

Estimation and Short-term Projections of Contraceptive Prevalence

Leontine Alkema, Clare Menozzi,
Ann Biddlecom and Vladimira Kantorova *

Extended abstract: February 26, 2011

1 Introduction

Contraceptive prevalence, defined as the percentage of women who are currently using (or whose male partner is currently using) at least one method of contraception, is an important indicator of the degree to which women and their partners are able to avoid unintended pregnancy. Change over time in contraceptive prevalence within and across countries, regions and worldwide highlights progress towards achieving universal access to reproductive health, one of the targets related to maternal health that is part of the internationally-agreed Millennium Development Goals. However, analysis of contraceptive use trends within and across countries, regions and worldwide is challenging. The number of data points for a country is often quite sparse and many countries, especially developing countries, did not have national-level data on contraceptive prevalence until the late 1980s. Even differences among data sources within a country – the population sampled, whether probed questions were used – can challenge the interpretation of trends over time in contraceptive use. In this paper we develop and apply a model to estimate country-specific contraceptive prevalence that capitalizes on a full set of data points, takes into account biases of particular data sources or sample types, incorporates global and regional trends in contraceptive prevalence over time and produces uncertainty estimates for country-specific trends. We provide estimates and short-term (back-) projections of contraceptive prevalence among women aged 15 to 49 years who are married or in union from 1970 to 2015 for 193 countries and territories.

*Leontine Alkema: Department of Statistics and Applied Probability, National University of Singapore, Singapore 117546; Contact: alkema@nus.edu.sg. Clare Menozzi, Ann Biddlecom and Vladimira Kantorova: Fertility Section, United Nations Population Division, New York, NY 10017; Email: biddlecom@un.org, kantorova@un.org, menozzi@un.org. The project described is solely the responsibility of the authors and does not necessarily represent the official views of the United Nations. Its contents have not been formally edited and cleared by the United Nations.

2 Data

The observations on contraceptive prevalence are based mainly on World Contraceptive Use 2010, an up-to-date set of national data on contraceptive prevalence for 193 countries and areas of the world (United Nations, Department of Economic and Social Affairs, Population Division 2010). The indicator is the percentage of women who are currently using (or whose male partner is currently using) at least one method of contraception, regardless of the method used. It is usually reported for married or in-union women aged 15 to 49. Contraceptive methods are for analytical purposes classified as either modern or traditional. Modern methods of contraception include female and male sterilization, oral hormonal pills, the intra-uterine device (IUD), the male condom, injectables, the implant (including Norplant), vaginal barrier methods, the female condom and emergency contraception. Traditional methods of contraception include rhythm (periodic abstinence), withdrawal, prolonged abstinence, breastfeeding, douching, lactational amenorrhea method (LAM) and folk methods. The indicator is obtained from nationally representative household surveys with questions on current use of contraception. Surveys that commonly include this information are: Demographic and Health Surveys (DHS), Fertility and Family Surveys (FFS), Reproductive Health Surveys (RHS), Multiple Indicator Cluster Surveys (MICS), the Living Standards Measurement Study (LSMS) and other national surveys.

The data have been categorized to take into account the potential differences in outcomes based on population type, data source, age group and geographical region (Figure 1). For instance, MICS does not use probe questions on contraceptive methods used while DHS does, possibly resulting in more reports of traditional method use from DHS, as for example seen in the case of Burundi (Figure 1). While the population of interest is all married or in-union women, some of the surveys provide information for all women irrespective of marital status or all sexually-active women, among other sub-groups. Similarly, age groups different from the baseline age group of 15-49 years might produce biased estimates of contraceptive use. In Bangladesh, the estimates of contraceptive use from surveys in 1979 and 1985 are for the age group 10 to 49 years while all surveys in the United States of America provide estimates for the age group 15 to 44 years (Figure 1). Some data points also refer only to certain geographical regions or subpopulations; for example, in the United States of America the surveys in 1970 and 1975 provide contraceptive use estimates for white women only.

The number of observations between 1970 and 2010 is limited for many countries, as illustrated in Figure 2: the majority of countries (66%) have less than five observations.

Figure 1: Observed modern and traditional prevalence in Burundi, Bangladesh and the United States of America.

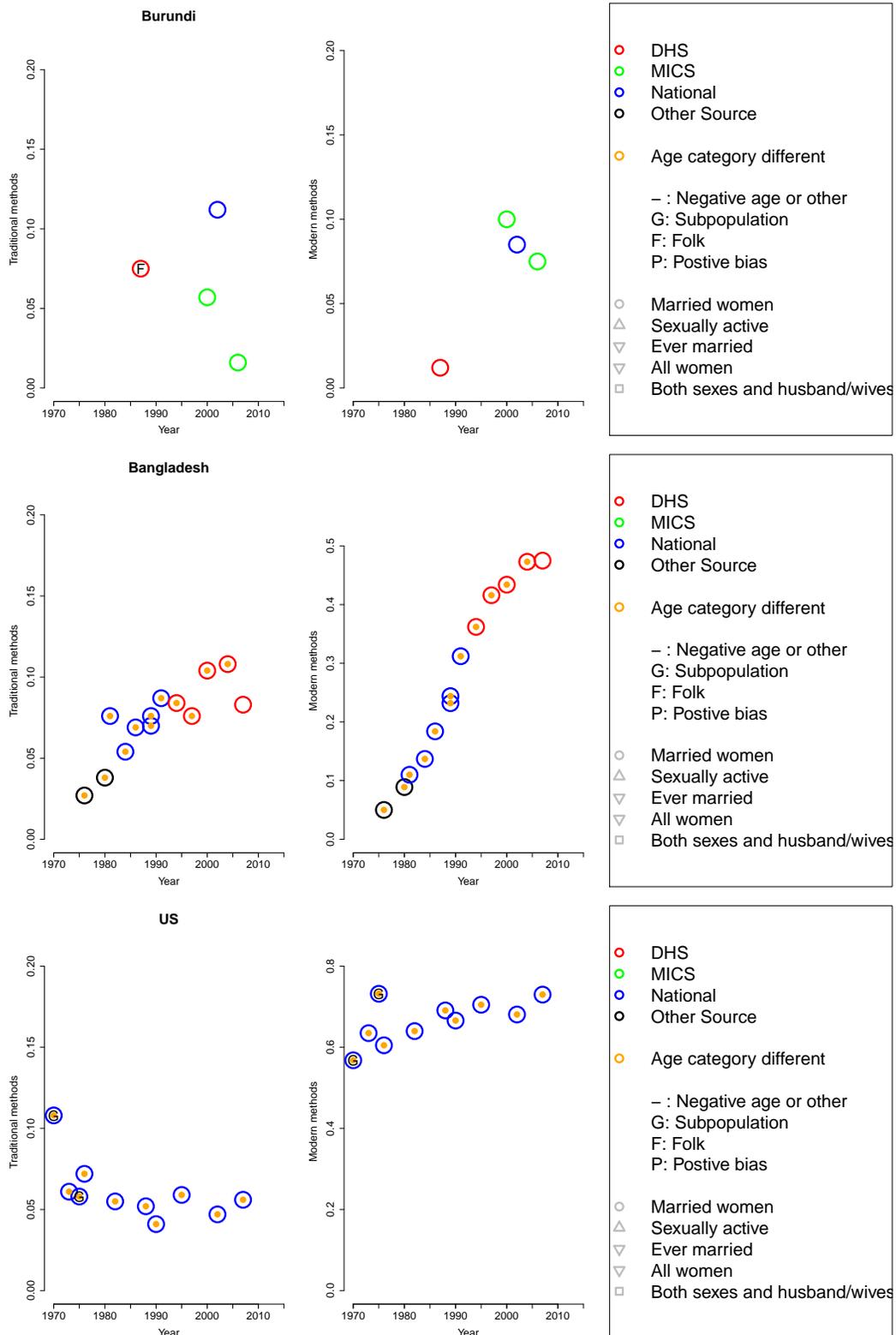
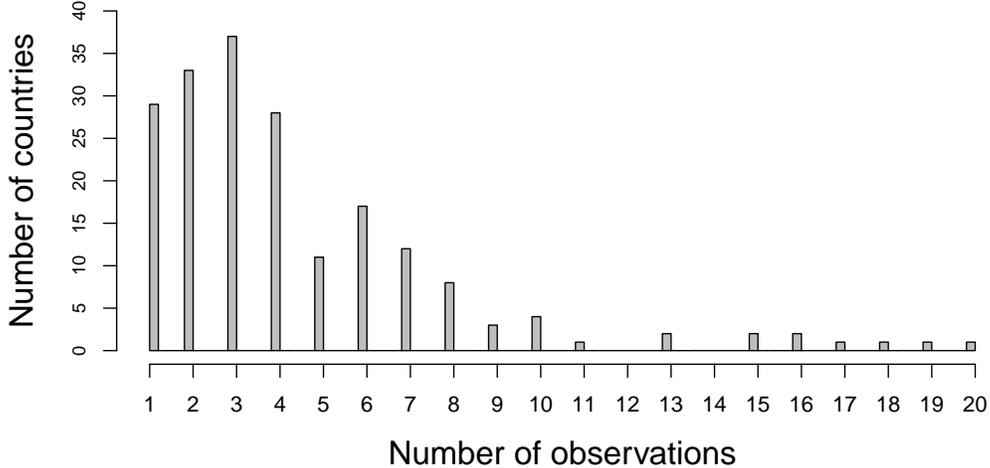


Figure 2: Summary of the number of observations for each country.



3 METHODS

The objective is to construct estimates and short-term (back-) projections of contraceptive prevalence among married women of ages 15 to 49 for all countries, from 1970 until 2015. Because the number of observations is limited in many countries, assumptions need to be made about the general trend in contraceptive prevalence over time. The model assumptions are illustrated in Figure 3. The first row illustrates the main trends: total prevalence is expected to increase over time, and modern prevalence increases as a proportion of total prevalence. The final level of total prevalence (its asymptote) as well as the pace of the uptake of contraceptive methods and its timing varies between countries. Similarly, the final level of the ratio of modern prevalence/total prevalence (its asymptote) as well as the pace of the uptake of modern methods and its timing will vary between countries. Contraceptive prevalence does not have to increase smoothly over time, but more likely, it will show some fluctuations around the main trends, as illustrated with the trajectories around total, traditional and modern prevalence on the second row. Observed trends in Bangladesh, France and Zimbabwe in the third row are in line with the model representation.

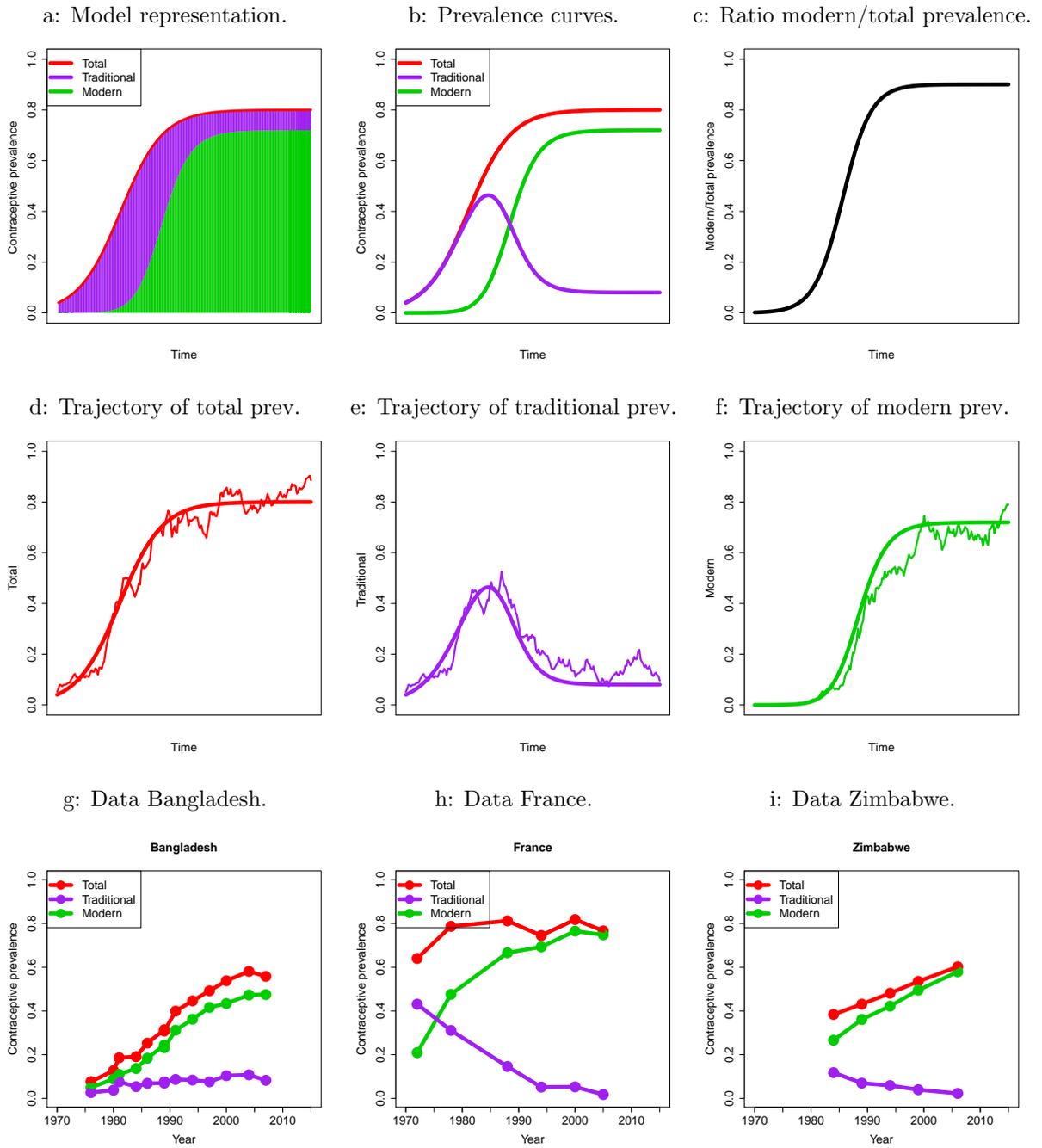
Logistic curves are used to model the overall trends in total prevalence and the ratio modern/total prevalence. The overall trend in total prevalence is denoted by $p_{c,t}^*$, and is assumed to follow a logistic growth curve:

$$p_{c,t}^* = \frac{p_{max}^{(c)}}{1 + \exp(-\omega_c^{(total)}(t - T_c^{(total)}))},$$

and similarly, the overall trend in the ratio modern/total is denoted by $r_{c,t}^*$, and is assumed to follow a logistic growth curve (with different parameters):

$$r_{c,t}^* = \frac{r_{max}^{(c)}}{1 + \exp(-\omega_c^{(ratio)}(t - T_c^{(ratio)}))}.$$

Figure 3: Model illustrations



In the expressions above, $p_{max}^{(c)}$ and $r_{max}^{(c)}$ represent the asymptotes for total prevalence and the ratio of modern/total prevalence, $\omega_c^{(total)}$ and $\omega_c^{(ratio)}$ the pace of the increase, and $T_c^{(total)}$ and $T_c^{(ratio)}$ the midpoints of both increases (where pace of increase is the fastest). The six parameters are estimated with a Bayesian hierarchical model as explained below. “True” total prevalence, $p_{c,t}$ and the “true” ratio of modern/total prevalence, $r_{c,t}$ fluctuate around their respective trends. This is modeled with an autoregressive process of order one, by adding distortions $P_{c,t}$ and $R_{c,t}$ to the overall trends on the logit-scale:

$$\begin{aligned} p_{c,t} &= \text{logit}^{-1}(\text{logit}(p_{c,t}^*) + P_{c,t}) \\ P_{c,t} &\sim N(\rho \cdot P_{c,t-1}, \sigma_{(total)}^2), \end{aligned}$$

and

$$\begin{aligned} r_{c,t} &= \text{logit}^{-1}(\text{logit}(r_{c,t}^*) + R_{c,t}) \\ R_{c,t} &\sim N(\rho \cdot R_{c,t-1}, \sigma_{(ratio)}^2). \end{aligned}$$

The parameters of the AR(1) processes ρ , $\sigma_{(total)}^2$ and $\sigma_{(ratio)}^2$ are assumed to be the same for all countries.

Bayesian hierarchical model: Estimating the country-specific parameters $p_{max}^{(c)}$, $r_{max}^{(c)}$, $\omega_c^{(total)}$, $\omega_c^{(ratio)}$, $T_c^{(total)}$ and $T_c^{(ratio)}$ presents a challenge because of the limited number of observations for each country. We use a Bayesian hierarchical model (Lindley and Smith 1972; Gelman et al. 2004) to estimate the parameters in each country, such that the estimates are based on the observations in the country of interest, as well as on the global experience. A hierarchical approach to estimating and projecting demographic outcomes for a number of countries is a natural way to exchange information between countries while constructing country-specific estimates and projections. The fewer the number of observations in the country of interest, the more its estimates and projections are driven by the experience of other countries, while in countries with many observations the results will be driven more by its own history.

In the Bayesian hierarchical modeling approach for $\omega_c^{(total)}$ we assume that for all countries, $\omega_c^{(total)}$ is drawn from a probability distribution that represents the range of outcomes of the average annual differences across all countries. For $\omega_c^{(total)}$ in a specific country, its probability distribution based on the world-level experience is then updated using Bayes’ theorem with the observed trend in the country, which results in the posterior distribution for $\omega_c^{(total)}$. The resulting estimates (draws from the posterior distribution) can be viewed as weighted averages of a “world pattern” and information from the country data. The hierarchical distribution for $\omega_c^{(total)}$ is given by:

$$\omega_c^{(total)} \sim \text{Beta}(a_\omega^{(total)}, b_\omega^{(total)}),$$

with hierarchical mean and variance determined by $a_\omega^{(total)}$ and $b_\omega^{(total)}$.

A similar approach is used for the other parameters:

$$\begin{aligned} \omega_c^{(ratio)} &\sim \text{Beta}(a_\omega^{(ratio)}, b_\omega^{(ratio)}), \\ \log(T_c^{(total)} - 1900) &\sim N(T_c^{(total)}, \sigma_{T^{total}}^2), \\ \log(T_c^{(ratio)} - 1900) &\sim N(T_c^{(ratio)}, \sigma_{T^{ratio}}^2), \\ p_{max}^{(c)} &\sim \text{Beta}(a_p, b_p), \\ r_{max}^{(c)} &\sim \text{Beta}(a_r, b_r). \end{aligned}$$

Diffuse prior distributions are assigned to the hierarchical mean and variance parameters.

Estimation: All model parameters are estimated in a Bayesian framework. Diffuse prior distributions are assigned to the additional model parameters. A Markov Chain Monte Carlo (MCMC) algorithm is used to get samples of the posterior distributions of the parameters (Gelfand and Smith 1990). The MCMC sampling algorithm was implemented using Winbugs software (Lunn et al. 2000). The result is a set of trajectories of contraceptive prevalence for each country.

4 PRELIMINARY RESULTS

Preliminary results for Bangladesh, Botswana, China, Indonesia, Nigeria and the United States of America are shown in Figure 4 to 9. The plots show estimates of total prevalence, the ratio of modern to total prevalence, modern and traditional prevalence: median outcomes and 80% confidence intervals are represented with lines; 95% confidence intervals are represented with the grey areas.

References

- Gelfand, A. and A. F. M. Smith (1990). Sampling-based approaches to calculating marginal densities. *Journal of the American Statistical Association* 85, 398–409.
- Gelman, A., J. B. Carlin, H. S. Stern, and D. B. Rubin (2004). *Bayesian Data Analysis* (2nd ed.). Boca Raton, Fl.: Chapman & Hall/CRC.
- Lindley, D. V. and A. F. M. Smith (1972). Bayes estimates for the linear model. *Journal of the Royal Statistical Society, Series B* 34, 1–41.
- Lunn, D., A. Thomas, N. Best, and D. Spiegelhalter (2000). WinBUGS - A Bayesian modeling framework: Concepts, structure and extensibility. *Statistics and Computing* 10(4), 325–337.
- United Nations, Department of Economic and Social Affairs, Population Division (2010, forthcoming). World contraceptive use 2010.

Figure 4: Preliminary results Bangladesh: median outcomes and 80% confidence intervals are represented with lines; 95% confidence intervals are represented with the grey areas.

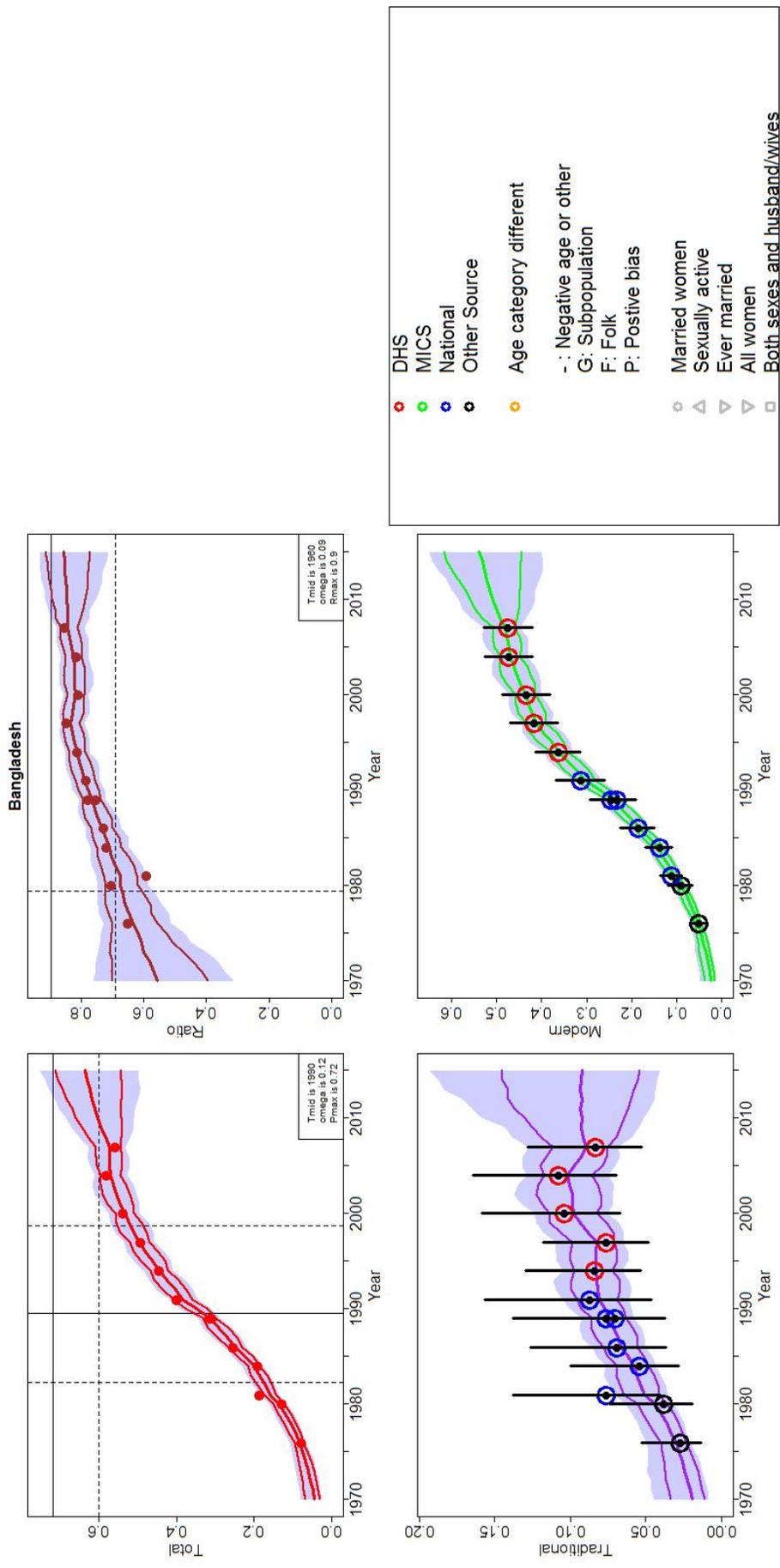


Figure 5: Preliminary results Botswana: median outcomes and 80% confidence intervals are represented with lines; 95% confidence intervals are represented with the grey areas.

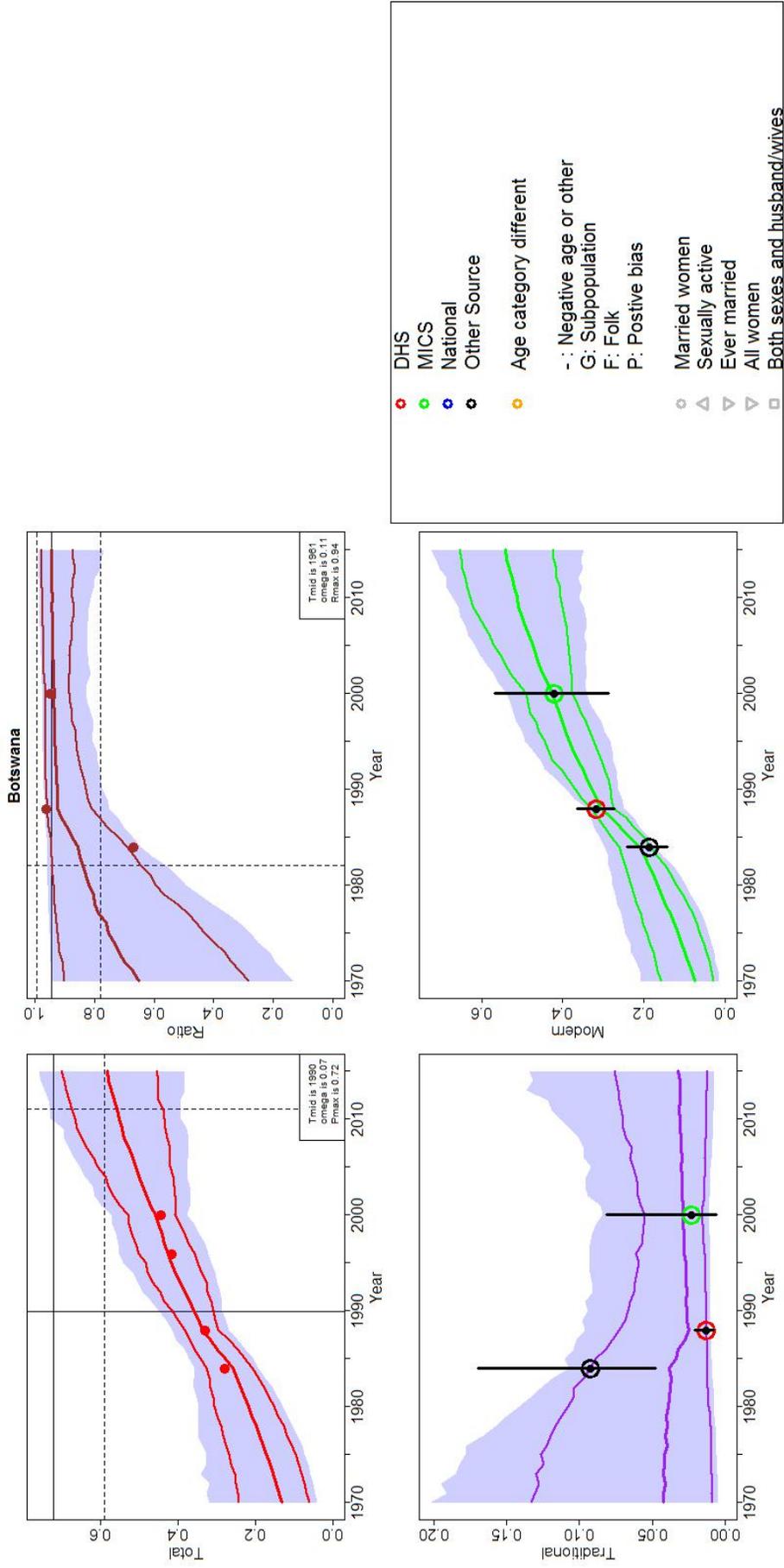


Figure 6: Preliminary results China: median outcomes and 80% confidence intervals are represented with lines; 95% confidence intervals are represented with the grey areas.

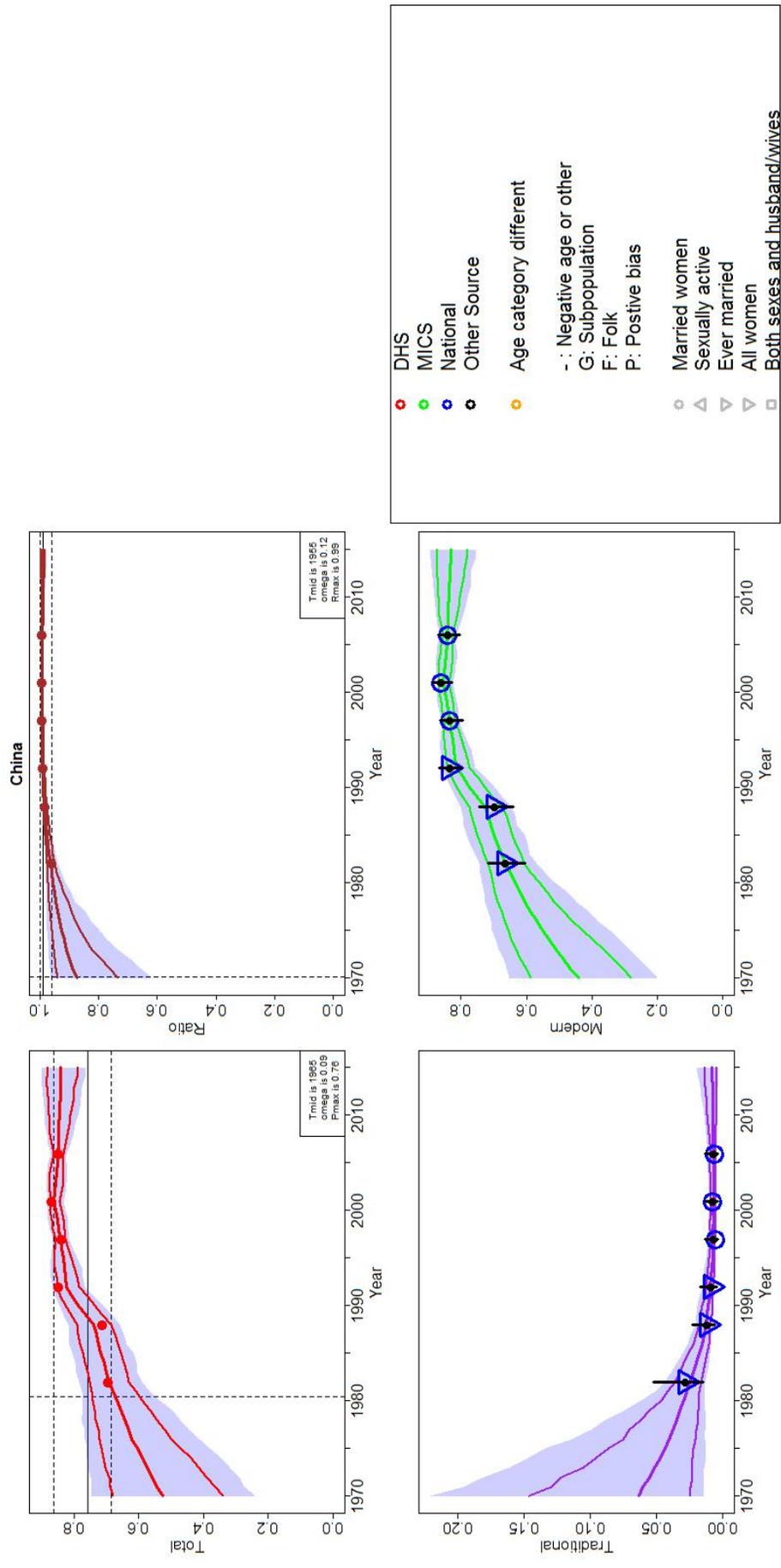


Figure 7: Preliminary results Indonesia: median outcomes and 80% confidence intervals are represented with lines; 95% confidence intervals are represented with the grey areas.

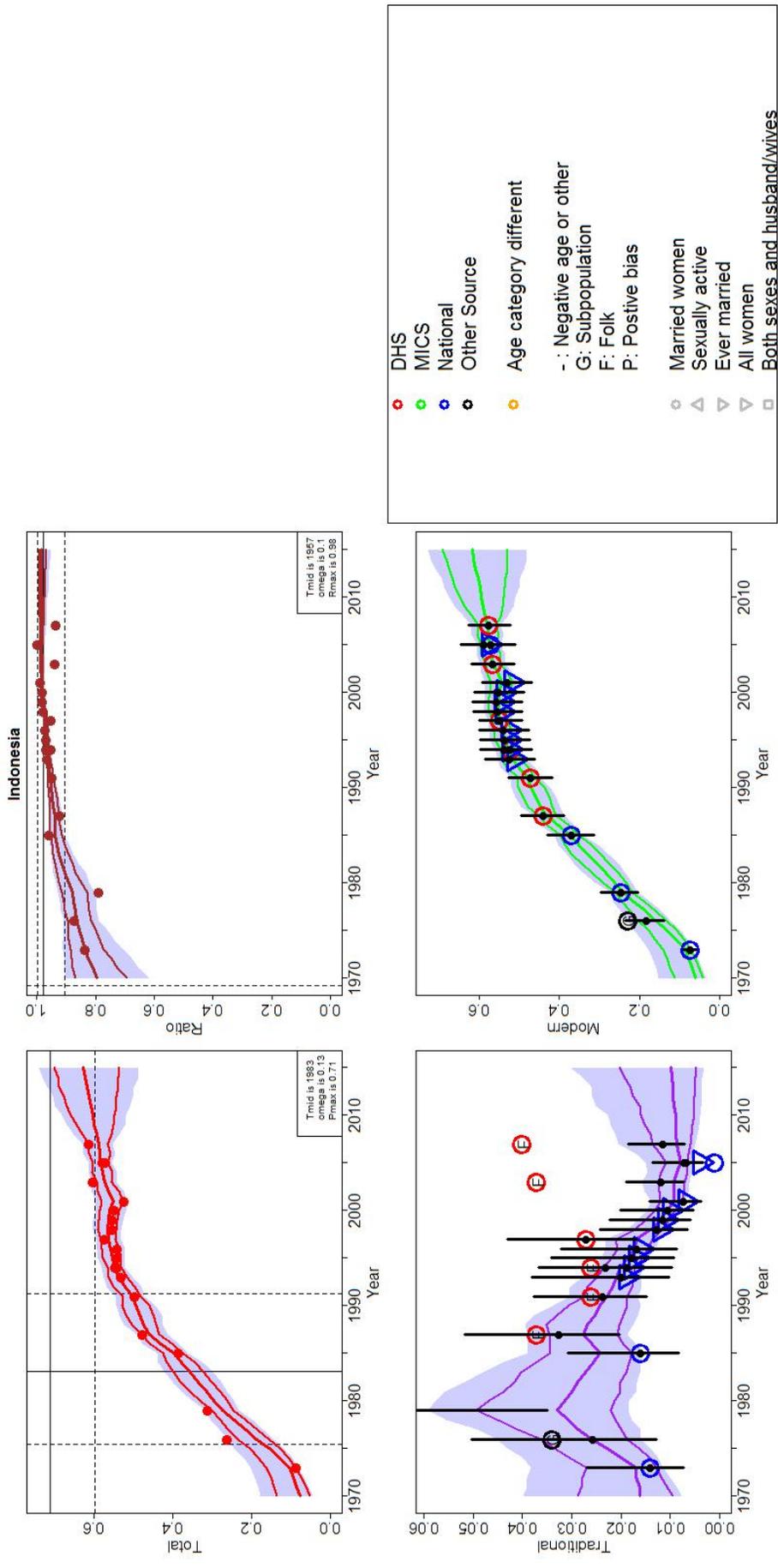


Figure 8: Preliminary results Nigeria: median outcomes and 80% confidence intervals are represented with lines; 95% confidence intervals are represented with the grey areas.

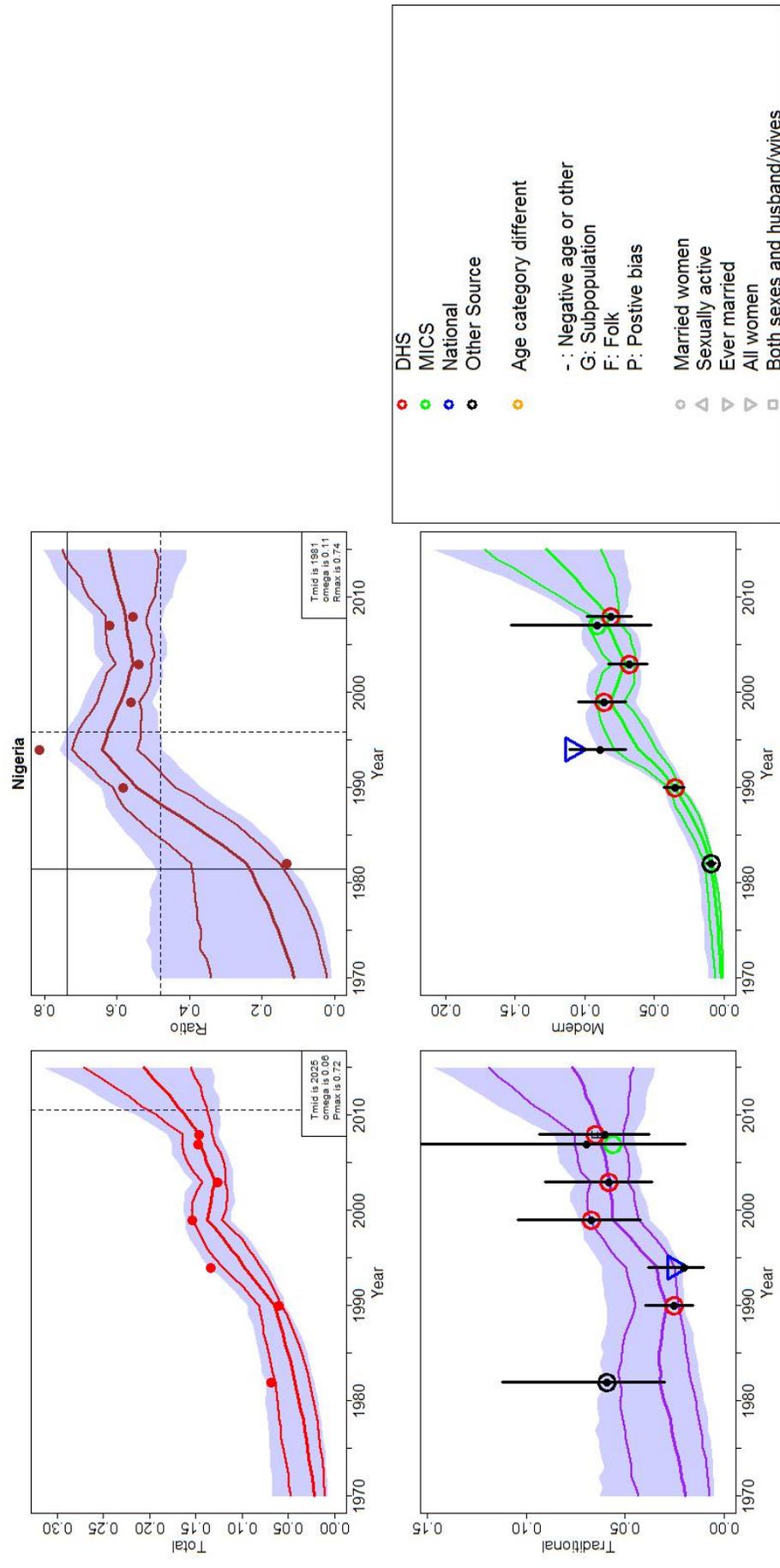


Figure 9: Preliminary results United States of America: median outcomes and 80% confidence intervals are represented with lines; 95% confidence intervals are represented with the grey areas.

