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# Bayesian Network for Abortion Prediction

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ISYE 6420 - Final Project

# Bayesian Network Application to Abortion Prediction

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# 1. Context

## 1.1. Key facts on contraceptive use and abortion in the US

The number of abortion recorded in the US has been decreasing since 1980, as can be seen on Figure 1. [1]

Currently, 51% of pregnancies in the US are unintended and 4 out of 10 are terminated with abortion. [2]

In the mean time, the proportion of women having ever used a contraceptive method increased from 94.8% in 1982 to 99.1% in 2006-2010. The main contraceptive methods used since 1982 are the pill (27.5%) and female sterilization (26.6%). [3] [4] [5]

However, although more hormonal methods have become available since 1990, the overall proportion of unintended pregnancies has not decreased. [6]

I wished to look at the factors influencing the probability of an unintended pregnancy and/or an abortion. I decided to build a Bayesian Network figuring the different contributing factors such as age, education, and choice of contraceptive method and use this Bayesian Network to predict probabilities of an abortion given different evidence.

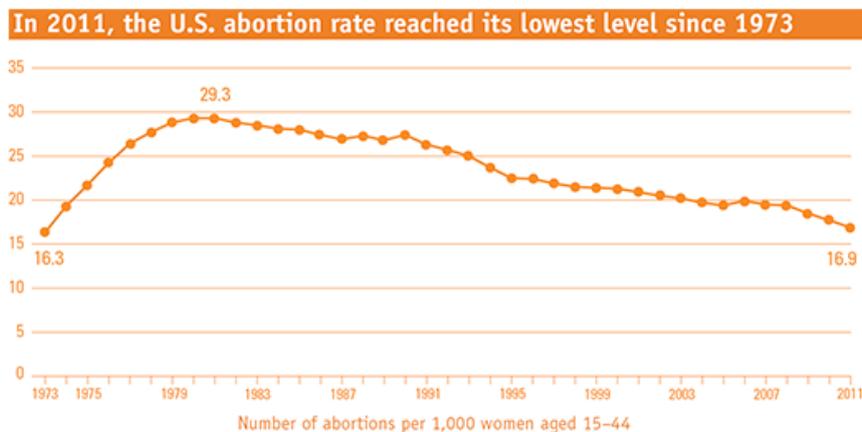
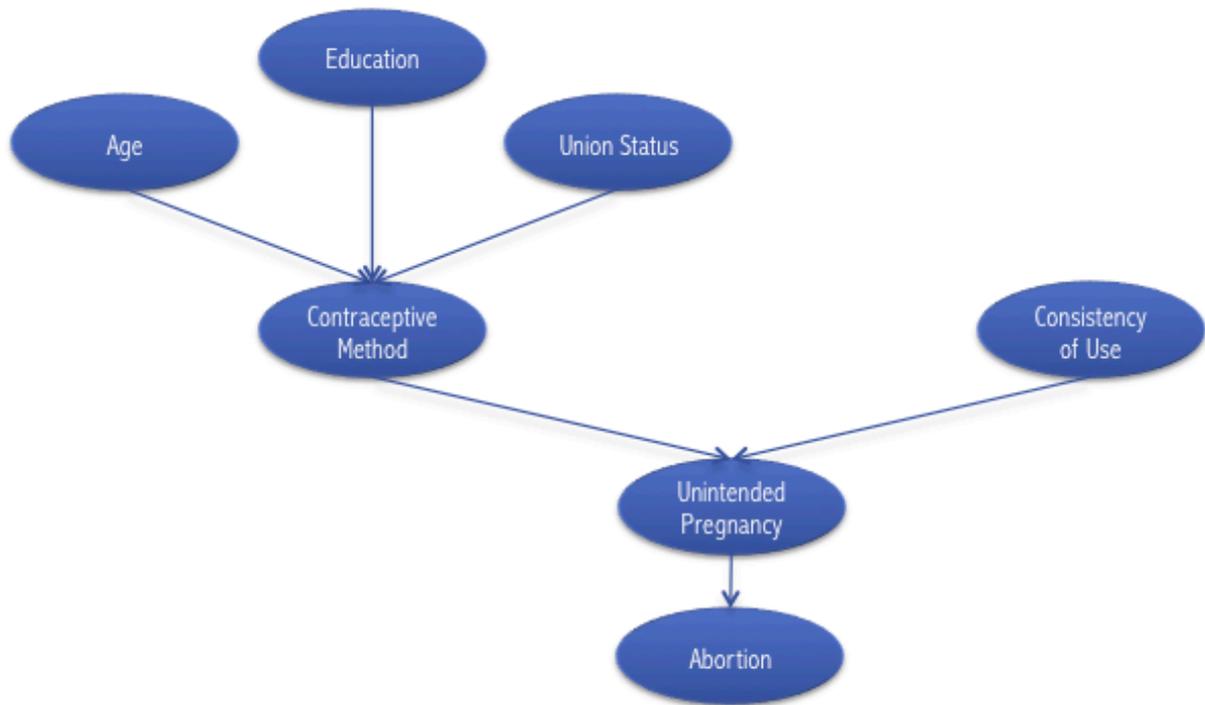


Figure 1 - Abortion rate in the US since 1973

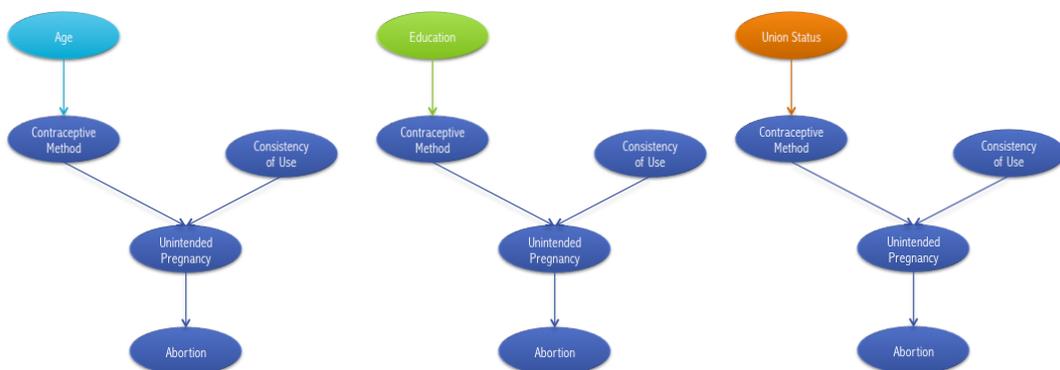
## 2. Setting up the Bayesian Network

### 2.1. Identifying the Nodes

The first network that I intended to build was the following:



However, this network would require knowing the probability of selecting a particular contraceptive method given an age group and an education group. Since I had only access to the probability of choosing a contraceptive given either the age group or the education, I decided to build three different models, with a different criterion influencing the choice of contraceptive method as shown below.



## 2.2. Categorical Nodes

The nodes are partly Boolean, partly categorical. The following categories were used:

Age		Education		Union Status	
1	15-19 years	1	No high school diploma	1	Married
2	20-24 years	2	High school diploma	2	Cohabiting
3	25-29 years	3	Some college experience	3	Formerly married, not cohabiting
4	30-34 years	4	Bachelor's degree or higher	4	Never married, not cohabiting
5	35-39 years				
6	40-44 years				

Contraceptive		Consistency of Use		Abortion	
1	Female Sterilization	1	Consistent	1	Yes
2	Male Sterilization	2	Inconsistent	2	No
3	Pill				
4	Other hormonal method				
5	IUD				
6	Condom				
7	Abstinence				
8	Other methods				

Unintended Pregnancy	
1	Yes
2	No

## 2.3. Conditional probabilities at each node

At each node, we must define the probabilities of each category, conditionally on the parent nodes, if any.

Studies conducted by the National Center for Health Statistics, data from the National Survey of Family Growth and reports from the Guttmacher Institute were used to determine these probabilities. [1] [2] [3]

The final probabilities used are given in the Appendix.

### 3. Model in OpenBUGS

For the first factor Age for instance, the OpenBUGS model was the following:  
model

```
{  
    union.status~ dcat(p.union.status[])  
    contraception ~ dcat(p.contraception[union.status,])  
    consistency ~dcat(p.consistency[])  
    pregnancy ~ dcat(p.pregnancy[contraception,consistency,])  
    abortion ~ dcat(p.abortion[pregnancy,])  
}
```

The same model was used, replacing age by education then union status and changing the Data accordingly.

## 4. Results

### 4.1. Influence of Age

#### 4.1.1. Probability of an abortion across age groups

The model with the factor “Age” was used to predict the probability of an abortion for each age group. We set the evidence age equal to the group we wish to study and look at the node abortion to assess the probability of an abortion. We obtain the probabilities across all the age groups considered shown in Figure 2.

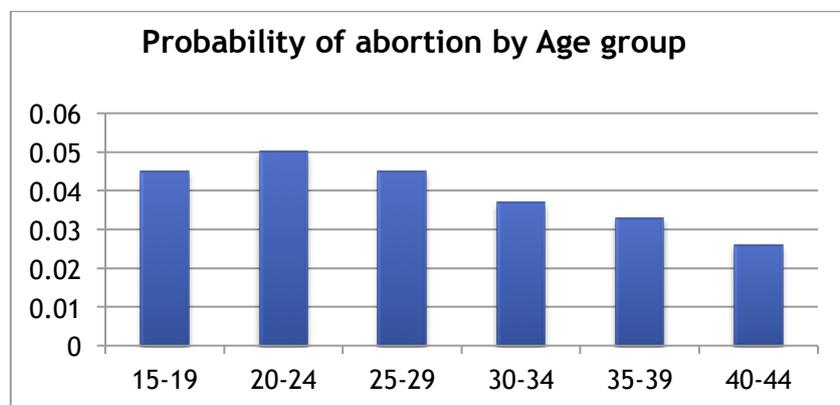


Figure 2 - Probability of an abortion by age group

#### 4.1.2. Distribution of women across the age groups given an abortion occurred

When setting the evidence abortion = 1, we can look at the posterior probability that the woman belonged to each age group.

We obtain the distribution by age given in Figure 3 on the left. We compare this distribution to results from studies of abortion patients on the right. [7] We notice that the distribution from the survey is quite different than the one predicted by the model.

We then used the evidence pregnancy = yes, and looked again at the distribution across age groups. It was again compared to surveys results. Both are given in Figure 4.

Whether considering the evidence abortion = yes or pregnancy = yes, the distribution given by the model is the same, because the only link between these two nodes is a direct link, stating the probability of having an abortion if there is an unintended pregnancy.

The distribution of unintended pregnancies is closer to the one gathered from the survey, where the distribution of abortions differed a lot more. This observation suggests that the age of a woman also directly influences the decision of a woman to have an abortion when found pregnant.

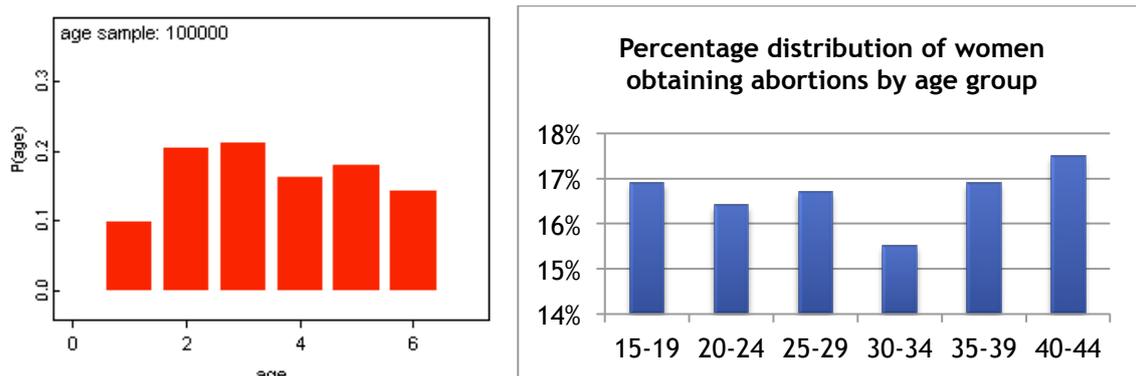


Figure 3 - Comparison of model results and survey results for abortion

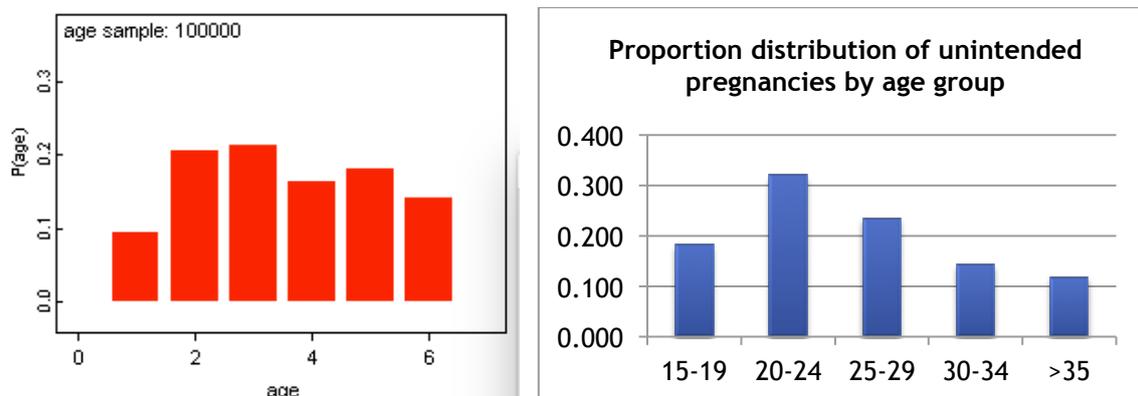


Figure 4 - Comparison of model results to survey results for prediction of unintended pregnancies

## 4.2. Influence of Education

Using different education categories as the evidence, we obtain the probability of having an abortion for every education group shown in **Erreur ! Source du renvoi introuvable**. Figure 5.

According to the model, the probability of having an abortion increases with the education level, which is relatively consistent to what has been observed from surveys. The higher the education, the more likely a woman is to terminate an unintended pregnancy.

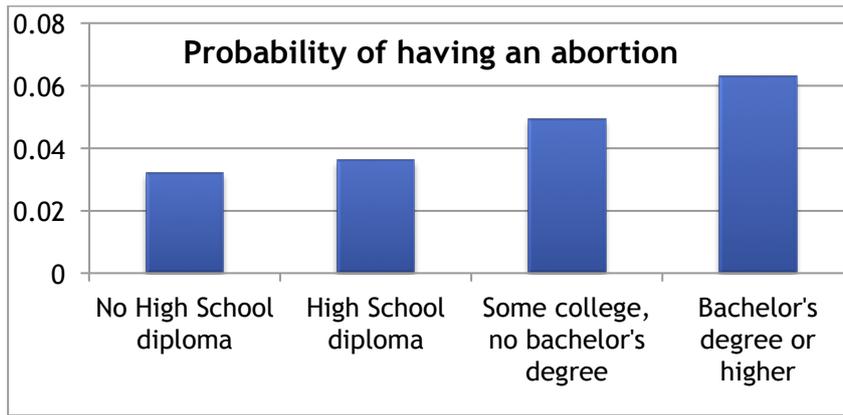


Figure 5 - Probability of having an abortion depending on education

We then proceeded like with the age factor and set the evidence to abortion = yes, displaying the distribution across education groups. The density of the factor “education” is given in Figure 6. These results were compared to those of surveys of women obtaining abortions, which are shown in Figure 7. The distribution from the model is relatively close from the one drawn from the surveys. Just like with the age factor, the difference suggests that the education level has a direct impact on the decision of having an abortion.

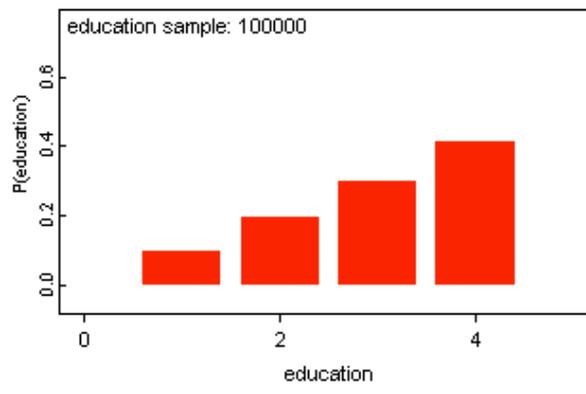


Figure 6 - Probability of belonging to education group given the evidence abortion

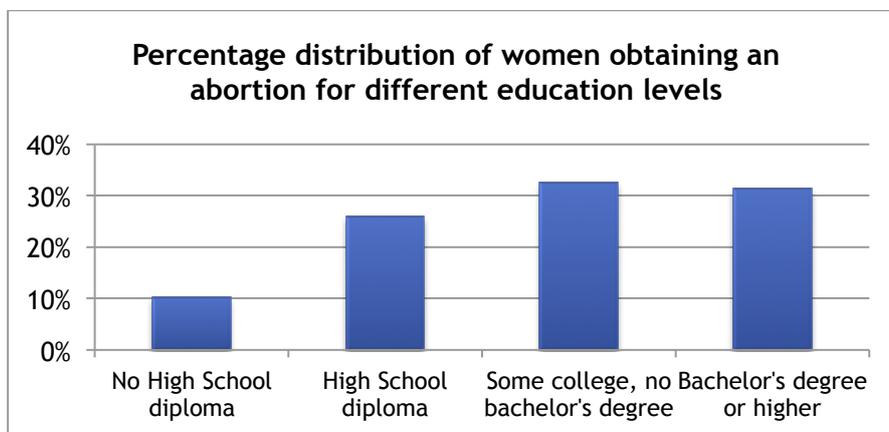


Figure 7 - Percentage distribution of women having an abortion according to surveys

### 4.3. Influence of Union Status

By setting the evidence to each union status group, we obtain the probability for each group of having an abortion. These probabilities are shown in Figure 8. The highest probability is observed for the never married, not cohabiting category. Indeed a woman with no steady partner is more likely to have an abortion.

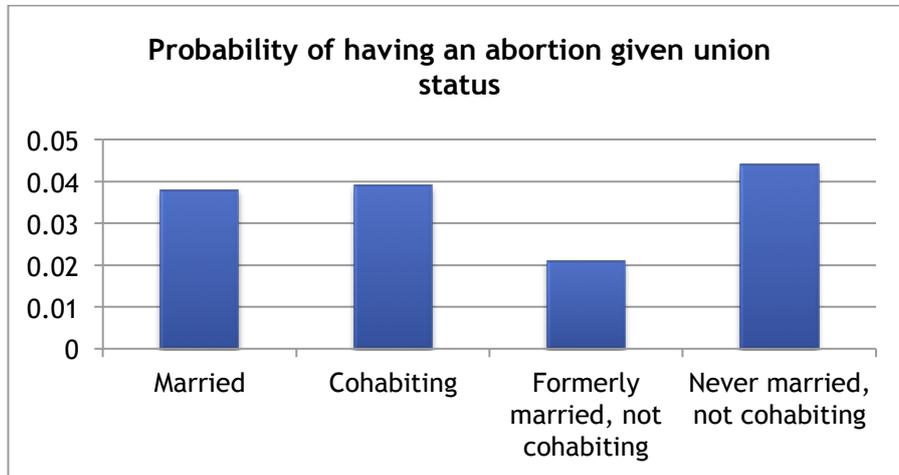


Figure 8 - Probability of having an abortion for a given union status

We then investigated what the distribution across union status categories would be if the woman had an abortion. Setting the evidence to abortion = yes, the distribution is given in Figure 9.

These results are once again compared to those of the surveys, shown in Figure 10. There is a clear difference for the group “Formerly married, not cohabiting”. This suggests that the union status not only influences the choice of contraceptive method, which is what the model currently implements, but it also affects the decision of having an abortion.

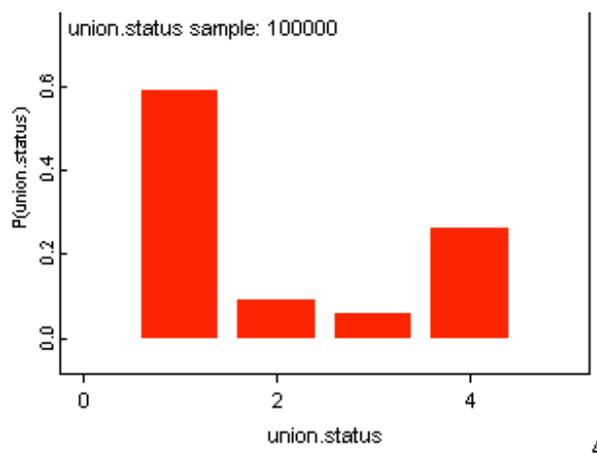


Figure 9 - Distribution across union status categories given there was an abortion

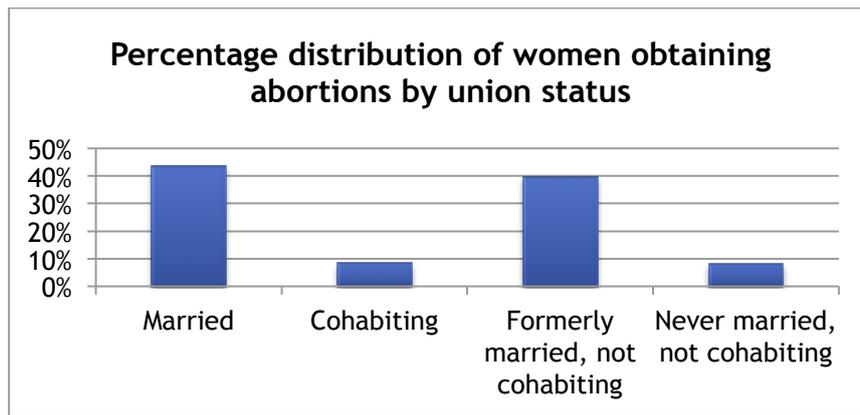


Figure 10 - Distribution of women obtaining an abortion by union status according to survey results

## 5. Conclusion

The Bayesian Network built enables the prediction of a woman obtaining an abortion depending on different factors: age, education and union status.

However, by comparing results with surveys of women obtaining abortions, we observe some discrepancies. These can be explained by the fact that the model figures only one direct link between an unintended pregnancy and an abortion. In reality, many other factors influence the decision of having an abortion.

The next steps would therefore be to include in each model a link between the factor age, education or union status and the abortion node, using the results from the surveys to set the conditional probabilities.

## 6. Appendix

The following tables give the conditional probabilities used at each node in the Bayesian Network, obtained through literature research.

Age	Probability
15-19	0.083
20-24	0.157
25-29	0.179
30-34	0.167
35-39	0.205
40-44	0.209

Education	Probability
No high school diploma	0.145
High school diploma	0.257
Some college, no bachelor's	0.290
Bachelor's degree or higher	0.308

Union Status	Probability
Married	0.586
Cohabiting	0.085
Formerly married, not cohabiting	0.107
Never married, not cohabiting	0.222

CONTRACEPTIVE								AGE
Female Sterilization	Male Sterilization	Pill	Other hormonal	IUD	Condom	Abstinence	Other methods	
0.000	0.000	0.532	0.161	0.027	0.200	0.000	0.080	15-19
0.026	0.009	0.471	0.122	0.056	0.255	0.003	0.058	20-24
0.164	0.041	0.329	0.113	0.073	0.208	0.007	0.065	25-29
0.300	0.095	0.253	0.056	0.071	0.155	0.018	0.052	30-34
0.373	0.166	0.170	0.027	0.065	0.121	0.017	0.061	35-39
0.506	0.200	0.098	0.019	0.032	0.090	0.015	0.040	40-44

CONTRACEPTIVE								EDUCATION
Female Sterilization	Male Sterilization	Pill	Other hormonal	IUD	Condom	Abstinence	Other methods	
0.000	0.000	0.532	0.161	0.027	0.200	0.000	0.080	No High School diploma
0.026	0.009	0.471	0.122	0.056	0.255	0.003	0.058	High School diploma
0.164	0.041	0.329	0.113	0.073	0.208	0.007	0.065	Some college, no bachelor's degree
0.300	0.095	0.253	0.056	0.071	0.155	0.018	0.052	Bachelor's degree or higher

CONTRACEPTIVE								UNION STATUS
Female Sterilization	Male Sterilization	Pill	Other hormonal	IUD	Condom	Abstinence	Other methods	
0.000	0.000	0.532	0.161	0.027	0.200	0.000	0.080	Married
0.026	0.009	0.471	0.122	0.056	0.255	0.003	0.058	Cohabiting
0.164	0.041	0.329	0.113	0.073	0.208	0.007	0.065	Formerly married, not cohabiting
0.300	0.095	0.253	0.056	0.071	0.155	0.018	0.052	Never married, not cohabiting

CONSISTENCY	Probability
Consistent use	0.79
Inconsistent use	0.21

UNINTENDED PREGNANCY		CONTRACEPTIVE	CONSISTENCY
Yes	No		
0.005	0.995	Female Sterilization	Consistent
0.041	0.959	Female Sterilization	Inconsistent
0.0015	0.9985	Male Sterilization	Consistent
0.0123	0.9877	Male Sterilization	Inconsistent
0.003	0.997	Pill	Consistent
0.0246	0.9754	Pill	Inconsistent
0.0021	0.9979	Other hormonal	Consistent
0.0172	0.983	Other hormonal	Inconsistent
0.006	0.994	IUD	Consistent
0.0492	0.9508	IUD	Inconsistent
0.2	0.8	Condom	Consistent
1	0	Condom	Inconsistent
0.22	0.78	Abstinence	Consistent
1	0	Abstinence	Inconsistent
0.25	0.75	Other methods	Consistent
1	0	Other methods	Inconsistent

ABORTION		UNINTENDED PREGNANCY
YES	NO	
0.4	0.6	YES
0	1	NO

## 7. References

- [1] Jones, Rachel K., and Jenna Jerman. 'Abortion Incidence And Service Availability In The United States, 2011'. *Perspect Sex Repro H* 46.1 (2014): 3-14. Web. 23 Apr. 2015.
- [2] Finer LB and Zolna MR, Shifts in intended and unintended pregnancies in the United States, 2001-2008, *American Journal of Public Health*, 2014, 104(S1): S44-S48.
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