material and Methods

Participants

We conducted in-person cognitive interviews with 26 women in four unequal-sized waves (N=4, 7, 8, and 7). Women were age 18-44, had ever had vaginal intercourse, and were able to speak and read English. We recruited women through a Family Medicine clinic, a University email list, and a women's health research center. We used purposive sampling [67] to

recruit women with a range of characteristics that might influence their perspective on comprehension, relevance, and acceptability. These characteristics were age, race/ethnicity, previous births and pregnancies, contraceptive method(s) used in the past three months, motivation to avoid pregnancy, and numeracy (Berlin single item scale [31]). We did not provide compensation for participation. The University of North Carolina at Chapel Hill institutional review board approved this study (IRB #17-1246).

Cognitive Interviewing Procedure

Cognitive interviewing is a method for studying how people process and feel about written and graphical materials [25]. It is iterative, with rounds of interviews followed by refinements to the material being tested [25]. Cognitive interviewing has been used to test comprehension of educational materials [68-70] and contraceptive information [26].

We presented the posters in alternating order by interview. We used the combined method of cognitive interviewing, which begins with the participant "thinking-aloud" [27] as they process a poster, and then exploring their cognitive processing further in a structured interview [27, 71].

Measures

We measured comprehension, relevance, and acceptability, the three key components of cognitive processing identified by Tourangeau's cognitive theory [72] as adapted by Vreeman and Choi [73, 74]. We also measured design and preference.

Comprehension is a measure with two constructs: (1) intent, whether the respondent understands the information presented, and (2) meaning, whether the respondent understands the specific words and phrases used. We assessed intent by probing whether participants could use the poster to correctly answer questions about contraception. We assessed meaning by probing whether the participant understood the key terms on each poster.

Relevance (Tourangeau's "response mapping") is a measure of whether the information applies to the respondent. We assessed relevance by probing whether the participant found the information on the poster useful.

Acceptability (Tourangeau's "sensitivity") is a measure of whether the information seems truthful and inoffensive. We assessed acceptability by probing whether anything on the poster offended the participant and whether she believed the information on the poster.

Design was assessed by asking the participant to identify missing or extraneous information and propose changes to the poster's appearance.

Preference was assessed by asking the participant to select which poster she preferred in terms of comprehension, relevance, design, and overall.

Analysis

We audio-recorded and transcribed each interview and developed a framework to code the interviews for our measures. Using NVivo 11, after each wave one interviewer (SA) coded all and a second researcher (MB) coded half of the interviews described. The kappa agreement scores for the two coders were 0.77 (range 0.41-0.94) for comprehension, 0.76 (0.44-0.99) for relevance, 0.77 (0.24-0.97) for acceptability, and 0.76 for design (0.55-0.89). The coders resolved discrepancies through discussion. We created an overview report for each poster documenting issues, the number of women mentioning an issue, and the number of mentions. After each round, we used the overview to revise the patient-centered poster. Our saturation criterion for each round was when an interview produced no new suggestions warranting serious modifications to the poster.

Derivation of Contraceptive Effectiveness Measures

The CDC poster expresses contraceptive effectiveness using the annual failure rate with typical use of contraception [17]. The first versions of the patient-centered poster instead used

the theoretical average time-to-pregnancy for each contraceptive method. We derived these from the annual failure rates using the binomial probability function to solve for the time at which there is a 50% probability of at least one pregnancy having occurred. This measure estimates the average time women might expect to use a contraceptive method before they have an unplanned pregnancy, similar to how flood risks are commonly expressed [75]. This measure assumes that failure rates are constant over time, which may not be the case. Later versions of the poster used a "times more effective" measure of contraceptive effectiveness, which is calculated by dividing the probability of pregnancy for unprotected sex by the failure probabilities for each method. This measures gives how many times more effective at pregnancy prevention a contraceptive method is compared to having unprotected sex

Results

Of the 62 eligible women we invited to participate, 34 (55%) agreed, and 26 (42%) were interviewed before we reached saturation. Table 3.1 provides descriptive statistics for participating women on key characteristics. In general, the study sample was less likely to have children than US women generally, more likely to use highly effective methods of contraception, and less likely to be in the top 50% of the population for numeracy. The majority of women were trying to avoid pregnancy.

Table 3.1 Characteristics of Interviewed Women by Interview Round

	Round 1 (N=4)	Round 2 (N=7)	Round 3 (N=8)	Round 4 (N=7)	Total (N=26)
Average Age (Years)	30.5	30.7	29.1	27.9	29.3
Race/Ethnicity					
White	3	4	4	4	15
Black	1	2	3	0	6
Asian	0	1	1	2	4
American Indian/Alaskan Native	0	0	0	1	1
Any Children					
Yes	2	2	3	2	9
No	2	5	5	5	17
Ever Pregnant					
Yes	2	2	4	2	10
No	2	5	4	5	16
Method(s) Used in Past 3 Months					
Vasectomy	0	1	0	0	1
Sterilization	0	1	1	0	2
IUD	2	1	3	4	10
Implant	1	0	0	0	1
Injectable	0	0	1	0	1
Pills	3	4	4	4	15
Patch	1	0	2	0	3
Ring	0	0	1	0	1
Male Condom	3	3	4	5	15
Withdrawal	0	2	2	3	7
Diaphragm	0	0	0	0	0
Sponge	0	0	0	0	0
Spermicide	0	0	0	1	1
Other	0	0	1	0	1
No Method	0	0	1	0	1
Pregnancy Intentions					
Trying to avoid pregnancy	2	5	5	5	17
Ambivalent	1	1	0	1	3
Trying to get pregnant	0	0	2	1	3
Don’t know	1	1	1	0	3
Numeracy					
Top 50%	1	4	4	2	11
Bottom 50%	3	3	4	5	15

Round 1 identified simple mistakes in the patient-centered poster, leading us to reach saturation quickly (N=4). In the other rounds, we reached saturation within 5-10 interviews, as is typical in cognitive interviewing studies [27]. In Round 4, participants made few suggestions for changes and preferred the

patient-centered poster overall, leading us to conclude the study. Tables 3.2 and 3.3 show abbreviated versions of the overview report for each poster by round. Figure 3.2 shows the final iteration of the patient-centered poster.

Table 3.2 Abbreviated Overview Report for the CDC Poster by Domain

Round	1 (N=4)	2 (N=7)	3 (N=8)	4 (N=7)	Total (N=26)	How Addressed by Patient-Centered Poster?
Problem	**n***	**n***	**n***	**n***	**n* (% of N)**	
COMPREHENSION: Information and words/phrases on the poster are clear						
Clinical terms (LAM, LNG IUD, nulli/parous, methods' clinical names) are unclear.	1	7	7	6	16 (62%)	All removed and replaced with suggested non-clinical terms.
Asterisk is not seen before the percentages, making the percentages confusing.	3	2	5	2	12 (46%)	Percentage legend added at the top of the column.
"Typical use" is unclear.	3	4	3	2	12 (46%)	Term not used.
Pictures unclear for some methods.	2	2	4	2	10 (38%)	Suggested change.
"Permanent" is confusing when there is a small risk of pregnancy.	1	1			2 (8%)	"Surgical" used instead.
RELEVANCE: Information on poster applies to the participant and is useful for her						
Missing how each method works and how long it lasts.	4	5	7	7	23 (88%)	Added information.
Missing side effects/contraindications.	1	2	3	5	11 (42%)	Suggests 2nd poster.
Women only interested in methods that are commonly used, relatively effective, and easy to obtain.		2	4	3	9 (35%)	Only shows commonly used methods.
"Family Planning" not inclusive and not equivalent to "birth control."		3	2	2	7 (27%)	"Birth control" used.
Missing unprotected sex.	1		4	1	6 (23%)	Added this information.
ACCEPTABILITY: Information on poster seems truthful and inoffensive						
Withdrawal picture is confusing or offensive.	1	3	4	2	10 (38%)	New withdrawal image.
Pictures of sterilization offensive.	1		1	2	4 (15%)	Suggested change.
Add number to call or website.		1	1	2	4 (15%)	Suggested change for sponsored projects with sponsor.
Add "Talk to your doctor."		1	2	1	4 (15%)	Added.
Picture of injectable is off-putting.		1	1		2 (8%)	Removed needle.
DESIGN: Poster is attractive and well-organized						
No color.	3	6	6	7	22 (85%)	In color.
Too much text/"looks" like a lot of text.	3	5	2	1	11 (42%)	Text is in separate column.
Not enough of a visual emphasis on STI prevention.	2	3	4	2	11 (42%)	Bolded and in main text.
Titles and headers are not noticed first.	1	3	3	2	9 (35%)	Title is in large font.
The order in which the information on the sheet should be read is unclear/Some information would not be read.	1	3	2	3	9 (35%)	Order to read information is signaled in design and color.

*Only the top five most mentioned issues for each category are included. *n represents the number of women who brought up that issue.*

Table 3.3 Abbreviated Overview Report for Patient-Centered Poster by Domain

Problem	Round 1 (N = 4) n*	Round 1 (N = 4) Change	Round 2 (N = 7) n*	Round 2 (N = 7) Change	Round 3 (N = 8) n*	Round 3 (N = 8) Change	Round 4 (N = 7) n*	Round 4 (N = 7) Change
COMPREHENSION: Information and words/phrases on the poster are clear								
Pregnancy risk measure confusing.	4	Title changed.	7	Added first-year failure percentages.	5	Replaced with "times better" scale.	3	No change; more prefer alternative.
Pictures unclear for some methods.	2	No change.	2	No change.	4	No change.	2	Suggested change.
Unclear what colors convey.			2	"No method" in different color from other methods.	2	Tried to reduce number of colors and intensity.	1	Surgical methods now same color.
Unclear what numbers mean.			2	Added explanation.			6	Header added.
Unclear reference/scale for arrow.			2	Added time for most effective.			4	Switched scale label to “times more effective”.
RELEVANCE: Information on poster applies to the participant and is useful for her								
Missing how each method works and how long it lasts.	2	No change.	5	Done for all but least effective methods.	4	Added information on least effective methods.	3	Updated IUD information.
Missing side effects/contraindications.	1	No change.	3	No change.	3	No change.	5	Suggests 2nd poster.
Missing brand names.	1	No change.			2	Added.	2	Added.
Women only interested in methods that are commonly used, relatively effective, and easy to obtain.			1	Retained all contraceptive options from CDC poster.	4	Removed sponge, spermicide, and female condom.	1	Removed diaphragm.
Missing LAM information.			1	More prefer removal.	1	More prefer removal.	1	More prefer removal.
ACCEPTABILITY: Information on poster seems truthful and inoffensive								
Feels less believable due to no logo, short citation, or poor design.	3	Added logo and citation.	3	Revised design.			1	No space for long citation.
“Advertising” most effective methods.	1	No change.	3	No red, yellow, green.			1	All methods in one color.
Add "Talk to your doctor.”			1	No change.	2	No change.	1	Done.
Pictures of sterilization offensive.	1	No change.			1	No change.	2	Suggested change.
Add number to call or website.			1	No change.	1	No change.	2	Suggested change.
DESIGN: Poster is attractive and well-organized								
The order in which the sheet should be read is unclear/sheet is crowded.			3	Decreased font size in order of importance.	7	New layout. Fewer numbers.	1	Removed diaphragm and technical names.
More visual weight on STI prevention.	1	No change.	4	Bolded STI box.	3	Bolded in text.		
Titles and headers are not noticed first.	2	No change.	2	Larger title font.			1	Headers added in blue.
More emphasis on surgical methods.			3	Retained box.	4	Separated methods.		
Too much text.			1	No change.			4	Removed surgical text.

*Only the top five most mentioned issues for each category are included. *n represents the number of women who brought up that issue.*

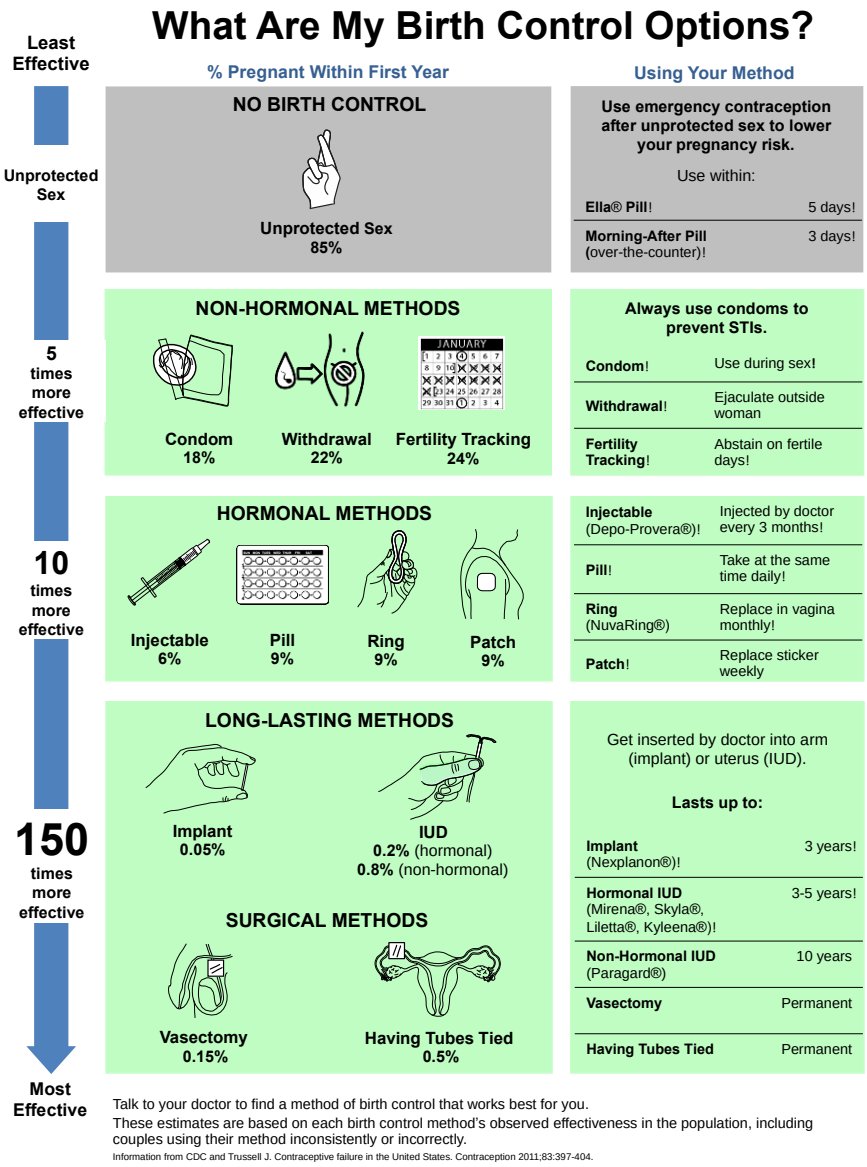


Figure 3.2 Final Iteration of the Patient-Centered Contraceptive Effectiveness Poster

In the interviews, the CDC logo was used in the Logo Space to ensure that the two posters were comparable. Recent research suggests that some long-acting reversible methods can be used for longer than they were initially approved for in some groups of women [76]; however, we use lengths of time for which these devices were approved for use by the U.S. Food and Drug Administration.

Comprehension

Technical language was the most common issue with comprehension. Women often did not know the meanings of lactational amenorrhea (62%), parous/nulliparous (54%), typical use (46%), the LNG IUD (23%), and hysteroscopic/laparascopic/abdominal sterilization (19%). As one woman said:

> *I think that some of it can read jargony. So it could be unapproachable. Not necessarily lying, but that it's just too much.*

Women often assumed that the information was not relevant to them if they did not understand a word, and few asked for clarification. This finding led us to incorporate women's preferred terminology into the patient-centered poster. For example, women suggested adding brand names and using "having tubes tied" instead of "female sterilization." As one woman said:

> *[The poster] broke down the names, the actual names that the doctor will usually use… When you're not in the medical profession, and you say, "Can I get the injectable?" and the doctor says, "Depo," and you're like, "Is that same thing?"… You feel a distance between who you're talking to. You want to feel the same. You don't want to feel as though the doctor is superior.*

When the poster used women's terminology it not only reduced confusion, but also increased the relevance of the information.

Another consistent comprehension problem was confusion about the patient-centered poster's average time-to-pregnancy measure. Women found it difficult to understand because it was unfamiliar and not how they thought about risk.

> *I think about birth control in a very immediate way. So it's kind of hard to pick [a contraceptive method] out in terms of, 10 years, when would I want an unplanned pregnancy? That I find a little confusing when I think about this.*

As a result, in the fourth round we transitioned to contextualizing the percent failure rate with a "times more effective" scale. Women preferred this scale to the CDC's use of a percent failure rate alone and were confident and accurate when interpreting it in their own words. Of the

five women with low numeracy in the fourth round, three preferred the “times more effective” scale, and one did not prefer either scale. In the final round, six out of seven women interviewed said the patient-centered poster was easier to understand than the CDC poster.

Relevance

An unexpected finding was that 27% of women felt the term “family planning” excluded single women or that it did not reflect their attitude when they chose contraception. One younger woman said:

I don't think it should be "family planning" unless it was maybe for a couple.

Women preferred “birth control” or “contraception,” so we use these in the patient-centered poster.

To increase relevance, 35% of women suggested removing uncommonly used methods from the poster. One woman observed:

I don't think I have ever met anybody who uses a sponge or a diaphragm.

In the final poster, we removed methods used by less than 0.2% of contraceptive users: the female condom, diaphragm, sponge, and spermicide [77].

When the poster provided information relevant to women’s options, it increased women’s perceived ability to process their contraceptive choices. As one woman said in Round 3:

> *[The patient-centered poster] is just more useful to me because it gives me more of what I need in terms of being able to make a decision about birth control. How often do I have to take it? What's the length of time that it will be effective for me in terms of not getting pregnant? ... Does it have hormones? … And how it's used. So I think that information is presented here in a much easier digestible frame. It's easier for me to understand.*

In each round, an increasing proportion of women said the patient-centered poster provided more relevant information than the CDC poster. By the final round, six out of seven women said that it was the more useful and relevant poster.

Acceptability

Some women found the withdrawal (38%) and sterilization (15%) pictures unacceptable. One woman (W) brought her sister (S) to the interview (I), and they discussed the issue:

I: I noticed you laughed at the withdrawal picture.

W: Yes. Because I had to really look at it to see what was going on there. [laughs]

I: What do you think about that one?

W: It's really detailed. Tell you the truth I don't think it should be in there.

S: Some people don't know. Especially if they're young. And maybe their parents don't talk about sex at all.

W: But my child. I'm thinking about my child.

S: It's not for kids.

W: But if she be in the room with me, she's going to see that.

Another participant said she cannot depict human genitalia when she teaches sexual education at her church. In response, we commissioned an artist to draw a less graphic image for withdrawal, which was preferred by the majority of women and raised no acceptability concerns.

Another acceptability problem for the patient-centered poster was women's perception that it was advertising highly effective methods. Black women were especially concerned about this, due to the history of forced sterilization in their community. As one Black woman said:

> *I do get some under-the-current, subliminal messages in that the [least effective methods] are in red, and then the middle one is in yellow… I've done more study on forced sterilization, stuff like that with certain populations. It gives me the subliminal message that women like me shouldn't look at these [least effective] methods. And it makes me feel like, would the doctor forced sterilize me? Or offer me that option versus these other options?*

We reduced these concerns by replacing the term "sterilization" and putting all the contraceptive methods in the same color.

Design

In every round, women said the patient-centered poster was more attractive than the CDC poster because it used color. One woman said:

> *I would probably be more likely to read the colorful one [the patient-centered poster]. So I would like [the doctor] to have that because it's going to draw my attention. I like that they are making this a priority and aren't trying to just put the information out. They want you to look at it; they want you to pay attention to it. To me, it would tell me that my doctor cares about these things.*

The colors also helped women digest the information. According to a woman in Round 4:

> *I like this because I like color-coding it this way. That way I'm actually looking at the entire row. I'm looking at the picture, the percentage, and then the information next to it… I like colors, and I feel they help direct the eyes.*

Over all the rounds, 85% of women asked for the CDC sheet to be more colorful, and all seven women in the final round said the patient-centered poster was more attractive than the CDC poster.

Preference

Table 3.4 shows the preferences of women by comprehension, relevance, attractiveness/design, and overall preference. Women preferred the patient-centered poster overall compared to the CDC poster and rated it as being more comprehensible, relevant, and attractive. By the final round, the only unaddressed acceptability issue with the patient-centered poster is that it shows male genitalia.

Table 3.4 Women's Choice of Preferred Poster by Round for Each Domain

	Round 1 (N=4)		Round 2 (N=7)		Round 3 (N=8)		Round 4 (N=7)	
	CDC	**Patient-centered**	**CDC**	**Patient-centered**	**CDC**	**Patient-centered**	**CDC**	**Patient-centered**
Comprehensible	3	1	3	4	5	3	1	6
Relevant	4	0	7	0	3	5	1	6
Attractive/Design	1	3	1	6	3	5	0	7
Overall Preference	3	1	4	3	3	5	1	5
Column Sum	**11**	**5**	**15**	**13**	**14**	**18**	**3**	**24**
Percent of Round's Total	**11/16 = 69%**	**5/16 = 31%**	**54%**	**46%**	**44%**	**56%**	**11%**	**89%**

Row totals within rounds do not always sum to the same number because women sometimes refused to voice a preference.

Discussion

Both written materials and graphical aids can provide effective contraceptive education [7, 56], and there are many contraceptive posters already available [78, 79]. However, to our knowledge, there are no studies documenting the process of developing these posters. The unique contribution of our study is creating a contraceptive poster using a structured process for incorporating women's feedback to ensure the poster is comprehensible, relevant, and acceptable for the majority of women. This process is in alignment with CDC and OPA guidelines for developing evidence-based educational materials [9].

Women preferred the final version of the patient-centered poster overall and on the dimensions that we measured: comprehension, relevance, and design. It also raised few remaining acceptability concerns, especially in comparison to the CDC poster. We had a number of findings that may be relevant to future projects designing reproductive educational materials. For example, we found that women are unfamiliar with several contraceptive terms, such as lactational amenorrhea and LNG IUD. Testing educational posters with the intended audience would likely uncover technical jargon and give designers the opportunity to clarify their language. We also found that women are more comfortable with educational materials that do not depict genitalia because they worried that children might see them before their parents are

ready to discuss sex and sexuality with them. While it is important not to compromise educational value, posters may be disseminated more broadly if they have child-friendly images. We also found that color should not be underrated as a tool to help women process information and draw their attention. Practically all of the women we interviewed strongly preferred that posters be presented in color. Finally, we found that some women were uncomfortable when a poster seemed to "advertise" highly effective contraception. Women preferred a neutral approach when being given educational information.

This study has several limitations. First, our study may have limited generalizability to US women because all interviews were conducted in North Carolina. Second, many of our participants used highly effective methods of contraception, which may bias our findings. However, we intentionally included participants that were users of less effective contraceptive methods, racially and ethnically diverse, and low-scoring in numeracy.

This study highlights a number of areas for future research. Our results suggest that low-numeracy women may prefer a "times more effective" scale for communicating contraceptive effectiveness. This finding should be quantitatively tested in larger, nationally representative samples of women. Future studies might also incorporate the preferences of health care providers into educational posters, who have important insight about women's potential misunderstandings and gaps in knowledge. Before implementing this poster in practice, future studies should also evaluate the impact of the patient-centered poster on contraceptive knowledge and reproductive health outcomes to ensure that the poster is accomplishing its intended goal. The poster should eventually be studied in a clinical setting, where it would actually be distributed.

When women underestimate the effectiveness of contraception or their risk of pregnancy with unprotected sex, they are less likely to use contraception [23, 35, 36, 40]. Therefore, posters

that clearly communicate contraceptive information could be a valuable tool to help achieve the Healthy People 2020 goal of reducing unplanned pregnancies [10]. The women in our study valued information about contraception and spoke highly of doctors and organizations increasing access to such knowledge.

CHAPTER 4: A RANDOMIZED CONTROL TRIAL OF TWO CONTRACEPTIVE EFFECTIVENESS POSTERS

Overview

Objective: To test the comparative effectiveness of the Centers for Disease Control and Prevention's (CDC) standard educational contraceptive effectiveness poster and a new, patient-centered poster on reducing risk factors for unplanned pregnancies.

Methods: In a randomized control trial, women were presented with either the CDC or the new poster. Women were eligible if they were aged 18-44, could speak and read English, were not trying to conceive or currently pregnant, and had engaged in vaginal intercourse in the past three months. Data were collected in an online survey administered through Amazon Mechanical Turk. Baseline and immediate follow-up data were collected on the following primary outcomes: contraceptive knowledge (measured using the Contraceptive Knowledge Assessment), perceived pregnancy risk, and the effectiveness of the contraceptive method the woman intended to use in the following year. Pre-specified subgroup analyses were conducted in women with prior pregnancy scares, low numeracy, and no current contraception. Within and between group differences were compared among equally balanced groups.

Results: From January 26 to February 13, 2018, 2,930 people were screened and 990 randomized. Both posters significantly improved contraceptive knowledge relative to baseline (CDC +3.6, patient-centered +6.4 percentage points, $p<0.0001$), and the patient-centered poster was significantly more effective than the CDC poster at improving contraceptive knowledge ($p<0.0001$). Both posters also significantly improved the effectiveness of the contraceptive method that women intended to use by three percentage points relative to baseline ($p<0.01$ for

patient-centered, p<0.001 for CDC). This is equivalent to 9 out of every 100 women who viewed a poster improving the effectiveness of their intended contraception.

Conclusion: This study suggests that both posters could be used to educate women about contraception and may reduce the risk of unplanned pregnancy by improving contraceptive intentions. The patient-centered poster performs better at increasing contraceptive knowledge.

Clinical Trial Registration: ClinicalTrials.gov, www.clinicaltrials.gov, NCT03372369.

Introduction

Increased contraceptive knowledge is associated with taking steps to reduce the risk of unplanned pregnancy, including using highly effective contraceptive methods [23]. However, contraceptive knowledge among US women is low; at least half underestimate the effectiveness of contraception for pregnancy prevention [7, 8, 23, 41]. For family planning services, the Centers for Disease Control and Prevention (CDC) recommends that clinicians educate patients about contraceptive effectiveness and refers to their own contraceptive effectiveness poster as a potential educational tool [9].

Specific dimensions of reproductive health knowledge that are associated with inconsistent or non-use of contraception include underestimating the overall likelihood of pregnancy with unprotected sex [40-42] and underestimating personal risk of pregnancy with unprotected sex [35, 36, 40, 41]. Between 14-25% of US women underestimate the overall risk of pregnancy associated with unprotected sex among all women of reproductive age [43], and at least twice as many women believe they are very likely to be infertile [41] than are actually infertile [39]. The CDC's poster may not improve knowledge of the risk of pregnancy with unprotected sex because it does not include this information. Furthermore, the CDC poster's design may be difficult to interpret for women with low health literacy or numeracy (i.e., facility

with mathematics). The Institute of Medicine has declared designing educational materials for low health-literacy and numeracy populations a key public health priority [65].

We designed a patient-centered poster that is appropriate for women with low numeracy that includes information about the risk of pregnancy with unprotected sex. The objective of this study is to compare the effectiveness of the patient-centered poster to the CDC poster to improve women's contraceptive knowledge, perceived pregnancy risk, and contraceptive preferences.

Materials and Methods

Our intervention compared exposure to either the CDC (Figure 4.1) or the patient-centered (Figure 4.2) contraceptive effectiveness poster for as long as desired, with a minimum of one minute (average: 1.96 minutes for CDC, 1.79 minutes for patient-centered). The patient-centered poster was developed through cognitive interviews with 26 women aged 18-44 living in North Carolina who spoke and read English and had ever had sex (see Chapter 3). In that study, the final version of the patient-centered poster was preferred over the CDC poster by women overall based on its ease of comprehension, relevance to their decision-making needs, and visual appeal.

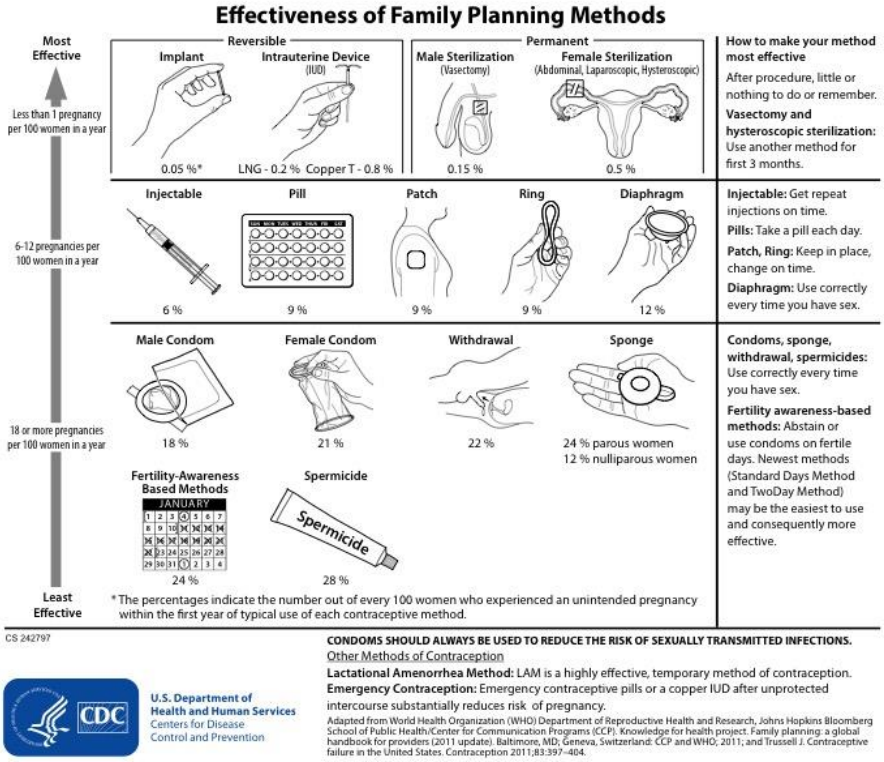


Figure 4.1 The CDC's Contraceptive Effectiveness Poster

For this study, we used Amazon Mechanical Turk (MTurk) to select a convenience sample of US women aged 18-44 who spoke and read English, were not seeking pregnancy, were not currently pregnant, and who had engaged in vaginal intercourse with a man in the past three months. MTurk is an online service which allows individuals to post surveys to be completed for a nominal fee [80]. Data from MTurk users have been found to be as reliable or more reliable than data from other sources: workers have been consistently found to be attentive, their answers to questions consistent, and their answers no more or less truthful than in high-quality probability samples of the general population [29].

We first screened potential participants for eligibility using a short survey, for which they were reimbursed $0.05. Eligible participants were invited to complete the full study survey and prevented from retaking the eligibility survey. Participants were reimbursed $3.60 upon

completion of the full survey, equivalent to the federal minimum wage for their time. Women gave their informed consent before participating in the full survey. The survey was implemented in Qualtrics, which automatically randomized women to equal-sized groups. The baseline data collection, intervention implementation, and outcome assessment were all conducted within one survey and the researchers were blind to assignment. The study was approved by the University of North Carolina at Chapel Hill Institutional Review Board (IRB number 17-2955).

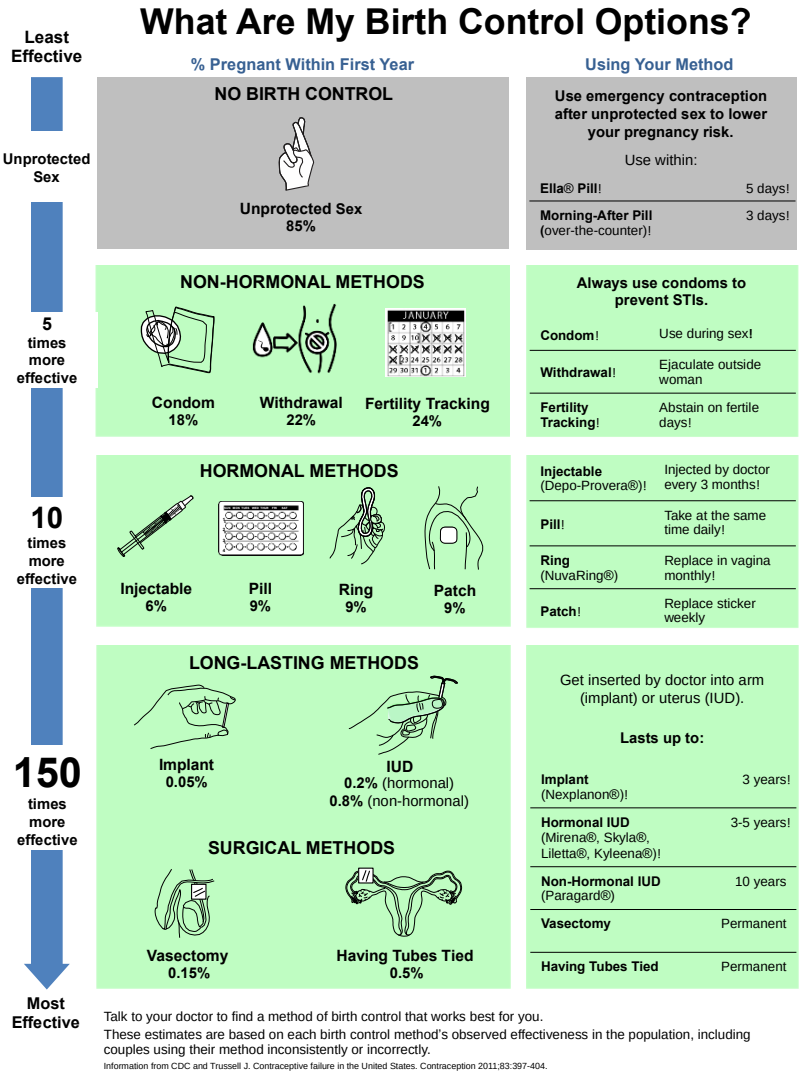


Figure 4.2 The Patient-centered Contraceptive Effectiveness Poster

This study measured change in the mean scores for three primary outcomes: contraceptive knowledge, effectiveness of most likely contraceptive method used in the next year, and accuracy of perceived pregnancy risk. We gathered baseline and follow-up measures for each of these outcomes immediately before and after the intervention, respectively.

Contraceptive knowledge was measured objectively using the 25-item Contraceptive Knowledge Assessment [30]. This produced a score between 0 (0% correct) and 25 (100% correct). Our contraceptive knowledge outcome was the change in this score between baseline and follow-up.

Effectiveness of most likely contraceptive method was operationalized using a woman's intention to continue using her current contraceptive method and the contraceptive method she reported being most likely to switch to were she to change methods in the next year. This measure was intended to be a realistic measure of the contraceptive method that women were most likely to use in the next year. We first asked women at both baseline and follow-up: "Do you intend to use the same birth control method(s) that you are currently using for the next year?" If the woman said she intended to keep her contraceptive method(s), the effectiveness of the most effective method she used in the past three months was used as her most likely method of contraception. The effectiveness of contraceptive methods was scored using the following WHO-defined categories [7]: IUDs, implants, and sterilization were considered highly effective (score = 3, 0-1% annual failure rate); the pill, patch, ring, and injection were considered effective (2, 2-9% annual failure rate); condoms, withdrawal, fertility tracking, and other methods were considered less effective (1, 10-30% annual failure rate); and no method was its own category (0, 85% annual failure rate). If a woman said she did not intend to keep her current contraceptive method, we used the effectiveness of the most likely alternative contraceptive she would use. We

measured this with the question, “If you had to change to a new birth control method in the next year, which of the following methods would you consider using?” Participants selected each method they would consider and then ranked the selected methods from most to least likely method. Our “effectiveness of most likely contraceptive method” outcome was the difference between a woman’s score at baseline and follow-up.

Finally, accuracy of perceived pregnancy risk was assessed by comparing a woman’s current contraceptive method to her perceived pregnancy risk. Perceived pregnancy risk was measured using the following question: “What is your chance of getting pregnant this year?” with possible responses being very high (score = 5, annual pregnancy risk >50%), high (4, annual pregnancy risk 25-50%), moderate (3, annual pregnancy risk 5-25%), low (2, annual pregnancy risk 1-5%), and very low (1, annual pregnancy risk ≤1%). We assessed the accuracy of perceived risk based on the most effective birth control method a woman used in the past three months. In accordance with the WHO categories [7], for highly effective methods, we coded an accurate perception to be very low risk; for effective methods, an accurate perception was low or moderate risk; for less effective methods, an accurate perception was moderate or high risk; for no method, an accurate perception was very high risk. An accurate perception was assigned a score of 1 and an inaccurate perception, 0. Our accuracy in perceived pregnancy risk outcome was the change in this score between baseline and follow-up.

Baseline data were collected on factors that might influence these outcomes. We measured prospective pregnancy intentions with the question, “Are you currently trying to get pregnant or avoid pregnancy?” [81] We measured past pregnancy scares by asking: “Have you ever had a pregnancy scare; that is, thought you were pregnant when you didn’t want to be, but later discovered that you weren’t pregnant after all?” We measured numeracy using the Berlin

single item numeracy scale [31]. This scale has been tested and validated to show that people who answer this question correctly are in the top 50% of the population in numeracy [31]. Data were also collected on the sexes of the woman's past sex partners, whether she had ever seen the poster before, and whether there were any types of birth control the woman could not use for health/safety or cost reasons. The following variables were measured using questions from the National Survey of Family Growth (NSFG): biological sex, age, whether the participant was trying to conceive or was currently pregnant, sexual intercourse in the past three months, education, time since first sex, and marital status. Finally, the following variables were measured using questions from the National Longitudinal Survey of Adolescent to Adult Health (Add Health): race/ethnicity (Wave V), income (Wave IV), relationship status (Wave IV), and health insurance type (Wave IV).

We first tested whether the demographic and other factors were balanced between our randomized groups using two-sample t-tests and likelihood-ratio tests as appropriate. We did not find any statistically significant imbalances for any of the variables. We conducted two-sample t-tests on the change in the mean score for each of our outcomes to test whether each poster improved the three primary outcomes relative to baseline and in comparison to the other poster. We used the Bonferroni correction to account for multiple comparisons. Using the same methods, we also tested the hypothesis that the three pre-specified subgroups (low numeracy, pregnancy scares, and no birth control) had greater increases in their mean scores for the patient-centered poster versus the CDC poster. We chose these subgroups because the patient-centered poster was designed to appeal to the needs of these groups. Finally, because correct answers to some of the questions on the Contraceptive Knowledge Assessment were not given by either poster, we could determine the proportion of the change in contraceptive knowledge that was

attributable to the posters. We did this by analyzing the change in contraceptive knowledge separately for questions that did and did not have the correct answer provided by either poster. All analyses were conducted in Stata (Stata/SE 15, College Station, TX, US).

For our power calculations, we assumed an alpha of 1% and a power of 80%. For our final analysis sample of N=936, comparing the two posters we can detect a 3 percentage point difference in mean change in contraceptive knowledge (standard deviation of 0.18 [30]), a 0.8 percentage point difference in accuracy of perceived pregnancy risk (standard deviation of 0.05), and a 6 percentage point difference in the mean change in effectiveness of most likely contraceptive method (standard deviation of 0.35 [82]).

Results

Participants were enrolled between January 26 and February 13, 2018 (Figure 4.3). Enrollment ended when our target enrollment goals were met.

To evaluate the representativeness of our sample, we descriptively compare the distributions of baseline factors in our study sample to their distribution in the 2013-2015 NSFG survey, weighted to represent the national population of US women who would have been eligible for our study. The baseline description of our study population and the 2013-2015 NSFG can be found in Table 4.1. We found no significant differences between the randomized groups on any of these baseline characteristics. However, there are a number of differences between the study population and the NSFG sample. The study sample appears to be more educated, more White, more middle-income, more likely to be cohabiting, less likely to be monogamous, more likely to have had female sexual partners, and less likely to be using effective methods of contraception.

Table 4.1 Descriptive Statistics for Full Sample, Randomized Poster Assignment Groups, and a Nationally Representative Survey

Variable	CDC Poster (N=466)	Patient-Centered Poster (N = 470)	Total (N = 936)	NSFG 2013-2015 (N = 3,021)
Age (mean, min, max)	32 (18, 44)	32 (18, 44)	32 (18, 44)	31.4 (18, 44)
Education				
Less than high school	* (<1%)	* (<1%)	* (<1%)	11%
High school graduate or GED	138 (30%)	130 (28%)	268 (29%)	34%
Two year college graduate	82 (18%)	94 (20%)	176 (19%)	19%
Four year college graduate	177 (38%)	184 (39%)	361 (39%)	23%
Graduate or professional school	68 (15%)	59 (13%)	127 (14%)	13%
Missing	* (<1%)	* (<1%)	* (<1%)	
Race/Ethnicity				
White	352 (76%)	350 (74%)	702 (75%)	62%
Black or African American	44 (9%)	35 (7%)	79 (8%)	13%
Hispanic or Latinx	17 (4%)	21 (4%)	38 (4%)	15%
Asian	26 (6%)	28 (6%)	54 (6%)	
Pacific Islander	* (<1%)	* (<1%)	* (<1%)	
American Indian/Alaskan Native	* (<1%)	* (<1%)	* (<1%)	11%
Some other race	* (<1%)	* (<1%)	* (<1%)	
Multiple race	25 (5%)	31 (7%)	56 (6%)	
Yearly Household Income				
<$5k	* (<1%)	* (<1%)	* (<1%)	5%
$5k to $9,999	* (<1%)	* (<1%)	17 (2%)	5%
$10k to $14,999	21 (5%)	18 (4%)	39 (4%)	7%
$15k to $19,999	19 (4%)	20 (4%)	39 (4%)	5%
$20k to $24,999	22 (5%)	31 (7%)	53 (6%)	4%
$25k to $29,999	33 (7%)	30 (6%)	63 (7%)	6%
$30k to $39,999	53 (11%)	55 (12%)	108 (12%)	11%
$40k to $49,999	62 (13%)	69 (15%)	131 (14%)	8%
$50k to $74,999	101 (22%)	118 (25%)	219 (23%)	19%
$75k to $99,999	72 (15%)	67 (14%)	139 (15%)	10%
$100k to $149,999	45 (10%)	38 (8%)	83 (9%)	21%
$150k>	22 (5%)	13 (3%)	35 (4%)	
Health Insurance Type				
No Insurance	52 (11%)	50 (11%)	92 (10%)	14%
Indian Health Service	* (<1%)	* (<1%)	* (<1%)	
Don't Know	* (<1%)	* (<1%)	* (<1%)	*
Work	140 (30%)	140 (30%)	280 (30%)	65%
Union	* (<1%)	* (<1%)	* (<1%)	

Variable	CDC Poster (N=466)	Patient-Centered Poster (N = 470)	Total (N = 936)	NSFG 2013-2015 (N = 3,021)
School	* (<1%)	* (<1%)	12 (1%)	
Spouse	111 (24%)	117 (25%)	228 (24%)	
Parent	31 (7%)	30 (6%)	61 (7%)	
Buy Private	41 (9%)	44 (9%)	85 (9%)	
Active Duty Military	* (<1%)	* (<1%)	* (<1%)	3%
Medicaid	77 (17%)	83 (18%)	160 (17%)	17%
Marital Status				
Never married	108 (23%)	107 (23%)	215 (23%)	25%
Living with a partner	116 (25%)	126 (27%)	242 (26%)	19%
Married	224 (48%)	216 (46%)	440 (47%)	49%
Divorced	14 (3%)	18 (4%)	32 (3%)	4%
Separated	* (<1%)	* (<1%)	* (<1%)	3%
Widowed	0 (0%)	0 (0%)	0 (0%)	0%
Sexual Relationship Status				
Dating exclusively	348 (75%)	380 (81%)	728 (78%)	94%
Dating frequently, but not exclusively	31 (7%)	17 (4%)	48 (5%)	
Dating once in a while	24 (5%)	22 (5%)	46 (5%)	1%
Only having sex	43 (9%)	34 (7%)	77 (8%)	
Not in a relationship	14 (3%)	14 (3%)	28 (3%)	5%
Missing	* (<1%)	* (<1%)	* (<1%)	
Ever Pregnant				
Yes	284 (61%)	276 (59%)	560 (60%)	72%
No	181 (39%)	192 (41%)	373 (40%)	28%
Missing	* (<1%)	* (<1%)	* (<1%)	
Parity				
0	211 (45%)	225 (48%)	436 (47%)	35%
1	90 (19%)	88 (19%)	178 (19%)	18%
2	104 (22%)	91 (19%)	195 (21%)	25%
3	36 (8%)	33 (7%)	69 (7%)	15%
4	18 (4%)	28 (6%)	46 (5%)	5%
5+	* (<1%)	* (<1%)	12 (1%)	2%
Sex of Sex Partners				
Exclusively male	378 (81%)	360 (77%)	738 (79%)	98%
Male and female	64 (14%)	86 (18%)	150 (16%)	2%
Exclusively female	0 (0%)	0 (0%)	0 (0%)	0%
Missing	24 (5%)	24 (5%)	48 (5%)	
Pregnancy Scare				
Yes	339 (73%)	351 (75%)	690 (74%)	

Variable	CDC Poster (N=466)	Patient-Centered Poster (N = 470)	Total (N = 936)	NSFG 2013-2015 (N = 3,021)
No	126 (27%)	118 (25%)	244 (26%)	
Missing	* (<1%)	* (<1%)	* (<1%)	
Age at First Sex (mean, min, max)	17.5 (7, 33)	17.3 (11, 34)	17.3 (7, 33)	17.1 (3, 40)
Effectiveness of Most Effective Contraceptive Used in Past Three Months				
Highly Effective (IUD, Implant, etc.)	72 (15%)	81 (17%)	153 (16%)	37%
Effective (Pill, Patch, Ring, Injection)	38 (8%)	45 (10%)	83 (9%)	24%
Less Effective (Condom, etc.)	258 (55%)	246 (52%)	504 (54%)	29%
No Method	98 (21%)	96 (20%)	194 (21%)	10%
Missing	* (<1%)	* (<1%)	* (<1%)	0%
Cannot Use Some Contraceptives for Health Reasons				
Yes	75 (16%)	79 (17%)	154 (16%)	
No	391 (84%)	391 (83%)	782 (84%)	
Cannot Use Some Contraceptives Due to Cost				
Yes	122 (26%)	97 (21%)	181 (19%)	
No	80 (17%)	101 (21%)	536 (57%)	
Missing	264 (57%)	272 (58%)	219 (23%)	
Pregnancy Intentions				
Trying to get pregnant	0 (0%)	0 (0%)	0 (0%)	
Wouldn't mind getting pregnant	36 (8%)	44 (9%)	80 (9%)	
Wouldn't mind avoiding pregnancy	33 (7%)	23 (5%)	56 (6%)	
Trying to avoid pregnancy	389 (83%)	396 (84%)	785 (84%)	
Don't know	0 (0%)	0 (0%)	0 (0%)	
Missing	* (<1%)	* (<1%)	15 (2%)	
Previously Seen Poster*				
Yes	36 (8%)	28 (6%)	64 (7%)	
No	415 (89%)	438 (93%)	853 (91%)	
Don't know	* (<1%)	* (<1%)	19 (2%)	
Numeracy				
Top 50%	211 (45%)	228 (49%)	439 (47%)	
Bottom 50%	255 (55%)	240 (51%)	495 (53%)	
Missing	* (<1%)	* (<1%)	* (<1%)	

* Indicates cells with <10 observations

Descriptive results for our outcomes can be found in Table 4.2. Both groups started with a score of about 66% correct on the Contraceptive Knowledge Assessment. At baseline, the majority of women in each poster group believed they were at very low risk of getting pregnant.

Only 23-24% of women had an accurate pregnancy risk perception at baseline. Finally, we saw high percentages of women at baseline in both poster groups (64% in CDC and 63% in patient-centered) who reported they were likely to use no or less effective methods.

Table 4.2 Pre- and Post-Exposure Results for Outcomes

Outcome Variable	CDC Poster (N=466)		Patient-Centered Poster (N = 470)	
	Pre	**Post**	**Pre**	**Post**
Mean Contraceptive Knowledge Score *Range: 0 to 25*	16.6 ± 3.76 *66.4% correct*	17.5 ± 3.68 *70% correct*	16.7 ± 3.63 *66.8% correct*	18.3 ± 3.49 *73% correct*
Perceived Pregnancy Risk				
Very High	*	*	*	*
High	*	12 (3%)	14 (3%)	17 (4%)
Moderate	72 (15%)	65 (14%)	50 (14%)	50 (11%)
Low	127 (27%)	130 (28%)	109 (23%)	117 (25%)
Very Low	252 (54%)	252 (54%)	293 (62%)	283 (60%)
Accuracy of Perceived Pregnancy Risk Score *Range: 0 to 1*	0.24 ± 0.43	0.24 ± 0.43	0.23 ± 0.42	0.24 ± 0.43
Most Effective Acceptable Method in Next Year				
Highly Effective *(IUD, etc.)*				
Effective *(Pill, etc.)*	148 (32%)	199 (43%)	151 (32%)	193 (41%)
Less Effective *(Condom, etc.)*	133 (29%)	128 (27%)	152 (32%)	154 (33%)
No Method	160 (34%)	124 (27%)	142 (30%)	106 (23%)
	25 (5%)	15 (3%)	25 (5%)	17 (4%)
Most Likely Method in Next Year				
Highly Effective *(IUD, etc.)*	106 (23%)	130 (28%)	105 (22%)	120 (26%)
Effective *(Pill, etc.)*	65 (14%)	59 (13%)	69 (15%)	76 (16%)
Less Effective *(Condom, etc.)*	222 (48%)	205 (44%)	220 (47%)	203 (43%)
No Method	73 (16%)	72 (15%)	76 (16%)	71 (15%)
Mean Most Likely Method Score	1.44 ± 1.01	1.53 ± 1.06	1.43 ± 1.01	1.52 ± 1.03

Many women in our sample had an inaccurately low perceived risk of pregnancy before the intervention (Table 4.3). The majority of women (72%) using no method believed they had a low or very low chance of getting pregnant in the next year, despite the fact that 85 out of 100 sexually active non-users of contraception (or 164 of the 194 non-users of contraception in our study) will conceive over the course of a year [17].

Table 4.3 Underestimating and Overestimating Pregnancy Risk in Study Population at Baseline

	Perceived Pregnancy Risk					
Effectiveness of Most Effective Contraceptive Used in Past Three Months	*Very Low (≤1% pregnancy risk)*	*Low (<5% pregnancy risk)*	*Moderate (5-25% pregnancy risk)*	*High (25-50% pregnancy risk)*	*Very High (>50% pregnancy risk)*	*Total*
Highly Effective *(IUD, etc.)*	**131 (86%)**	10 (7%)	5 (3%)	4 (3%)	3 (2%)	153 (100%)
Effective *(Pill, etc.)*	57 (69%)	**20 (24%)**	**4 (5%)**	0 (0%)	2 (2%)	83 (100%)
Less Effective *(Condom, etc.)*	276 (55%)	145 (29%)	**70 (14%)**	**10 (2%)**	3 (1%)	504 (100%)
No Method	80 (41%)	60 (31%)	43 (22%)	8 (4%)	**3 (2%)**	194 (100%)
Total	544	235	122	22	11	936

Cells with an accurate perception of pregnancy risk are bolded

Table 4.4 shows the results of our main hypothesis tests. Both posters significantly improved contraceptive knowledge relative to baseline ($p<0.0001$), and the patient-centered poster performed significantly better than the CDC poster at improving contraceptive knowledge ($p<0.0001$). The patient-centered poster improved contraceptive knowledge scores by 6.4 percentage points, or 1.6 additional correct questions, and the CDC poster improved scores by 3.6 percentage points, or 0.9 additional correct questions, on average.

Table 4.4 Results of T-Tests

Outcome	CDC Poster (N=466)	Patient-Centered Poster (N=470)	Comparison of Means
Mean Change in Contraceptive Knowledge Score (99% Confidence Interval) *Range: -25 to 25*	0.90*** (0.66-1.13)	1.6*** (1.31-1.90)	Patient-centered preferred***
Percent Change	5.4	9.6	
Percentage Point Change	3.6	6.4	
Mean Accuracy of Perceived Pregnancy Risk Score (99% Confidence Interval) *Range: -1 to 1*	0 (-0.02-0.02)	0.013 (-0.01-0.04)	Fail to reject the null hypothesis
Percent Change	0	5.4	
Percentage Point Change	0	1.3	
Mean Change in Most Likely Method Score (99% Confidence Interval) *Range: -3 to 3*	0.09** (0.02-0.17)	0.09* (0.01-0.17)	Fail to reject the null hypothesis
Percent Change	6.3	6.3	
Percentage Point Change	3	3	

*p<0.01, **p<0.001, ***p<0.0001 to account for multiple comparisons

The results for the analyses testing the change in contraceptive knowledge for questions that were and were not addressed by the posters can be found in Table 4.5. We found a smaller increase in the mean percent correct for questions that were not addressed by either poster (1.8 percentage points for CDC and 2.1 percentage points for patient-centered) as compared to questions that were addressed by the posters (5.8 percentage points for CDC and 11.9 percentage points for the patient-centered poster). The magnitude of the change in the mean score for questions that were not addressed by either poster did not significantly differ between the posters.

Table 4.5 Results of T-tests on Analysis of Contraceptive Knowledge Score Separated by Whether Posters Addressed the Questions

Outcome	CDC Poster (N=466)	Patient-Centered Poster (N=470)	Comparison of Means
Mean Change in Questions Addressed by Posters (99% Confidence Interval) *Range: -11 to 11*	0.64*** (0.50-0.78)	1.31*** (1.11-1.51)	Patient-centered preferred***
Percent Change	8.5	17.4	
Percentage Point Change	5.8	11.9	
Change in % Correct	68.5% to 74.4%	68.6% to 80.5%	
Mean Change in Questions Not Addressed by Either Poster (99% Confidence Interval) *Range: -14 to 14*	0.26*** (0.10-0.42)	0.29*** (0.12-0.47)	Fail to reject the null hypothesis
Percent Change	2.8	3.3	
Percentage Point Change	1.8	2.1	
Change in % Correct	64.9% to 66.6%	65.5% to 67.6%	

*p<0.01, **p<0.001, ***p<0.0001 to account for multiple comparisons

Both posters improved the effectiveness of the most likely method that would be used in the next year compared to baseline by 3 percentage points (p<0.001) (Table 4.4); however, neither poster performed significantly better than the other. This increase corresponds to 9 out of 100 women increasing the effectiveness of their most likely contraceptive method by one category (i.e., moving from no method to a less effective method).

The results in our subgroup analyses of women with pregnancy scares, low numeracy, or no current contraceptive method were similar for all outcomes (results available from corresponding author). Participants reported no harms or unintended effects.

Discussion

We found that both the standard educational CDC and patient-centered posters significantly improved contraceptive knowledge and the effectiveness of the most likely method of contraception used for the next year relative to baseline. The patient-centered poster was significantly more effective than the CDC poster at improving contraceptive knowledge. We also found that these increases in contraceptive knowledge were attributable to the posters themselves.

These results are aligned with a Cochrane review of decision aids, which found that decision aids like posters could increase knowledge, help patients make decisions, and help them experience less conflict about those decisions [63]. A second Cochrane review [55] identified interventions that increased contraceptive knowledge, including two that tested educational tables [7] or charts [83]. These two studies reported 14 to 37 percentage point increases, depending on the table/chart, for two questions asking participants to select the more effective contraceptive method from a pair of methods [7, 83]. However, compared to past studies that only assessed a small number of items tailored to the intervention [55], ours *comprehensively* assessed the impact of an educational poster or chart on contraceptive knowledge. Our study also found significant impacts on the effectiveness of the most likely method of contraception that women stated they intend to use, which is more proximal to contraceptive decision-making than contraceptive knowledge. Our results held in subgroups of participants who had low numeracy, prior pregnancy scares, and who do not use birth control, who may have a greater challenge understanding information about contraception. We also saw these results despite participants

only being exposed to the poster passively and for a very short period of time, similar to what they might experience if viewing the posters while waiting in a clinician's office.

Our results are not necessarily generalizable to the general population of US women, but the differences between our study sample and the NSFG sample are similar to the differences between Americans who use the internet and the general US population [84]. In the United States 99% of 18-29 year olds and 96% of 30-45 year olds use the internet [85]. Our study sample also appears to be more knowledgeable about contraception than the general population [30]; because of this, it is possible that our findings underestimate the impact of posters on contraceptive knowledge. Finally, our study does not assess the impact of these posters on actual behaviors. However, we did measure contraceptive intentions, which have been shown to be a good predictor of behavior [86, 87]. The impact of these posters on actual contraceptive choices in clinical practice should be studied in future research.

Clinicians often struggle to educate their patients about the multitude of important health topics in the limited amount of time they have during appointments [88]. This study tested two inexpensive tools to educate patients about contraception independently from a provider, and found that they effectively increase contraceptive knowledge and intentions to use more effective methods of contraception. Using these posters in practice could allow doctors to spend more of their time answering questions about the patient's specific contraceptive needs, rather than educating them on the basics of how each method works and how effective it is.

CHAPTER 5: A COST-EFFECTIVENESS ANALYSIS OF CONTRACEPTIVE EDUCATION USING THE CDC OR PATIENT-CENTERED POSTERS

Overview

Objectives: This study estimates the cost-effectiveness of two contraceptive effectiveness posters from a private payer perspective.

Methods: Two Markov models were constructed to simulate costs and health outcomes associated with education using the contraceptive effectiveness posters or the status quo in a cohort of 10,000 women of reproductive age avoiding pregnancy. Costs used 2017 US dollars, while outcomes were measured using quality-adjusted life years (QALYs) and the number of unplanned pregnancies. Input probabilities were derived from a literature review and primary data gathered in a randomized control trial. The model used a 5-year time horizon. Probabilistic uncertainty and bivariate sensitivity analyses were conducted to examine how implementation variation might affect the cost-effectiveness of the posters. One Markov model simulated discontinuation and switching of contraceptive methods, while the other assumed no switching of contraceptive methods. These two models represent the previous modeling approaches used in the literature and provide an upper and lower bound of the effects of contraceptive switching on outcomes.

Results: Both posters reduced costs and improved health outcomes compared to the status quo. The patient-centered and CDC posters averted 1,481 (95% CI 1479-1483) to 1,943 (95% CI 1937-1949) and 1,558 (95% CI 1556-1560) to 1,827 (95% CI 1821-1833) unintended pregnancies, respectively. Both models found that the posters increased the total number of

QALMs per woman by 0.12 (3.65 quality-adjusted life days). Total costs of intervention, birth control, and pregnancy per woman were reduced by $550-907 by the patient-centered poster and $488-705 by the CDC poster. All results were robust to the probabilistic uncertainty and bivariate sensitivity analyses.

Conclusions for Practice: The use of either contraceptive poster would reduce costs and improve health outcomes, even if costs of implementation were high and follow-through of women on their intentions was low.

Introduction

Previous research has found that reducing the 45% of pregnancies that are unintended in the US [11] would both save the public money [2] and improve the health of mothers and children [3]. One evidence-based way to prevent unintended pregnancies is to encourage women who want to avoid pregnancy to use highly effective contraception when they are sexually active [1, 89]. When women choose highly effective contraception, it is not only a way for them to take control of their fertility; it is also cost-effective [1, 90, 91].

Despite the widespread use of contraception, there is still the need for contraceptive education. The CDC's recent recommendations for family planning services [9] suggest educating women about contraceptive effectiveness in health care visits, and highlight a contraceptive effectiveness poster CDC has designed as one tool for accomplishing this goal. A previous study by the authors (see Chapter 4) found that the CDC poster significantly improved the effectiveness of the contraceptive methods that women were likely to use in the following year. This study also tested a novel, patient-centered contraceptive poster and found that it had the same impact on contraceptive preferences. However, we do not know whether the effects of these two posters offset the costs of producing and counseling women using them, especially with variations in implementation effectiveness. We test the *hypothesis* that exposure to the

patient-centered or CDC posters will be a cost-effective method of preventing unintended pregnancies compared to the status quo even under a variety of alternative implementation scenarios.

Methods

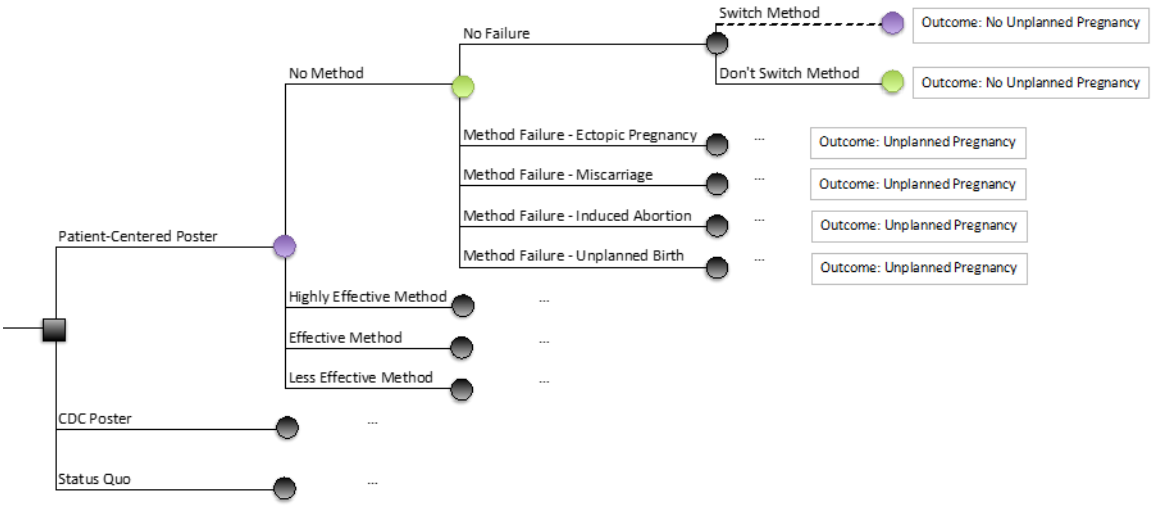
Intervention Alternatives

The model evaluated the costs and health outcomes associated with three alternatives: the patient-centered poster, the CDC poster, and the status quo. The posters changed the costs and health outcomes relative to the status quo by shifting the effectiveness of contraceptive methods that women use, a method demonstrated in a cost-effectiveness model of increased contraceptive coverage [92]. The status quo reflects the mix of contraceptive methods that women use without exposure to either poster. A previous study by the authors found that 2-8% of sexually active US women aged 18-44 reported having previously seen the CDC poster, suggesting that it is not widely used (see Chapter 4).

Model Structure

Figure 5.1 illustrates the structure of the models. Two Markov models were constructed in TreeAge Pro Healthcare (TreeAge Software, Williamstown, MA). Both use a 5-year time horizon and a Markov cycle length of 1 year. We chose a 5-year time horizon based on previous studies showing that longer-acting contraceptive methods have high up-front costs but also many benefits that accrue over the course of several years [1, 90]. The model structure was the same for all branches, but is only shown completely for one branch for the sake of brevity. A square decision node indicates that the entire hypothetical cohort travels down each of these branches. A circular chance node indicates that when women reach this node, they have a certain probability of entering each of the states branching off of the node, and these probabilities sum to one. In this model, some chance nodes are also cyclical Markov nodes. This means that when a woman

reaches this node, she records the outcome labeled at the node and then is put back into the model at the node of the same color to the left in the tree.



Legend: Dashed line is only present in the switching model.

Figure 5.1 Structure of Contraceptive Education Poster Markov Model

After being exposed to one of the alternatives (CDC poster, patient-centered poster, or status quo), women can choose a contraceptive method from four categories of effectiveness based on the World Health Organization definitions [7]. These categories are: highly effective, meaning sterilization, IUDs, or implants; effective, meaning the hormonal pill, patch, ring, or injection; less effective, meaning condoms, withdrawal, fertility tracking, or any other method of contraception; and no method. After women choose a contraceptive method, there are five subsequent potential fertility states: no contraceptive failure, ectopic pregnancy, miscarriage, induced abortion, and unintended birth. In the model that does not simulate contraceptive switching or discontinuation, women resume using their method after experiencing one of these five outcomes. This approach has been used in several previous contraceptive cost-effectiveness models [1, 90, 92].

In the model that simulates contraceptive switching and discontinuation, after experiencing one of the five fertility states, women can choose to discontinue their method and switch to a new category of effectiveness. The likelihood of discontinuation is a population-weighted average of the method-specific likelihoods of discontinuation using the most recent National Survey of Family Growth to derive the weights (see Table 5.1). The likelihood of switching to each category is the same as the probability of choosing that category initially, with the probability of choosing the discontinued category removed and renormalized between the remaining categories. Only one previous model allowed women to switch methods, and this model assumed that they switched to an "average" contraceptive method [93]. We chose to create two models, one modeling switching and the other not modeling switching, to understand whether there are differences in estimates of costs and benefits between the two and to increase the comparability of our results to previous cost-effectiveness models. Furthermore, the no switching model provides an upper bound on the potential effect of contraceptive method choice on outcomes, while the switching model provides a lower bound on this effect because it assumes choices reflective of the observed population, rather than women learning from experience.

In summary, women in these models experience an annual cycle of being exposed to a poster (or no poster in the status quo), choosing a contraceptive method by effectiveness category, experiencing a fertility state, and (in the switching model only) either switching to a new contraceptive category or continuing within same category. We also programmed versions of the switching and no-switching model that allowed women to choose specific methods of contraception, rather than categories, but the results from these models were not qualitatively substantially different from the models reported here (see Supplement for methods and results

for the additional models). We did not use method-specific transition probabilities because they have never been previously used in the literature and because we were unable to derive reliable estimates of these transitions from either our trial data or secondary data sets. Small cell sizes resulted in a large number of highly uncertain or unstable estimates when we attempted to estimate method-specific transitions using these data sets.

Key Model Assumptions

a. The models apply to reproductive-age women (18-44) who do not intend to conceive.
b. All women were assumed to be candidates for all contraceptive methods.
c. Women could only use one contraceptive method at a time.
d. In the base models, we assumed perfect implementation of the posters. In other words, every time a woman chose a contraceptive method she would be exposed to the poster and would choose a contraceptive method with the probabilities associated with that poster. This assumption is tested in the follow-through sensitivity analysis.
e. Contraceptive failures other than unintended births and method discontinuations were assumed to occur at the midpoint of the cycle [1, 90].
f. Couples were assumed to have 83 acts of intercourse per year [1].
g. Women could only conceive once per year.
h. We assumed that 60% of unintended births were mistimed rather than unwanted and would have occurred 2 years later [50]. Because of this we discounted the costs and benefits associated with mistimed births.
i. We assumed contraceptive method failure occur at rates corresponding to typical use. Typical use failure rates included failures due to incorrect or inconsistent use by contraceptive users.

j. Transition probabilities, costs, and utilities for categories of effectiveness use the population-weighted average of the methods within that category, with the weights being the observed proportion of the population using each method in the most recent National Survey of Family Growth.

k. We assumed that failure rates (by method) are constant over time.

l. A discount rate of 3% was used for all costs and quality-adjusted life years incurred after 1 year.

Input Parameters

We used parameter estimates derived from a literature review. This literature review was not systematic, but prioritized results that came from: 1) high-quality studies, 2) using US data, 3) studying women of reproductive age, and 4) with recent data. Table 5.1 has probabilities for continuing to use each contraceptive method after one year. We use these method-specific continuation probabilities to calculate population-weighted averages for each effectiveness category. We use primary data to estimate the mix of methods used if all women were counseled using the new poster or the CDC poster (see Table 5.1). The primary data came from a randomized control trial studying a sample of sexually active, female Amazon Mechanical Turk users aged 18-44 who were not pregnant or intending to conceive. The expected mix of methods was the percentage of this sample ranking each method as the most likely method they would use in the next year, combining both continuation of current method and anticipated switching of methods. For the status quo, we applied this definition to the baseline data. These counts were used to parameterize a Dirichlet distribution [94].

Table 5.2 shows probabilities of method failures and adverse events.

Table 5.1 Input Probabilities for Contraceptive Methods

Method	Method Failures After One Year[a]	Percent Continuing Use After One Year[b]	Pre-Intervention Number Using (N=902) (%)	Post-Patient-Centered Poster Number Using (N=902) (%)	Post-CDC-Poster Number Using (N=902) (%)	Observed Proportions in Population[c]
No Method	85%	15%	57 (6%)	35 (4%)	47 (5%)	10%
Pill	9%	68%	116 (13%)	112 (12%)	112 (12%)	23%
Male Condom	18%	53%	196 (22%)	154 (17%)	140 (16%)	14%
Withdrawal	22%	43%	141 (16%)	91 (10%)	79 (9%)	4%
Male Sterilization	0.15%	100%	80 (9%)	102 (11%)	104 (12%)	7%
Female Sterilization	0.5%	100%	37 (4%)	53 (6%)	35 (4%)	23%
IUD/IUS[d]	0.2%	80%	68 (8%)	112 (12%)	144 (16%)	7%
Injection	6%	56%	34 (4%)	50 (6%)	34 (4%)	4%
Patch	9%	68%	25 (3%)	37 (4%)	37 (4%)	1%
Ring	9%	68%	31 (3%)	29 (3%)	23 (3%)	2%
Implant	0.05%	84%	45 (5%)	71 (8%)	97 (11%)	1%
Fertility Tracking	24%	51%	66 (7%)	50 (6%)	48 (5%)	1%
Other Methods[c]	19%	50%	6 (1%)	6 (1%)	2 (0%)	1%
Spermicides	28%	42%				.06%
Sponge (Parous)	24%	57%				.06%
Sponge (Nulliparous)	12%	46%				.06%
Diaphragm	12%	57%				.06%
Female Condom	21%	49%				.06%
Highly Effective Methods	0.35%	95%	230 (25%)	338 (37%)	380 (42%)	
Effective Methods	8.58%	66%	206 (23%)	228 (25%)	206 (23%)	
Less Effective Methods	19.27%	51%	409 (45%)	301 (33%)	269 (30%)	

[a] Source: [17]

[b] Source: [95]

[c] Source: [96]. Assumes that "other" contraceptive method use is equally split between diaphragm, female condoms, spermicide, and sponge. Averages the continuation and failure rates of "other" methods to find joint continuation and failure rates. Used to generate population-weighted averages for each contraceptive category.

[d] Uses hormonal IUS continuation and failure rates [97].

Table 5.2 Input Probabilities for Method Failures and Adverse Events [1]

Method	Ectopic Pregnancy	Induced Abortion	Spontaneous Abortion	Birth	Amenorrhea	Venous Thrombo-embolism	Urinary Tract Infections	Postoperative Complications
No Method	0.01	0.4554	0.1683	0.3663				
Spermicides	0.01	0.4554	0.1683	0.3663			0.31	
Withdrawal	0.01	0.4554	0.1683	0.3663				
Fertility Awareness Methods	0.01	0.4554	0.1683	0.3663				
Sponge	0.01	0.4554	0.1683	0.3663				
Diaphragm	0.01	0.4554	0.1683	0.3663			0.31	
Male Condom	0.01	0.4554	0.1683	0.3663				
Female Condom	0.01	0.4554	0.1683	0.3663				
Pill	0.01	0.4554	0.1683	0.3663	0.03	0.00005	0.15	
Patch	0.01	0.4554	0.1683	0.3663	0.001	0.00005		
Ring	0.01	0.4554	0.1683	0.3663	0.03	0.00005		
Injection	0.01	0.4554	0.1683	0.3663	0.4			
IUS/IUD[a]	0.5	0.23	0.085	0.185	0.2			
Implant	0.01	0.4554	0.1683	0.3663	0.222			
Female Sterilization	0.33	0.3082	0.1139	0.2479				0.012
Male Sterilization	0.01	0.4554	0.1683	0.3663				0.00043

[a] Uses hormonal IUS rates [97].

Costs

Costs for private payers associated with contraception included those for the contraceptive method itself, physician services, method failures, and adverse events [1] (Table 5.3). The costs of adverse events were weighted by their likelihood and incorporated into the total cost of each method. Direct non-medical costs and indirect costs are not included in the model. The costs of the interventions are uncertain, so we incorporate the uncertainty into the model by parameterizing the cost per woman of the intervention using a uniform distribution from $1-$500. A previous cost-effectiveness study of a national media campaign to educate people about colorectal cancer screening found that the costs per person screened were $0.12-$2.44, so our estimate is likely high [98]. All costs were adjusted to 2017 US dollars using the medical care services or physician services component of the Consumer Price Index as appropriate [99]. Finally, we derived costs for each category of effectiveness using population-weighted averages of the costs for each method included in that category (see Supplement for method-specific costs).

Utilities

Utilities are measured using quality-adjusted life years (QALYs) and the natural unit outcome of the number of unintended pregnancies averted. QALYs are a commonly used outcome measure in comparative effectiveness research that incorporates morbidity and mortality into a single measure [32]. A QALY is an abstract concept representing one year of life in perfect health. To calculate QALYs, we have to associate each event with a utility, which is a score reflecting an individual's preference for a health state [32]. These scores range from zero – representing death – to 1 – representing perfect health [32]. We sourced utilities from our

literature review (Table 5.4) and derive a utility for each category of effectiveness by using a population-weighted average of the utilities of the methods within that category. Only two categories are reported because the other two have the default utility of 1.

Table 5.3 Cost Inputs for the Models

Treatment or Outcome and Code	Cost	Model Cost	Distribution	Notes	Source	Source Year
CONTRACEPTIVE CATEGORIES						
Highly Effective Methods *(First Year Only)*	$2,679.27	$2,679.27	Gamma	Population-weighted average of method costs Raw Range: $1,381.74-$4,697.29 Shape[c]: 10.03 Scale[c]: 267.01	Calculation	
Effective Methods *(Annually)*	$1,004.29	$1,004.29	Gamma	Population-weighted average of method costs Raw Range: $557.62-$2,414.66 Shape[c]: 4.49 Scale[c]: 223.47	Calculation	
Less Effective Methods *(First Year Only)*	$65.78	$65.78	Gamma	Population-weighted average of method costs Raw Range: $14.83-$466.54 Shape[c]: 0.33 Scale[c]: 201.87	Calculation	
Less Effective Methods *(Annually)*	$63.47	$63.47	Gamma	Population-weighted average of method costs Raw Range: $12.82-$461.73 Shape[c]: 0.31 Scale[c]: 206.62	Calculation	
No Method	$0	$0				
HEALTH OUTCOMES						
Birth[g]	$17,958	$18,885.14	Gamma	Raw Range: $16,996.41 - $20,773.86 Mean: $18,885.14 Shape[c]: 384.07 Scale[c]: 49.17	[100]	2015
Induced Abortion[h]	$535.45	$626.18	Gamma	Raw Range: $186.18 – $2,319.14 Mean: $626.18 Shape[c]: 1.32	[101]	2011

Treatment or Outcome and Code	Cost	Model Cost	Distribution	Notes	Source	Source Year
				Scale[c]: 472.82		
Spontaneous Abortion[i]	$535.45	$626.18	Gamma	Raw Range: $186.18 – $2,319.14 Mean: $626.18 Shape[c]: 1.32 Scale[c]: 472.82	[101]	2011
Ectopic Pregnancy (DRG 378)[j]	$10,613	$14,075.85	Gamma	Range: ±10% Mean: $14,075.85 Shape[c]: 384.16 Scale[c]: 36.64	[1] [92]	2005 2015
			ADVERSE EVENTS			
Urinary Tract Infection	$97.29	$119.98			[1]	2007
Venous Thromboembolism	$10,291	$15,472.71		Upper Range: $26,183	[102]	2004
Amenorrhea	$100	$110.14		Range: $74.46- $330.42	[92] [103]	2015 2011
Postoperative Complications - Vasectomy	$144					
Postoperative Complications – Tubal Sterilization	$5210					

[a] Costs are reported as average wholesale price (AWP). In the model, cost inputs are AWP-15% [1].

[b] Costs are weighted by the likelihood of an adverse event occurring.

[c] Assumes raw range is a 95% confidence interval around stated mean to derive standard deviation.

[d] Trussell, Lalla, et al assume that 0.2% of vasectomies are performed inpatient, 77.1% in a physician's office, and 22.7% as hospital outpatient [1, 104]. An updated source found that in 2001, 78.8% of vasectomies are performed in a physician's office, 11.5% as a hospital outpatient, 5.5% at freestanding surgery centers, and 4.2% in other settings [105].

[e] Assuming 50% are performed postpartum and 50% as interval procedures; 96% of interval procedures are outpatient [1, 106].

[f] Assuming 83 acts of intercourse per year [1].

[g] Assuming 60% of births are mistimed and would have occurred 2 years later, a 3% discount rate is applied [1].

[h] Assuming 35% of abortions are performed in the hospital, 49% occur in abortion or other clinics, and 17% in physician offices [107]. Assumes that 23% of abortions are medication abortions and the remaining 77% are surgical [101].

[i] Based on the DRG codes and proportion of in-hospital abortions used for induced abortion.

Table 5.4 Utilities for Switching and No-Switching Models

Health State	Mean	Standard Deviation	Source	Source Population	Method	Notes
Induced Abortion	0.992	0.043	Schwarz 2008	N=192 non-pregnant US women, sexually active women who were not trying to get pregnant when they presented at three Pittsburgh clinics in 2006	Time Trade-Off	Uses the utility estimate for unintended pregnancy.
Spontaneous Abortion	0.85	0.180	Kupperman 2004	N = 584 pregnant US women aged 16-47 years recruited from 23 San Francisco practices	Time Trade-Off	This utility estimate is confirmed by the following additional sources: Payne 2004 (expert estimate = 0.8), Kaimal 2015 (estimate = 0.88, SD =0.178).
Pregnancy and Birth	0.912	0.11	Kupperman 2004, Schwarz 2008	N = 584 pregnant US women aged 16-47 years recruited from 23 San Francisco practices	Time Trade-Off	Reducing by unintended pregnancy disutility to reflect the fact that all pregnancies in this model are unplanned and this utility was derived from a mixed/positive about pregnancy sample
Ectopic Pregnancy	0.982	0.13	Smith 2008, Lawrence 2001	N = 150 US women with no history of pelvic inflammatory disorder who were older than 18 and recruited in Pittsburgh	Time Trade-Off	Reducing by unintended pregnancy disutility to reflect the fact that all pregnancies in this model are unplanned and this utility was derived from a sample positive about their pregnancies. Used maximum SD giving a feasible beta.
Contraception	1					Assumption.
Urinary Tract Infection	0.994	0.03	Bermingham and Ashe 2012	N = 146 adult US women with mean age 34 (SD 12 years) with symptomatic, diagnosed UTI recruited from two family medicine clinics	Visual Analogue	
Venous Thromboembolism	0.982	0.009	Hogg 2013, Calculation	N = 216 patients of an Ottawa thrombosis clinic with a history of lower limb deep vein thrombosis or pulmonary embolism	Standard Gamble	Calculated the weighted utility including DVT and PE events

Health State	Mean	Standard Deviation	Source	Source Population	Method	Notes
Highly Effective Methods	0.994	0.07	Smith 2008, Hillis 1999	Sterilization utilities are <1 due to sterilization regret. N = 150 US women with no history of pelvic inflammatory disorder who were older than 18 and recruited in Pittsburgh	Time Trade-Off	Using lower bound of sterilization regret because sample of women who do not want pregnancy. Used maximum SD giving a feasible beta.
Induced Abortion	0.986	0.070	Calculation			
Spontaneous Abortion	0.844	0.250	Calculation			
Ectopic Pregnancy	0.976	0.12	Calculation			Used maximum SD giving a feasible beta.
Effective Methods	0.999	0.020	Trussell 2009, Calculation	Pill utility is <1 due to adverse events.		Population-weighted average of method specific utilities. Used maximum SD giving a feasible beta.
Induced Abortion	0.991	0.063	Calculation			
Spontaneous Abortion	0.849	0.200	Calculation			
Ectopic Pregnancy	0.981	0.100	Calculation			Used maximum SD giving a feasible beta.

Analyses

Uncertainty Analysis

We first conducted a probabilistic uncertainty analysis. For the probabilistic uncertainty analysis, we assigned probability distributions to uncertain input parameters, then ran the model 10,000 times, drawing a new value for each input parameter from its distribution for each run [33]. Our probabilistic uncertainty analysis incorporated uncertainty in costs, utilities, and the mix of contraceptive methods for each intervention. Costs were parameterized using Gamma distributions, except the cost of the intervention, and utilities were parameterized with Beta distributions [32]. Where standard deviations were unavailable for the total cost of the method, the distribution was parameterized so that the range of likely values reported in the literature was treated as a 95% confidence interval of a normal distribution, with the base value being the mean, to derive a standard deviation. This was done to avoid implausible distributions but incorporate a realistic portrayal of uncertainty over the parameter's range, as recommended by the International Society for Pharmacoeconomics and Outcomes Research-Society for Medical Decision Making (ISPOR-SMDM) Modeling Good Practices Task Force Working Group [108].

Threshold Analysis

We then conducted a threshold analysis on the costs of the interventions. To do this, we assumed a willingness-to-pay threshold of $0. A willingness-to-pay threshold is the amount that decision makers are willing to pay per QALY gained for an intervention [109]. We chose a willingness-to-pay threshold of $0 rather than the more typical $50,000 because the interventions were cost-saving and because reproductive health interventions often cannot rely on stable investment. Then we ran the model as described above and calculated net-benefits for each of the 10,000 runs [33]. This process was repeated for a range of values for the cost of the intervention. This analysis produces a graph showing the average net monetary benefit for the two posters and

the status quo on the Y-axis and the cost per woman of the intervention on the X-axis. The results tell us the cost per woman of each poster at which the intervention is no longer cost saving, and can be used to suggest how much could be spent on dissemination and wraparound services during implementation.

Sensitivity Analyses

Next, we conducted a bivariate sensitivity analysis on the percentage of women who follow through on their changed intentions as a result of the posters using the no-switching model. To do this, we assigned each poster a variable representing follow-through. We defined follow-through as the percent of women who experience the effects of the poster. In practice, this means that if only 80% of people who are exposed to the poster actually change their behavior based on their stated intentions as a result of its message, then 80% of the women in the model would exhibit the contraceptive behavior associated with the poster, while the remaining 20% would exhibit the status quo behavior. We then conducted a bivariate sensitivity analysis on these follow-through percentages to determine whether differences in follow-through for the posters might affect their cost-effectiveness. The results of this analysis suggest how differences in the attractiveness or "stickiness" of the posters might impact cost-effectiveness.

Supplemental Analyses

We conducted a number of additional analyses that can be found in the Supplement and which will briefly be described here.

First, we calculated incremental cost-effectiveness ratios (ICERs) for QALYs and unintended pregnancies averted. ICERs are calculated as the change in costs from usual care to the intervention divided by the change in outcomes; they represent the extra units of utility achieved per extra dollar spent on the intervention. In this study we calculated ICERs for both the patient-centered and CDC posters compared to the status quo, rather than using the usual

method for multiple comparisons, because there was no significant difference in effectiveness between the two interventions found in the previous study (see Chapter 4).

Second, we calculated cost-effectiveness acceptability curves (CEAC). To do this, we run the model 10,000 times as described previously and calculate net-benefits for each of the 10,000 runs using willingness-to-pay thresholds from $0-$100,000 [33]. We then graph the proportion of trials in which each intervention has the highest net-benefit against willingness-to-pay.

Finally, using the method-specific models, rather than the categories of effectiveness models, we performed validity checks on (1) the primary data set's generalizability to the US population of women who are at risk of unintended pregnancy, as well as (2) the comparability of results produced by the models to reality. The methods used for these validity checks, as well as the results, can be found in the Supplement.

Results

Table 5.5 shows the number of unplanned births total and per woman, QALYs per woman, and costs per woman for the status quo, the patient-centered poster, and the CDC poster over the course of the 5-year time horizon for both models. Both posters reduce costs, reduce unplanned pregnancies, and increase quality of life compared to the status quo.

Table 5.5 Results of No-Switching and Switching Models

No-Switching Model			
Outcome	**Status Quo**	**Patient-Centered Poster**	**CDC Poster**
Total Unintended Pregnancies	7,620	5,677	5,793
Mean Unintended Pregnancies Per Woman	0.76 (SD 0.03)	0.57 (SD 0.03)	0.58 (SD 0.03)
Mean Costs per Woman	$6,496.07 (SD $493.69)	$5,588.83 (SD $487.01)	$5,791.44 (SD $521.83)
Mean QALYs per Woman	4.66 (SD 0.09)	4.67 (SD 0.12)	4.67 (SD 0.13)
ICER (compared to Status Quo)		DOMINANT	DOMINANT
Switching Model			
Total Unintended Pregnancies	5,119	3,638	3,561
Mean Unintended Pregnancies Per Woman	0.51 (SD 0.01)	0.36 (SD 0.01)	0.36 (SD 0.01)
Mean Costs per Woman	$4,600.37 (SD $338.61)	$4,050.26 (SD $392.47)	$4,112.27 (SD $421.85)
Mean QALYs per Woman	4.67 (SD 0.15)	4.68 (SD 0.19)	4.68 (SD 0.20)
ICER (compared to Status Quo)		DOMINANT	DOMINANT

N=10,000 runs for each model, cohort of n=10,000

Figures 5.2 and 5.3 show the threshold analyses on the per-woman cost of the intervention for the no-switching and switching models, respectively. We found that for the no-switching model, the threshold for the CDC poster was approximately $1,000 and for the patient-centered poster it was approximately $1,150. For the switching model, the thresholds were approximately $740 for the both posters. This means that the threshold amount could be spent per woman and, on average, the intervention would still break even compared to the status quo.

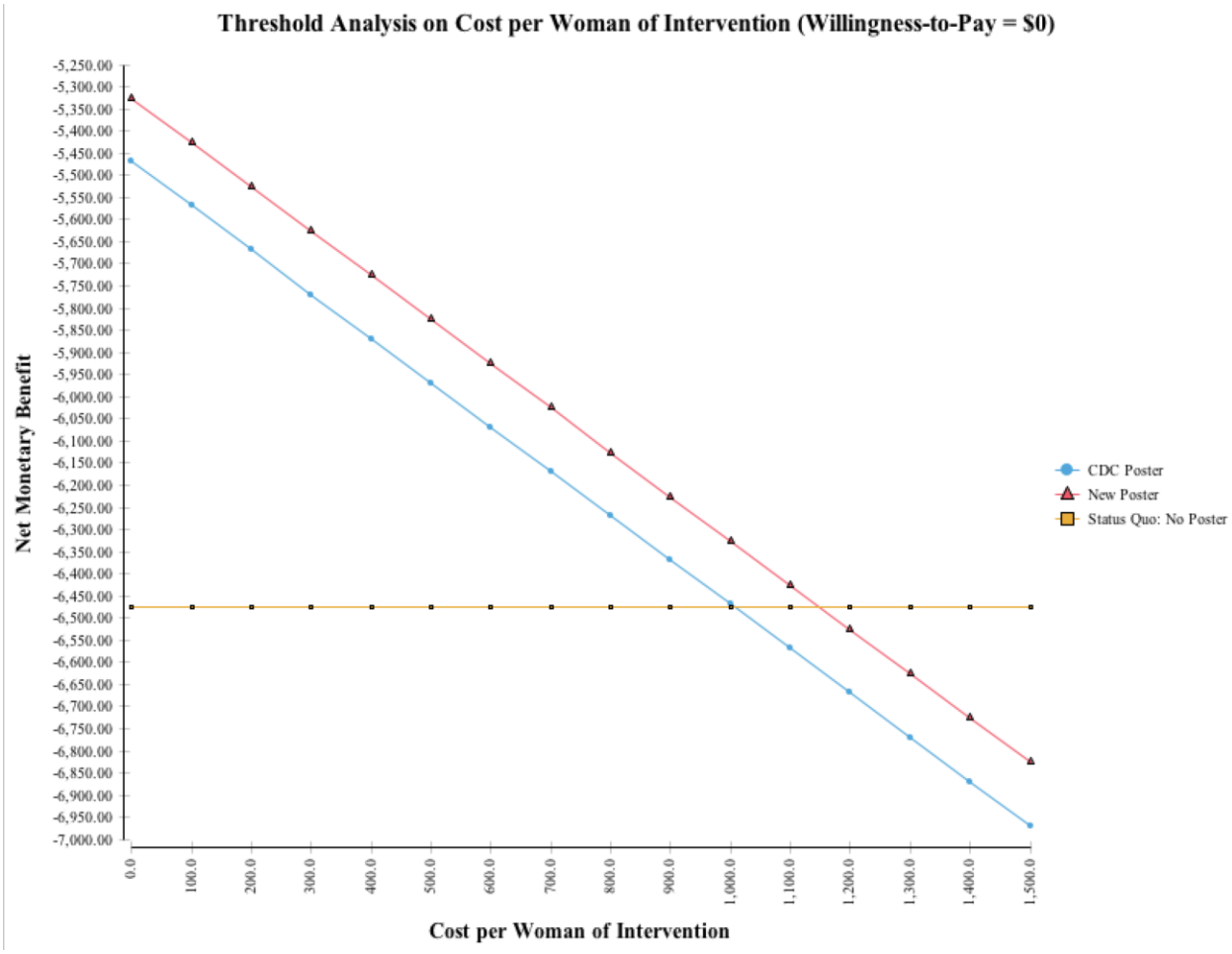


Figure 5.2 Threshold Analysis on Cost of Intervention per Woman for No-Switching Model

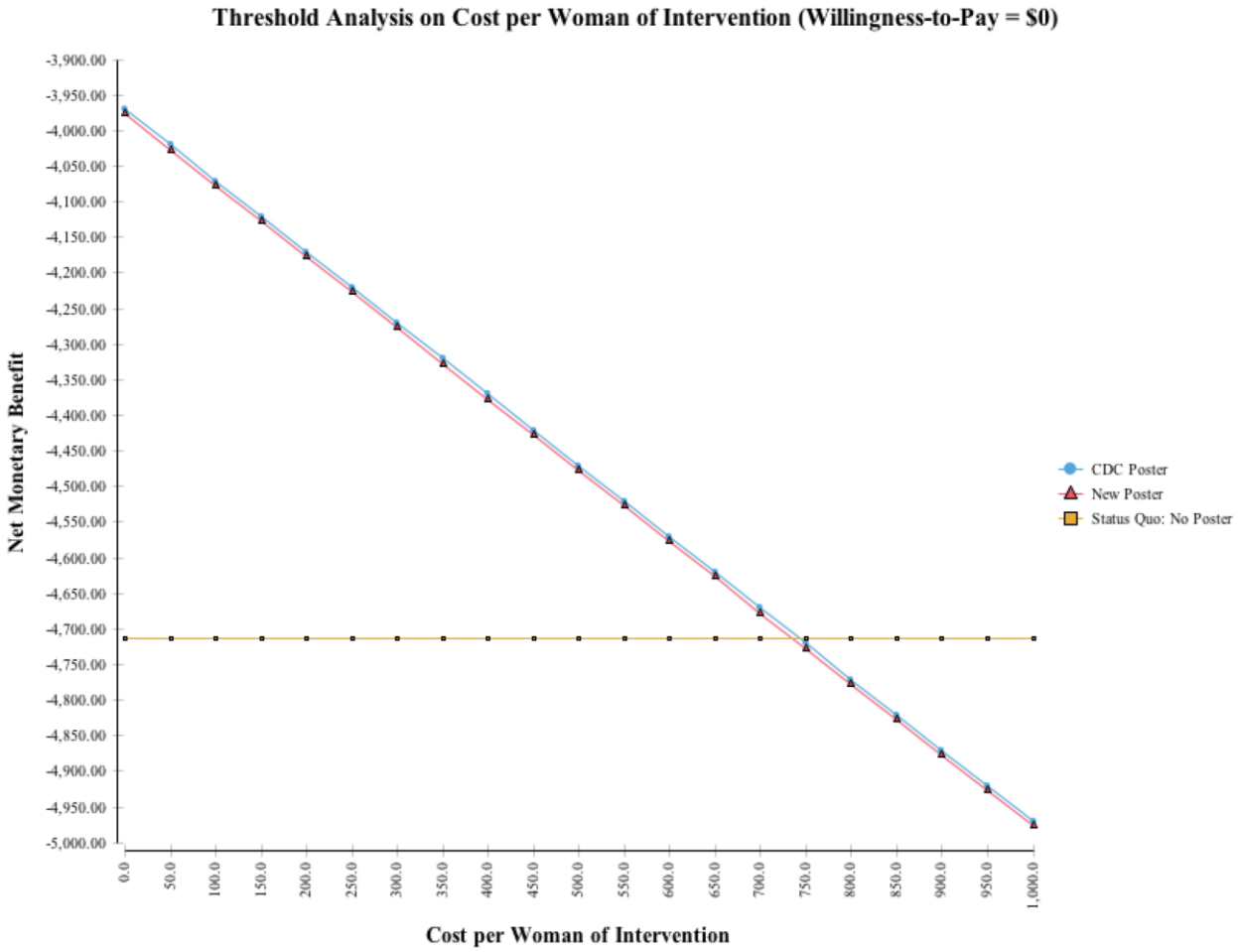


Figure 5.3 Threshold Analysis on Cost of Intervention per Woman for Switching Model

Figure 5.4 shows the results of the bivariate sensitivity analysis on follow-through using the no-switching model. The status quo is preferred at a willingness-to-pay threshold of $0 if follow-through for the CDC poster is <18% and follow-through for the patient-centered poster is <20% (the region highlighted in gold). Follow-through for the patient-centered poster must be at least 2% higher than the CDC poster follow-through for it to generate a higher net monetary benefit at a willingness-to-pay threshold of $0 (the region highlighted in red).

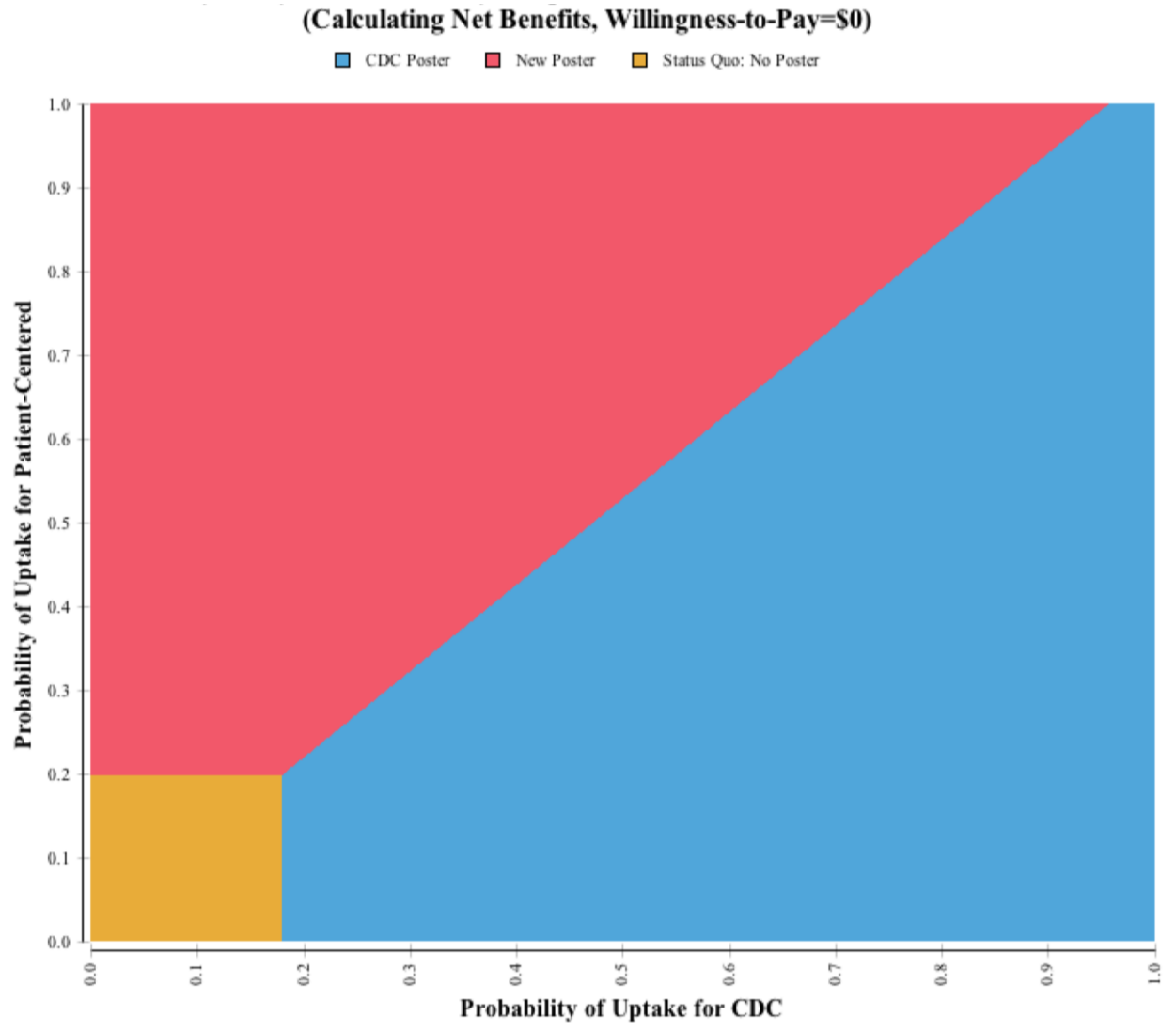


Figure 5.4 Bivariate Sensitivity Analysis of Variation in Follow-Through for Posters for No-Switching Model

Discussion

Our models show that both contraceptive effectiveness posters are dominant interventions- meaning they are cost saving and improve health outcomes—relative to the status quo. Depending on the modeling strategy, the patient-centered and CDC posters averted 1,481-1,943 and 1,558-1,827 unintended pregnancies, respectively. Both models found that the posters increased the total number of QALYs per woman by 0.01. Depending on the modeling strategy,

total costs per woman were reduced by $550-907 by the patient-centered poster and $488-705 by the CDC poster.

These results were robust in probabilistic uncertainty and bivariate sensitivity analyses. In particular, even if policymakers are unwilling to pay any additional money to improve outcomes, we found that implementing the posters could cost $740 per woman before they were no longer cost saving. We also found that the posters would have to change the behavior of as few as 18% of women to produce these cost savings. This suggests that the cost-effectiveness of these poster interventions is extremely robust to variations in implementation costs and effectiveness. The cost savings produced are more than enough to support additional time for providers to counsel patients on contraception or to finance an aggressive dissemination campaign.

This work adds to the previous literature on contraceptive cost-effectiveness modeling in a number of ways. First, these models rarely use the standard unit of health outcomes, QALYs, to measure improvements in health. It is valuable to use QALYs to measure outcomes in cost-effectiveness models because it allows policymakers to prioritize the most cost-effective interventions across diseases and conditions. While some studies [91, 110] have drawn on utilities estimated in one 2004 cost-effectiveness model [91], these utilities may not be generalizable to the general population because they were estimated using a convenience sample of female members of the research team. Other previous cost-effectiveness contraception models using QALYs may use more reliable sources, but incorporate such a limited number of reproductive health outcomes that they are unlikely to accurately estimate health benefits [111]. Our model synthesized the research on utility scores for commonly modeled reproductive health outcomes, prioritizing data that is representative of US women who use contraception. Future researchers can improve the policy usefulness of their contraceptive cost-effectiveness models by

drawing on the utilities in this model. However, our review to identify utilities also highlighted several areas of future research for the field. Direct estimates of utility scores for abortions and contraception would improve the accuracy of future cost-effectiveness studies of contraception.

Our work also adds to the contraceptive cost-effectiveness modeling literature by creating two models, one simulating contraceptive switching and one not. Previous studies have chosen one of these strategies, making it difficult to compare results between different models. We find that the results of our models are comparable, with lower total costs and total unintended pregnancies for the switching versus the no-switching model. Future research on contraceptive-method dependent probabilities of switching to other contraceptive methods, or on lifetime trajectories of contraceptive use, would improve contraceptive models that simulate contraceptive switching.

However, our work has a number of limitations. The first is that contraceptive transitions would ideally be modeled using method-specific transition probabilities. We have addressed this limitation by creating both a switching and a no-switching model to address the shortcomings of each approach. A second limitation is that the primary data used in this model to estimate contraceptive choices after viewing a poster was based on contraceptive preferences rather than actual behavior. While intentions and preferences are predictive of behavior [86, 87], it is likely that the actual effectiveness of these posters will be less than estimated in the base model. However, our bivariate sensitivity analysis demonstrates that even dramatically reducing women's likelihood of following through on their intentions as a result of these posters would still save costs and improve reproductive health outcomes.

Our work has a clear implication for clinical practice. Using contraceptive effectiveness educational posters in health care settings would be an inexpensive intervention that does not

require the time of health care providers to implement. This work demonstrates that even if the costs to produce and implement this intervention were much higher and its effectiveness reduced in the path to implementation, it would still be a cost-effective choice to improve women's reproductive health in the US. This work strongly suggests that either poster is preferable to no intervention at all.

CHAPTER 6: POLICY IMPLICATIONS, LIMITATIONS, AND CONCLUSIONS

Summary of Findings, Policy Implications, and Limitations

This study used three different methods—cognitive interviews, a randomized control trial, and cost-effectiveness modeling—to develop and evaluate the cost-effectiveness of a patient-centered poster designed to educate women about contraceptive effectiveness. Throughout the study we compared this poster to the CDC's current contraceptive effectiveness poster, performing a parallel evaluation in the process. This study is the first attempt to evaluate the CDC's poster, and is the first that we have identified that describes the design and evaluation of a reproductive health poster intended to be used without the guidance of a health care provider. Previous studies have examined the impact of charts on contraceptive knowledge [7, 83], but not complete posters, and have tested contraceptive knowledge using unvalidated instruments. No previous study that we have identified has examined the cost-effectiveness of an educational intervention on contraceptive behavior.

In Chapter 3, our objective was to refine the patient-centered poster and qualitatively test the comprehension, relevance, acceptability, design, and preference of the patient-centered poster compared to the CDC poster. By the conclusion of the study we found that the majority of women found the final version of the patient-centered poster to be more comprehensible and relevant than the CDC poster, and the majority also preferred the design of the patient-centered poster. The majority of women preferred the final version of the poster overall and few acceptability concerns were raised with it.

In Chapter 4, we examined whether the patient-centered poster or the CDC poster was more effective at improving women's contraceptive knowledge, the accuracy of their perceived pregnancy risk, and the effectiveness of the methods of contraception they were most likely to use in the following year. We found that both posters improved contraceptive knowledge significantly compared to baseline, with a 3.6 percentage point improvement for the CDC poster and a 6.4 percentage point improvement for the patient-centered poster ($p<0.0001$). We also found that exposure to the patient-centered poster resulted in significant improvements in contraceptive knowledge compared to the CDC poster ($p<0.0001$). Finally, we found that both posters led to a significant 3 percentage point improvement in the effectiveness of the contraceptive methods that women were most likely to use in the following year compared to baseline ($p<0.01$ for patient-centered and $p<0.001$ for CDC). These results are clinically significant given that they appeared after women were passively exposed to a poster for only a minute, suggesting that this intervention would require health care providers to invest little of their valuable time or resources to see effects.

In Chapter 5, we asked whether the CDC and patient-centered posters were more cost-effective than the status quo at preventing unintended pregnancies using a private payer's perspective. In two models, one of which simulated contraceptive switching and discontinuation and the other of which did not, we found that both posters reduced costs and improved health outcomes relative to the status quo. These results held in probabilistic sensitivity analyses of both models and a bivariate sensitivity analysis testing extreme values of the effectiveness and cost per woman of the interventions. This suggests that the posters would likely be cost-effective even if the implementation process led to reduced impact on contraceptive choices and the costs of using the posters were quite high.

This study makes a number of contributions to the literature. First, it demonstrates that educational posters on reproductive health are cost-effective interventions for improving contraceptive knowledge and intentions, which have been linked to improved contraceptive use [23, 86, 87, 114-116]. This is valuable because while many reproductive health posters may exist and be in use, none have previously been evaluated. Our study shows that not all posters are equally effective at improving contraceptive knowledge, and it suggests that further evaluations of other posters may identify more or less effective strategies of communicating reproductive health information.

Second, this study demonstrates that women's feedback on these posters can highlight comprehension, relevance, and acceptability issues that researchers alone may not identify. Women's health researchers, being well-educated, knowledgeable about reproductive health, and numerate, may not be able to identify when they are using specialized technical language or approaches to risk communication that do not suit a less health literate audience. They are also likely to have different priorities for contraception than the average user, since they are likely to have delayed childbearing to complete an advanced education. This affects the types and formats of information that they are likely to include in an educational poster. Women from the target population for educational materials should and can be involved in the design process, as recommended by CDC and OPA [9].

Third and finally, this is one of the first studies to use the Contraceptive Knowledge Assessment, a validated instrument for measuring women's contraceptive knowledge [30]. Previously, the only contraceptive knowledge assessment (the Contraceptive Knowledge Inventory) that had been validated was created in 1976 and had a number of questions on methods that were out of date or are rarely used now, such as douching, cervical caps, and the

Lippes Loop [117]. Our study demonstrates that the Contraceptive Knowledge Assessment is *responsive*, meaning that when individuals are tested with the instrument, provided with information that should change their responses, and then re-tested, their responses do in fact change. Our study also gathered baseline contraceptive knowledge using the Contraceptive Knowledge Assessment in a much larger and more diverse population than it has ever previously been used in. Our baseline data can act as a reference point for future studies interested in knowing how their results might differ from a population that is generalizable to the US female internet-using population aged 18-44.

This dissertation has several limitations, of which the largest are highlighted here. First, we were only able to gather contraceptive preferences and intentions in the randomized control trial testing the posters. While intentions are predictive of future contraceptive behavior [86, 87, 116], there are differences. These differences would reduce the generalizability of the results of Aims 2 and 3 to women's real-world behavior. Second, in Aim 1 we only interviewed North Carolina women from the Research Triangle area. While we were able to recruit a relatively diverse sample, further interviews with women from around the nation would likely produce additional problems with the acceptability of both posters. Third, in Aim 3 we were not able to use contraceptive-method-specific transition probabilities in the model that simulated contraceptive switching and discontinuation. This resulted in a model that did not produce good approximations of observed contraceptive use in the population.

Despite these limitations, this study is a policy-relevant contribution to the literature on unplanned pregnancy prevention interventions. It provides a window into the development, refinement, and evaluation of an intervention that could relatively easily be implemented across the country to reduce unplanned pregnancies.

Future Research Agenda

The most pressing future research needed is testing whether the posters significantly change actual contraceptive behavior in the clinical setting. Actual contraceptive behavior could be measured in a variety of ways: contraceptive choices made at clinical visits, continuation of use of those contraceptives at later follow-up visits, consistency of use of contraceptive methods that require regular maintenance, and/or accuracy of use for methods that require correct use to be effective. Furthermore, clinical implementation of these posters could be accomplished in a variety of ways. They could be combined with counseling from providers (nurses, community health workers, clinicians), as in previous health education studies [56]. They could also be combined with computerized decision aids for contraceptive selection, an area of growing interest and research [56, 118, 119]. Because of the large cost savings produced by the posters, they could be paired with significant wraparound services to increase their effectiveness and likely remain cost-effective.

Using the data we collected, we could also look health and cost barriers to using certain contraceptive methods. For example, new insurance rules regarding contraception that were passed as part of the Affordable Care Act should have made contraception accessible financially to practically all women with private insurance. However, we still saw that 19% of our study sample reported being unable to use some contraceptive methods due to the costs, despite only 10% of the sample being uninsured. Furthermore, 16% of the sample reported being unable to use some contraceptive methods for health reasons. Patterns in these reported health barriers to contraceptive use could illuminate the need for education in this area so that women know the full range of contraceptive methods that are available to them.

There is also the need for future research to improve future contraceptive cost-effectiveness modeling projects. First, secondary data analyses should be performed to identify

contraceptive-method specific transition probabilities that can be used in more accurate future models of contraceptive behavior. Second, preference studies should be conducted to estimate utilities for important reproductive health states like abortions, miscarriages, and the use of different contraceptive methods.

This dissertation also collected data that could be used to psychometrically evaluate the Contraceptive Knowledge Assessment. The previous validation of the Contraceptive Knowledge Assessment was done in a small sample, which prevented the authors from estimating the predictive ability of individual questions relative to the larger instrument. This type of analysis can be used to assess the overall quality of an instrument and reduce the length of an instrument. This work would be useful to any reproductive health researcher interested in measuring contraceptive knowledge.

Finally, other posters that are currently being used to educate women about reproductive health should be evaluated in the same way that the patient-centered and CDC posters were evaluated in this study. There is no comprehensive catalogue of the posters that are in use, and the posters available online are constantly changing. To ensure that women are getting the best possible educational outreach, these posters should be designed and tested thoughtfully.

Conclusions

This dissertation strongly suggests that the patient-centered poster should begin to be tested in the clinical setting because it is a promising intervention for increasing contraceptive knowledge and reducing risk factors for unplanned pregnancy. In Chapter 3 we demonstrated that the patient-centered poster is preferred by women overall and would generate have few acceptability concerns. In Chapter 4 we showed that the patient-centered poster has a significant impact on contraceptive knowledge and the effectiveness of contraceptive methods that women are most likely to use, both important predictors of contraceptive behavior. In Chapter 5 we

demonstrated that the patient-centered poster is projected to save costs and improve health outcomes when using a private payer perspective. These findings will be help the CDC in its planned revision of their contraceptive effectiveness poster, and should help clinicians and public health specialists when they select how to allocate their limited time, effort, and resources towards interventions to reduce unplanned pregnancies.

APPENDIX A: SUPPLEMENTAL MATERIAL FOR CHAPTER 5

Additional Material for Models Using Categories of Effectiveness

Figures A.1-A.4 show additional results for the models using contraceptive categories rather than individual contraceptive methods. Figures A.1 and A.2 are the cost-effectiveness acceptability curves for the no-switching and switching models, respectively. In both models the patient-centered poster is preferred to the CDC poster in over half of the model runs. The no-switching model shows an increased preference for the patient-centered poster over the CDC poster over a wider range of willingness-to-pay values.

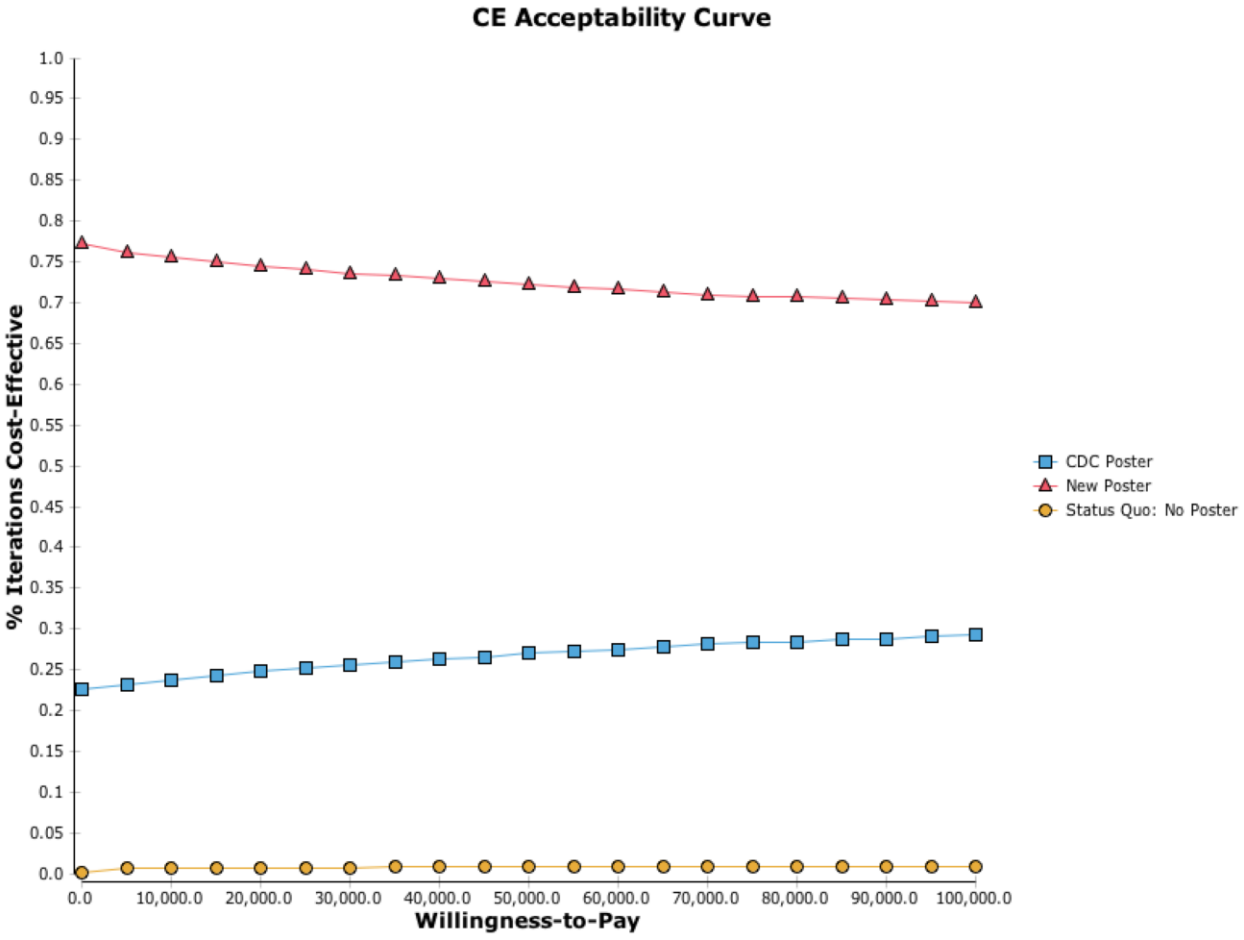


Figure A.1 CEAC for No-Switching Model with Categories

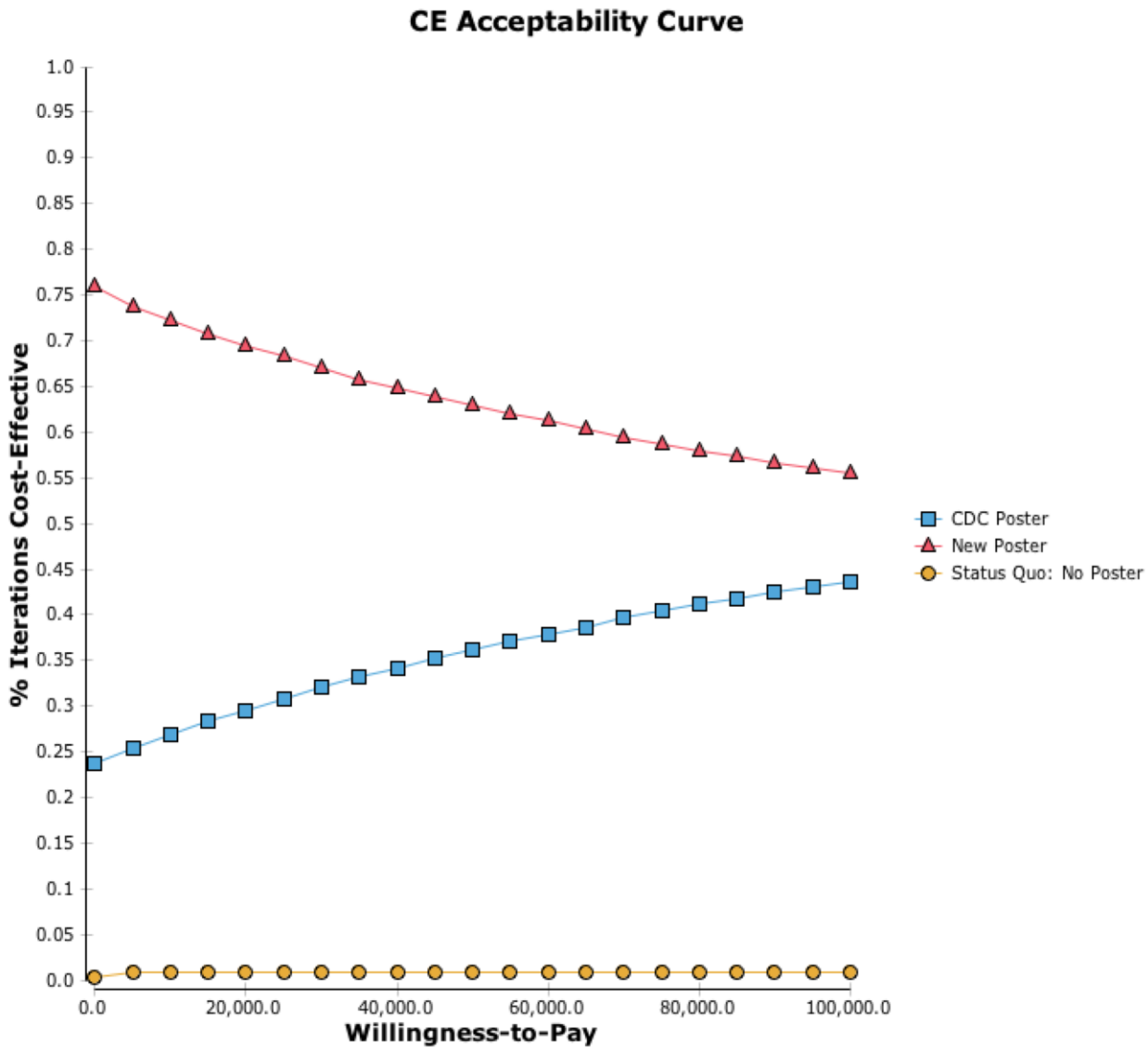


Figure A.2 CEAC for Switching Model with Categories

Figures A.3 and A.4 show the ICER planes for the no-switching and switching models, respectively. In both models the results for the CDC and patient-centered posters have a great deal of overlap, indicating that there is little difference in costs and effectiveness between the two posters. The results are also tightly clustered along the maximum possible QALY result, suggesting that in general the increase in QALYs for the posters is small.

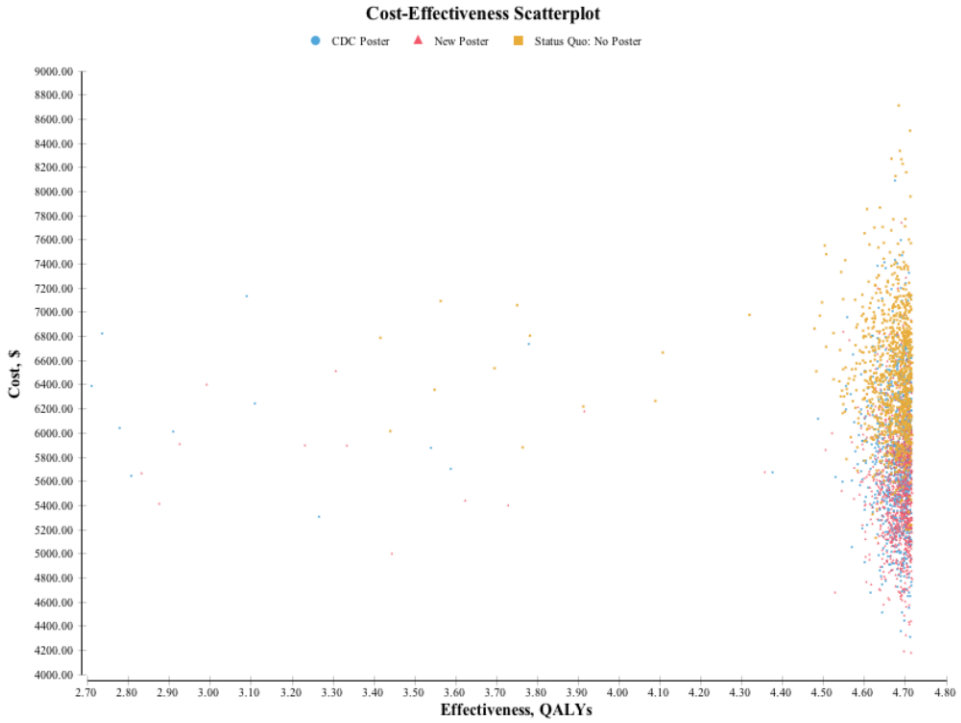


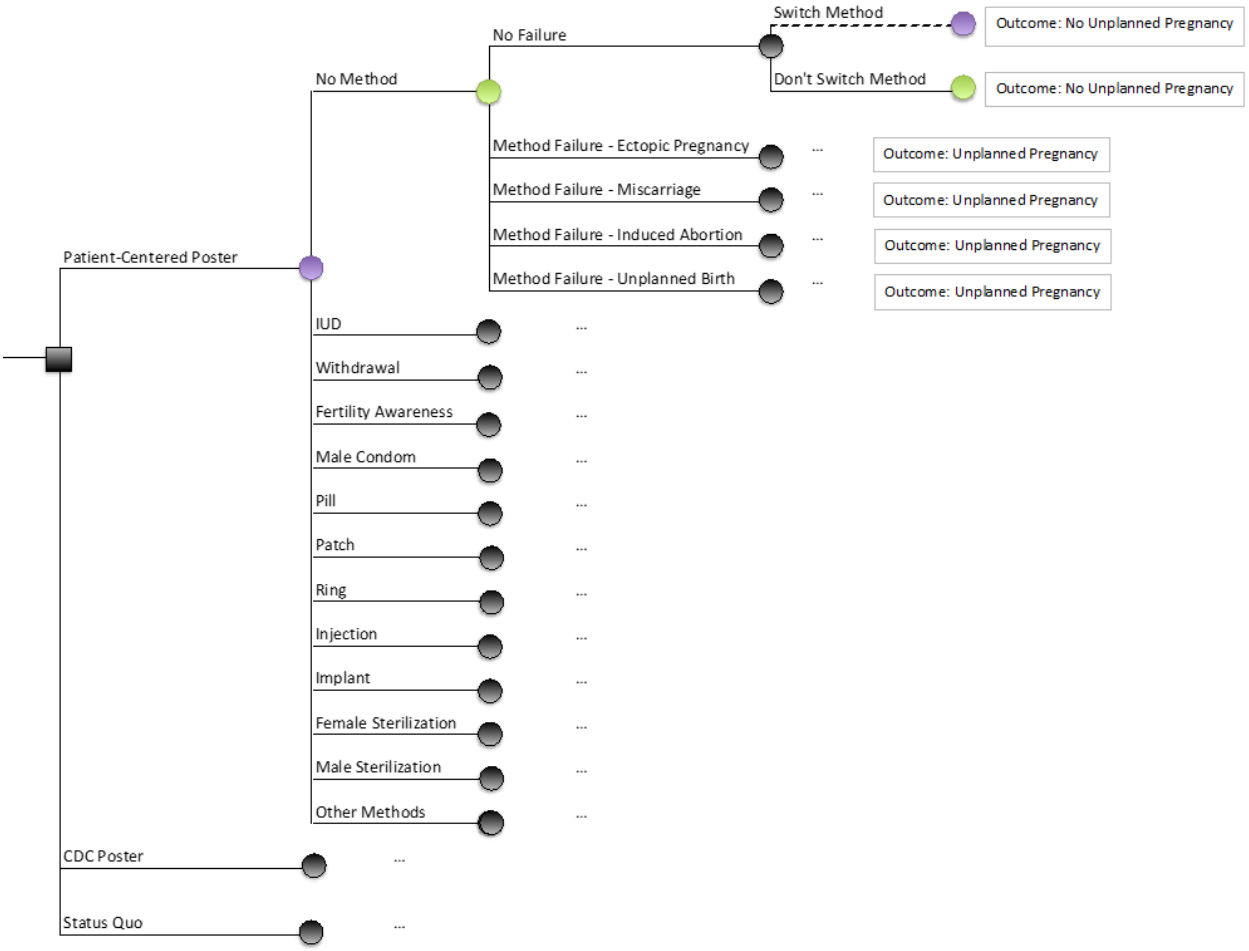
Figure A.3 Incremental Cost-Effectiveness Ratio Plane for No-Switching Model

Figure A.4 Incremental Cost-Effectiveness Ratio Plane for Switching Model

Material Describing Models Using Individual Contraceptive Methods

Model Structure

Figure A.5 illustrates the structure of the models. Two Markov models were constructed in TreeAge Pro Healthcare (TreeAge Software, Williamstown, MA). Both use a 5-year time horizon and a Markov cycle length of 1 year. We chose a 5-year time horizon based on previous studies showing that longer-acting contraceptive methods have high up-front costs but also many benefits that accrue over the course of several years [1, 90]. The model structure was the same for all branches, but is only shown completely for one branch for the sake of brevity. A square decision node indicates that the entire hypothetical cohort travels down each of these branches. A circular chance node indicates that when women reach this node, they have a certain probability of entering each of the states branching off of the node, and these probabilities sum to one. In this model, some chance nodes are also cyclical Markov nodes. This means that when a woman reaches this node, she records the outcome labeled at the node and then is put back into the model at the node of the same color to the left in the tree.



Legend: Dashed line is only present in the switching model.

Figure A.5 Structure of Contraceptive Education Poster Markov Model

After being exposed to one of the alternatives (CDC poster, patient-centered poster, or status quo), women can choose to use one of twelve contraceptive methods or no method. After women choose a contraceptive method, there are five subsequent potential fertility states: no contraceptive failure, ectopic pregnancy, miscarriage, induced abortion, and unintended birth. In the model that does not simulate contraceptive switching or discontinuation, women resume using their method after experiencing one of these five outcomes. This approach has been used in several previous contraceptive cost-effectiveness models [1, 90, 92].

In the model that simulates contraceptive switching and discontinuation, after experiencing one of the five fertility states, women can choose to discontinue their method and switch to a new one. The likelihood of discontinuation is method-specific. The likelihood of switching to each method is the same as the probability of choosing that method initially, with the probability of choosing the discontinued method removed and evenly divided between the remaining methods. Only one previous model allowed women to switch methods, and this model assumed that they switched to an "average" contraceptive method [93]. We chose to create two models, one modeling switching and the other not modeling switching, to understand whether there are differences in estimates of costs and benefits between the two and to increase the comparability of our results to previous cost-effectiveness models.

In summary, women in these models experience an annual cycle of being exposed to a poster (or no poster in the status quo), choosing a contraceptive method, experiencing a fertility state, and (in the switching model only) either switching to a new contraceptive method or continuing with the same method.

Key Model Assumptions

m. The models apply to reproductive-age women (18-44) who do not intend to conceive.
n. All women were assumed to be candidates for all contraceptive methods.
o. Women could only use one contraceptive method at a time.
p. We assumed perfect implementation of the posters. In other words, every time a woman chose a contraceptive method she would be exposed to the poster and would choose a contraceptive method with the probabilities associated with that poster.
q. Contraceptive failures other than unintended births and method discontinuations were assumed to occur at the midpoint of the cycle [1, 90].

r. Individuals who choose to contracept using tubal ligation or a partner's vasectomy did not discontinue their method [90].
s. Couples were assumed to have 83 acts of intercourse per year [1].
t. Women could only conceive once per year.
u. We assumed that 60% of unintended births were mistimed rather than unwanted and would have occurred 2 years later [50]. Because of this we discounted the costs and benefits associated with mistimed births.
v. We assumed contraceptive method failure occur at rates corresponding to typical use. Typical use failure rates included failures due to incorrect or inconsistent use by contraceptive users.
w. We assumed that failure rates are constant over time.
x. A discount rate of 3% was used for all costs and quality-adjusted life years incurred after 1 year.

Input Parameters

We used parameters estimates derived from a literature review. This literature review was not systematic, but prioritized results that came from: 1) high-quality studies, 2) using US data, 3) studying women of reproductive age, and 4) with recent data. Table A.1 has probabilities for continuing to use each contraceptive method after one year. We use primary data to estimate the mix of methods used if all women were counseled using the new poster or the CDC poster (see Table A.1). The primary data was from a randomized control trial studying a sample of sexually active, female Amazon Mechanical Turk users aged 18-44 who were not pregnant or intending to conceive. The expected mix of methods was the percentage of this sample ranking each method as the most likely method they would switch to were they to switch methods in the next year,

excluding their current method. For the status quo, we applied this definition to the baseline data. These counts were used to parameterize a Dirichlet distribution [94].

Table A.2 shows probabilities of method failures and adverse events.

Table A.1 Input Probabilities for Contraceptive Methods

Method	Methods Failures After One Year[a]	Percent Continuing Use After One Year[b]	Pre-Intervention Number Using (N=902) (%)	Post-Patient-Centered Poster Number Using (N=902) (%)	Post-CDC-Poster Number Using (N=902) (%)	Observed Proportions in Population[c]
No Method	85%	15%	57 (6%)	35 (4%)	47 (5%)	10%
Pill	9%	68%	116 (13%)	112 (12%)	112 (12%)	23%
Male Condom	18%	53%	196 (22%)	154 (17%)	140 (16%)	14%
Withdrawal	22%	43%	141 (16%)	91 (10%)	79 (9%)	4%
Male Sterilization	0.15%	100%	80 (9%)	102 (11%)	104 (12%)	7%
Female Sterilization	0.5%	100%	37 (4%)	53 (6%)	35 (4%)	23%
IUD/IUS[d]	0.2%	80%	68 (8%)	112 (12%)	144 (16%)	7%
Injection	6%	56%	34 (4%)	50 (6%)	34 (4%)	4%
Patch	9%	68%	25 (3%)	37 (4%)	37 (4%)	1%
Ring	9%	68%	31 (3%)	29 (3%)	23 (3%)	2%
Implant	0.05%	84%	45 (5%)	71 (8%)	97 (11%)	1%
Fertility Tracking	24%	51%	66 (7%)	50 (6%)	48 (5%)	1%
Other Methods[c]	19%	50%	6 (1%)	6 (1%)	2 (0%)	1%
Spermicides	28%	0.42				.06%
Sponge (Parous)	24%	0.57				.06%
Sponge (Nulliparous)	12%	0.46				.06%
Diaphragm	12%	0.57				.06%
Female Condom	21%	0.49				.06%

[a] Source: [17]

[b] Source: [95]

[c] Source: [96]. Assumes that "other" contraceptive method use is equally split between diaphragm, female condoms, spermicide, and sponge. Averages the continuation and failure rates of "other" methods to find joint continuation and failure rates.

[d] Uses hormonal IUS continuation and failure rates [97].

Table A.2 Input Probabilities for Method Failures and Adverse Events [1]

Method	Ectopic Pregnancy	Induced Abortion	Spontaneous Abortion	Birth	Amenorrhea	Venous Thrombo-embolism	Urinary Tract Infections	Postoperative Complications
No Method	0.01	0.4554	0.1683	0.3663				
Spermicides	0.01	0.4554	0.1683	0.3663			0.31	
Withdrawal	0.01	0.4554	0.1683	0.3663				
Fertility Awareness Methods	0.01	0.4554	0.1683	0.3663				
Sponge	0.01	0.4554	0.1683	0.3663				
Diaphragm	0.01	0.4554	0.1683	0.3663			0.31	
Male Condom	0.01	0.4554	0.1683	0.3663				
Female Condom	0.01	0.4554	0.1683	0.3663				
Pill	0.01	0.4554	0.1683	0.3663	0.03	0.00005	0.15	
Patch	0.01	0.4554	0.1683	0.3663	0.001	0.00005		
Ring	0.01	0.4554	0.1683	0.3663	0.03	0.00005		
Injection	0.01	0.4554	0.1683	0.3663	0.4			
IUS/IUD[a]	0.5	0.23	0.085	0.185	0.2			
Implant	0.01	0.4554	0.1683	0.3663	0.222			
Female Sterilization	0.33	0.3082	0.1139	0.2479				0.012
Male Sterilization	0.01	0.4554	0.1683	0.3663				0.00043

[a] Uses hormonal IUS rates [97].

Costs

Costs for private payers associated with contraception included those for the contraceptive method itself, physician services, method failures, and adverse events [1] (Table A.3). The costs of adverse events were weighted by their likelihood and incorporated into the total cost of each method. Direct non-medical costs and indirect costs are not included in the model. All costs were adjusted to 2017 US dollars using the medical care services or physician services component of the Consumer Price Index as appropriate [99]. In the base model we assume that the costs associated with producing and implementing the posters are negligible.

Utilities

Utilities are measured using quality-adjusted life years (QALYs) and the natural unit outcome of the number of unintended pregnancies averted. QALYs are a commonly used outcome measure in comparative effectiveness research that incorporates morbidity and mortality into a single measure [32]. A QALY is an abstract concept representing one year of life in perfect health. To calculate QALYs, we have to associate each event with a utility, which is a score reflecting an individual's preference for a health state [32]. These scores range from zero – representing death – to 1 – representing perfect health [32]. We sourced utilities from our literature review (Table A.4).

Table A.3 Cost Inputs for the Models

Treatment or Outcome and Code	Annual Cost	Model Cost	Distribution	Notes	Source	Source Year
			CONTRACEPTIVE METHODS			
IUD						
Average IUD/IUS Cost [a]	$976.24	$829.81		Range: $698.07 – $927.15 Standard Deviation: $89.07	[112]	2017
IUD Insertion (CPT 58300)	$150	$165.21		Range: $72.42-$330.42	[92] [103]	2015 2011
IUD Removal (CPT 58301)	$235	$258.83		Range: $187.24 - $330.42	[103]	2011
Office Visit (CPT 99212)	$100	$110.14		Range: $74.46- $330.42	[92] [103]	2015 2011
Total First Year Cost[b]		$1,388.66	Gamma	Raw Range: $1,047.09 – $1,984.50 Mean: $1,388.66 Shape[c]: 33.72 Scale[c]: 41.18		
Implant						
Nexplanon® [a]	$1017.48	$864.86			[112]	2017
Cost of Insertion (CPT 11975)	$143	$145.87			[92]	2015
Cost for Removal (CPT 11976)	$146.08	$180.15		Upper Bound: $404.63	[92] [103]	2015 2011
Office Visit (CPT 99212)	$100	$110.14		Range: $74.46- $330.42	[92] [103]	2015 2011
Total First Year Cost[b]		$1,323.66	Gamma	Raw Range: $1,281.87 – $1,819.13 Mean: $1,323.66 Shape[c]: 93.27 Scale[c]: 14.19		
Injectable Contraceptive						
Depo Provera® [a]	$915.56	$778.23			[112]	2017
Injection (CPT 90782) (three times per year)	$64.89	$80.03			[1]	2007
Office Visit (CPT 99212)	$100	$110.14		Range: $74.46- $330.42	[92] [103]	2015 2011

Treatment or Outcome and Code	Annual Cost	Model Cost	Distribution	Notes	Source	Source Year
Total Annual Cost[b]		$1,009.19	Gamma	Raw Range: $962.50 - $1,320.84 Mean: $1,009.19 Shape[c]: 121.88 Scale[c]: 8.28		
Vasectomy						
Procedure cost [d]	$707.97	$938.97		Range: $409.38 – $1,169.52	[1] [103]	2007 2011
Total First Year Cost[b]		$939.05	Gamma	Raw Range: $409.38 – $1,169.52 Mean: $939.05 Shape[c]: 23.45 Scale[c]: 40.04		
Tubal Ligation						
Procedure cost [e]	$2,833.79	$3,758.41		Range: $1,754.16-$7,016.66	[1] [103]	2007 2011
Total First Year Cost[b]		$3,841.33	Gamma	Raw Range: $1,837.08 - $7,099.58 Mean: $3,841.33 Shape[c]: 8.19 Scale[c]: 469.17		
Oral Contraceptive						
Average Birth Control Pill [a]	$946.05	$804.14		Range: $280.36-$2,305.06 Standard Deviation: $610.75	[112]	2017
Office Visit (CPT 99212)	$100	$110.14		Range: $74.46- $330.42	[92] [103]	2015 2011
Total Annual Cost[b]		$936.36	Gamma	Raw Range: $375.83 - $2,665.37 Mean: $936.36 Shape[c]: 2.57 Scale[c]: 364.32		
Transdermal Patch						
Xulane® [a]	$577.32	$490.72			[112]	2017
Office Visit (CPT 99212)	$100	$110.14		Range: $74.46- $330.42	[92]	2015

Treatment or Outcome and Code	Annual Cost	Model Cost	Distribution	Notes	Source	Source Year
					[103]	2011
Total Annual Cost[b]		$601.75	Gamma	Raw Range: $566.03 - $823.44 Mean: $601.75 Shape[c]: 83.97 Scale[c]: 7.17		
Vaginal Ring						
NuvaRing® [a]	$2,230.44	$1,895.87			[112]	2017
Office Visit (CPT 99212)	$100	$110.14		Range: $74.46- $330.42	[92] [103]	2015 2011
Total Annual Cost[b]		$2,010.09	Gamma	Raw Range: $1,973.34 – $2,238.18 Mean: $2,010.09 Shape[c]: 885.23 Scale[c]: 2.27		
Male Condom						
Retail – Male Condom [f]	$1	$83.87	Gamma	Raw Range: 12.58 ($0.15 per condom) – $654.18 ($7.80 per condom) Mean: $83.87 Shape[c]: 0.26 Scale[c]: 319.41	[113]	2016
Fertility Awareness Methods	0	0				
Withdrawal	0	0				
No Method	0	0				
Other Methods						
Female Condom						
FC Female Condom [f]	$2	$167.64		Raw Range: $109.03 ($1.30 per condom) – $293.54 ($3.50 per condom)	[113]	2016
Diaphragm						
Caya Contoured Diaphragm® [a]	$90	$76.50			[112]	2017
Gynol II [f]	$9.28	$42.79		Range: $37.74 ($0.45 per use) – $234.83 ($2.80 per use)	[112] [113]	2017 2017

Treatment or Outcome and Code	Annual Cost	Model Cost	Distribution	Notes	Source	Source Year
Diaphragm Fitting (CPT 57170)	$91.12	$120.85		Range: $116.94-$233.89	[1] [103]	2007 2011
Office Visit (CPT 99212)	$100	$110.14		Range: $74.46- $330.42	[92] [103]	2015 2011
Total First Year[b]		$387.48		Raw Range: $342.84 - $912.84		
Total Subsequent Years[b]		$79.99		Raw Range: $74.94 - $272.03		
Spermicides						
Gynol II[f]	$9.28	$42.79		Range: $37.74 ($0.45 per use) – 234.83 ($2.80 per use)	[112] [113]	2017 2017
Total Cost Annually[b]		$79.99		Raw Range: $74.54 - $269.59		
Sponge						
Today Sponge[f]	$415	$419.34		Raw Range: $293.54 ($3.50 per sponge) – $545.15 ($6.50 per sponge)	[113]	2016
Other Methods Average Total Cost First Year		$263.64	Gamma	Raw Range: $138.01-$505.28 Mean: $263.64 Shape[c]: 11.84 Scale[c]: 22.26		
Other Methods Average Total Cost Subsequent Years		$186.76	Gamma	Raw Range: $138.01-$345.08 Mean: $186.76 Shape[c]: 12.5 Scale[c]: 14.94		
			HEALTH OUTCOMES			
Birth[g]	$17,958	$18,885.14	Gamma	Raw Range: $16,996.41 - $20,773.86 Mean: $18,885.14 Shape[c]: 384.07 Scale[c]: 49.17	[100]	2015
Induced Abortion[h]	$535.45	$626.18	Gamma	Raw Range: $186.18 – $2,319.14 Mean: $626.18 Shape[c]: 1.32	[101]	2011

Treatment or Outcome and Code	Annual Cost	Model Cost	Distribution	Notes	Source	Source Year
				Scale[c]: 472.82		
Spontaneous Abortion[i]	$535.45	$626.18	Gamma	Raw Range: $186.18 – $2,319.14 Mean: $626.18 Shape[c]: 1.32 Scale[c]: 472.82	[101]	2011
Ectopic Pregnancy (DRG 378)[j]	$10,613	$14,075.85	Gamma	Range: ±10% Mean: $14,075.85 Shape[c]: 384.16 Scale[c]: 36.64	[1] [92]	2005 2015
ADVERSE EVENTS						
Urinary Tract Infection	$97.29	$119.98			[1]	2007
Venous Thromboembolism	$10,291	$15,472.71		Upper Range: $26,183	[102]	2004
Amenorrhea	$100	$110.14		Range: $74.46- $330.42	[92] [103]	2015 2011
Postoperative Complications - Vasectomy	$144					
Postoperative Complications – Tubal Sterilization	$5210					

[a] Costs are reported as average wholesale price (AWP). In the model, cost inputs are AWP-15% [1].

[b] Costs are weighted by the likelihood of an adverse event occurring.

[c] Assumes raw range is a 95% confidence interval around stated mean to derive standard deviation.

[d] Trussell, Lalla, et al assume that 0.2% of vasectomies are performed inpatient, 77.1% in a physician's office, and 22.7% as hospital outpatient [1, 104]. An updated source found that in 2001, 78.8% of vasectomies are performed in a physician's office, 11.5% as a hospital outpatient, 5.5% at freestanding surgery centers, and 4.2% in other settings [105].

[e] Assuming 50% are performed postpartum and 50% as interval procedures; 96% of interval procedures are outpatient [1, 106].

[f] Assuming 83 acts of intercourse per year [1].

[g] Assuming 60% of births are mistimed and would have occurred 2 years later, a 3% discount rate is applied [1].

[h] Assuming 35% of abortions are performed in the hospital, 49% occur in abortion or other clinics, and 17% in physician offices [107]. Assumes that 23% of abortions are medication abortions and the remaining 77% are surgical [101].

[i] Based on the DRG codes and proportion of in-hospital abortions used for induced abortion.

[j] Costs of ectopic pregnancy are based on the Medical Expenditure Panel Survey from 2004 and HCUP from 2005 [1].

Table A.4 Utilities for Switching and No-Switching Models

Health State	Mean	Standard Deviation	Source	Source Population	Method	Notes
Induced Abortion	0.992	0.043	Schwarz 2008	N=192 non-pregnant US women, sexually active women who were not trying to get pregnant when they presented at three Pittsburgh clinics in 2006	Time Trade-Off	Uses the utility estimate for unintended pregnancy.
Spontaneous Abortion	0.85	0.180	Kupperman 2004	N = 584 pregnant US women aged 16-47 years recruited from 23 San Francisco practices	Time Trade-Off	This utility estimate is confirmed by the following additional sources: Payne 2004 (expert estimate = 0.8), Kaimal 2015 (estimate = 0.88, SD =0.178).
Pregnancy and Birth	0.912	0.11	Kupperman 2004, Schwarz 2008	N = 584 pregnant US women aged 16-47 years recruited from 23 San Francisco practices	Time Trade-Off	Reducing by unintended pregnancy disutility to reflect the fact that all pregnancies in this model are unplanned and this utility was derived from a mixed/positive about pregnancy sample
Ectopic Pregnancy	0.982	0.13	Smith 2008, Lawrence 2001	N = 150 US women with no history of pelvic inflammatory disorder who were older than 18 and recruited in Pittsburgh	Time Trade-Off	Reducing by unintended pregnancy disutility to reflect the fact that all pregnancies in this model are unplanned and this utility was derived from a sample positive about their pregnancies. Used maximum SD giving a feasible beta.
Contraception	1					Assumption.
Urinary Tract Infection	0.994	0.03	Bermingham and Ashe 2012	N = 146 adult US women with mean age 34 (SD 12 years) with symptomatic, diagnosed UTI recruited from two family medicine clinics	Visual Analogue	
Venous Thromboembolism	0.982	0.009	Hogg 2013, Calculation	N = 216 patients of an Ottawa thrombosis clinic with a history of lower limb deep vein thrombosis or pulmonary embolism	Standard Gamble	Calculated the weighted utility including DVT and PE events

Health State	Mean	Standard Deviation	Source	Source Population	Method	Notes
Vasectomy	0.994	0.07	Smith 2008, Hillis 1999	N = 150 US women with no history of pelvic inflammatory disorder who were older than 18 and recruited in Pittsburgh	Time Trade-Off	Using lower bound of regret because sample of women who do not want pregnancy. Used maximum SD giving a feasible beta.
Induced Abortion	0.986	0.070	Calculation			Utility is decremented by vasectomy decrement and SD is sum of both.
Spontaneous Abortion	0.844	0.250	Calculation			Utility is decremented by vasectomy decrement and SD is sum of both.
Ectopic Pregnancy	0.976	0.12	Calculation			Utility is decremented by vasectomy decrement and SD is sum of both. Used maximum SD giving a feasible beta.
Tubal Ligation	0.991	0.09	Smith 2008, Hillis 1999	N = 150 US women with no history of pelvic inflammatory disorder who were older than 18 and recruited in Pittsburgh	Time Trade-Off	Using lower bound of regret because this is a sample of women who don't want pregnancy. Used maximum SD giving a feasible beta.
Induced Abortion	0.983	0.125	Calculation			Utility is decremented by sterilization decrement and SD is sum of both. Used maximum SD giving a feasible beta.
Spontaneous Abortion	0.841	0.270	Calculation			Utility is decremented by sterilization decrement and SD is sum of both.
Ectopic Pregnancy	0.973	0.13	Calculation			Utility is decremented by sterilization decrement and SD is sum of both. Used maximum SD giving a feasible beta.
Patch	1.000		Trussell 2009, Calculation	Utility for venous thromboembolism*Probability of venous thromboembolism+1*(1-Probability of venous thromboembolism)		

Health State	Mean	Standard Deviation	Source	Source Population	Method	Notes
Pill	0.999	0.020	Trussell 2009, Calculation	Utility for VT*Probability of VT+Utility for UTI*Probability of UTI+1*(1-probability of VT-probability of UTI)		Used maximum SD giving a feasible beta.
Induced Abortion	0.991	0.063	Calculation			Utility is decremented by pill decrement and SD is sum of both.
Spontaneous Abortion	0.849	0.200	Calculation			Utility is decremented by pill decrement and SD is sum of both.
Ectopic Pregnancy	0.981	0.100	Calculation			Utility is decremented by pill decrement and SD is sum of both. Used maximum SD giving a feasible beta.
Ring	1.000		Trussell 2009, Calculation	Utility for venous thromboembolism*Probability of venous thromboembolism+1*(1-Probability of venous thromboembolism)		
Other Method	0.999	0.03	Trussell 2009, Calculation	Average of (probability of UTI*utility of UTI) for "other" methods: spermicide, sponge, female condom, and diaphragm.		
Induced Abortion	0.991	0.073	Calculation			Utility is decremented by "other" decrement and SD is sum of both.
Spontaneous Abortion	0.849	0.210	Calculation			Utility is decremented by "other" decrement and SD is sum of both.
Ectopic Pregnancy	0.981	0.1	Calculation			Utility is decremented by "other" decrement and SD is sum of both. Used maximum SD giving a feasible beta.

Analyses

Main Analysis

We calculated incremental cost-effectiveness ratios (ICERs) for QALYs and unintended pregnancies averted. ICERs are calculated as the change in costs from usual care to the intervention divided by the change in outcomes; they represent the extra units of utility achieved per extra dollar spent on the intervention. In this study we calculated ICERs for both the patient-centered and CDC posters compared to the status quo, rather than using the usual method for multiple comparisons, because there was no difference in effectiveness between the two interventions.

We also calculated a cost-effectiveness acceptability curve (CEAC). To do this, we first assign a probability distribution to uncertain input parameters and then run the model 10,000 times, drawing a value for each input parameter from its distribution [33]. To create the cost-effectiveness acceptability curve, we calculated net-benefits for each of the 10,000 runs using willingness-to-pay thresholds from $0-$100,000 [33]. A willingness-to-pay threshold is the amount that decision makers are willing to pay per QALY gained for an intervention, and $50,000 is the willingness-to-pay threshold typically used in US cost-effectiveness literature [109].

Sensitivity Analyses

We conducted a bivariate sensitivity analysis on the cost of implementing the poster interventions and their effectiveness using the no-switching model. To do this, we selected a small number of possible values for the costs of implementing the poster interventions per woman: $0, $10, and $100 per woman. We also selected a small range of multipliers on the effectiveness of the intervention: 0.1X, 0.5X, 1X, 1.5X, and 2X. Then we created a CEAC for

each combination of these two variables. This bivariate sensitivity analysis explores how the transition to implementing the posters in reality might affect their cost-effectiveness.

We also conducted a probabilistic sensitivity analysis. Probabilistic sensitivity analyses use the same first steps as the cost-effectiveness acceptability curve [33]: assigning probability distributions to uncertain input parameters, then running the model many times while drawing a value for each input parameter from its distribution. Then, for each of the 10,000 runs we calculated the ICERs and graph their incremental utility (x) and incremental costs (y). The resulting graph shows the distribution of possible outcomes taking into account the uncertainty in our input parameters. Our probabilistic sensitivity analysis incorporated uncertainty in costs, utilities, and the mix of contraceptive methods for each intervention. Costs were parameterized using Gamma distributions and utilities were parameterized with Beta distributions [32]. Where standard deviations were unavailable for the total cost of the method, the distribution was parameterized so that the range of likely values reported in the literature was treated as a 95% confidence interval of a normal distribution, with the base value being the mean, in order to derive a standard deviation. This was done to avoid implausible distributions but incorporate a realistic portrayal of uncertainty over the parameter's range, as recommended by the International Society for Pharmacoeconomics and Outcomes Research-Society for Medical Decision Making (ISPOR-SMDM) Modeling Good Practices Task Force Working Group [108].

Validity

We performed validity checks on (1) the primary data set's generalizability to the US population of women who are at risk of unintended pregnancy, as well as (2) the comparability of results produced by the models to reality.

We tested these two different aspects of external validity by using two different data sets to parameterize the initial mix of methods. To check (1) whether our primary data set is

generalizable to the US population of women who are at risk of unintended pregnancy, we first used the primary data described in section 2.3. To check (2) whether the model's structure and assumptions produce results that reflect reality, we used a nationally representative National Survey of Family Growth (NSFG) data on the proportion of US women aged 15-44 who are at risk of unintended pregnancy using each method in 2011-2013. We then identified the proportions of women using each contraceptive method in the status quo alternative at the end of the model time horizon. We compared these proportions to the proportions using each contraceptive method in the nationally representative NSFG data.

Results for Models Using Individual Contraceptive Methods

Table A.5 shows the number of unplanned births total and per woman, QALYs per woman, and costs per woman for the status quo, the patient-centered poster, and the CDC poster over the course of the 5-year time horizon for both models. Both posters reduce costs, reduce unplanned pregnancies, and increase quality of life compared to the status quo.

Table A.5 Results of No-Switching and Switching Models

No-Switching Model			
Outcome	**Status Quo**	**Patient-Centered Poster**	**CDC Poster**
Total Unintended Pregnancies	7,828	5,773	5,891
Mean Unintended Pregnancies Per Woman	0.78 (SD 0.03)	0.58 (SD 0.03)	0.59 (SD 0.03)
Mean Costs per Woman	$7,488.33 (SD $566.92)	$6,223.679 (SD $496.52)	$6,165.55 (SD $501.69)
Mean QALYs per Woman	4.66 (SD 0.05)	4.68 (SD 0.05)	4.68 (SD 0.05)
ICER (compared to Status Quo)		DOMINANT	DOMINANT
Switching Model			
Total Unintended Pregnancies	3,486	2,384	2,472
Mean Unintended Pregnancies Per Woman	0.35 (SD 0.01)	0.24 (SD 0.01)	0.25 (SD 0.01)
Mean Costs per Woman	$6,430.89 (SD $491.39)	$5,417.37 (SD $428.08)	$5,230.99 (SD $407.16)
Mean QALYs per Woman	4.67 (SD 0.07)	4.68 (SD 0.08)	4.68 (SD 0.07)
ICER (compared to Status Quo)		DOMINANT	DOMINANT

N=10,000 runs for each model, cohort of n=10,000

Figures A.6 and A.7 show the ICER planes for the no-switching and switching models, respectively. In both models the results for the CDC and patient-centered posters have a great deal of overlap, indicating that there is little difference in costs and effectiveness between the two posters.

Figure A.6 Incremental Cost-Effectiveness Ratio Plane for No-Switching Model

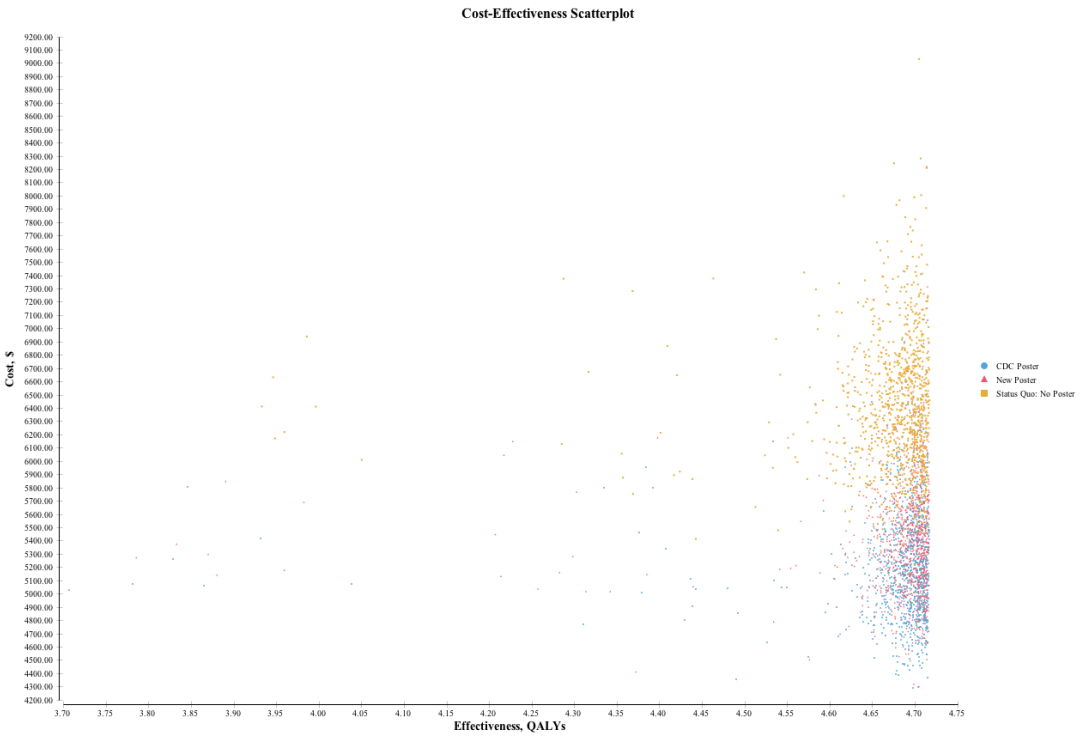


Figure A.7 Incremental Cost-Effectiveness Ratio Plane for Switching Model

Figures A.8 and A.9 show the CEACs for the no-switching and switching models, respectively. In both models the CDC poster is preferred to the patient-centered poster in over half of the model runs. The switching model shows an increased preference for the CDC poster over the patient-centered poster.

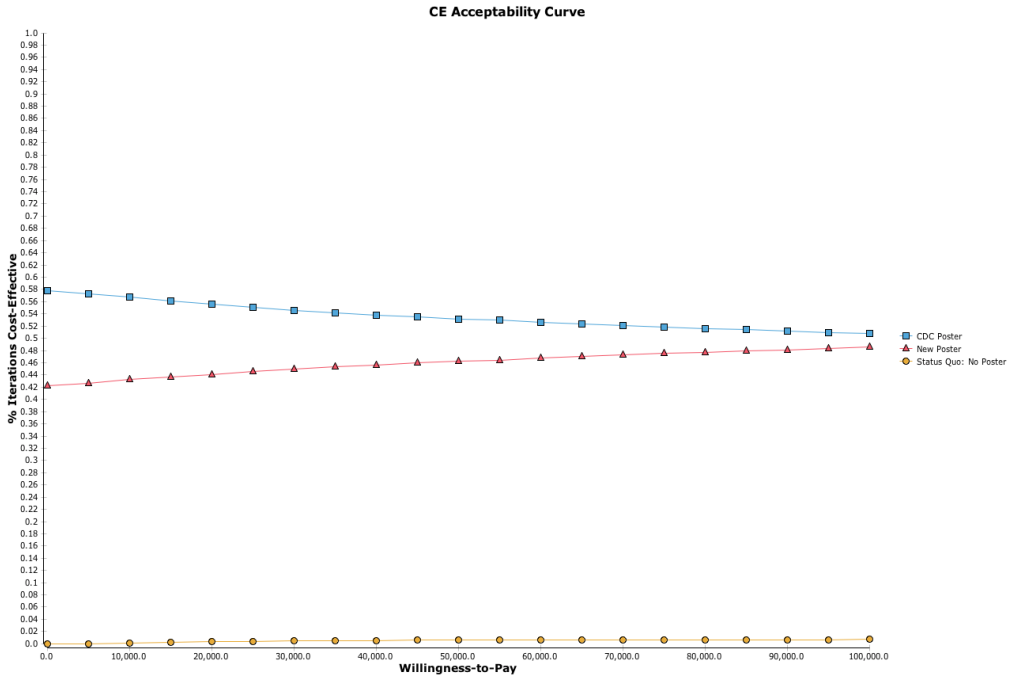


Figure A.8 Cost-Effectiveness Acceptability Curve for No-Switching Model

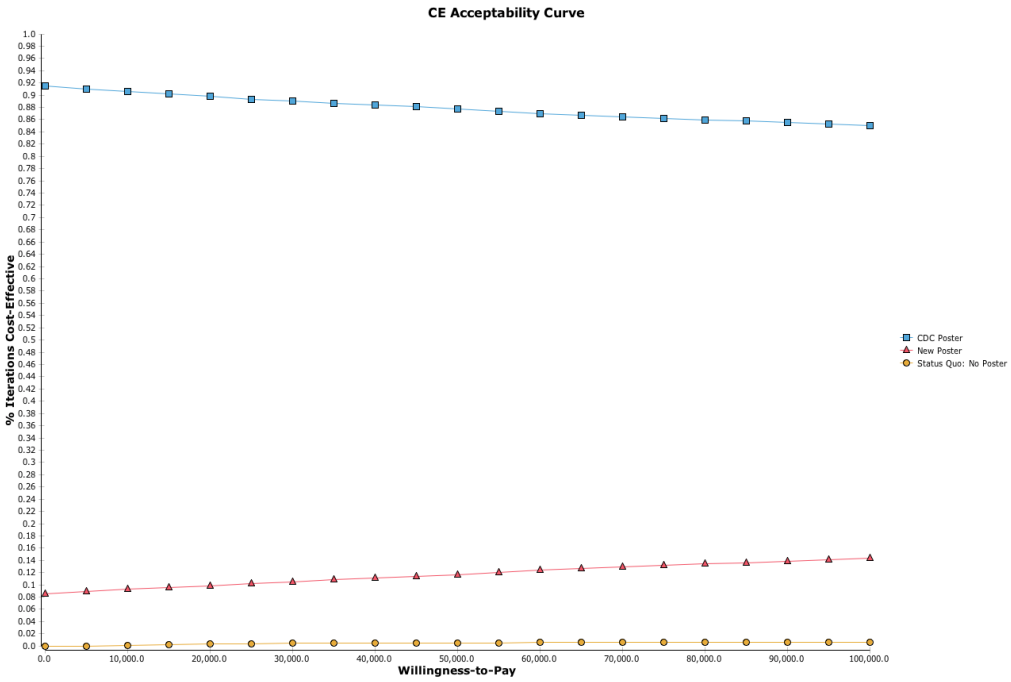


Figure A.9 Cost-Effectiveness Acceptability Curve for Switching Model

Figure A.10 shows the heat map for the bivariate sensitivity analysis. The results are very similar to each other even at extreme values of both costs for implementing the posters per woman and of intervention effectiveness.

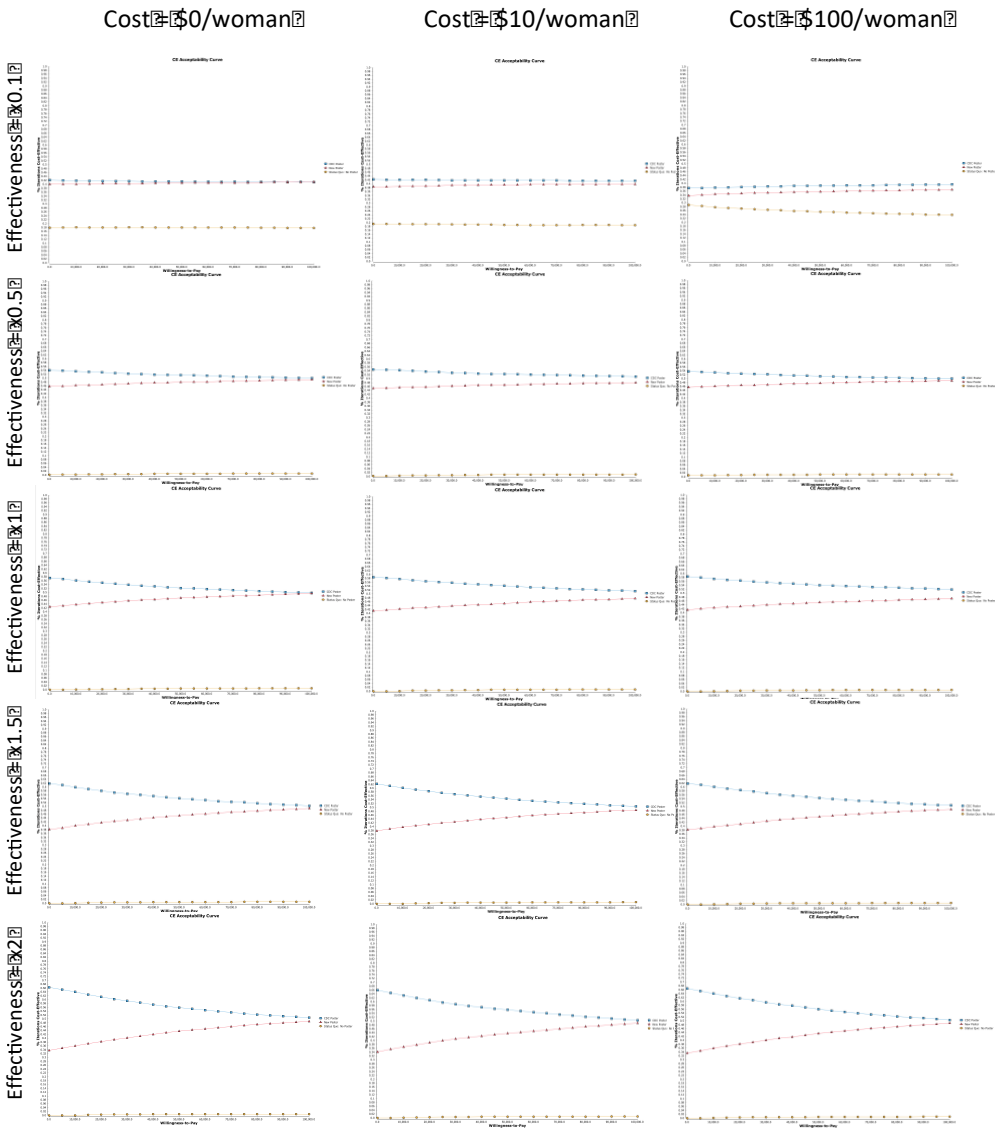


Figure A.10 Heat Map Showing Bivariate Sensitivity Analysis of Variation in Costs of Implementation and Effectiveness of Posters for No-Switching Model

Finally, Table A.6 shows the results of the validity check on both models. Differences of greater than five percentage points are highlighted in red. The final models using primary data have a number of large differences between the proportion using some methods in the model

versus the proportion using that method in reality. The switching model also shows a number of large differences when it is parameterized initially with the population data.

Table A.6 Validity Check of Final Proportions of Women Using Each Method in the Status Quo Branch of Both Models

	No-Switching Model	No-Switching Model Using Population Data[a]	Switching Model	Switching Model Using Population Data[a]	Observed Proportions in Population[a]
No Method	6.3%	10.0%	2.0%	1.7%	10.0%
Pill	12.9%	23.3%	11.5%	11.8%	23.3%
Male Condom	21.7%	13.7%	11.2%	4.8%	13.7%
Withdrawal	15.6%	4.4%	7.0%	1.4%	4.4%
Male Sterilization	8.9%	7.4%	24.6%	16.2%	7.4%
Female Sterilization	4.1%	22.6%	11.4%	49.4%	22.6%
IUS/IUD	7.5%	9.3%	10.5%	9.2%	9.3%
Injection	3.8%	4.1%	2.7%	1.8%	4.1%
Patch	2.8%	0.5%	2.8%	0.3%	0.5%
Ring	3.4%	1.8%	3.4%	1.2%	1.8%
Implant	5.0%	1.2%	8.1%	1.5%	1.2%
Fertility Awareness	7.3%	1.2%	4.4%	0.5%	1.2%
Other Methods	0.7%	0.5%	0.4%	0.2%	0.5%

Cells with a greater than 5 percentage point difference between the final proportion of women using that method and the observed proportion in the US population are highlighted in red.

[a] Source: Population data is from National Survey of Family Growth 2011-2013 [96].

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