Web Appendix for Levels and trends in fertility rates among adolescents aged 15–19 in 21 States and Union Territories in India from 1990 to 2050: A Bayesian Modelling Study

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ASFR	Age-speccific Fertility Rate
DHS	Demographic and Health Survey
GATHER	Guidelines for Accurate and Transparent Health Estimates Reporting
INLA	Integrated Nested Laplace Approximation
JAGS	Just another Gibbs Sampler
MCMC	Markov chain Monte Carlo
NFHS	National Family Health Survey
PC	Penalized Complex
PI	Prediction Interval
SRS	Sample Registration System
TFR	Total Fertility Rate
UN	United Nations
UT	Union Territory
WPP	World Population Prospects

Figure 1 presents an overview of the database construction and Bayesian model process for this study.

1 Data

We compiled the database for the age-specific fertility rate (ASFR) for adolescent females aged 15–19 in the largest 29 Indian states/UTs[1] Table 1 lists the 29 Indian states/UTs included in our study and the 21 bigger states/UTs (with population more than 10 million as per Census 2011) for which we present the state-level results.

	[21] Bigger states/UTs	[8] Smaller states/UTs
Indian States/UT names	former state of Andhra Pradesh (including Telangana); Assam; Bihar; Chhattisgarh; Delhi; Gujarat; Haryana; Himachal Pradesh; Jammu and Kashmir (including Ladakh); Jharkhand; Karnataka; Kerala; Madhya Pradesh; Maharashtra; Odisha; Punjab; Rajasthan; Tamil Nadu; Uttar Pradesh; Uttarakhand; West Bengal	Arunachal Pradesh; Goa; Manipur; Meghalaya; Mizoram; Nagaland; Sikkim; Tripura

Table 1: **Indian states/UTs classification by population size.** The red numbers at the beginning of a cell refer to the number of states/UTs that fall under that category. Bigger states/UTs: with population more than 10 million as per Census 2011.

Table 2 gives an overview of the Indian state-level ASFR 15–19 observations by different data series. There are 1,510 observations available from all states/UTs in India. The reference year of observations ranges from 1967 to 2020. The database is publicly available at figshare repository (2)

Data Type	Series Name (Series Year)	# Obs.	# states/UTs
DHS	NFHS 1992–1993	207	29
	NFHS 1998–1999	216	
	NFHS 2005–2006	252	
	NFHS 2015–2016	261	
	NFHS 2019–2021	261	
SRS	–	313	26
Total		**1,510**	**29**

Table 2: **Observation distribution by source type for ASFR 15–19.** DHS: Demographic and Health Surveys. NFHS: National Family Health Survey, refers to India Demographic and Health Surveys. SRS: Sample Registration System.

1.1 Age-specific fertility rate 15–19 data pre-processing

Data from full birth histories collected in the five National Family Health Survey (NFHS; i.e. India Demographic and Health Surveys) 1992–1993, 1998–1999, 2005–2006, 2015–2016, and 2019–2021 to compute the observations (Section 1.1.1) and corresponding sampling errors (Section 1.1.2) of ASFR for mothers aged 15–19. The database we use for model fitting (summarized in Section 1) is based on multiple data quality assessments and pre-processing steps as detailed in the rest of this section.

[1]Telangana is combined with Andhra Pradesh because it separated from Andhra Pradesh only in 2014. Hence, we use the name "former state of Andhra Pradesh" to refer to the combination of Andhra Pradesh and Telangana in our study. Jammu and Kashmir includes Ladakh (bifurcated in 2019)

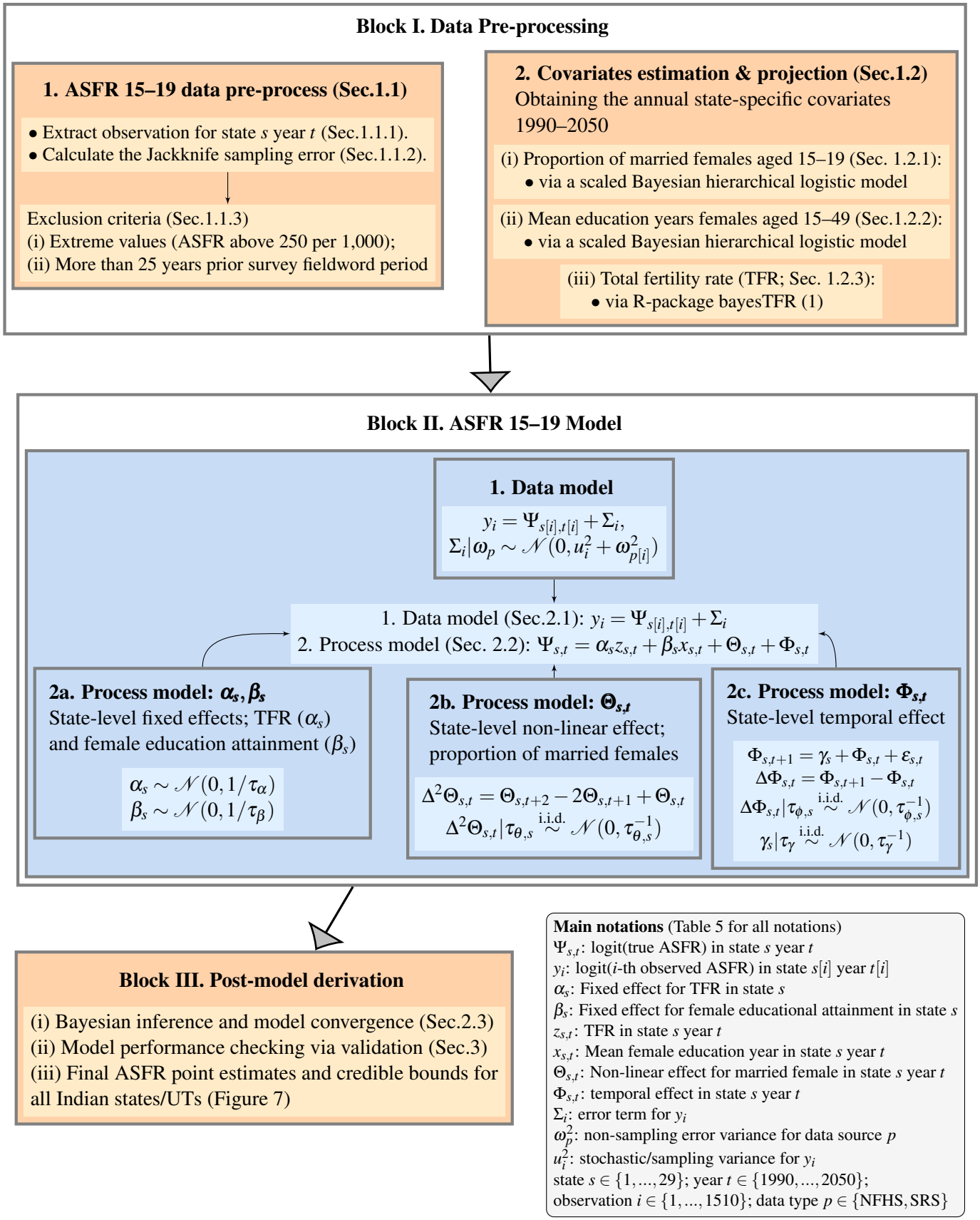

Figure 1: **Flowchart for data and model process overview.** This flow chart summarizes the main steps of data pre-processing (Block I), Bayesian modelling (Block II), where $\Psi_{s,t}$ refers to the true age-specific fertility rate 15–19 on the logit-scale, and the post-model derivation (Block III).

1.1.1 Extracting observations by data source type

Birth and sibling histories in surveys NFHS data were used to compute fertility rates for adolescent females aged 15–19, for a fixed period of three years for all fertility observations. For simplicity, all notations in this subsection refers to women from age group 15–19 and hence the age group index is omitted.

Let $B_{s,t}$ be the observed number of total births born by mothers within the age group [15, 19] at the time of births for a certain Indian state/UT s year t. $N_{s,t}^{\text{female}}$ refers to the number of woman-year exposure in the age group [15, 19]. The observed ASFR for a certain Indian state/UT s year t, $z_{s,t}$ is computed as:

$$z_{s,t} = B_{s,t}/N_{s,t}^{\text{female}}.$$

Birth records from Sample Registration System Data are available in the majority of Indian states/UTs from the sample registration system (SRS). Among the 29 states/UTs we modeled, Jharkhand, Chhattisgarh, and Uttarakhand do not have SRS data.

Given that the SRS data are considered as administrative records and with high-level of completeness across states over time, we assume that the coefficient of variation of all SRS observations is at 0.01, expressed as $\text{CV}_{\text{ST}} = 0.01$. Consequently, the associated stochastic errors of SRS data are imputed as $\sigma_{\text{ST}} = z \cdot \text{CV}_{\text{ST}}$, where z denotes any observation from SRS.

1.1.2 Compute sampling variance

NFHS adopts a two-stage stratified sampling frame for rural areas and a three-stage sample design for urban areas, except for the 2015–2016 and 2019–2021 NFHS where two-stage sampling frame were applied to both rural and urban areas (3; 4). The first stage is to sample the primary sampling units with probability proportional to population size, followed by random selection of census enumeration blocks and/or households. To simplify, all notations in this section refer to state level in India, for a specific NFHS. Hence, we remove the subscription s from all notations in this section.

The ASFR 15–19 extraction approach from NFHS data is mainly based on the approach described in (5). For a specific NFHS, we calculate the Jackknife sampling error for ASFR 15–19 for each consecutive three-year window period prior the time of interview (i.e. from three years prior interview to date of interview, from six to three years prior interview, etc.). The reference year t of the ASFR 15–19 for a NFHS is taken as the mid point of the period. The u-th partial prediction of ASFR 15–19 observation from a certain state-specific survey within a certain reference three-year period is given by:

$$z_{-u} = \frac{\sum_{n=1}^{N} \mathbb{I}(15 \le a_n \in [t-1.5, t+1.5) \le 19; d_n \ne u) \cdot w_n}{\sum_{m=1}^{M} N_m \mathbb{I}(15 \le a_m \in [t-1.5, t+1.5) \le 19; d_n \ne u) \cdot w_m \cdot q_m}, \text{ for } u \in \{1, \ldots, U\},$$

where n indexes the live births in the survey-year, N is the total number of live births for a particular survey-year. $a_n \in [t-1.5, t+1.5)$ refers to the age of month at time of the birth that happened in the three-year period of $[t-1.5, t+1.5)$ with the mid-point of the period t as the reference year, d_n refers to the cluster number with a total of U clusters, and w_n the sampling weight for the n-th live birth. In the denominator, the index m refers to each woman (regardless of giving birth or not) in the sample. N_m denotes the woman-year exposure during the period $[t-1.5, t+1.5)$. The exposures are only summed for women at age $15 \le a_m \le 19$. w_m is the sampling weight for the m-th woman. q_m is the total-woman adjustment factor applied to ever-married woman samples (i.e. two surveys NFHS 1992–1993 and 1998–1999) for the m-th woman so that the sampled ever-married woman exposure can be approximated as the exposure for all the women. For NFHS phases III to V, we have $w_m = 1$. Indicator $\mathbb{I}(\cdot) = 1$ if the condition inside the brackets is true, otherwise $\mathbb{I}(\cdot) = 0$. The u-th pseudo-value estimate of ASFR 15–19 in a particular survey-year is:

$$\begin{aligned} z_u^* &= U \cdot z - (U-1) \cdot z_{-u}, \text{ where} \\ z &= \frac{\sum_{n=1}^{N} \mathbb{I}(15 \le a_n \in [t-1.5, t+1.5) \le 19) \cdot w_n}{\sum_{m=1}^{M} N_m \mathbb{I}(15 \le a_m \in [t-1.5, t+1.5) \le 19) \cdot w_m \cdot q_m}. \end{aligned}$$

The Jackknife standard error is:

$$\sigma_{\text{JK}} = \sqrt{\frac{\sum_{u=1}^{U}\left(z_u^* - \overline{z^*}\right)^2}{U(U-1)}}, \text{ where } \overline{z^*} = \frac{1}{U}\sum_{u=1}^{U} z_u^*.$$

1.1.3 Exclusion criteria

Before fitting the ASFR 15–19 observations to the Bayesian model, the state analysts reviewed the data sources and data points available. Some of the data points were excluded due to concerns about data quality and completeness. We used the following exclusion criteria to ensure data quality used in our model:

- Exclude ASFR 15–19 data with outlying high values. Specifically, we only keep observations below 250 per 1,000;
- For survey data, exclude data points beyond 25 years prior survey fieldword period.

1.2 Preparing covariates

When estimating and projecting ASFR 15–19 across Indian states/UTs up till 2050, we incorporated three external variables in our state-level ASFR process model (Section 2.2). All covariates are Indian state-year-specific:

1. Section 1.2.1: Proportion of married females aged 15–19;
2. Section 1.2.2: Mean education years among females aged 15–49; and
3. Section 1.2.3: Total fertility rate.

Figure 2 illustrates the exploratory analyses of the potential relationships between the aforementioned variables against the outcome of interest state-level ASFR 15–19.

Before we get into the modeling of the ultimate outcome of interest which is state-level ASFR for females aged 15–19 in India, we need the three variables for each state/UT annually from 1990 to 2050. The rest of this section explains how we imputed the values of these variables given that none of the variables is available for all state-years.

1.2.1 Obtaining proportion of married female aged 15–19 across Indian states/UTs overtime

The proportion of married females aged 15–19 in Indian state/UT s in year t is denoted as $V_{s,t}$, which is used as an input variable later on in Section 2.2. The resulting $V_{s,t}$ are illustrated in Figure 4. We obtained its annual estimates and projections through a scaled Bayesian hierarchical logistic model. Specifically, for the j-th observed proportion of married female aged 15–19 v_j from Indian state $s[j]$ in year $t[j]$, we assume it follows a normal distribution on the log-scale:

$$v_j \sim \mathcal{N}(V_{s[j],t[j]}, \omega_v^2), \text{ for } j \in \{1, \cdots, 133\}.$$

v_j denotes the j-th reported proportion of married females aged 15–19 from the five NFHS. We applied the "all woman factor" to NFHS 1992–93 and 1998–99 surveys since they only collected information from ever-married females. We processed NFHS microdata and compiled a database with 133 observations of proportion of married females aged 15–19. The detailed data sources for each Indian state/UT is in Table 8.

The variance of the distribution is ω_v^2, the non-sampling variance parameter for all the NFHS observations (hence estimated in the model), representing the data errors that are not possible to quantify or be eliminated mainly due to non-response, recall errors, and data recording errors. We assigned an informative prior to ω_v by assuming that the true underlying state-level proportion of married female aged 15–19 are close to the NFHS observations with little deviation away from them.

The mean of the distribution $V_{s[j],t[j]}$ is the true proportion of married female aged 15–19 on the log-scale for India in state $s[j]$ in year $t[j]$ for the j-th observation. The mean $V_{s,t}$ is modeled as a scaled logistic function with independent variable $\log(t)$ log of time index and state-specific parameters that define the features of a logit curve, including coefficients λ_s (for rate of decline), intercept parameters ζ_s (for the average level), and the scale parameter δ_s which models the maximum proportion of married female aged 15–19 for each state s. All state-specific parameters

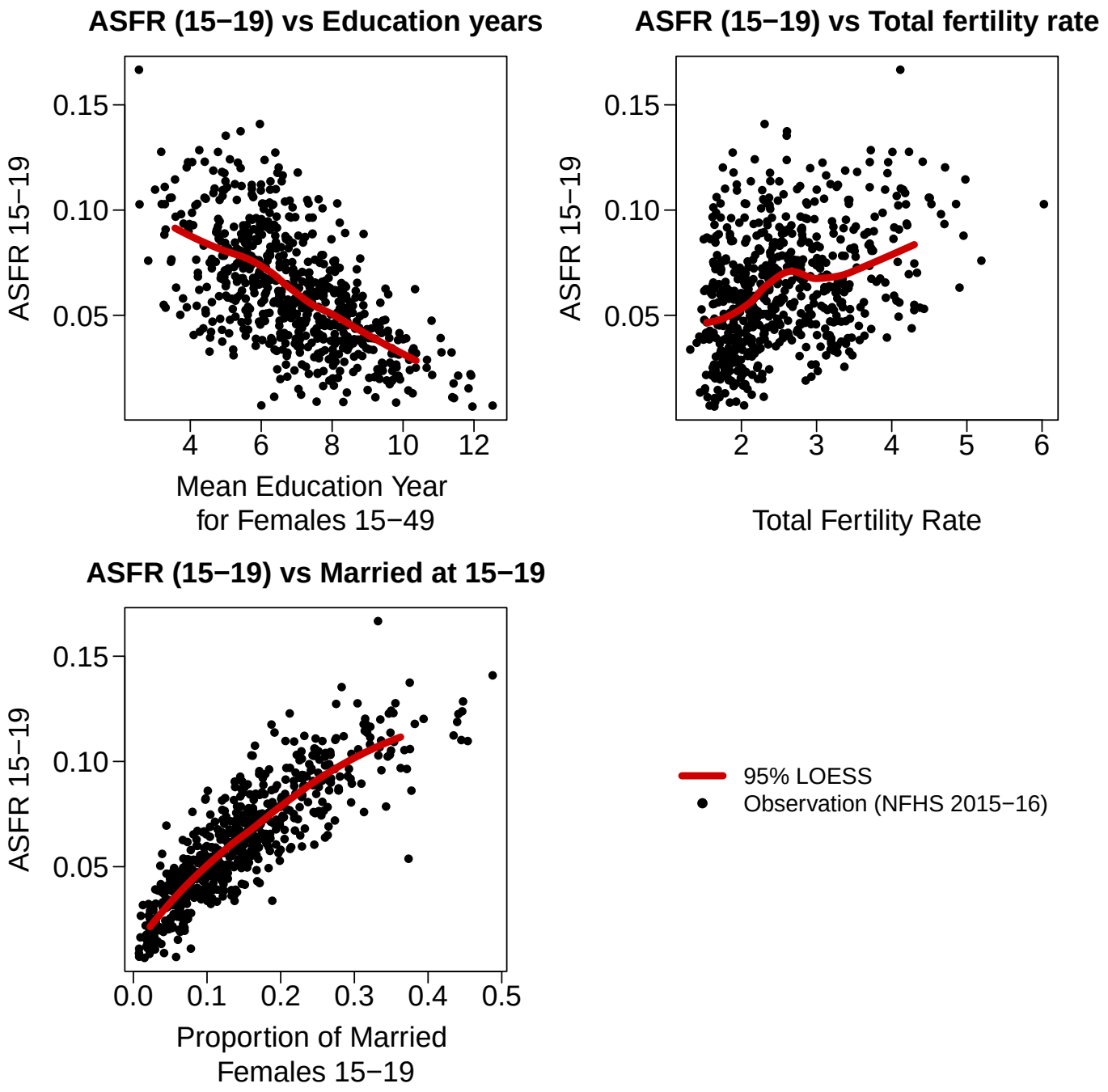

Figure 2: **Motivation of variable choice in model.** Red curve: 95% LOESS curve based on observations between 2.5th and 97.5th percentiles of each variable. Black dots: 640 district-level observations from the NFHS 2015–16. LOESS: Local Polynomial Regression Fitting.

were assigned with hierarchical distributions so that the logit curve patterns can be pooled towards an average shape when a certain state lack data, and can still follow observations wherever available. Specifically, we used a truncated hierarchical normal distribution for δ_s by assigning an upper bound of $\log(100)$ (i.e. the upper bound of 100% on the original scale) to reflect the fact that early marriage in India has long been prepubertal historically (6).

$$\begin{aligned}
v_j &\sim \mathcal{N}(V_{s[j],t[j]}, \omega_v^2), \text{ for } j \in \{1, \cdots, 133\}, \\
\exp\{V_{s,t}\} &= \frac{\delta_s^{\text{mar}} \cdot \exp\{\lambda_s^{\text{mar}} \cdot \log(t) + \zeta_s^{\text{mar}}\}}{1 + \exp\{\lambda_s^{\text{mar}} \cdot \log(t) + \zeta_s^{\text{mar}}\}}, \text{ for } \forall s, \forall t, \\
\delta_s^{\text{mar}} &\sim \mathcal{N}\left(\mu_\delta^{\text{mar}}, \left(\sigma_\delta^{\text{mar}}\right)^2\right), \text{ for } \forall s, \\
\lambda_s^{\text{mar}} &\sim \mathcal{N}_{(-\infty, \log(100))}\left(\mu_\lambda^{\text{mar}}, \left(\sigma_\lambda^{\text{mar}}\right)^2\right), \text{ for } \forall s, \\
\zeta_s^{\text{mar}} &\sim \mathcal{N}\left(\mu_\zeta^{\text{mar}}, \left(\sigma_\zeta^{\text{mar}}\right)^2\right), \text{ for } \forall s.
\end{aligned}$$

We assigned non-informative priors to the global parameters μ_δ^{mar}, μ_λ^{mar}, μ_ζ^{mar}, $\sigma_\delta^{\text{mar}}$, $\sigma_\lambda^{\text{mar}}$, and $\sigma_\zeta^{\text{mar}}$.

1.2.2 Obtaining mean education years in females aged 15–49 across Indian states/UTs overtime

The mean education years among females aged 15–49 in Indian state/UT s in year t, denoted as $x_{s,t}$ later on in Section 2.2, are model results from a Bayesian hierarchical model. The resulting $x_{s,t}$ are illustrated in Figure 5.

The model inputs were reported mean education years among females aged 15–49 from the five NFHS. We applied the "all woman factor" to NFHS 1992–93 and 1998–99 surveys since they only collected information from ever-married females. We processed NFHS microdata files and compiled a database with 132 observations of mean education years among females aged 15–49. The detailed data sources for each Indian state/UT is in Table 9.

We obtained the annual estimates and projection through a Bayesian hierarchical scaled-logistic model. Specifically, for the i-th observed log of female mean education years x_i from Indian state $s[i]$ in year $t[i]$, we assume it follows a normal distribution on the log-scale:

$$\begin{aligned}
x_i &\sim \mathcal{N}(\chi_{s[i],t[i]}, \omega_\chi^2), \text{ for } i \in \{1, \cdots, 132\}, \\
\exp\{\chi_{s,t}\} &= \frac{\delta_s^{\text{edu}} \cdot \exp\left\{\lambda_s^{\text{edu}} \cdot \log(t) + \zeta_s^{\text{edu}}\right\}}{1 + \exp\{\lambda_s^{\text{edu}} \cdot \log(t) + \zeta_s^{\text{edu}}\}}, \text{ for } \forall s, \forall t, \\
\delta_s^{\text{edu}} &\sim \mathcal{N}\left(\mu_\delta^{\text{edu}}, \left(\sigma_\delta^{\text{edu}}\right)^2\right), \text{ for } \forall s, \\
\lambda_s^{\text{edu}} &\sim \mathcal{N}_{(-\infty, \log(20))}\left(\mu_\lambda^{\text{edu}}, \left(\sigma_\lambda^{\text{edu}}\right)^2\right), \text{ for } \forall s, \\
\zeta_s^{\text{edu}} &\sim \mathcal{N}\left(\mu_\zeta^{\text{edu}}, \left(\sigma_\zeta^{\text{edu}}\right)^2\right), \text{ for } \forall s.
\end{aligned}$$

The mean of the distribution $\chi_{s[i],t[i]}$ is the true female mean education years on the log-scale for India in state $s[i]$ in year $t[i]$ for the i-th observation. The the mean is modeled as a scaled logistic function with independent variable $\log(t)$ log of time index. All state-specific parameters that define the features of a logit curve were assigned with hierarchical normal distributions with global means and variances. The distribution for the state-level scale parameters is truncated with upper limit of $\log(20)$ by assuming that it is highly unlikely to have more than 20 years of education for females aged 15–49. The variance of the distribution is ω_χ^2 with an informative prior assigned to ω_χ by assuming that the true underlying state-level female mean education years follow closely to the NFHS observed levels and trends.

1.2.3 Obtaining total fertility rate across Indian states/UTs overtime

The reported total fertility rate (TFR) in Indian states/UTs was obtained through the bayesTFR (1) subnational Bayesian hierarchical model. Input data for modelling the subnational TFR in India is detailed in (7) and can be directly downloaded from the BayesPop webpage (bayesTFR is one of the subsidiary projects under the BayesPop

project). The original input data for modeling were in a five-year interval with the most recent observations in 2010, containing 510 data points. We supplemented the original data file with NFHS survey data up to reference year 2020. The final input database we used to fit the bayesTFR model has 638 observations.

The bayesTFR model generated state-level TFR estimates and projections at a five-year interval, assuming the state-specific TFR is a multiplicative ratio of the national TFR in the same year. To obtain annual results, simulated fertility trajectories were generated through annual interpolation between the five-year knots. From these trajectories, we obtained annual posterior medians and 95% credible intervals for each state and year from 1950 to 2050. The TFR observations and model results are in Figure 6.

2 Methods

In Section 2.1 and Section 2.2, we summarize the model to estimate fertility rate for age group 15–19. The logit-scaled ASFR 15–19 is modeled as the combination of the effect of female marital status, female education attainment, TFR, and temporal correlation.

The outcome of interest is the ASFR for age group 15–19 in Indian state/UT s in year t, where we model it on the logit scale and is denoted as $\Psi_{s,t}$. Throughout the report, $\mathcal{N}(\mu,\sigma^2)$ refers to a normal distribution with mean μ and variance σ^2 and $\mathcal{U}(a,b)$ refers to a continuous uniform distribution with lower and upper bounds at a and b respectively. The notations and indexes are summarized in Table 5. The detailed explanations of the model is in the rest of this section.

2.1 Data model

Let z_i to be the i-th observed ASFR 15–19 and $y_i = \text{logit}(z_i)$. We assumed the following:

$$
\begin{aligned}
y_i &= \Psi_{s[i],t[i]} + \Sigma_i, \text{ for } i \in \{1,\cdots,n\}, && (1)\\
\Sigma_i|\omega_p &\sim \mathcal{N}(0, u_i^2 + \omega^2_{p[i]}), && (2)\\
\omega_p^{-2} &\sim \mathcal{PC}(z, 0.01), \text{ for } p \in \{1,2\}. && (3)
\end{aligned}
$$

For women aged 15–19, the ASFR observations are indexed by $i \in \{1,\cdots,n\}$. y_i denotes the i-th logit of observed ASFR in state $s[i]$ in year $t[i]$ and is modeled on the logit scale. $1/(1+\exp\{-\Psi_{s,t}\})$ is the outcome of interest, the true ASFR in Indian state/UT s in year t. Σ_i is the error term for y_i.

The error term Σ_i follows a normal distribution as shown in Equation 2. The variance is the sum of two parts: (i) known stochastic/sampling error variance u_i^2 for the i-th observation, and (ii) unknown non-sampling error variance $\omega^2_{p[i]}$ for data source type p in which the i-th observation belongs. The sampling variance is pre-calculated using the Jackknife resampling method as explained in Section 1.1.2 to account for the uncertainty due to the sample design of the surveys. The non-sampling error variances reflect the uncertainty due to non-response, errors made in data input, recall biases, etc. that can be minimized but difficult to eliminate. We assume it differ across data source types $p \in \{1,2\}$ where $p = 1$ refers to NFHS and $p = 2$ refers to SRS. z is the standard deviation of y_i. We assign Penalized Complexity (PC) priors for the precision parameter ω_p^{-2} for each data source type $p \in \{1,2\}$ (8). Given such data model, the Bayesian estimates are pooled towards informative observations and are less influenced by weakly informative observations.

PC priors are default priors assigned to precision parameters used in the `R`-package `INLA` (9), which we used for Bayesian inference (refer to Section 2.3 for information regarding the statistical computation). The main advantages of PC priors are that they are invariant to reparameterizations and have excellent robustness properties according to (8).

2.2 Process model of state-level ASFR 15–19

The process model for $\Psi_{s,t}$, the ASFR for age group 15–19 on logit scale, is defined as:

$$
\Psi_{s,t} = \alpha_s z_{s,t} + \beta_s x_{s,t} + \Theta_{s,t} + \Phi_{s,t}, \quad (4)
$$

where

- $z_{s,t}$: total fertility rate (TFR) for Indian state/UT s in year t on log scale (refer to Section 1.2.3 for details);
- $x_{s,t}$: mean education years among all females aged 15–49 for Indian state/UT s in year t on log scale (refer to Section 1.2.2 for details);
- α_s: state-specific coefficient for the TFR effect;
- β_s: state-specific coefficient for the female education attainment effect;
- $\Theta_{s,t}$: state-specific effect from the proportion of married females aged 15–19 for Indian state/UT s in year t (more explanations later this section);
- $\Phi_{s,t}$: year-by-year fluctuation with a drift, capturing the intra-state temporal correlation between state-specific observations.

α_s and β_s are the state-level fixed effects for TFR and female education attainment. They follow hierarchical normal distributions with mean at zero and a global precision parameter. For $s \in \{1, \cdots, k\}$, we have:

$$\alpha_s \sim \mathcal{N}(0, 1/\tau_\alpha), \tag{5}$$

$$\beta_s \sim \mathcal{N}(0, 1/\tau_\beta). \tag{6}$$

We assign non-informative priors to the global precision parameters τ_α and τ_β.

$\Theta_{s,t}$ models the state-level non-linear relation between $\Psi_{s,t}$ and the state-level proportion of married females aged 15–19 in Indian state/UT s, year t. We allow potential non-linear effect from this variable because it shows the strongest association among all three variables against the ASFR 15–19 according to the exploratory plot in Figure 2.

Specifically, let $V_{s,t}$ denote the log of proportion of married females aged 15–19 per 1,000 for Indian state/UT s in year t based on simple Bayesian model detailed in Section 1.2.1. We define a grid of values κ_d for $d \in \{1, \cdots, x\}$. $x = 1000$ is the number of grid points where $\Theta_{s,t}$ is evaluated. Let $\kappa_1 = \log(9.8)$, the minimum $V_{s,t}$, corresponding to 0.98% of the females aged 15–19 are married on the log scale. We set $\kappa_x = \log(938.9)$ as the maximal of $V_{s,t}$ across all state-years. We match each $V_{s,t}$ to the κ_d with the smallest absolute difference from $V_{s,t}$, denoting the d-th index for state-year s,t as $d[s,t]$. To model the relation between $\Theta_{s,t}$ and κ_d, we use a second-order random walk (RW2) process. We assume $\Theta_{s,t}$ is constant outside the range of κ_1 and κ_x across all s and t. In particular,

$$\Delta^2\Theta_{s,t} = \Theta_{s,t+2} - 2\Theta_{s,t+1} + \Theta_{s,t}, \text{ for } s \in \{1, \cdots, k\} \text{ and } t \in \{1, \cdots, x-2\} \tag{7}$$

$$\Delta^2\Theta_{s,t} | \tau_{\theta,s} \overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \tau_{\theta,s}^{-1}), \text{ for } s \in \{1, \cdots, k\} \text{ and } t \in \{1, \cdots, x-2\}. \tag{8}$$

We assign a Penalized Complex (PC) prior to the regional precision parameter $\tau_{\theta,s}$:

$$\tau_{\theta,s} \sim \mathcal{PC}(z, 0.01), \text{ for } s \in \{1, \cdots, k\}. \tag{9}$$

where z is the standard deviation of y_i. The PC prior is a vague prior ((8) documented the PC prior specification in detail). Figure 3 illustrates the RW2 model results for $\Theta_{s,t}$, the state-specific effects for the proportion of married females aged 15–19 on ASFR, for ages 15–19. We limit the plot presentation to only show the effect within the range of proportions during 1990–2050 on the x-axis. As the model results suggest, the non-linear effect of state-specific proportion of married females aged 15–19 on the ASFR 15–19 is different across Indian states/UTs and the non-linear effect is evident in most states/UTs.

$\Phi_{s,t}$ models the state-specific temporal effects. We use a first-order random walk (RW1) model with a drift for $\Phi_{s,t}$ and assign a gamma prior to global precision parameter τ_γ and a PC prior to state-specific precision parameter $\tau_{\phi,s}$:

$$\Phi_{s,t+1} = \gamma_s + \Phi_{s,t} + \varepsilon_{s,t}, \tag{10}$$

$$\gamma_s | \tau_\gamma \overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \tau_\gamma^{-1}), \text{ for } s \in \{1, \cdots, k\}, \tag{11}$$

$$\varepsilon_{s,t} = \Delta\Phi_{s,t} = \Phi_{s,t+1} - \Phi_{s,t}, \text{ for } s \in \{1, \cdots, k\}, t \in \{1, ..., j-1\} \tag{12}$$

$$\Delta\Phi_{s,t} | \tau_{\phi,s} \overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \tau_{\phi,s}^{-1}), \text{ for } s \in \{1, \cdots, k\}, t \in \{1, ..., j-1\}, \tag{13}$$

$$\tau_\gamma \sim \mathcal{G}(1, 0.00005), \tag{14}$$

$$\tau_{\phi,s} \sim \mathcal{PC}(1, 0.01), \text{ for } s \in \{1, \cdots, k\}. \tag{15}$$

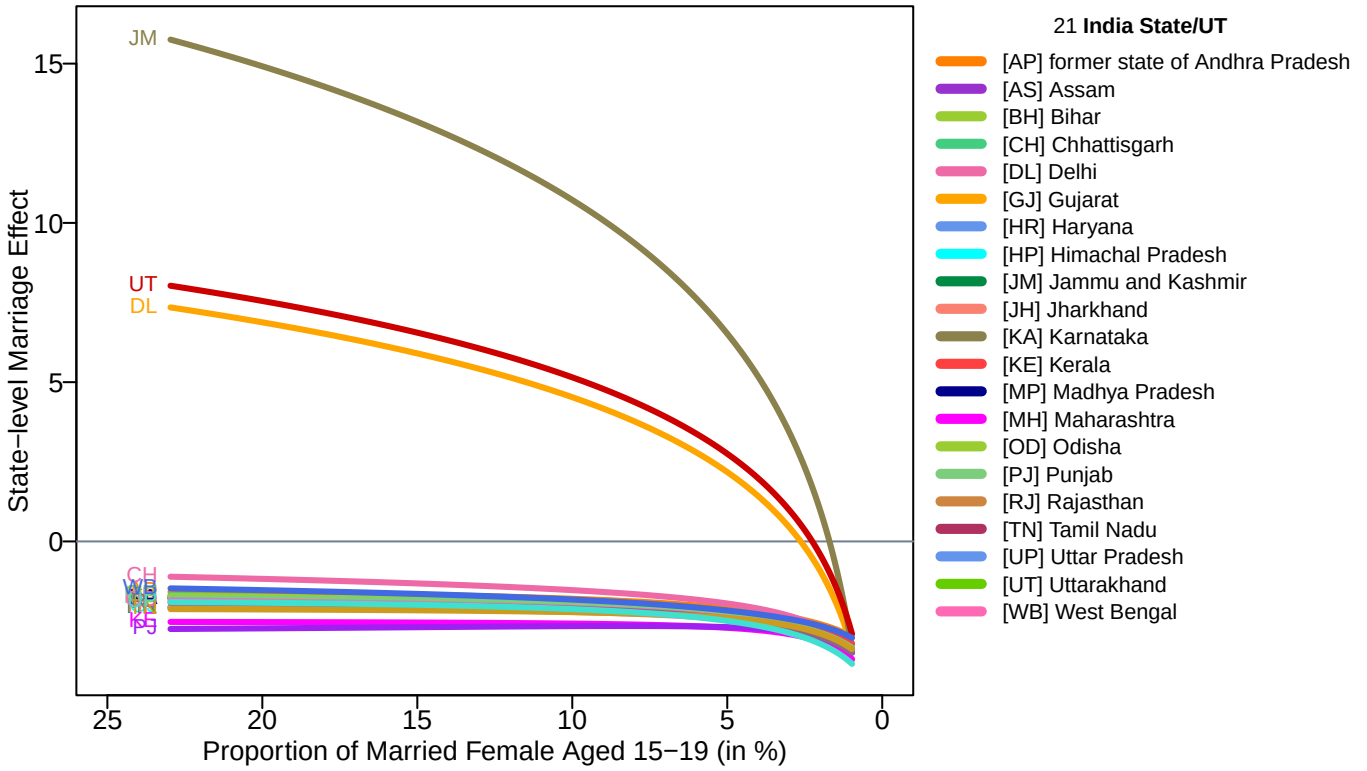

Figure 3: **State-level relation between proportion of married females aged 15–19 and ASFR 15–19.** The model median estimates for the proportion of married females effect in different Indian states/UTs are differentiated by colors. Indian state/UT code are shown next to each curve and in legend.

The sum-to-zero constraint is imposed on $\Phi_{s,t}$ so that the precision matrix is full-rank:

$$\sum_{t=1}^{j} \Phi_{s,t} = 0, \text{ for } s \in \{1, \cdots, k\}. \tag{16}$$

2.3 Statistical computation

Computing of state-specific ASFR model We use the Integrated Nested Laplace Approximation (INLA) for Bayesian inference (10) of the state-level ASFR 15–19. We use the `R`-package **INLA** (9) to implement the INLA estimation procedure.

Computing of state-level female mean education years & proportion of married females models We obtained posterior samples of all the model parameters and hyperparameters using a Markov chain Monte Carlo (MCMC) algorithm, implemented in the open source softwares `R 4.4.0` (11) and `JAGS 4.3.2` (12) (Just another Gibbs Sampler), using `R`-packages **R2jags** (13) and **rjags** (14). Results were obtained from 8 chains with a total number of 1,000 iterations in each chain, while the first 2,000 iterations were discarded as burn-in. After discarding burn-in iterations and proper thinning, the final posterior sample size for each parameter is 8,000. Convergence of the MCMC algorithm and the sufficiency of the number of samples obtained were checked through visual inspection of trace plots and convergence diagnostics of Gelman and Rubin (15), implemented in the **coda** `R`-package (16).

3 Validation exercise and results

We validate the model performance by leaving out data collected after 2019 (equivalent to leaving out all data from NFHS 2019–21), rather than randomly leaving out data. This validation approach has been used in previous global health and population studies (17; 18; 19; 20; 21; 22). The left-out observations are 21.8% of the total observations (due to the varying number of observations collected in each survey year, the left-out observations can be slightly above 20%). We call the left-out observations "testing dataset" and the remaining observations "training dataset". The validation results were calculated for 1,000 sets of left-out observations, where each set consisted of only one randomly selected left-out observation from each Indian state/UT. The reported validation results were based on the average of the outcomes from the 1,000 sets of left-out observations and the complete testing dataset for the validation exercise.

For each left-out observation in the testing dataset, we generate a posterior predictive distribution based on the Bayesian model fittings for the training dataset. We compute the error as the difference between the left-out observation and the median of the posterior predictive distribution. We report the median errors of all the left-out observations and the median of the absolute errors. We also report the coverage of the 95% prediction intervals (PIs). The lower and upper bounds of the 95% PI for each left-out observation is the 2.5th and 97.5th percentiles of the posterior predictive distribution. To summarise the coverage, we compute the proportion of left-out observations that fall outside the 95% in Table 3. Median errors and median absolute errors are close to zero for left-out observations. Observations fall below and above their respective uncertainty interval slightly more often than expected (6.4% and 3.1% of the left out observations falling below/above their respective 95% PI, as compared to the expected 2.5%). This is primarily due to the small sample number of left-out observations per state/UT.

We also validate the model performance by comparing the model estimates based on the full and training datasets. We compute the error for each state-year as the difference between the median estimates based on the full dataset and those based on the training dataset. We report the median of these errors and absolute errors for all the state-years. We calculate the percentage of the state-years where the median estimates based on the full dataset fall outside the credible bounds of the estimates based on the training dataset. Table 4 shows the results for the comparison between estimates obtained based on the full dataset and estimates based on the training set. Median errors and the median absolute errors were close to zero. The proportion of updated estimates that fell below the uncertainty intervals constructed based on the training set was higher than expected due to the small number of states involved.

4 Model Summary

Notation Summary Table 5 summarizes the notations and indexes used for the ASFR 15–19 model. The notations for obtaining the covariates are not listed here.

	All left-out obs. (1 complete set)	1 left-out obs. per state (1,000 sets average)
Median error	0.00	0.00
Absolute median error	0.01	0.01
% of left-out observations below 95% prediction interval	6.1 (16)	6.4 (1.9)
% of left-out observations above 95% prediction interval	3.1 (8)	3.1 (0.9)
Expected proportions(%)	**$\leq$2.5**	**$\leq$2.5**
# left out observations	261	29
% of left out to total observations	21.8%	–

Table 3: **Validation results for testing dataset.** Errors are defined as the difference between a left-out observation and the posterior median of its predictive distribution. Numbers in brackets after the percentages are the corresponding number of left-out observations fall below/above 95% PIs. Obs.: observation(s).

Year	**2000**	**2005**	**2015**
Median Error	0.00	0.00	0.00
Absolute median error	0.00	0.00	0.00
Below 95% uncertainty interval (%)	0.0	3.4 (1)	6.9 (2)
Above 95% uncertainty interval (%)	0.0	0.0	0.0
Expected proportions(%)	**$\leq$2.5**	**$\leq$2.5**	**$\leq$2.5**
Below 80% uncertainty interval (%)	17.2 (5)	3.4 (1)	3.4 (1)
Above 80% uncertainty interval (%)	0.0	0.0	10.3 (2)
Expected proportions(%)	**$\leq$10**	**$\leq$10**	**$\leq$10**

Table 4: **Validation results for model run based on training dataset.** Errors are the differences between estimates based on the full dataset and the training set. Proportions are full run estimates that fall below or above 95% and 80% uncertainty interval of the validation run. The numbers of states/UTs fall above/below the uncertainty intervals are within the brackets after the proportions.

Table 5: Notation summary.

Symbol	Description
	Indexes
i	Indicator for observations across all state-years, $i \in \{1, \cdots, n\}$, where $n = 1510$.
t	Indicator for year, $t \in \{1, \cdots, j\}$, where $j = 61$. $t = 1$ corresponds to the year 1990 and $t = j$ to the year 2050.
s	Indicator for state, $s \in \{1, \cdots, k\}$, where $k = 29$. We only present results in 21 states/UTs even though we model for all the 29 states/UTs.
p	Indicator for data source type, $p \in \{1, 2\}$. $p = 1$ corresponds to data source type NFHS, $p = 2$ to SRS.
d	Indicator for unique values of log-scaled proportion of married females aged 15–19 $V_{s,t}$, $d \in \{1, \cdots, 1000\}$, where $d = 1$ corresponds to 9.75% and $d = 1000$ to 93.89%.
	Unknown parameters
$\Psi_{s,t}$	The true logit of ASFR aged 15–19 for Indian state/UT s, year t.
α_s	State-specific coefficient for the TFR effect.
β_s	State-specific coefficient for the female education attainment effect.
$\Theta_{s,t}$	The state-level relation between $\Psi_{s,t}$ and log-scaled proportion of married females aged 15–19 $V_{s,t}$.
$\Phi_{s,t}$	The temporal correlation within state discrepancy between state-specific observations.
γ_s	State-specific drift for the temporal correlation process $\Phi_{s,t}$.
τ_ω	The precision parameter for non-sampling error variance.
τ_α	The precision parameter for α_s.
τ_β	The precision parameter for β_s.
τ_γ	The precision parameter for γ_s.
$\tau_{\theta,s}$	The precision parameter for the second-order increment $\Delta^2\Theta_{s,t}$.
$\tau_{\phi,s}$	The state-specific precision parameter for the first-order increment $\Delta\Phi_{s,t}$ for Indian state/UT s.
	Known quantities
y_i	i-th observed ASFR aged 15–19 for state $s[i]$ in year $t[i]$ on the logit scale.
u_i^2	The i-th sampling error variance for y_i.
z	The standard deviation of all y_i.
$x_{s,t}$	The mean education years among all females aged 15–49 for Indian state/UT s in year t.
$z_{s,t}$	The TFR for Indian state/UT s in year t.
$V_{s,t}$	The log of proportion of married females aged 15–19 in Indian state/UT s in year t.
$\kappa_1, \cdots, \kappa_x$	Unique values of $V_{s,t}$ where $\Theta_{s,t}$ is evaluated.

Model for State-level age-specific fertility rate 15–19

$$
\begin{aligned}
y_i &= \Psi_{s[i],t[i]} + \Sigma_i, \text{ for } \forall i, \\
\Sigma_i|\omega_p &\sim \mathcal{N}(0, u_i^2 + \omega_{p[i]}^2), \text{ for } \forall i, \\
\Psi_{s,t} &= \alpha_s z_{s,t} + \beta_s x_{s,t} + \Theta_{s,t} + \Phi_{s,t}, \text{ for } \forall s, \forall t, \\
\alpha_s &\sim \mathcal{N}(0, 1/\tau_\alpha), \text{ for } \forall s, \\
\beta_s &\sim \mathcal{N}(0, 1/\tau_\beta), \text{ for } \forall s, \\
\Delta^2\Theta_{s,t} &= \Theta_{s,t+2} - 2\Theta_{s,t+1} + \Theta_{s,t}, \text{ for } \forall s, t \in \{1, \cdots, x-2\}, \\
\Delta^2\Theta_{s,t}|\tau_{\theta,s} &\overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \tau_{\theta,s}^{-1}), \text{ for } \forall s, t \in \{1, \cdots, x-2\}, \\
\Phi_{s,t+1} &= \gamma_s + \Phi_{s,t} + \varepsilon_{s,t}, \\
\gamma_s|\tau_\gamma &\overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \tau_\gamma^{-1}), \text{ for } s \in \{1, \cdots, k\}, \\
\varepsilon_{s,t} = \Delta\Phi_{s,t} &= \Phi_{s,t+1} - \Phi_{s,t}, \text{ for } s \in \{1, \cdots, k\}, t \in \{1, ..., j-1\} \\
\Delta\Phi_{s,t}|\tau_{\phi,s} &\overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \tau_{\phi,s}^{-1}), \text{ for } \forall s, t \in \{1, ..., j-1\}, \\
\sum_{t=1}^{j} \Phi_{s,t} &= 0, \text{ for } \forall s, \\
\omega_p^{-2} &\sim \mathscr{PC}(z, 0.01), \text{ for } p \in \{1, 2\} \\
\tau_\alpha &\sim \mathscr{G}(1, 0.00005), \\
\tau_\beta &\sim \mathscr{G}(1, 0.00005), \\
\tau_\gamma &\sim \mathscr{G}(1, 0.00005), \\
\tau_{\theta,s} &\sim \mathscr{PC}(z, 0.01), \text{ for } \forall s, \\
\tau_{\phi,s} &\sim \mathscr{PC}(1, 0.01), \text{ for } \forall s.
\end{aligned}
$$

where $z = 0.61$ is the standard deviation of all the observations on the logit-scale.

Model for State-level proportion of married females aged 15–19

$$
\begin{aligned}
v_j &\sim \mathcal{N}(V_{s[j],t[j]}, \omega_v^2), \text{ for } j \in \{1, \cdots, 133\}, \\
\exp\{V_{s,t}\} &= \frac{\delta_s^{\text{mar}} \cdot \exp\{\lambda_s^{\text{mar}} \cdot \log(t) + \zeta_s^{\text{mar}}\}}{1 + \exp\{\lambda_s^{\text{mar}} \cdot \log(t) + \zeta_s^{\text{mar}}\}}, \text{ for } \forall s, \forall t, \\
\delta_s^{\text{mar}} &\sim \mathcal{N}\left(\mu_\delta^{\text{mar}}, \left(\sigma_\delta^{\text{mar}}\right)^2\right), \text{ for } \forall s, \\
\lambda_s^{\text{mar}} &\sim \mathcal{N}_{(-\infty, \log(100))}\left(\mu_\lambda^{\text{mar}}, \left(\sigma_\lambda^{\text{mar}}\right)^2\right), \text{ for } \forall s, \\
\zeta_s^{\text{mar}} &\sim \mathcal{N}\left(\mu_\zeta^{\text{mar}}, \left(\sigma_\zeta^{\text{mar}}\right)^2\right), \text{ for } \forall s \\
\mu_\delta^{\text{mar}} &\sim \mathscr{U}(-0.5, 0.5), \\
\mu_\lambda^{\text{mar}} &\sim \mathscr{U}(-0.5, 0.5), \\
\mu_\zeta^{\text{mar}} &\sim \mathscr{U}(-0.5, 0.5), \\
\sigma_\delta^{\text{mar}} &\sim \mathscr{U}(0, 2), \\
\sigma_\lambda^{\text{mar}} &\sim \mathscr{U}(0, 2), \\
\sigma_\zeta^{\text{mar}} &\sim \mathscr{U}(0, 2), \\
\omega_v &\sim \mathscr{U}(0.001, 0.05).
\end{aligned}
$$

$\mathscr{U}(a, b)$ denotes a continuous uniform distribution with lower and upper bounds at a and b respectively.

Model for state-level mean education years in females aged 15–49

$$
\begin{aligned}
x_i &\sim \mathcal{N}(\chi_{s[i],t[i]}, \omega_\chi^2), \text{ for } i \in \{1,\cdots,132\},\\
\exp\{\chi_{s,t}\} &= \frac{\delta_s^{\text{edu}} \cdot \exp\left\{\lambda_s^{\text{edu}} \cdot \log(t) + \zeta_s^{\text{edu}}\right\}}{1+\exp\left\{\lambda_s^{\text{edu}} \cdot \log(t) + \zeta_s^{\text{edu}}\right\}}, \text{ for } \forall s, \forall t,\\
\delta_s^{\text{edu}} &\sim \mathcal{N}\left(\mu_\delta^{\text{edu}}, \left(\sigma_\delta^{\text{edu}}\right)^2\right), \text{ for } \forall s,\\
\lambda_s^{\text{edu}} &\sim \mathcal{N}_{(-\infty,\log(20))}\left(\mu_\lambda^{\text{edu}}, \left(\sigma_\lambda^{\text{edu}}\right)^2\right), \text{ for } \forall s,\\
\zeta_s^{\text{edu}} &\sim \mathcal{N}\left(\mu_\zeta^{\text{edu}}, \left(\sigma_\zeta^{\text{edu}}\right)^2\right), \text{ for } \forall s,\\
\mu_\delta^{\text{edu}} &\sim \mathcal{U}(-0.5, 0.5),\\
\mu_\lambda^{\text{edu}} &\sim \mathcal{U}(-0.5, 0.5),\\
\mu_\zeta^{\text{edu}} &\sim \mathcal{U}(-0.5, 0.5),\\
\sigma_\delta^{\text{edu}} &\sim \mathcal{U}(0, 2),\\
\sigma_\lambda^{\text{edu}} &\sim \mathcal{U}(0, 2),\\
\sigma_\zeta^{\text{edu}} &\sim \mathcal{U}(0, 2),\\
\omega_v &\sim \mathcal{U}(0.001, 0.05).
\end{aligned}
$$

5 GATHER Compliance

Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) are reported in Table 6.

Table 6: **GATHER checklist.** Checklist of information that should be included in new reports of global health estimates. M: main manuscript. A: Appendix. Section titles after "M" are stated for the main manuscript. Page numbers after "A" are shown for the appendix. GATHER: Guidelines for Accurate and Transparent Health Estimates Reporting

Item #	Checklist item	Reported on page # or section #
Objectives and funding		
1	Define the indicator(s), populations (including age, sex, and geographic entities), and time period(s) for which estimates were made.	M-Introduction, A1–1
2	List the funding sources for the work.	M-Abstract
Objectives and funding		
For all data inputs from multiple sources that are synthesized as part of the study:		
3	Describe how the data were identified and how the data were accessed.	M-Database construction, A1–4
4	Specify the inclusion and exclusion criteria. Identify all ad-hoc exclusions.	M-Database construction, A4–4
5	Provide information on all included data sources and their main characteristics. For each data source used, report reference information or contact name/institution, the population represented, data collection method, year(s) of data collection, sex and age range, diagnostic criteria or measurement method, and sample size, as relevant.	A1–1 & A18–31

Continued on next page

Table 6 – continued from previous page

Item #	Checklist item	Reported on page # or section #
6	Identify and describe any categories of input data that have potentially important biases (e.g., based on characteristics listed in item 5).	A4–7
For data inputs that contribute to the analysis but were not synthesized as part of the study:		
7	Describe and give sources for any other data inputs.	M-Database construction, A18–31
For all data inputs:		
8	Provide all data inputs in a file format from which data can be efficiently extracted (e.g., a spreadsheet rather than a PDF), including all relevant meta-data listed in item 5. For any data inputs that cannot be shared because of ethical or legal reasons, such as third-party ownership, provide a contact name or the name of the institution that retains the right to the data.	M-Database construction
Data analysis		
9	Provide a conceptual overview of the data analysis method. A diagram may be helpful.	M-Database construction, A7
10	Provide a detailed description of all analysis steps, including mathematical formulae. This description should cover, as relevant, data cleaning, data pre-processing, data adjustments and weighting of data sources, and mathematical or statistical model(s).	M-Statistical analysis, A7–9
11	Describe how candidate models were evaluated and how the final model(s) were selected.	M-Statistical analysis, A7
12	Provide the results of an evaluation of model performance, if done, as well as the results of any relevant sensitivity analysis.	A7–9
13	Describe methods for calculating the uncertainty of the estimates. State which sources of uncertainty were, and were not, accounted for in the uncertainty analysis.	A9–10
14	State how analytic or statistical source code used to generate estimates can be accessed.	M-Statistical analysis
Results and Discussion		
15	Provide published estimates in a file format from which data can be efficiently extracted.	M-Results, A35-64
16	Report a quantitative measure of the uncertainty of the estimates (e.g., uncertainty intervals).	A9–10
17	Interpret results in light of existing evidence. If updating a previous set of estimates, describe the reasons for changes in estimates.	M-Results
18	Discuss limitations of the estimates. Include a discussion of any modelling assumptions or data limitations that affect the interpretation of the estimates.	M-Discussion

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6 Supplementary Tables

- Table 7: Data sources for age-specific fertility rate aged 15–19, by Indian state/UT (page 18–22).
- Table 8: Data sources for proportion of married females aged 15–19, by Indian state/UT (page 23–26).
- Table 9: Data sources for mean education years among females aged 15–49, by Indian state/UT (page 27–30).

Table 7: **Data sources for age-specific fertility rate aged 15–19, by Indian state/UT.** For each Indian state/UT, the total number of observations and the most recent observation year are shown after the state/UT name. For each state-specific data series, the number of observations and the most recent observation year within that series are shown before each data series name. The source type that each data series falls in is shown in parentheses after each data series name.

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
former state of Andhra Pradesh	54	2018.5	
	9	1991.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Arunachal Pradesh	63	2020.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]
Assam	54	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Bihar	52	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	7	2007.5	Sample Registration System [SRS Direct]
Chhattisgarh	27	2020.5	
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
Delhi	45	2020.5	

Continued on next page

Table 7 – continued from previous page

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]
Goa	63	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]
Gujarat	54	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Haryana	54	2020.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Himachal Pradesh	63	2018.5	
	9	1991.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]
Jammu and Kashmir	36	2019.5	
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2019.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Jharkhand	27	2020.5	
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
Karnataka	54	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]

Continued on next page

Table 7 – continued from previous page

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Kerala	54	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Madhya Pradesh	54	2020.5	
	9	1991.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Maharashtra	54	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Manipur	63	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]
Meghalaya	63	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]
Mizoram	57	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	12	2007.5	Sample Registration System [SRS Direct]
Nagaland	63	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]

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Table 7 – continued from previous page

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]
Odisha	54	2020.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Punjab	54	2020.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Rajasthan	53	2020.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	8	2007.5	Sample Registration System [SRS Direct]
Sikkim	54	2018.5	
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]
Tamil Nadu	54	2020.5	
	9	1991.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Tripura	63	2018.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1999.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	18	2007.5	Sample Registration System [SRS Direct]

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Table 7 – continued from previous page

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
Uttar Pradesh	54	2020.5	
	9	1992.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2015.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	9	2007.5	Sample Registration System [SRS Direct]
Uttarakhand	18	2020.5	
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2020.5	2019–2021 National Family Health Survey [Standard DHS Direct]
West Bengal	52	2018.5	
	9	1991.5	1992–1993 National Family Health Survey [Standard DHS Direct]
	9	1998.5	1998–1999 National Family Health Survey [Standard DHS Direct]
	9	2005.5	2005–2006 National Family Health Survey [Standard DHS Direct]
	9	2014.5	2015–2016 National Family Health Survey [Standard DHS Direct]
	9	2018.5	2019–2021 National Family Health Survey [Standard DHS Direct]
	7	2007.5	Sample Registration System [SRS Direct]

Table 8: **Data sources for mean education years among females aged 15–49, by Indian state/UT.** For each Indian state/UT, the total number of observations and the most recent observation year are shown after the state/UT name. For each state-specific data series, the number of observations and the most recent observation year within that series are shown before each data series name. The source type that each data series falls in is shown in parentheses after each data series name.

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
former state of Andhra Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Arunachal Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Assam	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Bihar	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Chhattisgarh	3	2020.4	
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Delhi	3	2020.4	
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Goa	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Gujarat	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]

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Table 8 – continued from previous page

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Haryana	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Himachal Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Jammu and Kashmir	3	2020.4	
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Jharkhand	3	2020.4	
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Karnataka	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Kerala	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Madhya Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Maharashtra	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]

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Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Manipur	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Meghalaya	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Mizoram	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Nagaland	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Odisha	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Punjab	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Rajasthan	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Sikkim	4	2020.4	
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]

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Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Tamil Nadu	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Tripura	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Uttar Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Uttarakhand	2	2020.4	
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
West Bengal	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]

Table 9: **Data sources for mean education years among females aged 15–49, by Indian state/UT.** For each Indian state/UT, the total number of observations and the most recent observation year are shown after the state/UT name. For each state-specific data series, the number of observations and the most recent observation year within that series are shown before each data series name. The source type that each data series falls in is shown in parentheses after each data series name.

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
former state of Andhra Pradesh	4	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Arunachal Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Assam	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Bihar	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Chhattisgarh	3	2020.4	
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Delhi	3	2020.4	
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Goa	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Gujarat	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]

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Table 9 – continued from previous page

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Haryana	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Himachal Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Jammu and Kashmir	3	2020.4	
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Jharkhand	3	2020.4	
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Karnataka	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Kerala	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Madhya Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Maharashtra	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]

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Table 9 – continued from previous page

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Manipur	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Meghalaya	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Mizoram	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Nagaland	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Odisha	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Punjab	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Rajasthan	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Sikkim	4	2020.4	
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]

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Table 9 – continued from previous page

Indian state/UT	# obs.	Most recent obs. year	Data series name [source type]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Tamil Nadu	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Tripura	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Uttar Pradesh	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
Uttarakhand	2	2020.4	
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]
West Bengal	5	2020.4	
	1	1993	1992–1993 National Family Health Survey [Standard DHS Direct]
	1	1999.4	1998–1999 National Family Health Survey [Standard DHS Direct]
	1	2006.2	2005–2006 National Family Health Survey [Standard DHS Direct]
	1	2016	2015–2016 National Family Health Survey [Standard DHS Direct]
	1	2020.4	2019–2021 National Family Health Survey [Standard DHS Direct]

7 Supplementary Figures

- Figure 4: Proportion of married females aged 15–19 by Indian state/UT model results.
- Figure 5: Mean education years for females aged 15–49 by Indian state/UT model results.
- Figure 6: Total fertility rate by Indian state/UT model results.
- Figure 7: ASFR age 15–19 estimates and projections by Indian state/UT, 1990–2050 (page 35–64).

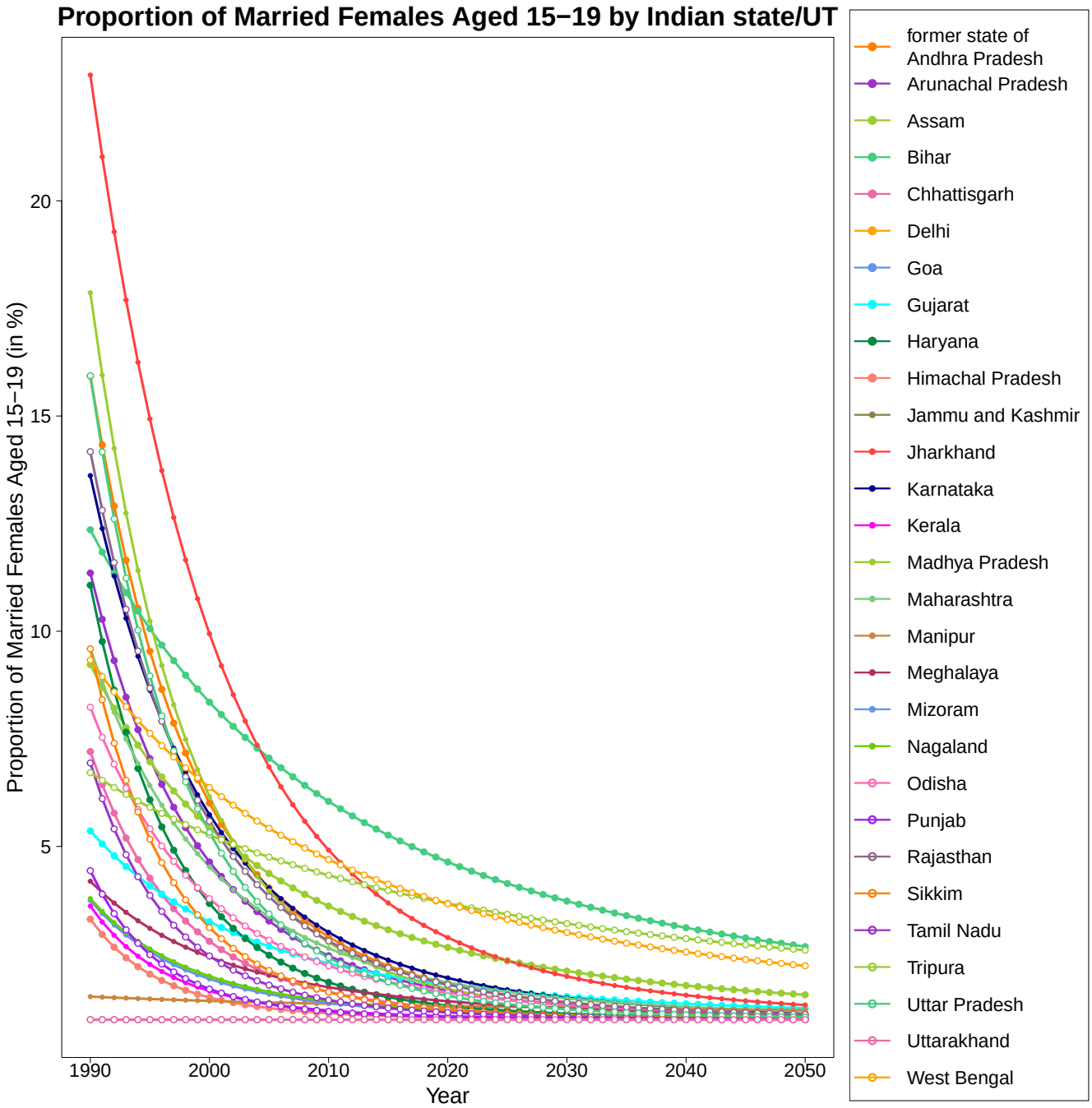


Figure 4: **Proportion of married females aged 15–19 by Indian state/UT model results.** Model medians are shown. States/UTs are differentiated by colors.

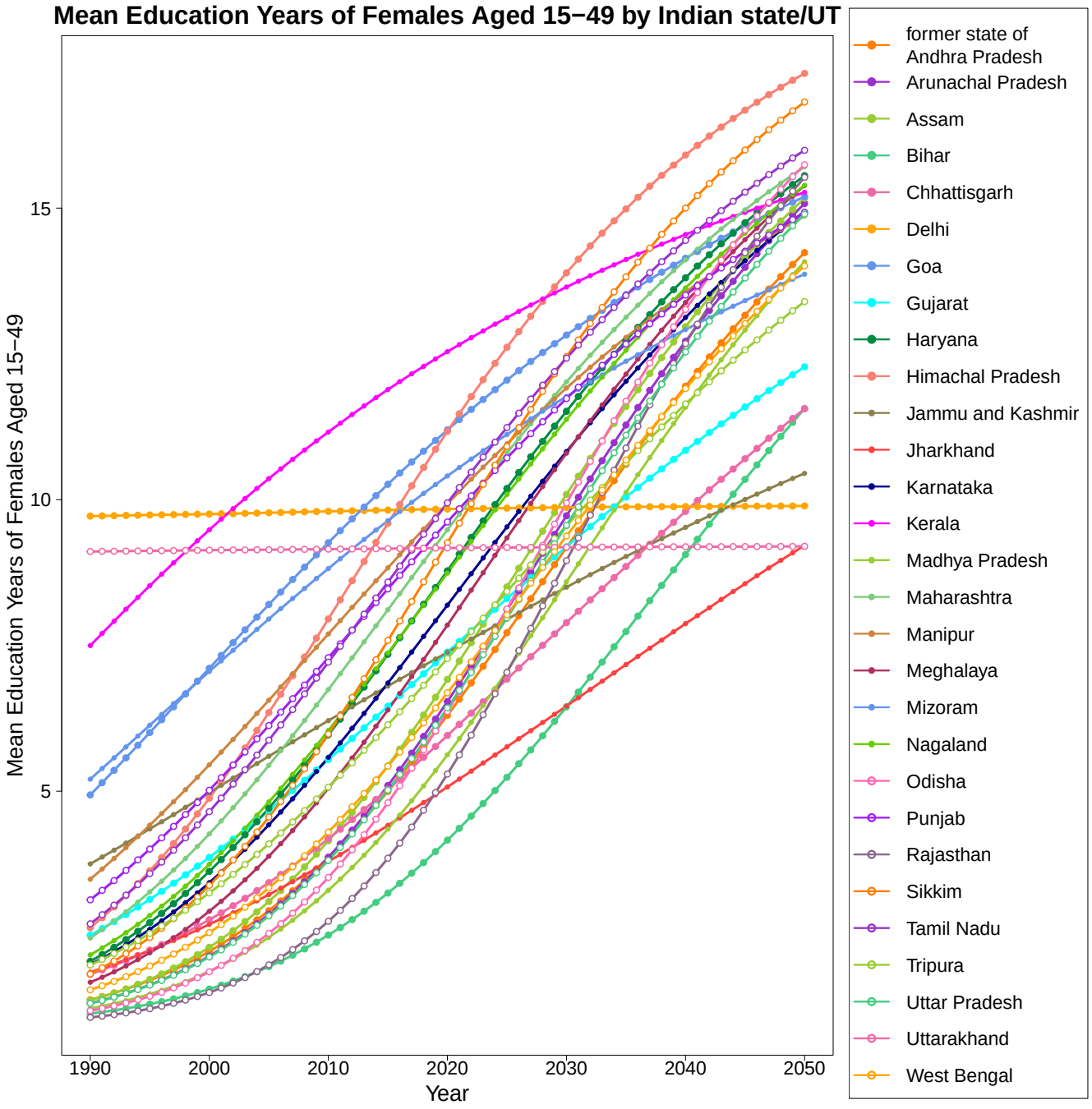


Figure 5: **Mean education years of females aged 15–49 by Indian state/UT model results.** Model medians are shown. States/UTs are differentiated by colors.

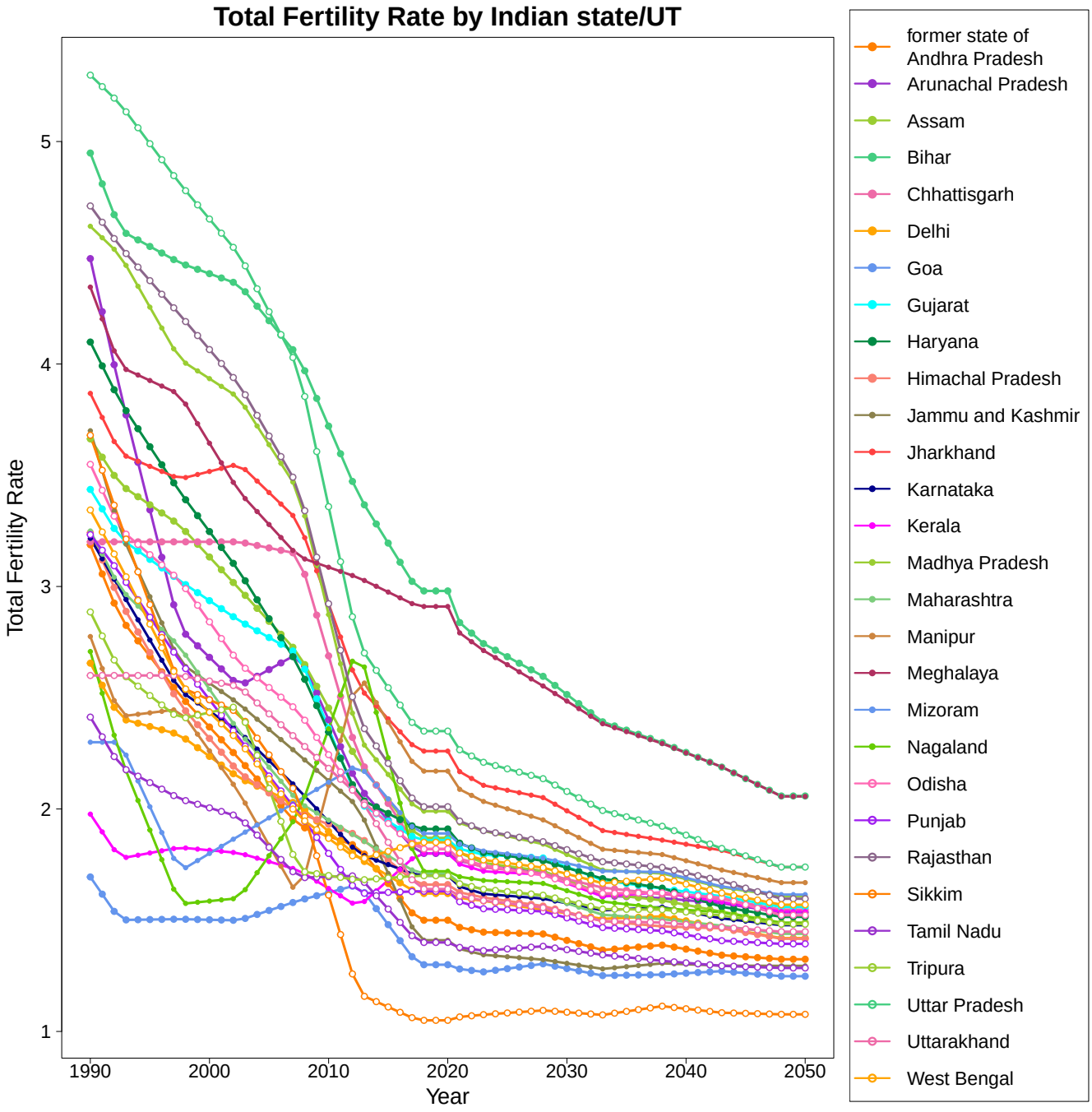
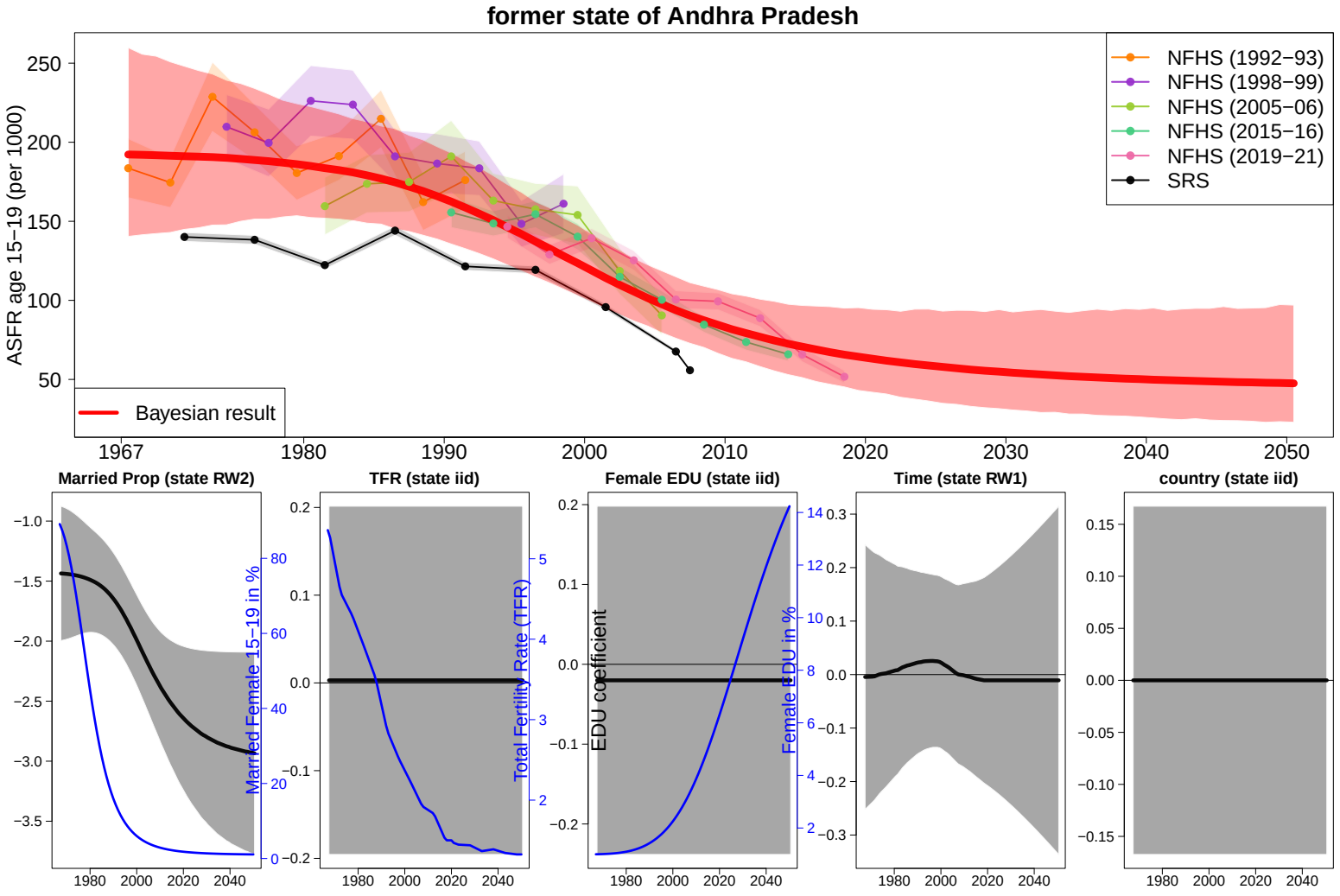
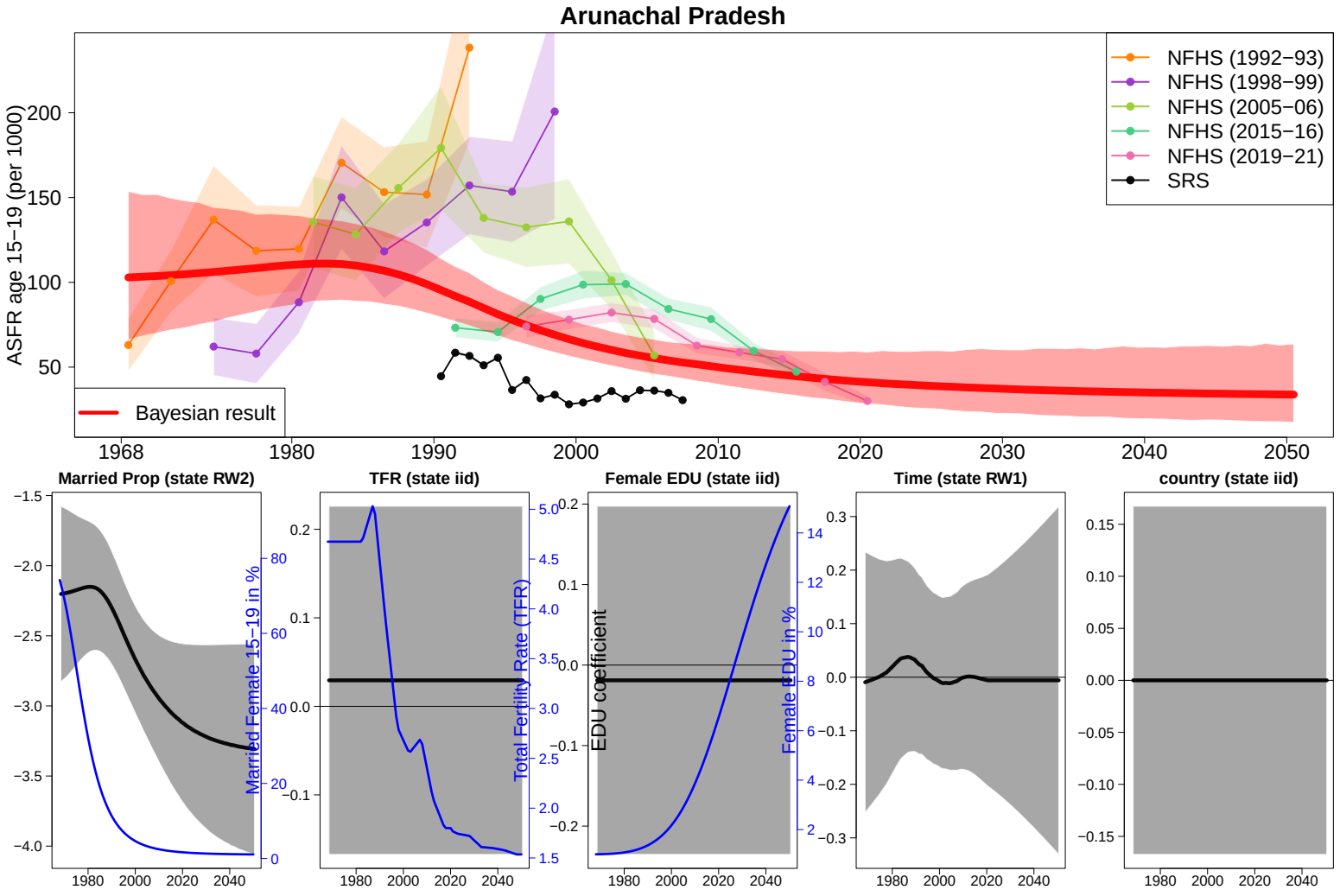
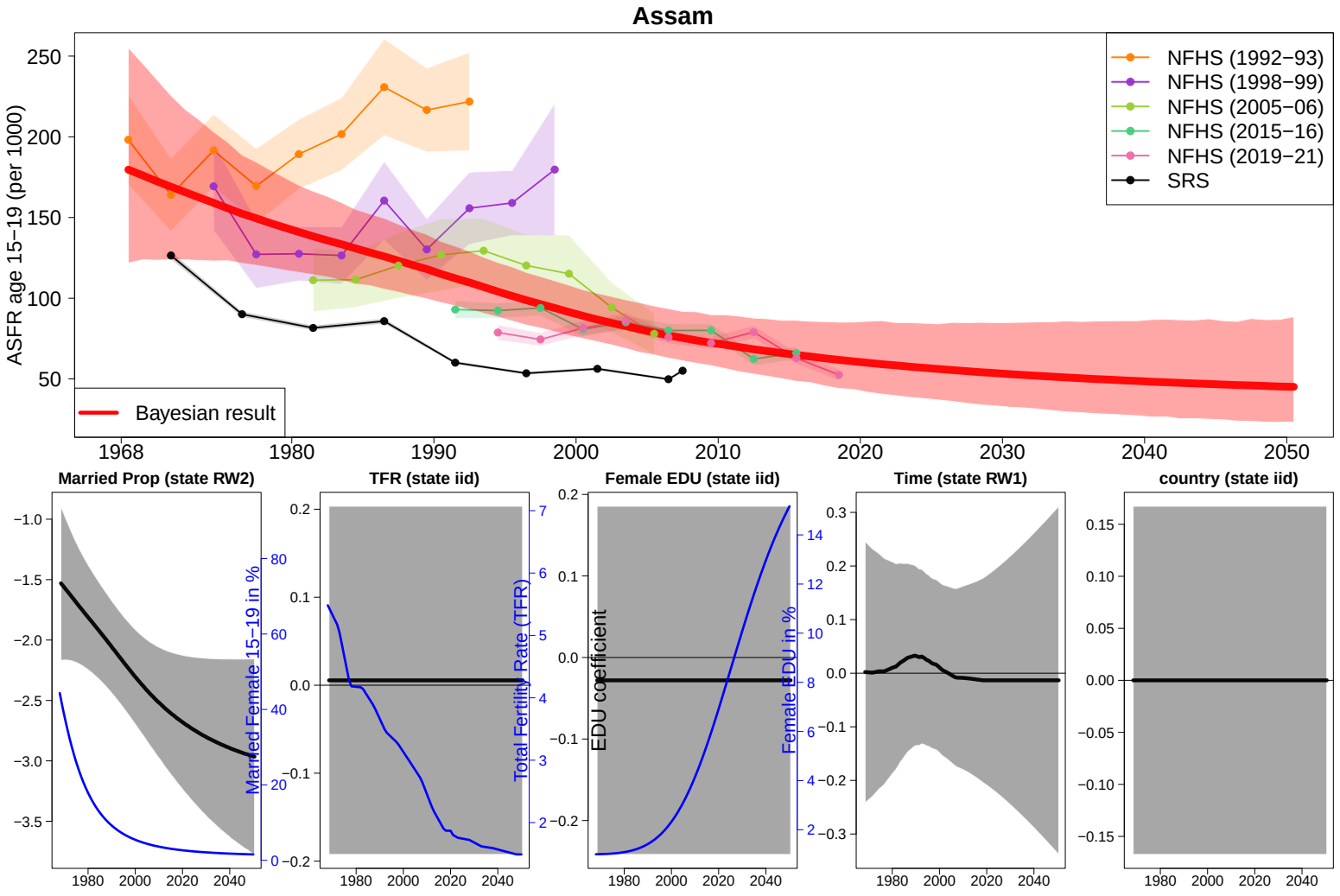


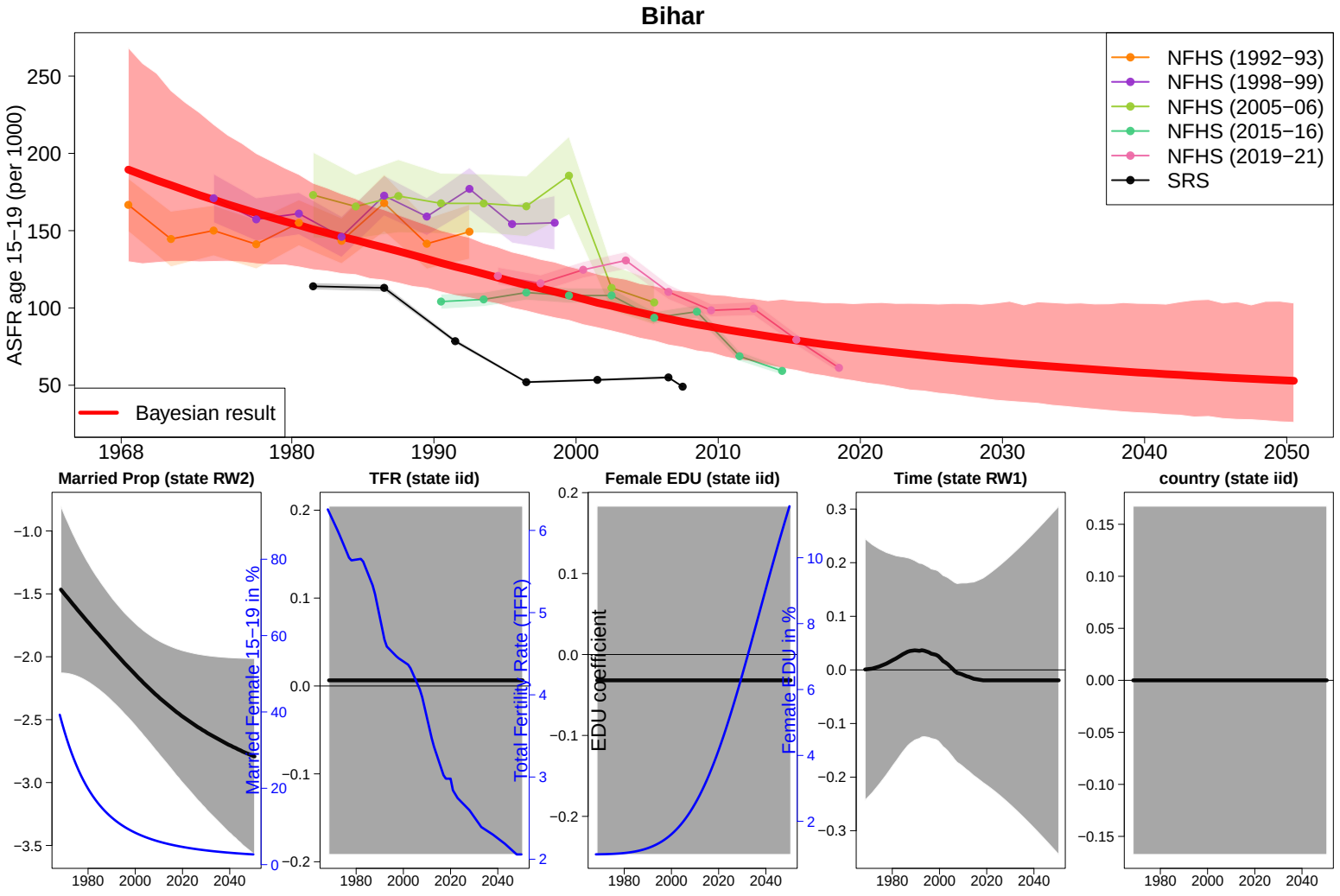
Figure 6: **Total fertility rate by Indian state/UT model results.** Model medians are shown. States/UTs are differentiated by colors.

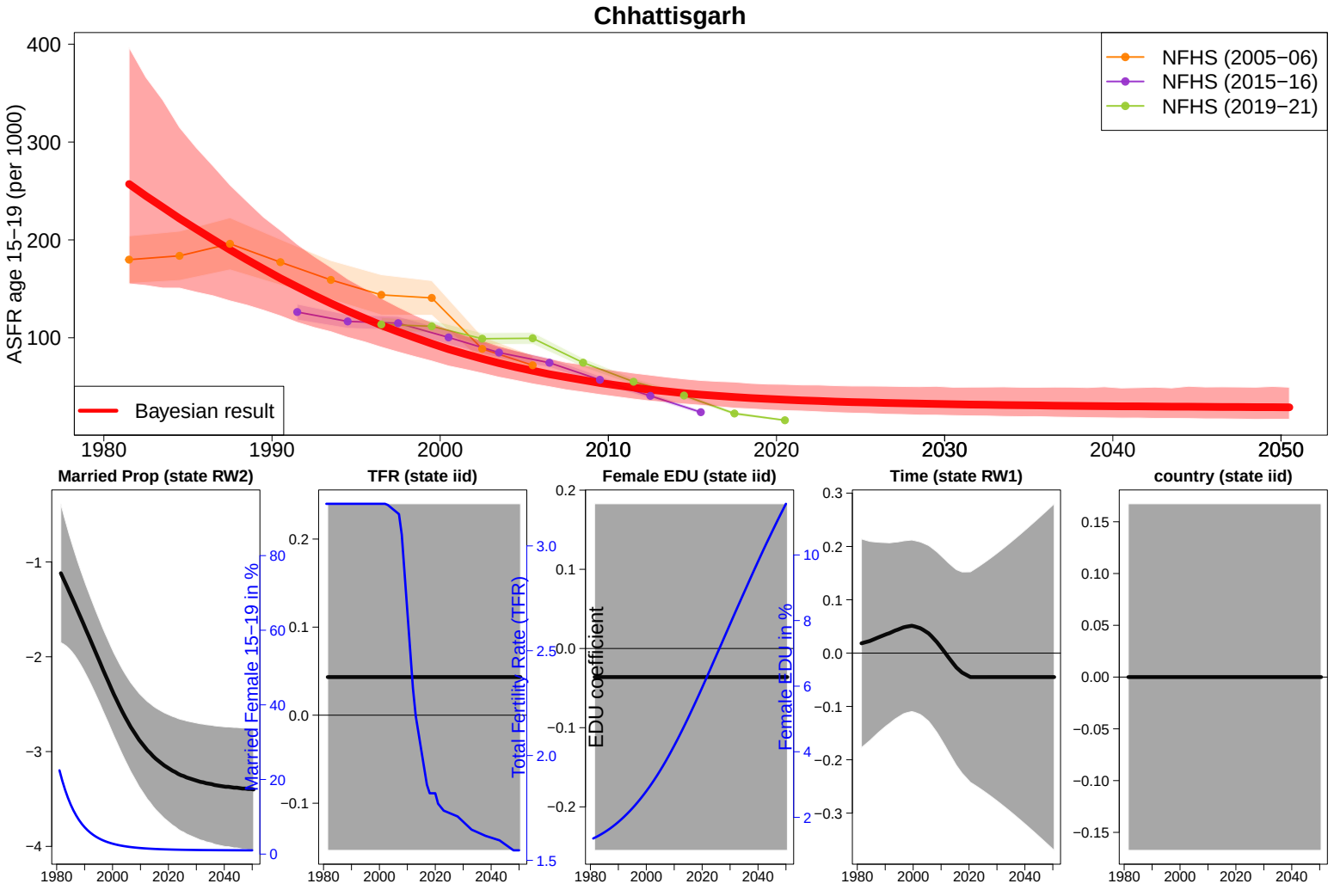
Figure 7: **ASFR age 15–19 estimates and projections by Indian state/UT, 1990–2050.** The red line and shades are the median and 95% credible intervals of the state-specific ASFR 15–19. ASFR 15–19 observations are displayed with dots and observations are connected with lines when obtained from the same source. Shades/vertical line segments around the data series represent the sampling variability in the series (quantified by two times the stochastic/sampling standard errors). Bayesian model parameter results and corresponding input covariates are shown at the bottom of each page.

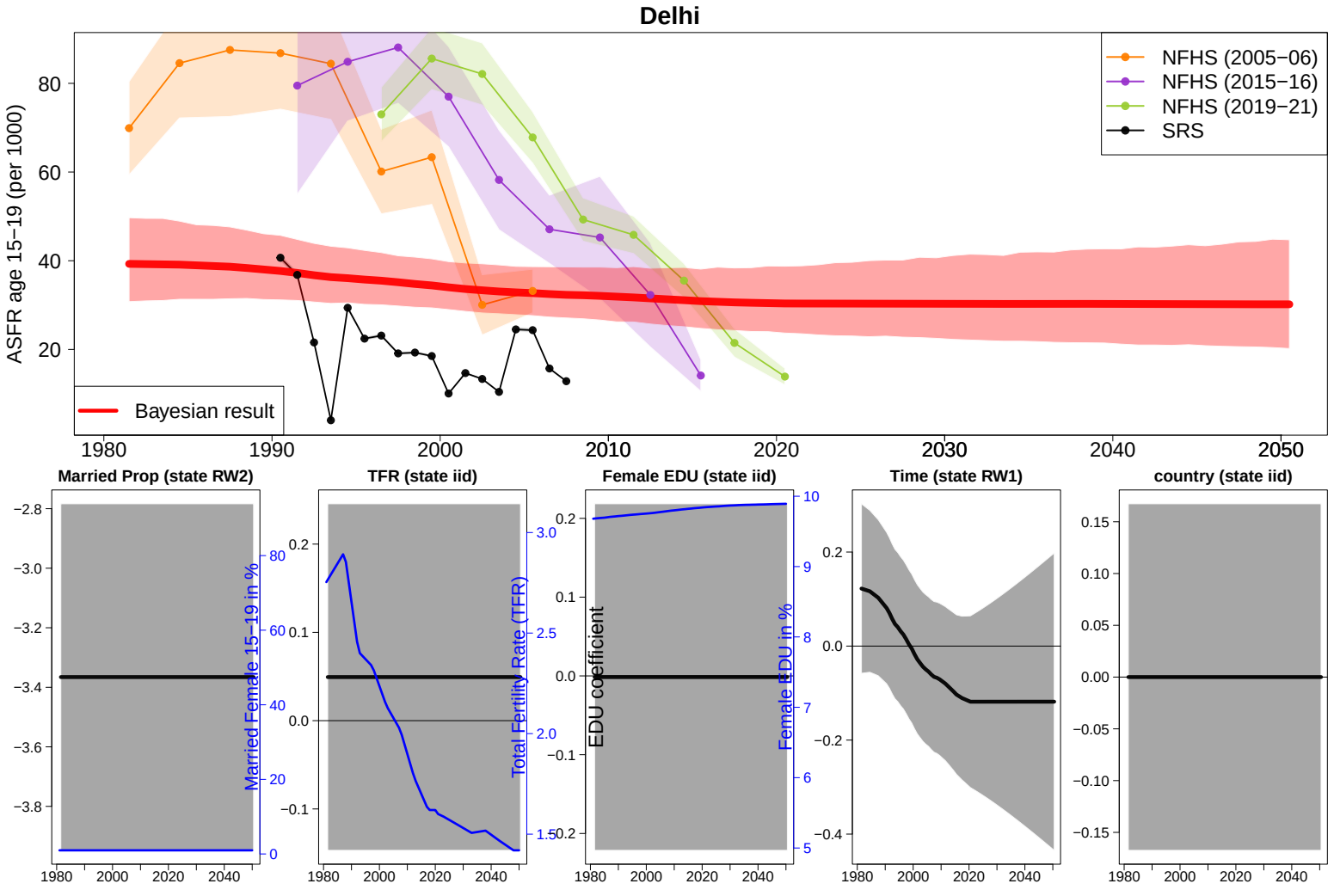

former state of Andhra Pradesh
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

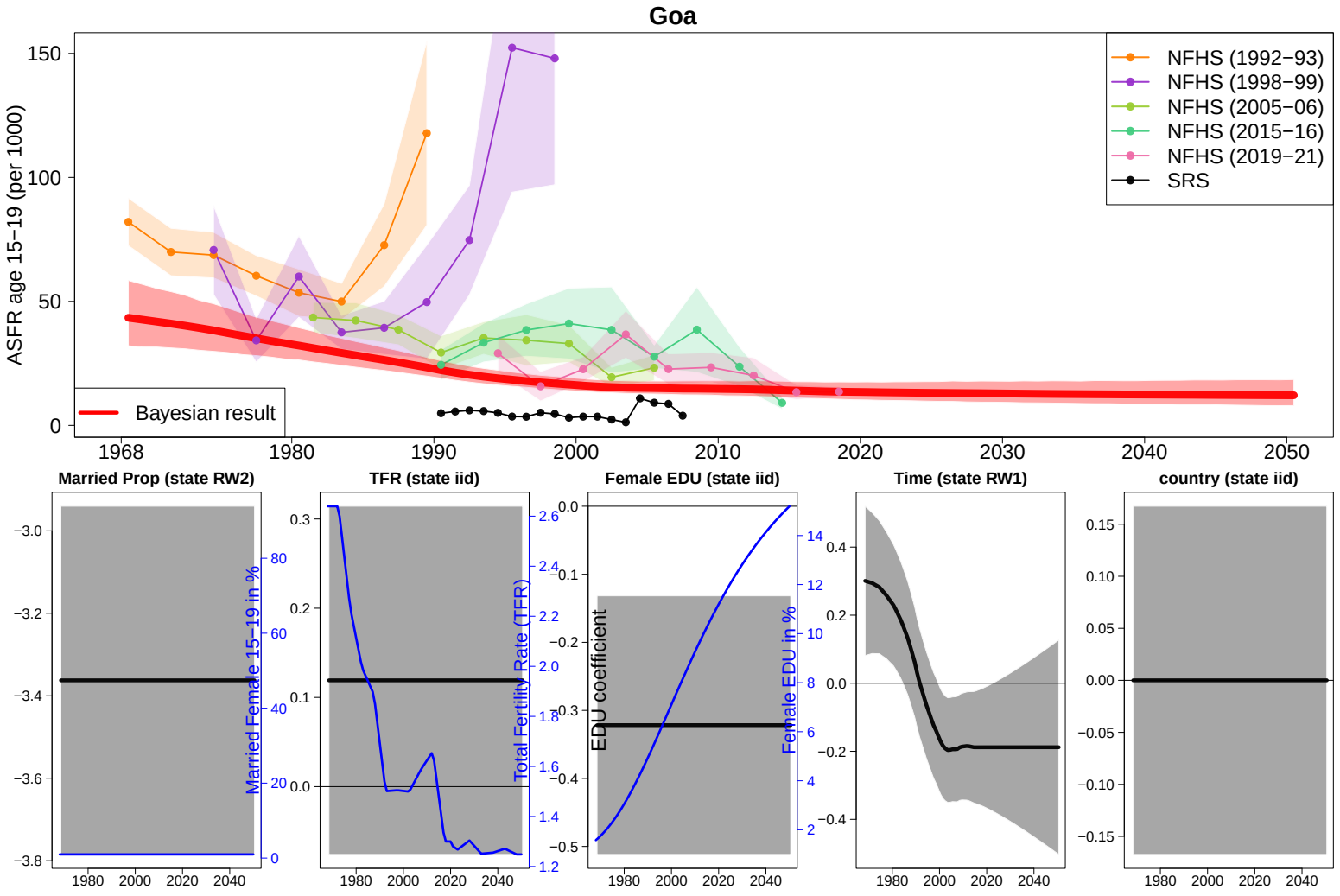

Arunachal Pradesh
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

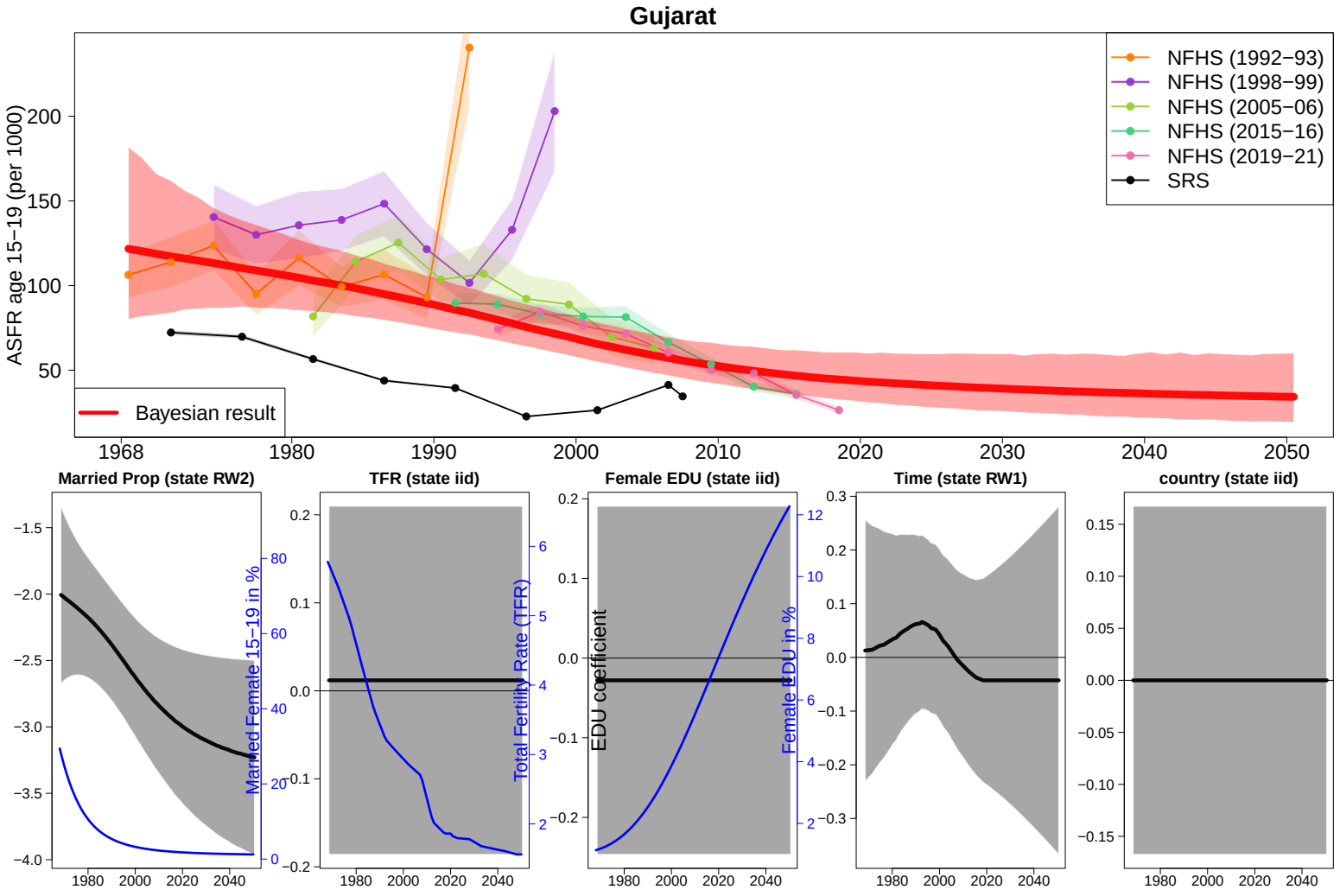

Assam
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

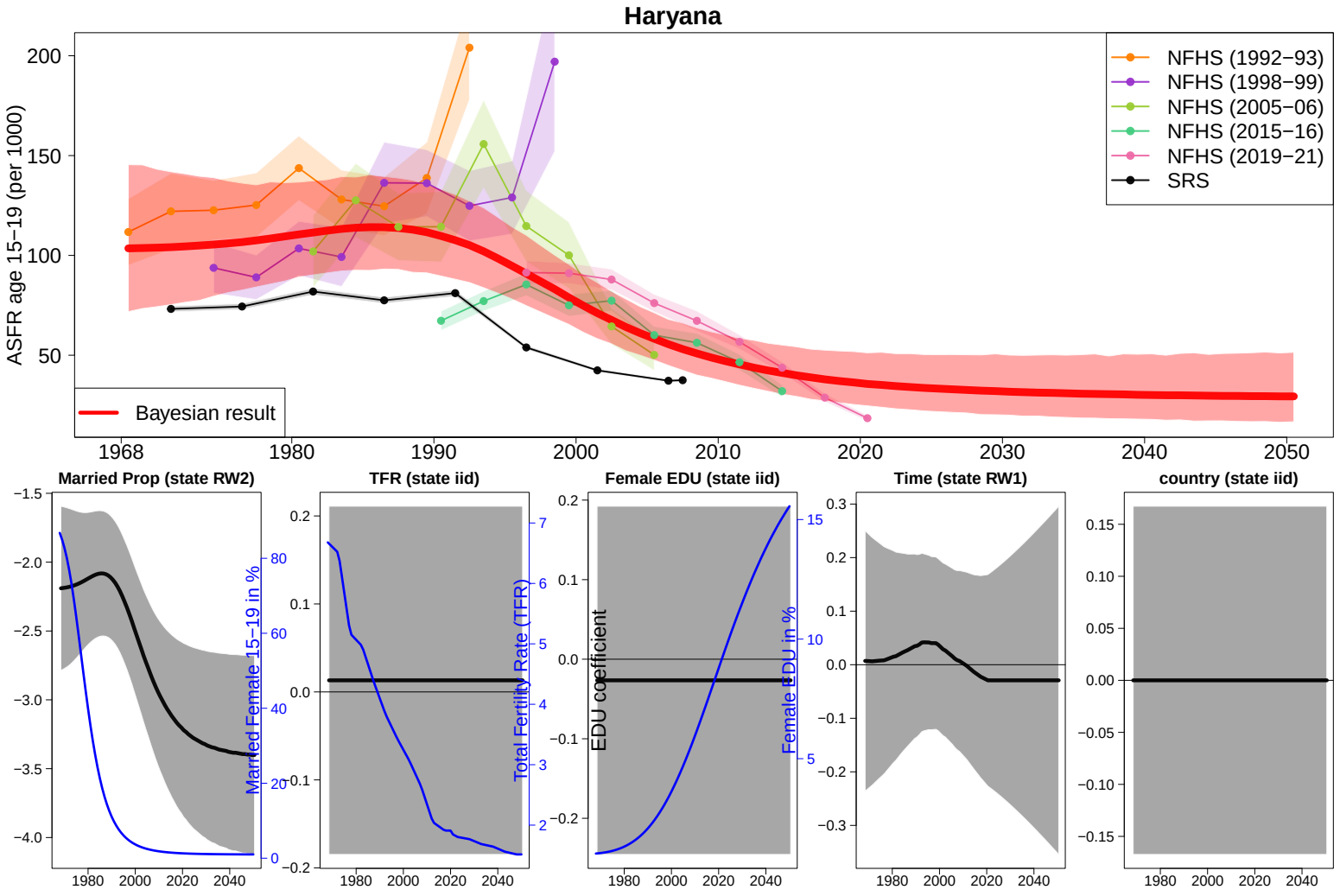

Bihar
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

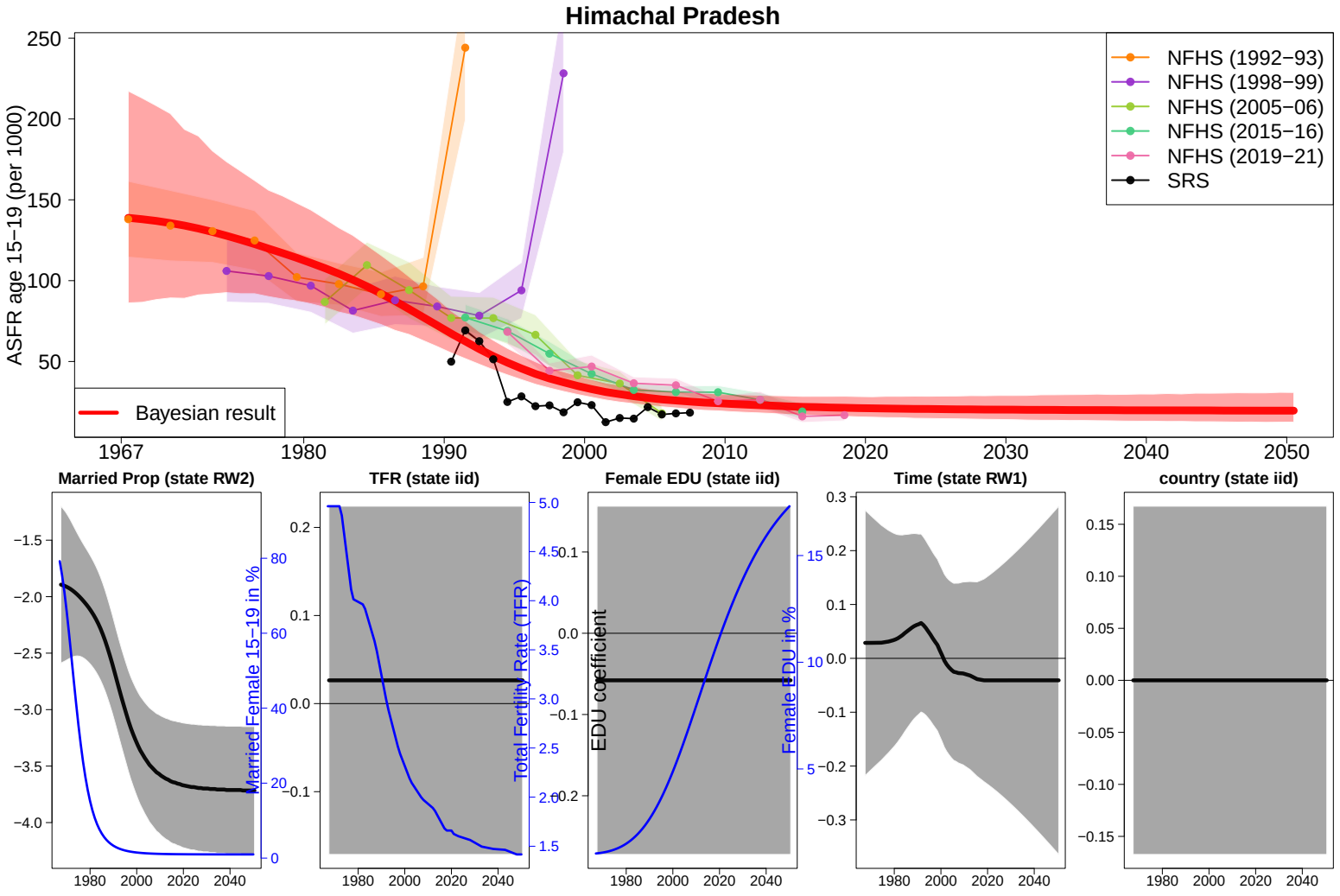

Chhattisgarh
ASFR age 15−19 (per 1000)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

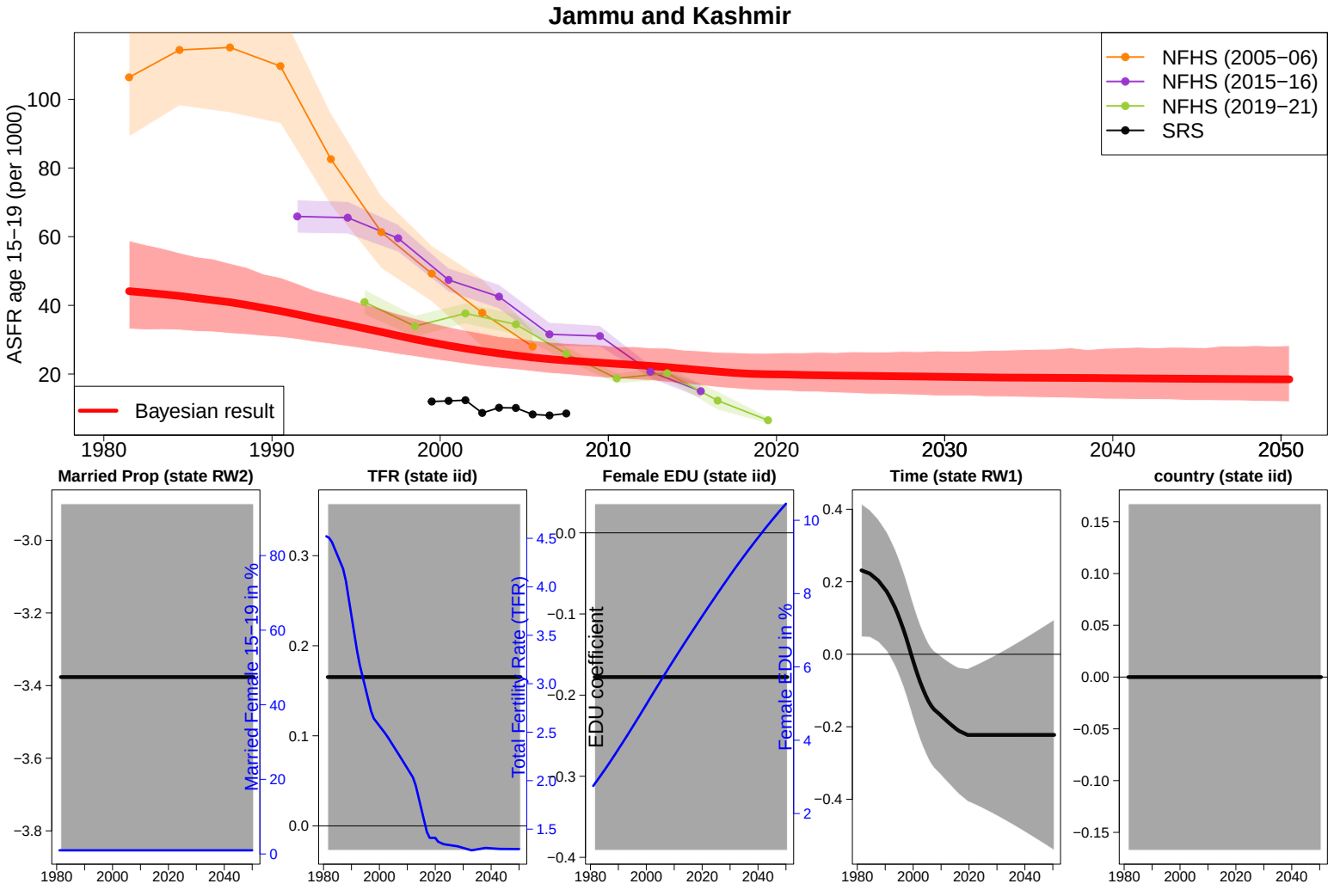

Delhi
ASFR age 15−19 (per 1000)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %

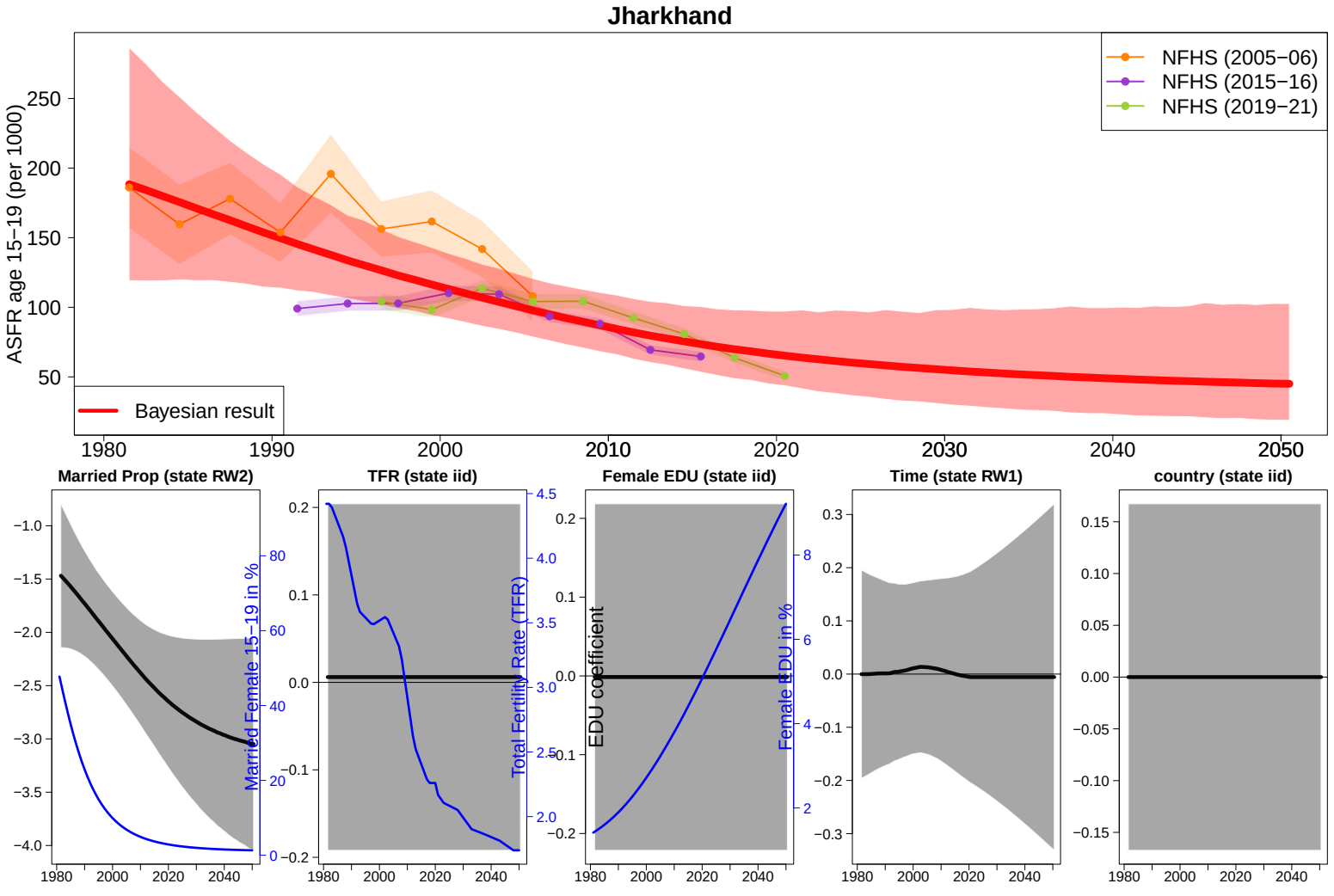

Goa
ASFR age 15−19 (per 1000)
150
100
50
0
1968
1980
1990
2000
2010
2020
2030
2040
2050
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

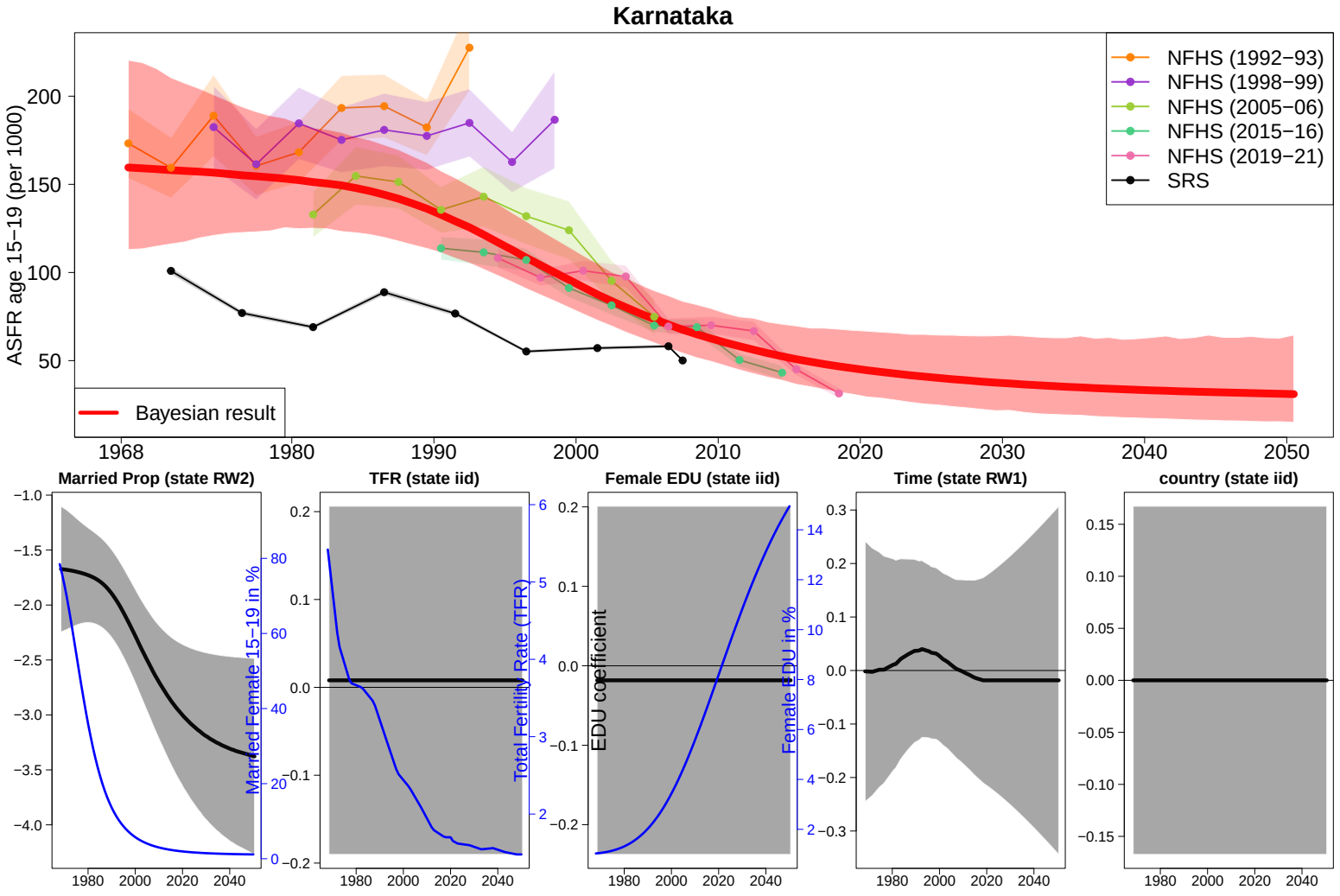

Gujarat
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

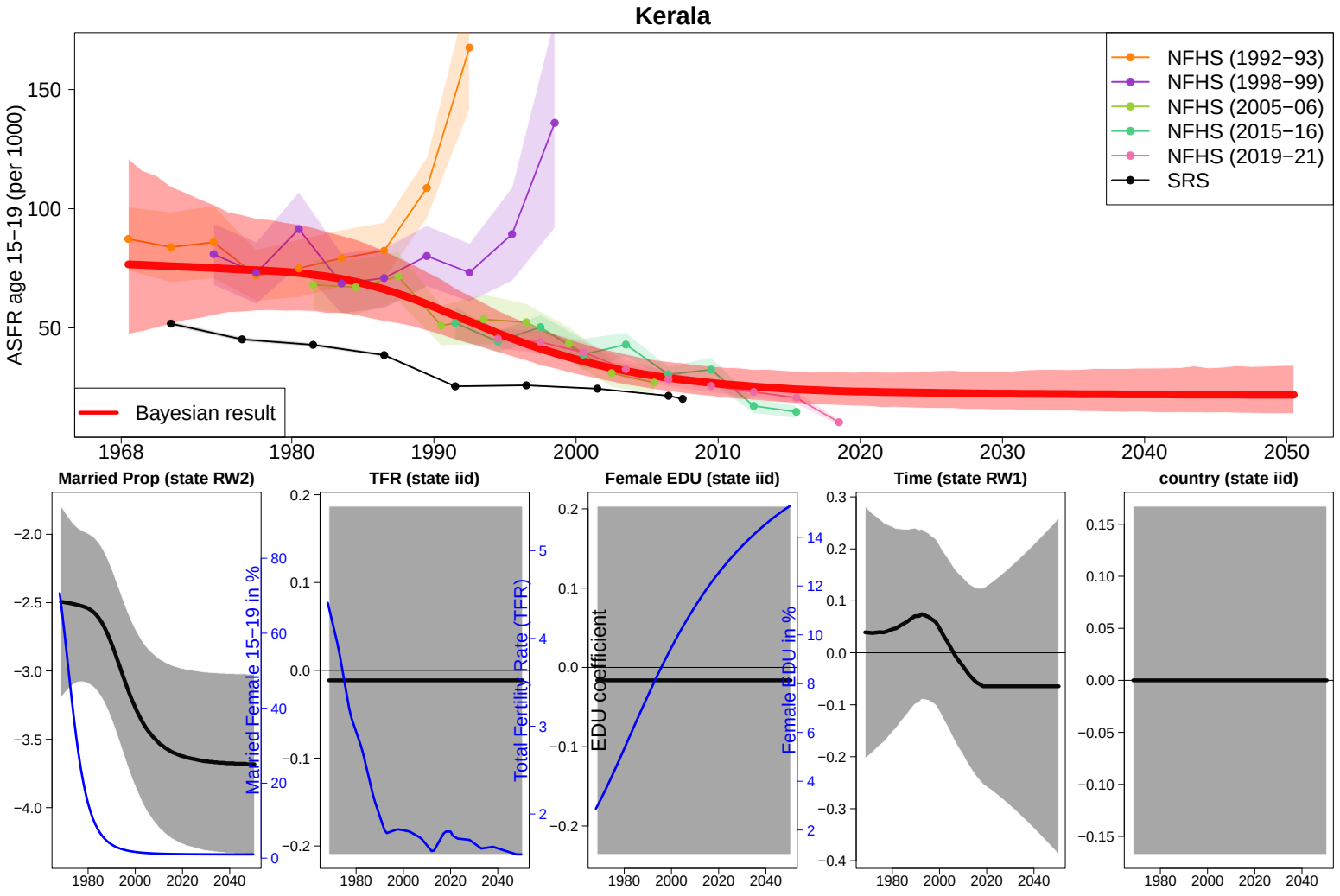

Haryana
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

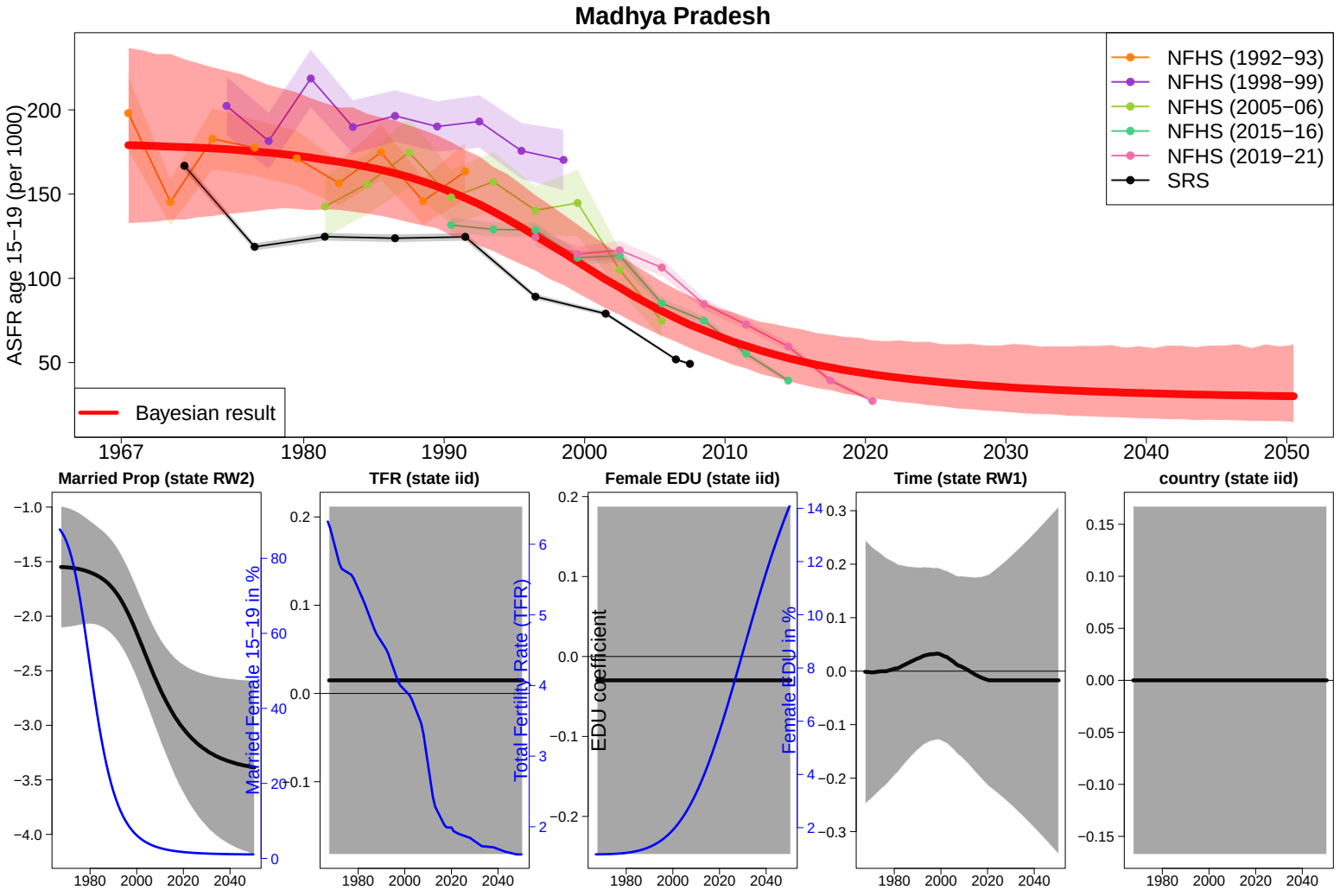

Himachal Pradesh
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)


Jammu and Kashmir
ASFR age 15−19 (per 1000)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %


Jharkhand
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
Bayesian result
ASFR age 15−19 (per 1000)
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)


Karnataka
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)


Kerala
ASFR age 15−19 (per 1000)
150
100
50
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
1968
1980
1990
2000
2010
2020
2030
2040
2050
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)
1980
2000
2020
2040


Madhya Pradesh
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
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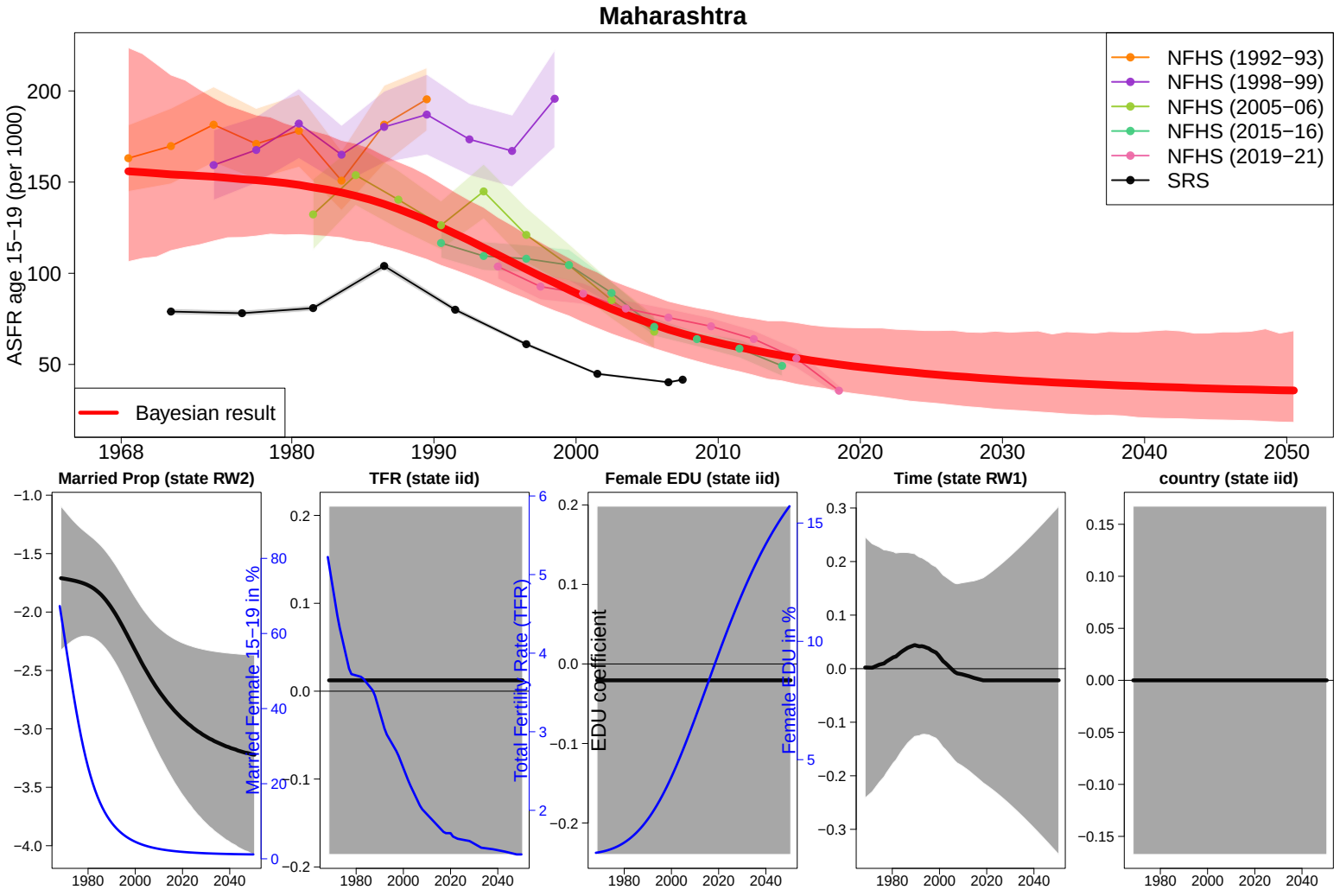
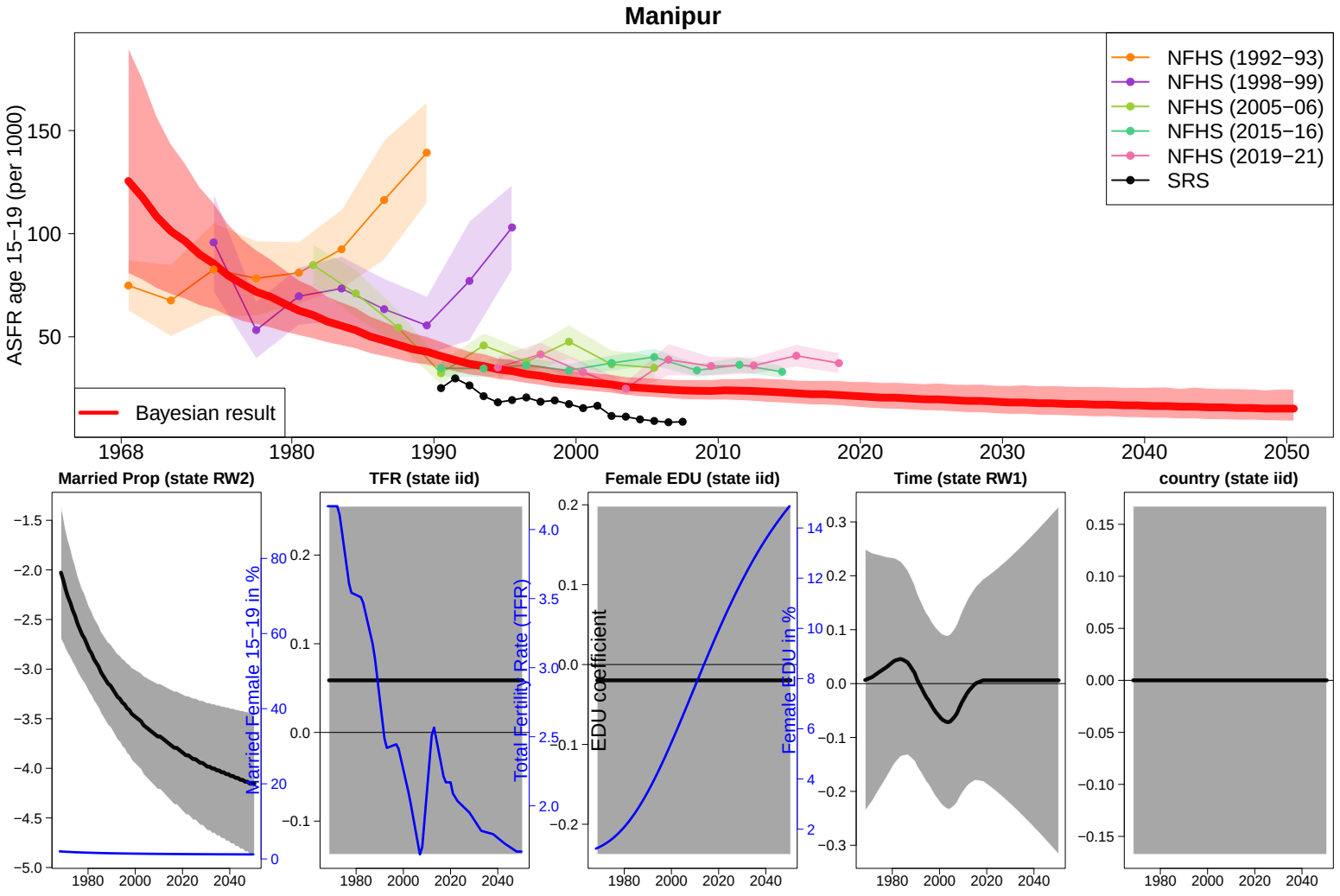
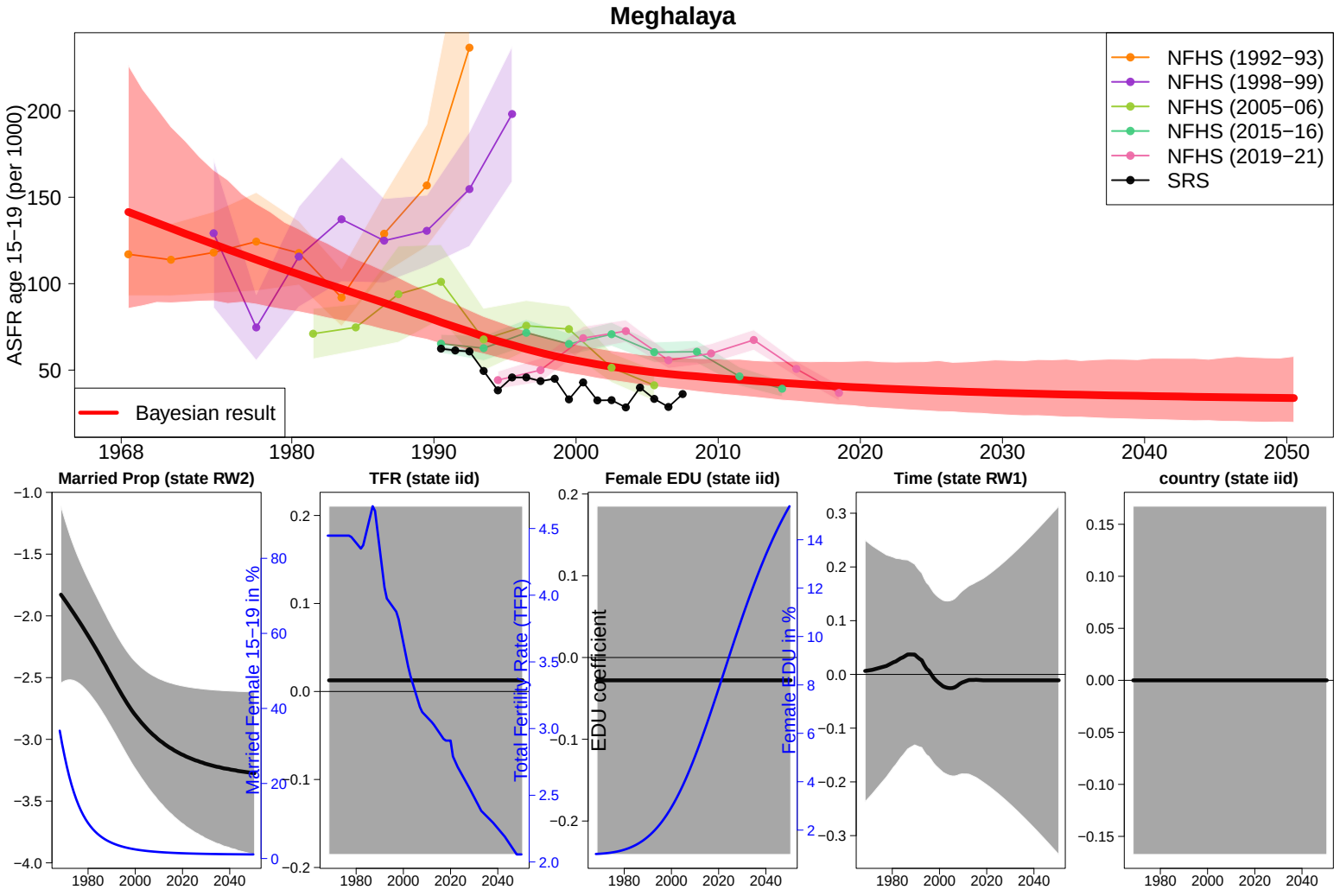
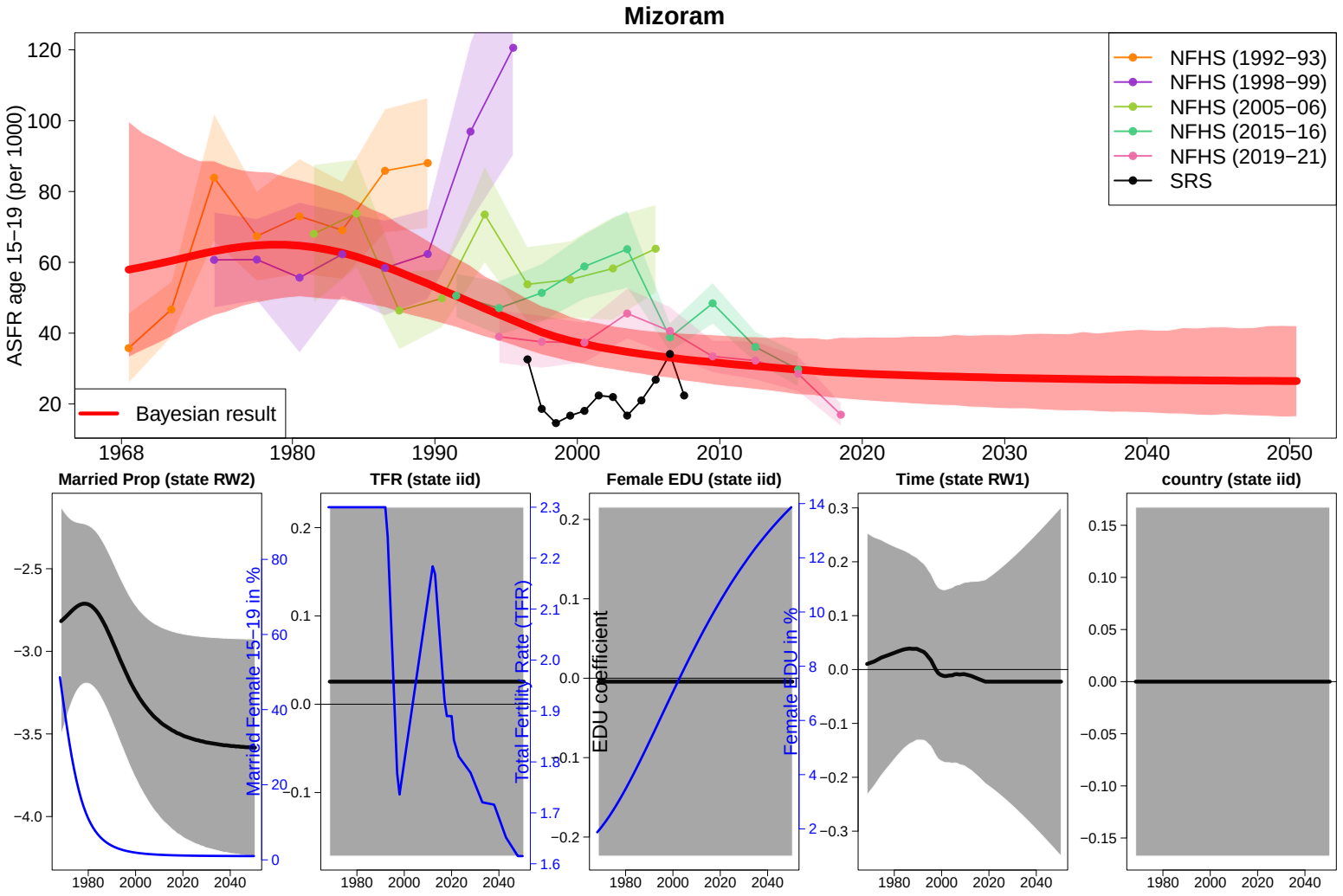
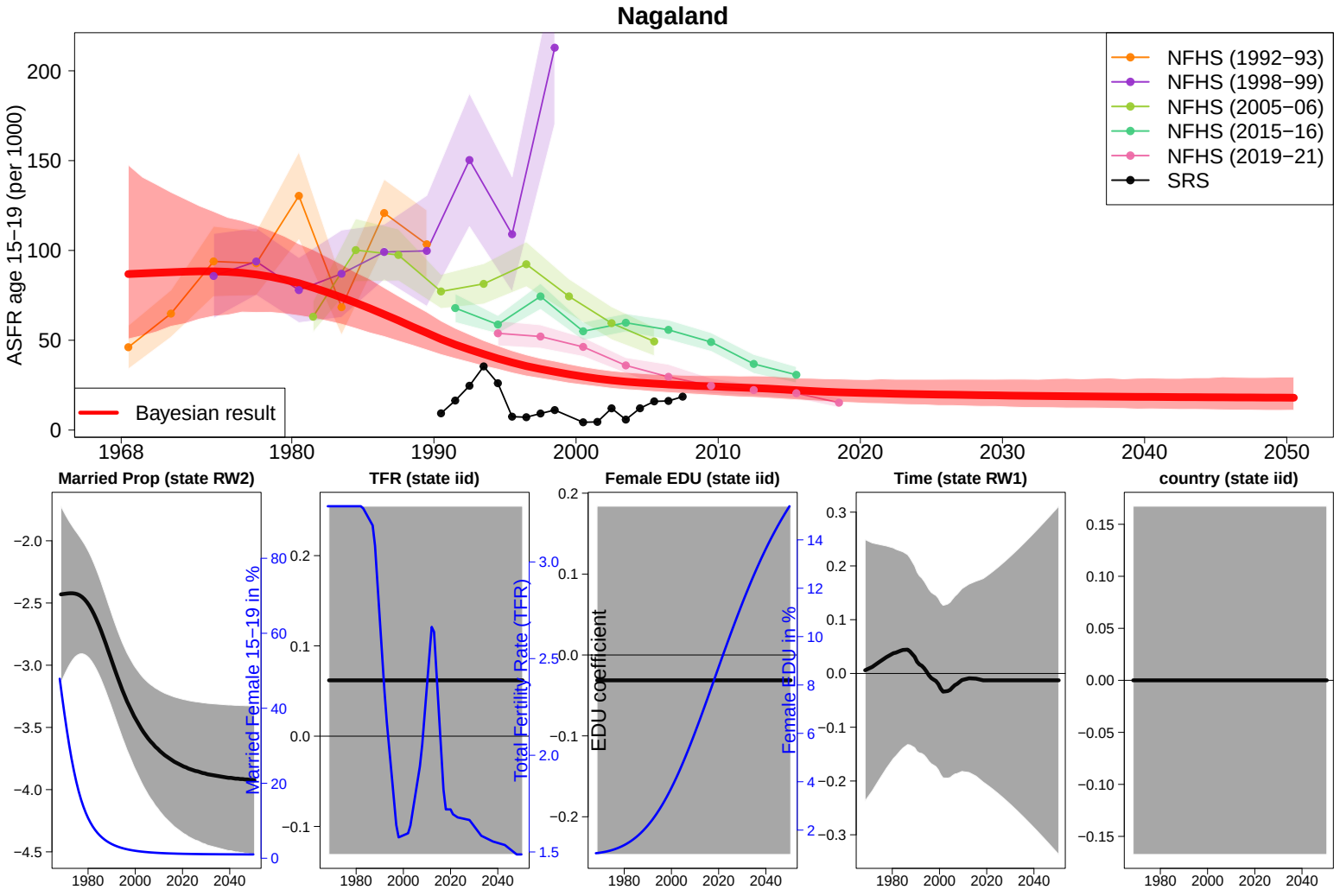
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

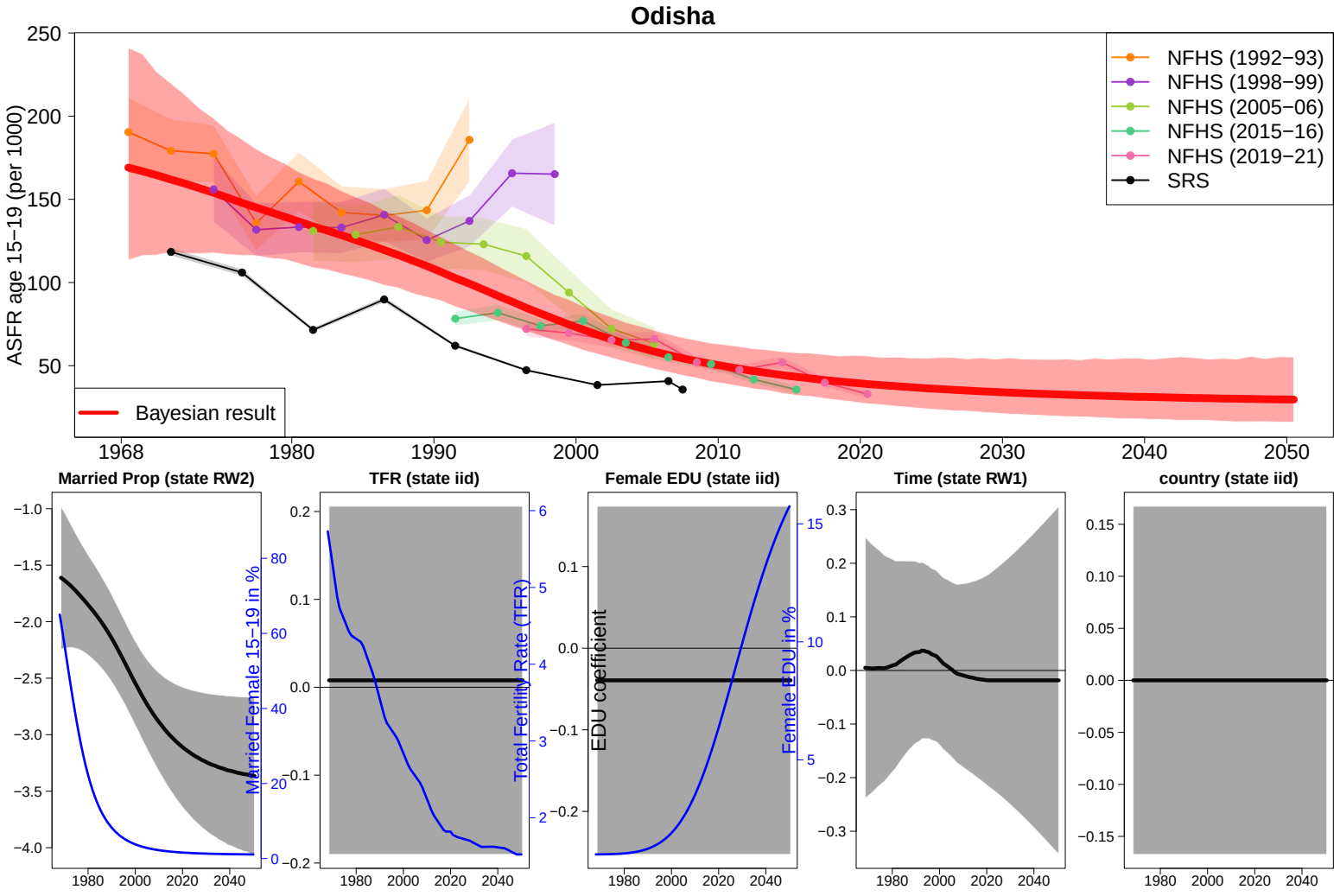

Maharashtra
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %

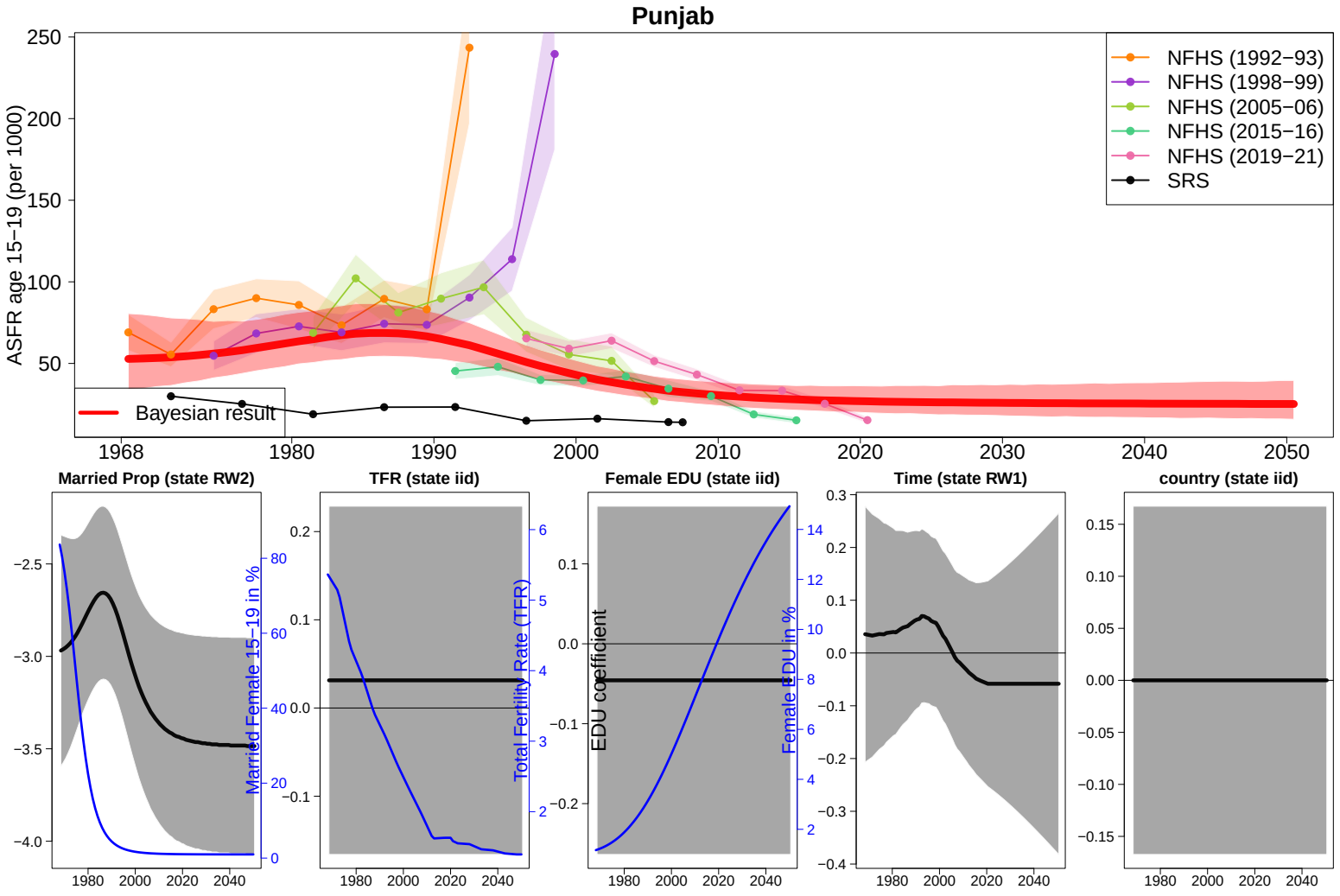

Manipur
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %

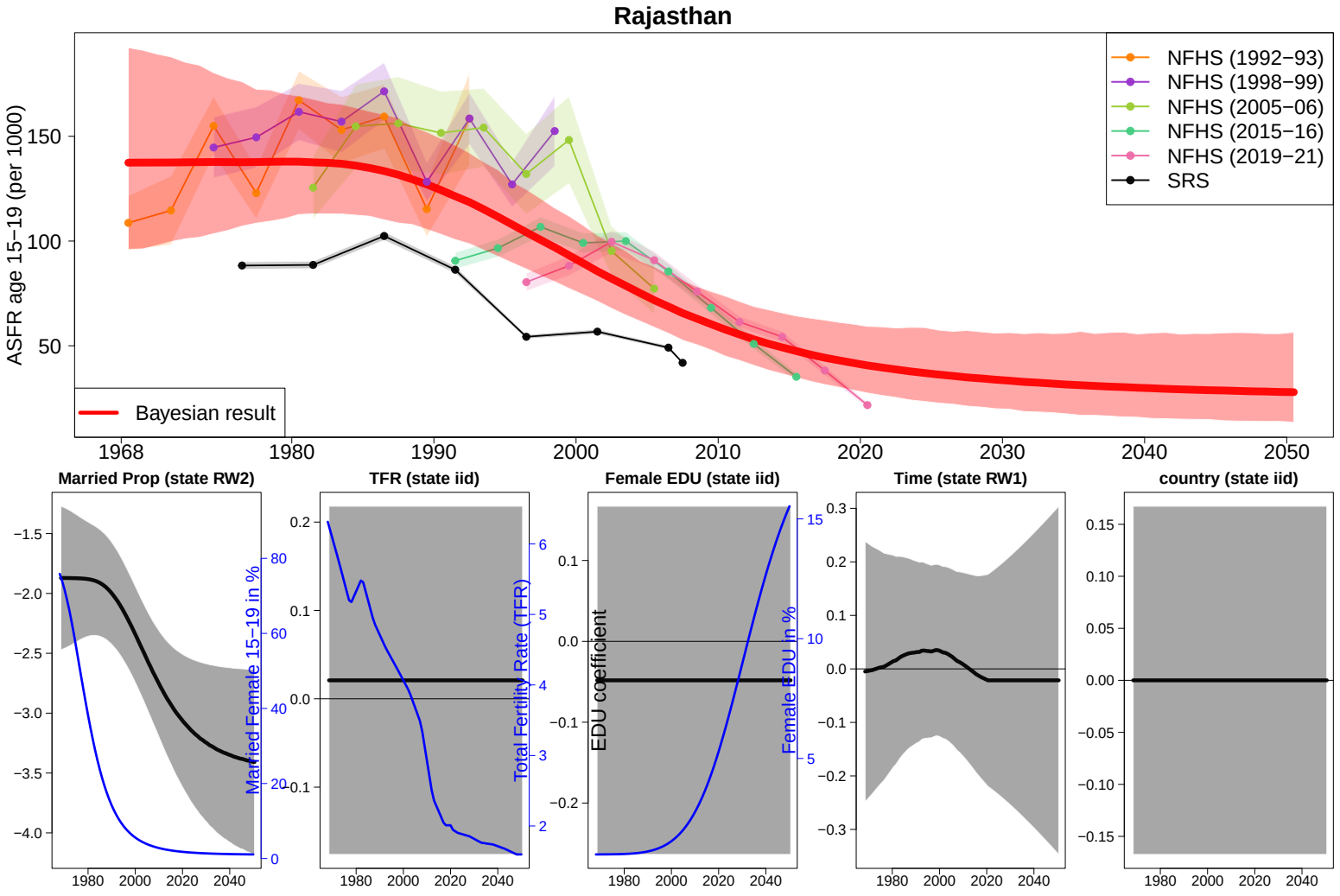

Meghalaya
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %

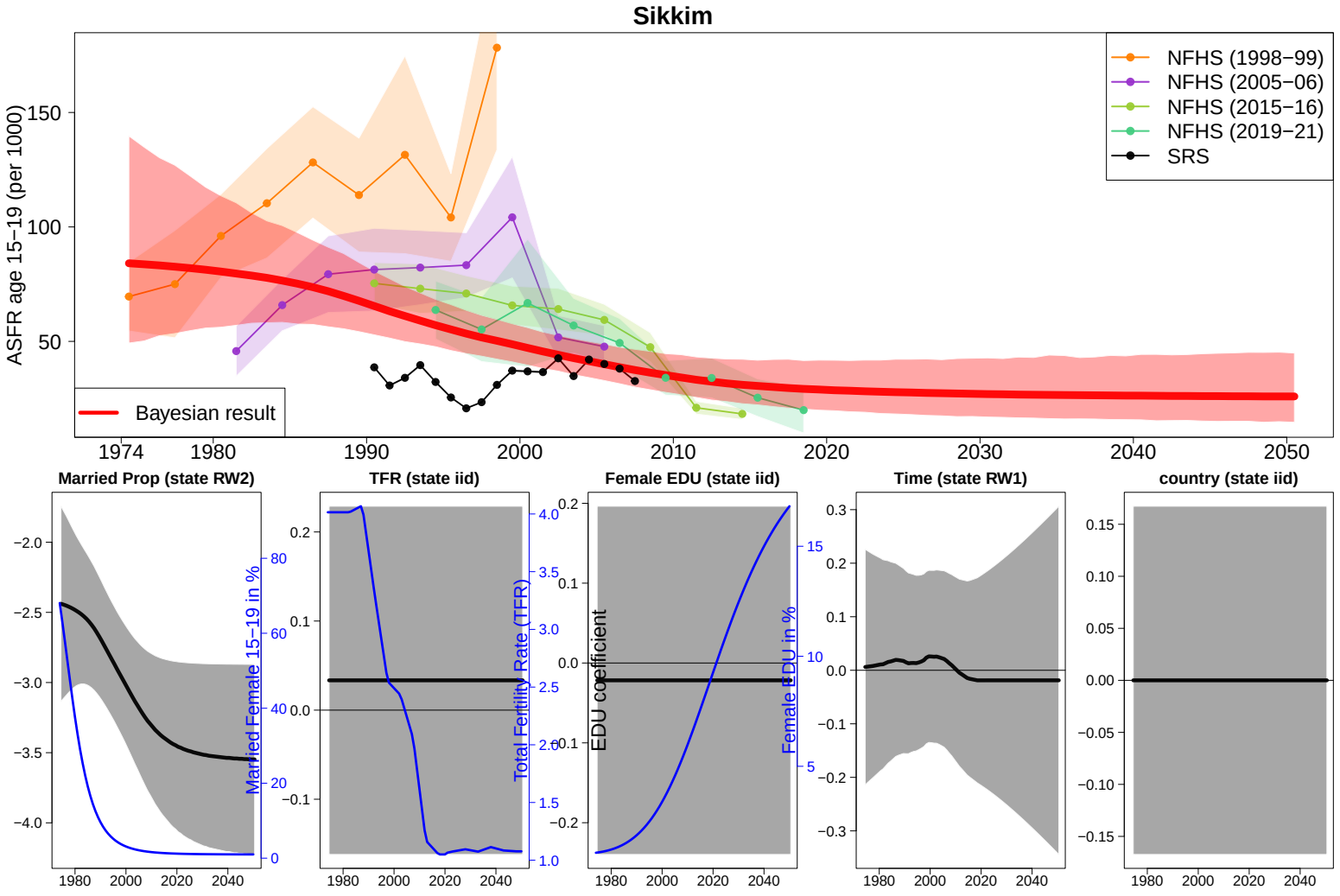

Mizoram
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

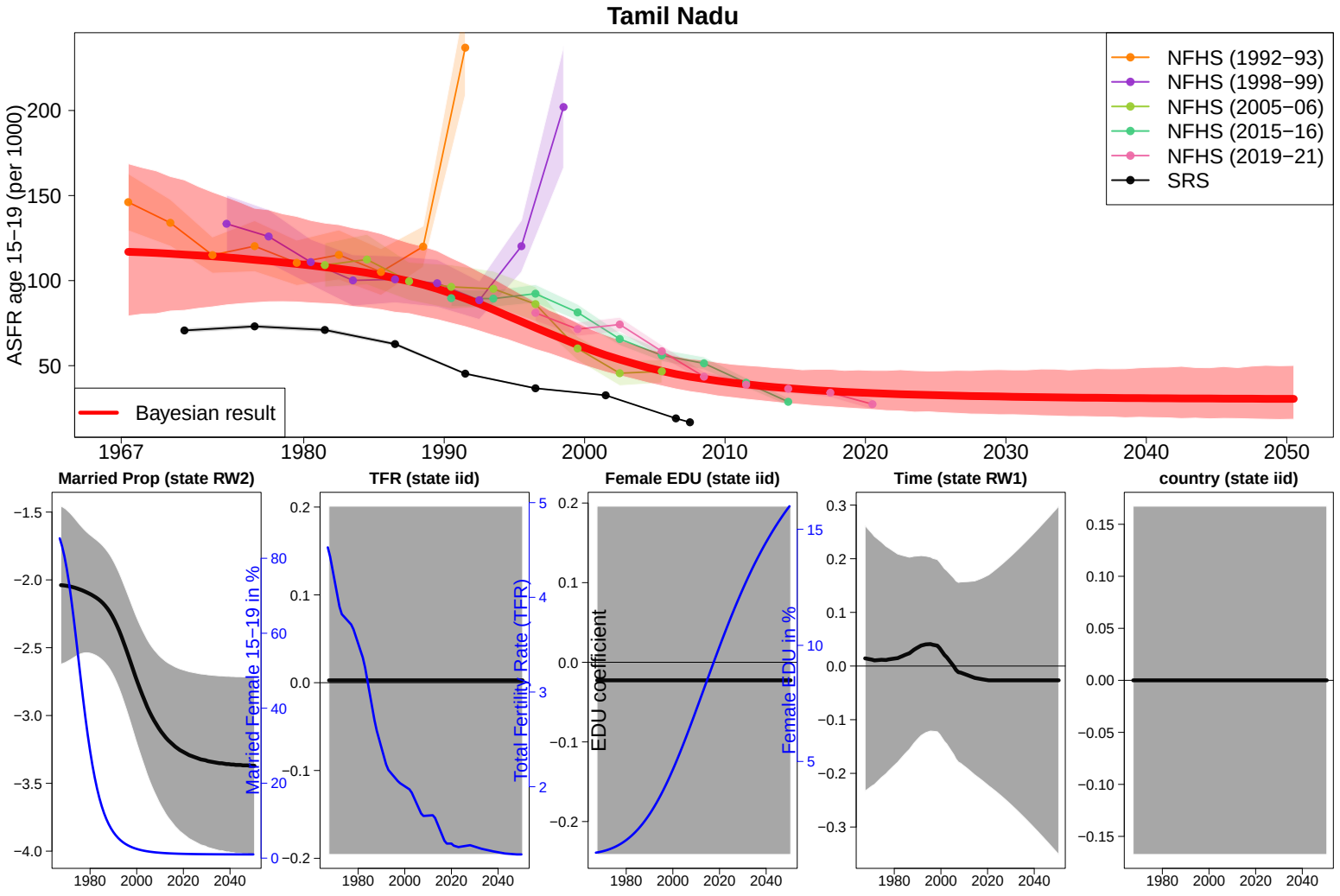

Nagaland
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %

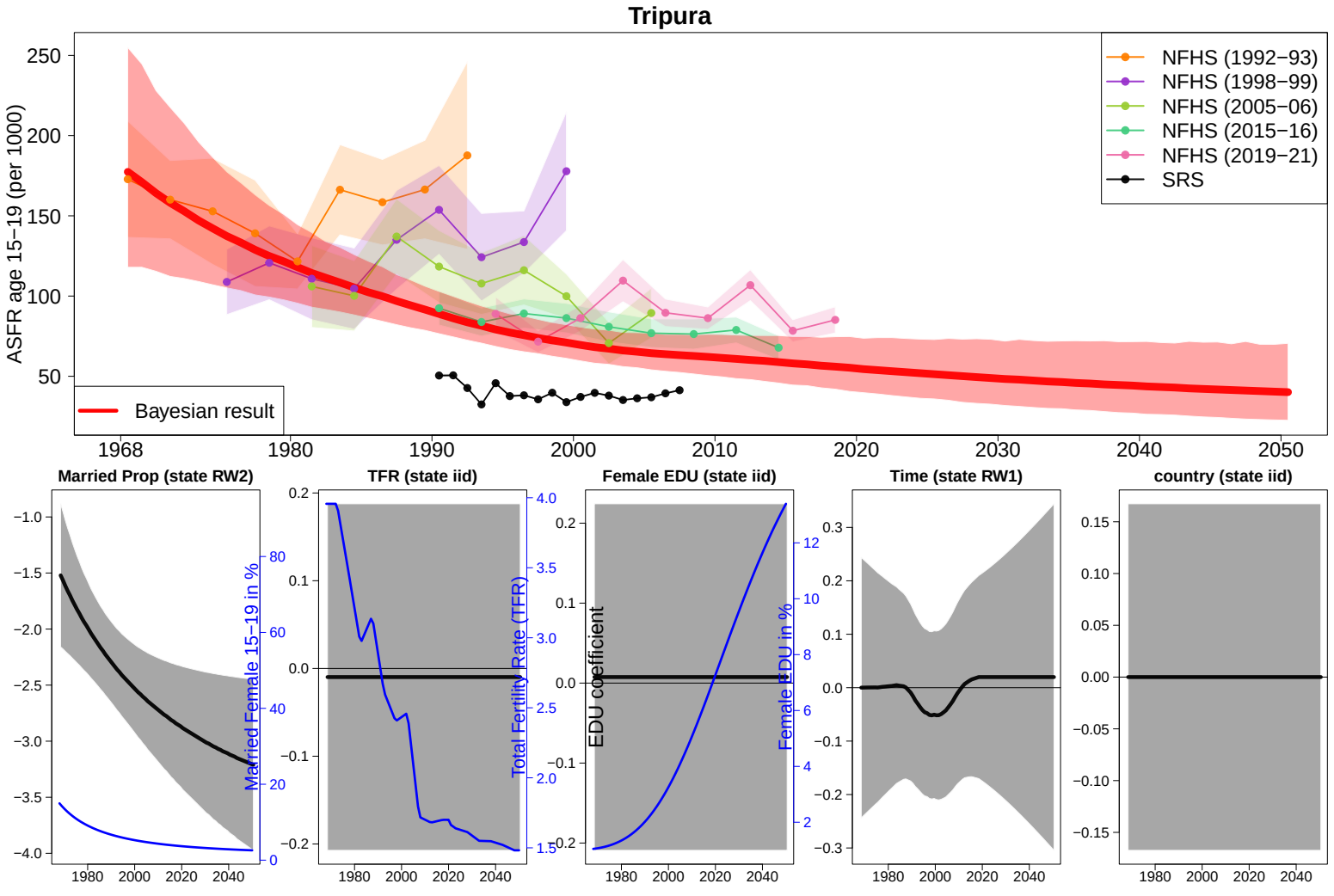

Odisha
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %

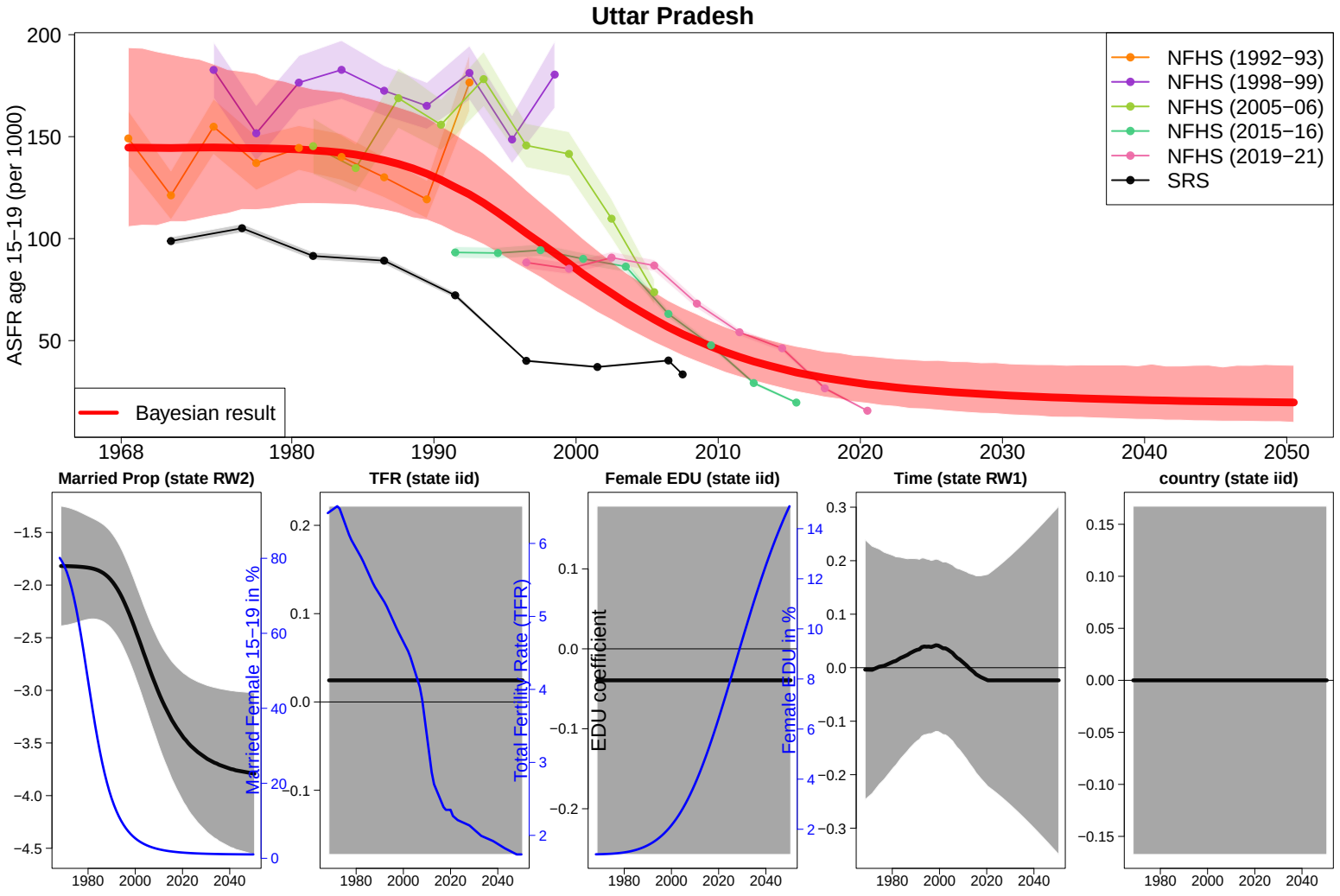

Punjab
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %

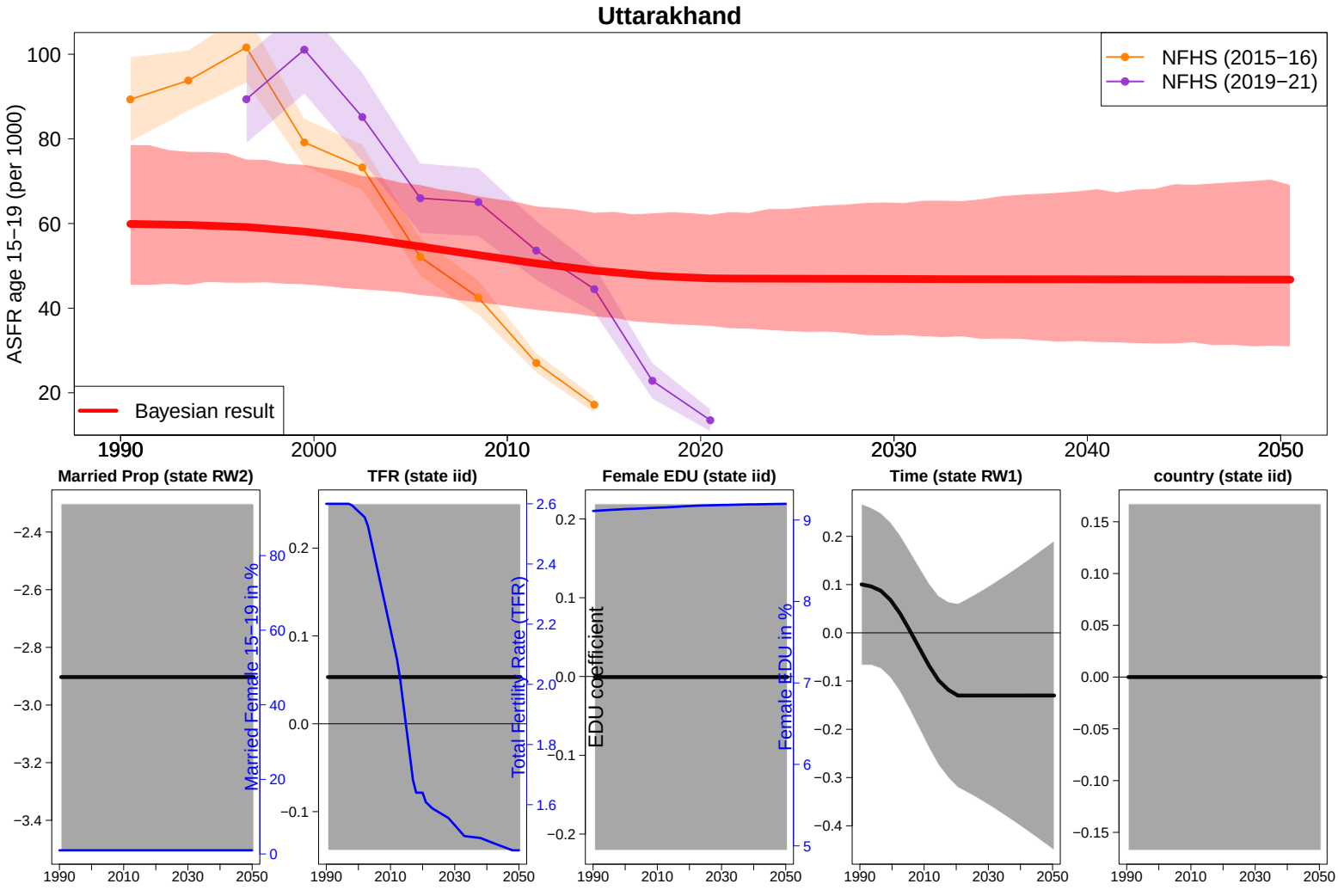

Rajasthan
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)

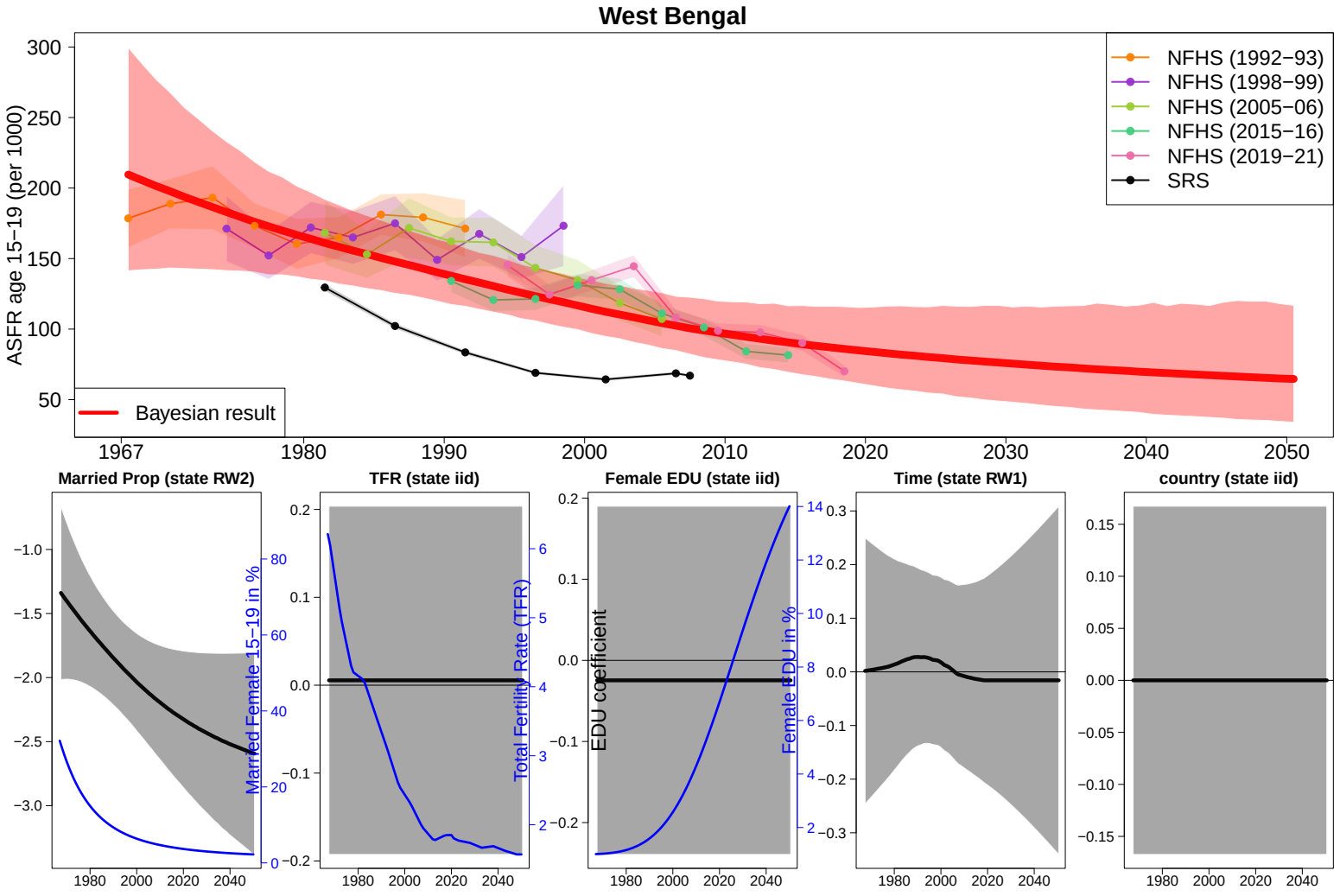

Sikkim
ASFR age 15−19 (per 1000)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)


Tamil Nadu
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)


Tripura
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)


Uttar Pradesh
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)


Uttarakhand
ASFR age 15−19 (per 1000)
NFHS (2015−16)
NFHS (2019−21)
Bayesian result
Married Prop (state RW2)
Married Female 15−19 in %
TFR (state iid)
Total Fertility Rate (TFR)
Female EDU (state iid)
EDU coefficient
Female EDU in %
Time (state RW1)
country (state iid)


West Bengal
ASFR age 15−19 (per 1000)
NFHS (1992−93)
NFHS (1998−99)
NFHS (2005−06)
NFHS (2015−16)
NFHS (2019−21)
SRS
Bayesian result
Married Prop (state RW2)
TFR (state iid)
Female EDU (state iid)
Time (state RW1)
country (state iid)
Married Female 15−19 in %
Total Fertility Rate (TFR)
EDU coefficient
Female EDU in %