Appendix: Estimates of credible intervals for unintended pregnancy rates

We estimated the unintended pregnancy rate among women younger than 20 by combining data on the number of births and abortions to that age-group with data on the pregnancy intention status of the pregnancies that led to those outcomes (see Methodology section). The intention status of pregnancies leading to births among women younger than 20 was estimated from state PRAMS surveys, while the intention status of pregnancies leading to abortions in that same age-group was estimated from a national survey of abortion patients. Each of these surveys has its own set of sampling errors; in addition, while we assume that the intention status of pregnancies leading to abortions is similar in each state, we also expect there to be some level of variability between states that should be accounted for in our estimates. In order to account for these multiple sources of error, we used the software package Stan to estimate credible intervals using a Hamiltonian Monte Carlo algorithm. The equations describing the model from which these intervals were estimated are presented below, along with the rationale for each model specification choice. The model specification in Stan code can be found at the end of this appendix.

The unintended pregnancy rate for each state i can be expressed as follows:

$$UnintendedPR_i = \frac{(P(UB)_i \times Births_i \times 1.2) + (P(UA)_i \times Abs_i \times 1.1)}{Pop_i} \times 1{,}000$$

Where $P(UB)_i$ is the proportion of births to women younger than 20 that are from unintended pregnancies in a given state i, $P(UA)_i$ is the proportion of abortions to women younger than 20 that are from unintended pregnancies in that same state, $Births_i$ is the number of resident births to this age-group, Abs_i is the number of abortions to this age-group and Pop_i is the population size of women aged 15–19 in that state. As with the overall pregnancy rates, we multiplied births by 1.2 and abortions by 1.1 to estimate fetal losses; we assumed that the intention status of a pregnancy is unrelated to whether or not it ends in a fetal loss.

It is important to note that $P(UB)_i$ and $P(UA)_i$ are parameters estimated by our model and not the estimates obtained directly from PRAMS or the survey of abortion patients, respectively. Instead, we assumed that for each state, $P(UB)_i$ comes from a normal distribution with mean μ_i and standard deviation σ_i, where μ_i is the estimated proportion of births to women younger than 20 that are unintended in that state (estimated from PRAMS), and σ_i is the standard error of that estimate. This can be expressed as:

$$P(UB)_i \sim N(\mu_i, \sigma_i), \text{ with the additional constraint that } 0 < P(UB)_i < 1$$

$P(UA)_i$ is modeled slightly differently, as we have no state-specific data on the proportion of abortions to women younger than 20 that are from unintended pregnancies. Instead, we assumed that the state-specific proportions vary to some degree around a national mean. We modeled this in the following manner:

$$P(UA)_i \sim N(\delta, .1), \text{ again constraining } P(UA)_i \text{ such that } 0 < P(UA)_i < 1$$

Here δ is the national proportion of abortions to women younger than 20 that are from unintended pregnancies and .1 is an informed estimate of how much each state is likely to vary around this mean. Given the historically low proportions of abortions to women younger than 20 that are the result of intended pregnancies (around 2% in 2014), it is unlikely that in any state the proportion of abortions from an unintended pregnancy is lower than 10 percentage points below the national average. We chose to use this standard deviation as a more conservative estimate, however, given our lack of state-specific data.

Finally, δ is modeled as coming from a normal distribution with mean π and standard deviation τ, where π is the estimated national proportion from the survey of abortion patients, and τ is the standard error of that estimate:

$$\delta \sim N(\pi, \tau), \text{ with } 0 < \delta < 1$$

We used the Hamiltonian Monte Carlo algorithm implemented in Stan to generate samples of the distributions of all model parameters. We used these samples to construct 95% credible intervals around our estimated unintended pregnancy rates using the 2.5th and 97.5th percentiles of the distributions. These intervals are shown surrounding the estimates in Figure 7.

```
model_string <- "
data {

  int<lower=0> N;                       # number of states


  real<lower=0,upper=1>   estub[N];     # Estimated percent of births to women under 20 that are unintended (from PRAMS)
  real<lower=0,upper=1>   estua;        # Estimated percent of abortions to women under 20 that are unintended (from national survey of abortion patients)
  real<lower=0>           ubse[N];      # Standard error of estimate of proportion of births that are unintended
  real<lower=0>           uase;         # Standard error of estimate of proportion of abortions that are unintended
  real births[N];                       # Number of births to women under in each state
  real abortions[N];                    # Number of abortions to women under 20 in each state
  real pop[N];                          # Population of women under 20 in each state

}

parameters {

  real<lower=0,upper=1> ub[N];          # Percent of births to women under 20 that are unintended in each state
  real<lower=0,upper=1> ua[N];          # Percent of abortions to women under 20 that are unintended in each state
  real<lower=0,upper=1> natua[N];       # Percent of abortions to women under 20 that are unintended nationally


}
transformed parameters{
  real<lower=0>           uprate[N];    # Unintended pregnancy rate for women under 20
  real<lower=0, upper=1> percunpreg[N]; # Percent of pregnancies to women under 20 that are unintended

  for(i in 1:N){

    uprate[i] = (((ub[i]*births[i]*1.2)+(ua[i]*abortions[i]*1.1))/pop[i])*1000 ;

    percunpreg[i]= ((ub[i]*births[i]*1.2)+(ua[i]*abortions[i]*1.1))/((births[i]*1.2)+(abortions[i]*1.1));
  }
  }


model{

  for(i in 1:N){

  ub[i]~ normal(estub[i], ubse[i]);
  ua[i]~ normal(natua, .1);
  natua~ normal(estua, uase);

}


}"
```