Appendix 1.

Statistical Models

To estimate the rates of expected and unassisted plural births from 1971-2015 we developed a Bayesian multilevel logistic regression model using plural births data from 1949-1966. Let C_{ary}, n_{ary} and p_{ary} be the number of plural live births, the total number of live births, and the proportion of plural births at age group a, race r and year y, respectively. We assumed that

$$C_{ary} \sim Binomial(p_{ary}, n_{ary}) \; ,$$

$$\log\left(\frac{p_{ary}}{1-p_{ary}}\right) = \beta_0 + \beta_a + \beta_r + \beta_{ar} + \epsilon_{ary}, \qquad (1)$$

where β_0 is the intercept, β_a is a coefficient for age group a, β_r is a coefficient for race r, β_{ar} is the interaction coefficient for age group a and race r and $\epsilon_{ary} \sim N(0, \sigma^2)$. To complete the Bayesian model we assumed that $\beta_0, \beta_a, \beta_r, \beta_{ar} \overset{i.i.d}{\sim} N(0,1000)$ and that $\sigma^2 \sim Unif[0,1000]$, where $Unif$ is the uniform distribution. These prior distributions are relatively vague and uninformative. The model in Equation (1) allows for variation in rates across race and age group and enables these rates to vary across years.

Given $n_{ar\tilde{y}}$ for $\tilde{y} \in \{1971-2015\}$ we can predict the expected and the age-adjusted unassisted plural rate for $\tilde{y} \in \{1971-2015\}$ by sampling from the posterior predictive distribution

$$P(C_{ar\tilde{y}} \mid C_{ary}, n_{ary}, n_{ar\tilde{y}}), y \in \{1949-1966\}, \tilde{y} \in \{1971-2015\} \; [1].$$

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The authors provided this information as a supplement to their article.

Let $\hat{c}_{ar1971}$ be the expected number of plural births for age group a and race r at 1971, then the rate for the expected national plural births for race r is calculated using $\sum_a \hat{c}_{ar1971} / \sum_a n_{ar1971}$. Similarly, let $\hat{c}_{ar\tilde{y}}$ be the age-adjusted number of plural births for age group a and race r for $\tilde{y} \in \{1971-2015\}$, then the age-adjusted national plural rate for race r at year $\tilde{y}$ is calculated as $\sum_a \hat{c}_{ar\tilde{y}} / \sum_a n_{ar\tilde{y}}$.

The expected number of plural births was obtained by multiplying the expected rate $\sum_a \hat{c}_{ar1971} / \sum_a n_{ar1971}$ by the annual number of births for race r for year $\tilde{y} \in \{1971-2015\}$, $\sum_a n_{ar\tilde{y}}$.

The age-adjusted number of plural births is defined as $\sum_a \hat{c}_{ar\tilde{y}}$, and the cumulative contribution of delayed childbearing to the plural birth complement of white and black women is estimated as the sum of the difference between the expected number of plural births from its age-adjusted counterpart from 1972 to 2015, $\sum_a \hat{c}_{ar\tilde{y}} - \left(\sum_a \hat{c}_{ar1971} \times \sum_a n_{ar\tilde{y}} \right) / \sum_a n_{ar1971}$.

<u>Simulated Projection through 2025</u>

The simulated projection of live birth counts for each age and race group relied on a Bayesian log-linear models with a spline along the years and an autoregressive component for each age and race group separately. Formally, we forecasted $n_{ary'}$ $y' \in \{2016-2025\}$ using $n_{ar\tilde{y}}$ and assuming the following model:

$$
\begin{aligned}
&n_{ar\tilde{y}} \sim Poisson(\lambda_{ar\tilde{y}}) \\
&\log(\lambda_{ar\tilde{y}}) = \eta_{ar0} + s_{ar}(\tilde{y}) + \gamma(\log(n_{ar\tilde{y}-1}) - \log(\lambda_{ar\tilde{y}-1})),
\end{aligned}
\tag{2}
$$

where η_{ar0} is the intercept for age group a and race r, s_{ar} is a univariate smooth based on spline like basis expansion with quadratic penalties for age group a and race r [2], and γ is an auto-regressive lag 1 coefficient. We assumed that $\gamma \sim Uniform[-1,1]$, and the prior distributions for the spline and intercept are defined in the mgcv package [3, 2]. Using this model one can sample from the posterior predictive distribution of $P(n_{ary'} \mid n_{ar\tilde{y}})$ to generate future counts for each age and race group separately.

Simulated projection for the age-adjusted national plural birth rate relied on model (1) and the projected number of births as derived from Model (2). Formally, let $\hat{n}_{ary'}$ $y' \in \{2016-2025\}$ be the forecast of the number of live births for age group a and race r at year y'. These forecasts were used to predict the number of plural births within each race and age group, $\tilde{C}_{ary'}$ $y' \in \{2016-2025\}$, from the posterior predictive distribution using the model in Equation (1). The age-adjusted rate for race r for future years can be approximated by

$$
\sum_a \tilde{C}_{ary'} / \sum_a \hat{n}_{ary'} \quad y' \in \{2016-2025\}.
$$

Simulated projection for the overall national plural birth rates were derived using two separate Bayesian log-linear models with a spline along the years, an autoregressive component, and age-group adjustments for both white and black women. Let $o_{r\tilde{y}}$ be the observed number of plural births for year $\tilde{y} \in \{1971-2015\}$ for race r, we assumed that

$$\begin{aligned} &o_{r\tilde{y}} \sim Pois(\lambda_{r\tilde{y}}) \\ &\log(\lambda_{r\tilde{y}}) = \alpha_{r0} + s_r(\tilde{y}) + \sum_a \alpha_{ar} n_{ar\tilde{y}} + \gamma_{r1}(\log(o_{r\tilde{y}-1}) - \log(\lambda_{r\tilde{y}-1})), \end{aligned} \tag{3}$$

where α_{r0} is the intercept, s_r is a spline like basis expansion with quadratic penalties, α_{ar} are coefficients for the count of live births for age group a and race r, and γ_{r1} is an auto-regressive lag 1 coefficient. We assumed that $\gamma_{r1} \sim Uniform[-1,1]$, $\alpha_{ar} \overset{i.i.d}{\sim} N(0,10000)$, and the prior distributions for the spline and intercept are defined in the mgcv package [3, 2].

The overall number of plural births (assisted and unassisted) for each race is estimated by sampling from the posterior predictive distribution based on Equation (3) using the forecasted $\hat{n}_{ary'}$ $y' \in \{2016-2025\}$. Dividing this number by $\sum_a \hat{n}_{ary'}$ results in the overall predicted plural rate for that year.

Bibliography

[1] A. Gelman, J. B. Carlin, H. S. Stern, D. B. Dunson, A. Vehtari and D. B. Rubin, Bayesian Data Analysis, Boca Raton, FL: CRC Press, 2014.

[2] S. N. Wood, "Just another Gibbs additive modeller: Interfacing JAGS and mgcv," arXiv preprint arXiv:1602.02539, 2016.

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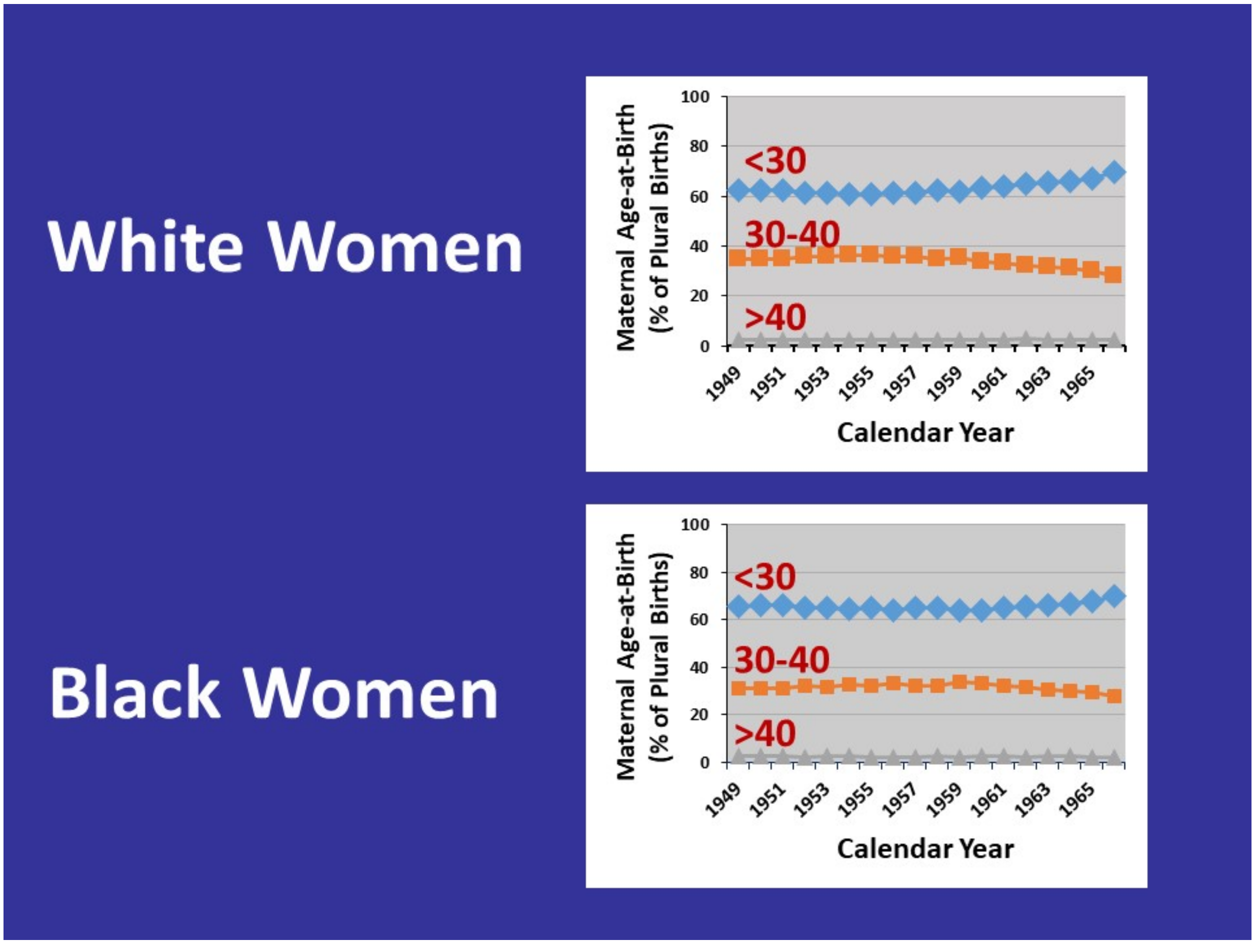
Number of Live Births by Plurality, Race and Year

Race	White			Black		
Year	Higher order multiple	Single	Twin	Higher order multiple	Single	Twin
1949	772	3117022	59648	184	510713	11288
1950	790	2998207	61192	221	475815	12230
1951	697	3170429	62730	212	498825	12525
1952	903	3253743	65196	190	508941	13181
1953	836	3286987	66479	215	528859	14452
1954	912	3372174	67639	232	566881	14889
1955	853	3386094	69047	268	571795	15298
1956	927	3470876	68690	228	599960	16013
1957	785	3549252	68760	214	615198	16388
1958	826	3501294	68278	271	613320	16596
1959	966	3525928	69206	260	628988	17178
1960	968	3531280	68410	274	639752	17026
1961	910	3532432	67436	262	649664	17484
1962	846	3331364	61782	246	625512	15787
1963	786	3264454	61062	294	622242	16356
1964	886	3306198	62076	316	641136	16878
1965	766	3064658	58436	246	620094	16158
1966	778	2937022	55430	194	597940	14910
1971	834	2884490	49890	196	540622	12450
1972	729	2624619	46582	154	507671	11452
1973	751	2522247	44779	165	488164	10957
1974	810	2546891	45988	171	482417	10748
1975	909	2525450	46611	151	484339	11354
1976	852	2540682	47973	205	485309	11432
1977	897	2665236	49272	159	513173	12157
1978	940	2653215	49878	205	518066	12749
1979	997	2772309	51719	185	541608	13327
1980	1095	2869889	52931	208	552325	13616
1981	1181	2880409	54145	172	549134	13912
1982	1197	2913812	55774	240	552840	13559
1983	1317	2875211	56355	214	546919	13668
1984	1401	2892866	56974	192	551969	13574
1985	1639	2966551	60147	238	565458	14610
1986	1566	2946637	62181	197	576646	14638
1987	1818	2970533	63852	241	594262	15435
1988	2047	3026159	66205	285	620550	16307

1989	2483	3120499	69373	262	655018	17844
1990	2639	3215017	72617	321	665851	18164
1991	2905	3165323	73045	368	663641	18593
1992	3444	3124687	73547	361	654653	18619
1993	3748	3071442	74643	327	639997	18551
1994	4127	3041559	75318	358	617689	18344
1995	4505	3018184	76196	352	585787	17000
1996	5383	3007997	79677	439	577057	17285
1997	6005	2984470	82044	530	581393	17987
1998	6862	3024613	87122	529	590365	18999
1999	6545	3035677	90141	569	586019	19370
2000	6530	3094107	93168	521	601440	20623
2001	6616	3075577	95239	553	585179	20408
2002	6529	3069798	98218	609	572650	20418
2003	6720	3117673	101188	650	578540	20629
2004	6317	3112998	103310	599	593832	21608
2005	5737	3119989	103225	646	609883	22566
2006	5597	3199247	105079	620	641809	23994
2007	5389	3224606	106239	657	650541	24412
2008	5334	3162869	105553	613	645835	24300
2009	5255	3063794	103800	727	632434	24396
2010	4565	2963955	100378	619	612571	23154
2011	4389	2916536	99034	695	609070	23038
2012	3919	2904376	98490	668	610720	22942
2013	3743	2882774	98773	663	610222	23766
2014	3615	2915720	100052	561	614805	25065
2015	3218	2910391	98757	648	614586	24697
2016	3011	2802847	94563	668	599012	24070

Appendix 2. The observed distribution pattern of maternal age-at-birth per calendar year for white and black women in a plural national birth cohort (n=1,455,648) corresponding to the 1949-1966 interval. Maternal age-at-birth categories include <30, 30–40, and >40 years of age.



Appendix 3. The observed distribution pattern of maternal age-at-birth by calendar year for white and black women in a plural national birth cohort (n=4,521,653) corresponding to the 1971–2016 interval. The maternal age-at-birth categories include <30, 30–40, and >40 years of age.