What is the Best Way to Reduce Unintended Pregnancies? An Agent-based Simulation of Contraceptive Switching, Discontinuation and Failure Patterns in France

Nadia Diamond-Smith, Caroline Moreau and David Bishai

Abstract: Despite high rates of contraceptive use in France, over a third of pregnancies are unintended. We built a dynamic agent based model which applies data from the French COCON study on method switching, discontinuation, and failure rates to a hypothetical population of 10,000 women, followed for 10 years. We use the model to estimate the adjustment factor needed to make the survey data fit the demographic profile of France, by adjusting for underreporting of contraceptive non-use and abortions. We then test three policy scenarios which would aim to reduce unintended pregnancies: decreasing method failure, increasing time spent on effective methods, and increasing switching from less to more effective methods. Our model suggests that decreasing method failure is the most effective strategy for reducing unintended pregnancies, but all policy scenarios reduced unintended pregnancies by at least 25%. Dynamic micro simulations such as this can help guide policy makers.

Introduction: Contraceptive use is high in France where over 60% of women use a very effective method (IUD, pill, sterilization or implant) and less than 3% of women who need contraception are not using any method [1,2]. However, over a third of pregnancies in 2000 were reported to be unintended [1]. In this paper, we build a dynamic agent-based model and apply discontinuation, failure, and switching rates from previous data (the French COCON study) to a hypothetical population of 100,000 women. Prior models connecting method mix to fertility have been linear and static exercises in multiplying the percent of each method user times effectiveness rates. Given the COCON findings that effectiveness varies with each woman's time on a method and that the method mix of individual women is in flux over the life course, we hypothesized that a dynamic model would offer a better fit to observed fertility outcomes. Additionally, micro simulations are underutilized in demographic research and can potentially provide insight on data quality and policy implications.

We first validate the model's ability to closely replicate the fertility profile of France during the period of the study. From this we can draw conclusions about under-reporting and hypothesize methods of estimation to account for this. Subsequently, we use the model to undertake policy experiments comparing policies that attempt to improve use-effectiveness of prevalent methods against policies that attempt to alter the rate of method switching. We test two possible outcomes of policy changes on unintended pregnancy rates in France using this model. Policy change 1 would invest to increase method effectiveness of methods that require daily compliance (methods showing a wide gap between typical use and perfect use failure rates). This would apply to about 80% of contraceptive users in France. Policy change 2 would decrease method switching (especially rates of switching to less effective methods), which in turn increases effectiveness, but through a different mechanism.

Contraceptive failure rates differ by method type and by duration of use, where failure rates are generally higher in the first few months of use [3]. Women who switch methods from a more to less effective method are at an increased risk of unintended pregnancy. The COCON study found that when asked the reason for unintended pregnancies, 46% of women cited incorrect or inconsistent contraceptive use, 19% did not know why they became pregnant despite using a method (assumed to be method failure), and 35% cited no contraceptive use [4]. Thirty percent of contraceptive failures were in very effective contraceptive methods [4]. Of the roughly one third of pregnancies reported to be unintended, 60% ended in an abortion [2].

Methodology: The French COCON study, a population based cohort study, gathered longitudinal data on the contraceptive behaviors of a random sample of 2863 women aged 18 to 44 over a five year period (2000-2004) [5]. This dataset provides information on method switching, failure, and discontinuation patterns of French women, and can help shed light onto the causes of persistently high rates of unintended pregnancies.

An agent-based model was built using STATA11. First, a sample of hypothetical women was created with a uniform distribution of ages from 15-49. The hypothetical women were programmed to update their status each month for 120 months. The population was held constant so each woman having her 49th birthday was replaced by another woman having her 15th birthday. Mortality and migration rates were zero.

Current pregnancy status was initialized according to age to be consistent with data from France for 2000 [2]. All pregnant women were randomly generated a date of last menstrual period. At each month of pregnancy a random variable determined if she continued with the pregnancy, miscarried or aborted the pregnancy. Age specific rates of induced abortion from France and pregnancy loss (miscarriage, ectopic pregnancy and stillbirth) from European data were applied [6,7] (Table. 1). Women who gave birth were given a 3-month non-susceptible period, and women who miscarried or aborted were fecund in the following month.

All women who were not pregnant were initialized to use one of eleven states: no partner, partner and no family planning, condom, birth control pills, IUD, long acting hormonal methods (patch or ring), withdrawal, spermicide, sterilization, rhythm method, or trying to get pregnant. Women were initialized on a contraception method based on age-specific contraceptive rates from COCON [1]. If a woman was sterilized, she remained sterilized for the duration of the model. At each month, each woman experienced a probability of switching methods, which differed by method type and length of time on that method. Also in each month, each woman experienced a probability of method failure, which also differed both by method type and which was specific to the length of time a woman had used that method. Women who experienced a method failure and became pregnant then followed the pregnancy algorithm described above (see Fig. 1).

Rates of method switching and failure were based on data from the French COCON study and are reported by duration of time on that method in Tables 2 and Table 3. Finally, Table 4 shows an example of the pattern of switching from the Pill to something else or no method among women who discontinued the pill. Similar switch rates by time of use for all other methods parameterized the model for every possible switch for each time period. As found elsewhere, switching rates were quite high in the first few months of use of barrier or natural methods [4].

Women who transitioned into the "trying to get pregnant" and "no method" states were given age-specific probabilities of conception based on previous studies on conception rates among non-contracepting populations [8]. Women who stated that they were not using contraception because they had no partner were assumed to have no risk of conception.

To test the impact of Policy Change type 1 (uptake of more effective methods), we reduce failure rates of the pill and condom by 30% and see how this impacts over all unintended pregnancy rates. To test the impact of a Policy Change type 2, we test two different scenarios. In Scenario 1 we increase the amount of time people stay on the pill by 20%. In Scenario 2, we increase the amount of people who switch from the pill to a highly effective method (the IUD in this case) by 50% and reduce the number of women switching to "no method", holding constant the mean duration of use. We then model how these two scenarios (separately) would affect unintended pregnancy rates.

Results: The initial model (Model A), built using the parameters from the COCON data, underestimated the age specific fertility pattern and the unintended pregnancy rate in France during this time period [9] (Table 5). It is possible that women under-reported the amount of time spent in the state of wanting and trying to have a child. We also

hypothesize that women under-reported discontinuation of contraception, periods of time when they briefly stopped using contraception. Finally, we attribute part of the underreporting to an underestimation of contraceptive failures. Contraceptive failures may have been underestimated for 2 reasons: the underreporting of abortions in the COCON survey [10] and the fact that the estimates only account for failures resulting in unintended pregnancies.

Given these hypotheses as to why the survey data did not replicate the French demographic situation, we adjusted the model parameters (Model B). The period of time spent in the states of "trying to become pregnant" and "no methods" were increased by 20% each, and the proportional number of women were removed from the state of "pill use." Additionally, we increased failure rates to match failure rates previously found in studies in the US that adjusted for non-reporting [11]. Model B produced higher than expected fertility rates, the majority of which was from unintended pregnancies. The unintended pregnancy rate generated by Model B was as high as 50% in some age groups. Therefore, we ran another adjusted model (Model C), and applied the average of the French and US failure rates. Model C produced a TFR very close to the French TFR for this time period (Table 5).

All Policy changes were made in reference to Model C. Policy change 1 (Model D), in which we reduced failure rates for the pill and condom by 30%, reduced unintended pregnancy rates by 32% (to 32.4% of pregnancies being unintended). In Scenario 1 of Policy change 2 (Model E), we reduced the number of people switching from the pill to another method by 20%, in other words, we extended the amount of time spent on one method and there were more people using the pill at any one time. Model E reduced unintended pregnancy rates by 25% (to 35.7% of pregnancies being unintended) because it increased time spent on an effective method and reduced switching (which puts people at an increased risk of failure method). In the final model, Model F, we tested Scenario 2 of Policy Change 2, where we increased the proportion of women switching from the pill to the IUD, and reduced the proportion switching from the pill to no method. In Scenario 2, unintended pregnancy rate fell to an average of 34.8% (a decline of about 27%).

Discussion: The TFR estimated by modeling the demographic profile of France using survey data was lower than expected. We hypothesize that this is due to women underreporting the time spent in the "wanting to become pregnant" and "no method" state. Since using contraception is the norm in France, women might be reluctant to admit to spending time exposed to sex but not using a method, especially in the context of responding to a survey conducted by the French National Health and Medical Research Institute. Second, women underreport abortions, and therefore are likely to omit reporting a method failure if the pregnancy is terminated, especially when the pregnancy is due to the use of less effective methods or incorrect use on their part.

We therefore propose an adjustment factor that increased the amount of method failure and the amount of time spent in the two states of "trying to become pregnant" and "no method." This type of adjustment may be applicable to other survey data on fertility behavior in developed countries (predominantly European) where low fertility and high contraception use are the norm. An adjustment using US data on failure rates appears to be inappropriate, as this resulted in too high a TFR. The adjustment factor which took an

average of reported French and US adjusted data, in addition to increasing the time spent exposed to conception by 20%, accounted for survey error. We are limited in that we do not have switching and discontinuation rates by age group, and therefore, we see relatively similar pregnancy rates across all age groups. Future models should incorporate age specific rates of switching and discontinuation, rather than rates based solely on time spent on each method.

Policy change 1 results in 32% reduction in unintended pregnancies. Increasing current method effectiveness is a challenging goal, which could be achieved via various efforts that would aim to help women follow their family planning method regimen. Empowering women to make an informed choice which best suits her needs is an important step towards improving contraceptive compliance. Other interventions, such as receiving daily reminders to take their pill (via phone calls, text messaging or emails) may prove useful in improving use. Similarly, partners could be involved to help remind women to use their family planning more effectively. A significant proportion of failures come from the use of barrier or natural methods, even though a minority of women use these methods. In this case, increasing effectiveness, involves partner negotiation and the use of backup options such as emergency contraception to reduce the risk of pregnancy after errors in use.

Policy change 2 results in a 25% and 27% reduction in unintended pregnancies for scenarios 1 and 2, respectively. Both policies could be implemented by giving patients longer supplies of effective methods (such as the pill) so that they did not run out as quickly (at which time they might switch to less effective or no method). Additionally, a policy could also target access, by making pills available over the counter, so patients would not have as many barriers to refilling their prescriptions. Programs could be enacted to encourage patients to adopt longer acting methods such as the IUD or long acting hormonal methods (injections, etc.) to begin with, or when they switch methods.

Conclusion: This micro simulation allows for a dynamic model of reproductive behavior, which has allowed for important insights into fertility behavior. Our model suggests that survey data on this topic fairly closely represents actual behavior, and adjusting for under reporting of abortions and time spent at risk of conception can make survey data such as this more accurate. By using this model to test different policy scenarios aimed to reduce the unintended pregnancy rate, we find evidence that policies that addressed increasing method efficacy would be the most effective way of reducing unintended pregnancy. However, the tested policy simulations all had significant impacts on unintended pregnancy rates. Future iterations of the model will prepare confidence intervals, as well as sensitivity and cost-benefit analyses to help policy makers understand which approach to take to reduce unintended pregnancies.

References:

1. Bajos, N., Leridon, H., Goulard, H., Oustry, P., Job-Spira, N. and The COCON Group. (2003) "Contraception: from accessibility to efficiency" *Human Reproduction* Vol.18, No.5 pp. 994-999

2. Bajos. N. Moreau, C. Leridon, H and M. Ferrand. (2004) "Why has the number of abortions not declined in France in the past 30 years?" *Population and Societies*, No. 407

3. Moreau, C., Trussell, J.,Rodriguez, G., Bajos, N. and J. Bouyer. (2007) "Contraceptive failure rates in France: results from a population-based survey" *Human Reproduction* Vol.22, No.9 pp. 2422–2427

4. Goulard, H., Moreau, C., Gilbert, F. Job-Spira, N., Bajos, N. and the Cocon Group (2006) "Contraceptive failures and determinants of emergency contraception use" *Contraception* 74 208–213

5. Bajos, N., Leridon, H., and Job-Spira, N. (2004). La contraception et le recours à l'avortement en France dans les années 2000 : présentation et premiers résultats de l'enquête Cocon : introduction au dossier. *Population* 59(3-4): 409-418.

6. Anderson, A., Wohlfahrt, J., Christens, P., Olsen, J. & Melbye, M. (2000) "Maternal Age and Fetal Loss: population Based Register Linkage Study" *British Medical Journal* 320:1708

7. Vilain, A. (2011) "Les interruptions volontaires de grossesse en 2008 et 2009" Direction de la recherche, des études, de l'évaluation et des statistiques (DREES) No 765

8. Larsen, U., Yan, S. and Yashin, A. (2003). "Controlling for Postpartum Amenorrhea and Heterogeneity in the Analysis of Fecundability Using Birth Interval Data: A Simulation Study with Application to Hutterite Reproductive Histories" Population Review, Volume 42, Number 1-2, pp. 1-22

9. Human Fertility Database, http://www.humanfertility.org/, last accessed September 19, 2011

10. Moreau C., Bajos N., Bouyer J. and COCON group. "Questions comprehension and Recall : The Reporting of Induced Abortions in Quantitative Surveys on the General Population".Population-E – English edition, 2004, 59(3-4): 439-454.

11. Kost K. et al., Estimates of contraceptive failure from the 2002 National Survey of Family Growth, *Contraception*, 2008, 77(1):10–21.
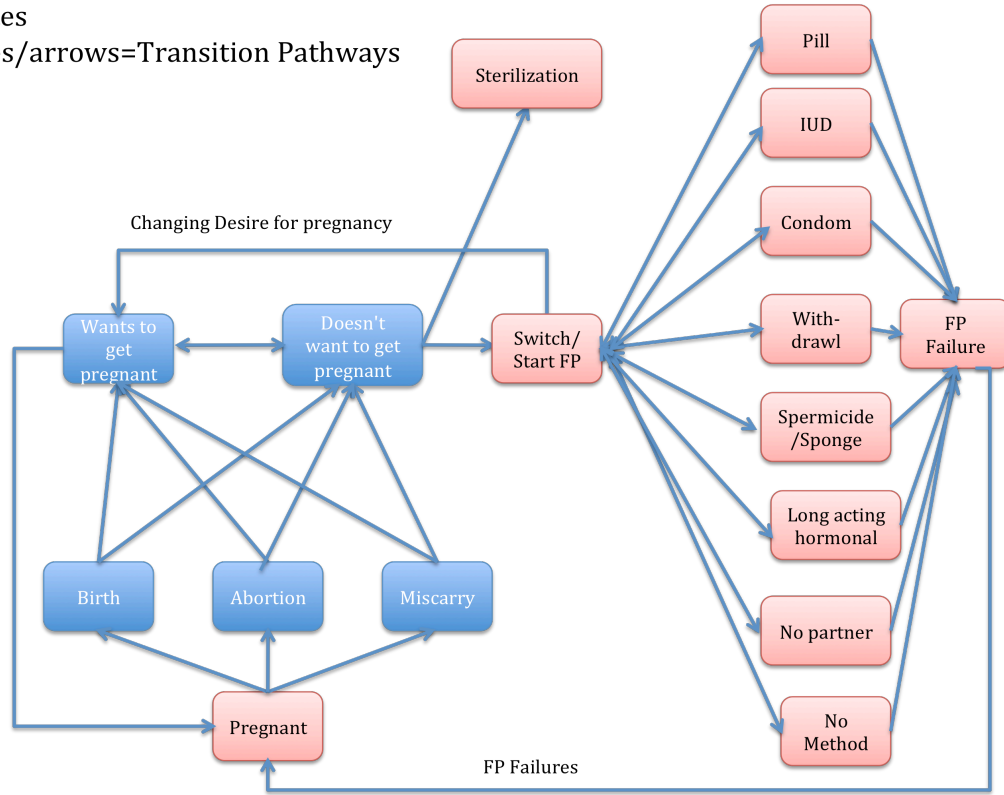
Figure 1: Diagram of Model States and Transition Pathways

Table 1: Age Specific Conception, Fertility, Abortion and Pregnancy Loss Rates

Age Group (years)	Conception [8]	Fertility [9]	Pregnancy Loss (Miscarriages, Ectopic Pregnancy and Stillbirths) [6]	Induced Abortions [7]
<19	0.25	0.04035	0.0639	0.0158
20-24	0.25	0.27862	0.0847	0.0273
25-29	0.25	0.64657	0.1020	0.0241
30-34	0.188	0.5816	0.1232	0.0187
35-39	0.125	0.25808	0.1519	0.0139
40-44	0.062	0.05646	0.1834	0.0059
>45	0.062	0.00269	0.3024	0.0006
Total		1.86437	1.0116	0.1063

Table 2: Method Failure Rates: percent of women who experienced a method failure [5]

	12 months	12-24 months	24-36 months	36-48 months	48-60 months
Birth Control Pill	2.4	1.2	1.4	1.1	0.7
IUD	1.1	3.2	0.4	0.5	1.6
Condom	3.3	4.5	1.4	1	2.1

Withdrawl	10.1	5.2	7.9	0	0
Spermicide	21.7	0	0	0	0
Fertility Awareness	7.7	11.1	0	0	0

Table 3: Discontinuation Rates: percent of women who discontinued the method [5]

	6 months	12 months	24 months	36 months
Birth Control Pill	13.4	8.1	11.2	15
IUD	7.5	3.2	6.9	12.2
Condom	27.4	10.9	15.5	22.6
Withdrawl	27.4	11.5	20.6	15.2
Spermicide	45.8	11.9	3.6	32.6
Fertility Awareness	25.7	8.8	21.5	19.6

Table 4: Switching Rates for the Pill: Of those who switch from the pill to something else in each time period, what method do they switch to? [5]

	Pill <6 months	Pill 6-12 months	Pill 1-2 years	Pill 2-3 years	Pill over 3 years
No method	0.165	0.1419	0.1044	0.1413	0.1153
IUD	0.1962	0.199	0.07	0.1145	0.0822
Condom	0.186	0.208	0.2253	0.2648	0.1578
Withdrawal	0.0401	0.0202	0.0453	0.0443	0.0233
Fertility Awareness	0.0167	0	0.0145	0.0028	0.0123
Spermicides	0.0061	0.0045	7.60E-04	0.0252	0.0061
Long acting hormonal	0.0439	0.0654	0.0332	0.0047	0.0382
Sterilization	0.0124	0.0098	7.60E-04	0.0014	0.0231
Pregnant	0.048	0.0413	0.081	0.0711	0.0594
Trying to become pregnant	0.1819	0.2176	0.3573	0.2448	0.3763
No partner	0.1037	0.0924	0.0674	0.0851	0.106

Table 5: Total Fertility Rate and Unintended Pregnancy Rates Models A-E

	Model A: COCON	Model B: US failures	Model C: US-COCON failures	Model D: Better Methods	Model E: Less OC stopping	Model F: More OC starting
Total Fertility Rate	1.47	2.00	1.81	1.68	1.91	1.70
Percent of Pregnancies	18.0%	53.1%	47.6%	32.4%	35.7%	34.8%

from Failures						
Percent reduction in unintended pregnancies compared to Model C				32%	25%	27%

*Model A: COCON parameters only

Model B: Adjusted to US Failure rates and 20% more time spent "wanting to get pregnant" and "not using family planning"

Model C: Adjusted to average of French and US Failure rates and 20% more time spent "wanting to get pregnant" and "not using family planning"

Model D: Policy 1—reduce failure rates for pill and condom users by 30%

Model E: Policy 2, Scenario 1—reduce switching from the pill by 20% per time period

Model F: Policy 2, Scenario 2—increase switching to more effective methods, 50% more women switching from the pill now switch to the IUD rather than no method.