Identifying drivers of exemplary family planning performance in low- and middle-income countries between 2000 and 2017

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Abstract

Identifying drivers of exemplary family planning performance in low- and middle-income countries between 2000 and 2017

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Between 2000 and 2017, average modern contraceptive prevalence increased by 7.8 percentage points and demand satisfied with modern methods increased by 12.8 percentage points among 108 low- and middle-income countries (LMICs). What drove these increases as well as which drivers best explain varying family planning performance during this time period remains unclear. We developed a comprehensive framework of potential drivers to investigate, including enabling environment factors and family planning interventions and their outcomes. We used standardized linear regression and Shapley decomposition to evaluate the effect and relative importance of 17 indicators quantifying the drivers. The most important drivers of differential performance across LMICs were: knowledge of methods, desire for limiting, conflict, decision-making to use contraception, education, and income. Based on these findings, we recommend policymakers and programmers invest in expanding method availability and awareness, ensure continuity of family planning services during times of conflict, and continue to prioritize the education and economic well-being of women in order to close gaps in family planning across LMICs.

Introduction

Family planning has continued to gain momentum and attention on the global agenda since the 1950's. Its influence on societal outcomes – population growth, social and economic development, and women's empowerment and health – has provoked the support of organizations and policymakers with a variety of motives. Contraceptive use enables women to limit and space births, making it easier for women to pursue educational and employment opportunities and invest more time and resources into their children, leading to long-term reductions in gender inequities, healthier and better educated children, and ultimately stronger economies.[1–4] Additionally, through the prevention of unintended pregnancies and high-risk births among women younger than age 18, use of contraceptives reduces maternal mortality and neonatal mortality.[5–7] Averted pregnancies and better maternal and child health outcomes make contraceptive use one of the most cost-effective investments to improve health and reduce burden on health systems.[8,9]

International targets call for substantial improvements in family planning performance. These include the Family Planning 2020 (FP2020) goal to increase the number of contraceptive users in 69 countries by 120 million between 2012 and 2020,[10] and the 2030 Sustainable Development Goal (SDG) to ensure universal access to sexual and reproductive health services, including family planning, as measured by the proportion of women aged 15-49 whose need for family planning is satisfied with modern methods.[11] Funding is primarily directed at low- and middle-income countries (LMICs) which received an estimated $1.1 billion in development assistance for family planning in 2018, in addition to domestic government expenditure that totaled $1.7 billion among LMICs in 2017.[12] In order to most efficiently meet targets and effectively invest funds, it is imperative to understand what drives increases in contraceptive use.

Debate around the most important factors that influence a woman's decision to use contraception have gone on for decades and can be distilled to a fundamental question of supply versus demand. Proponents of the supply-side approach to contraceptive use argue that women will adopt contraception when it is easily accessible and affordable.[13–15] Meanwhile, demand-side factors work to change women's desired fertility by reducing the number of children wanted and consequently increasing their need for and eventual use of contraceptives regardless of access.[16] Attempts to disentangle the contribution of supply and demand interventions on fertility and contraceptive use, plus the role that socioeconomic conditions versus program efforts play, have produced mixed results.[17,18] Mwaikambo et al. (2011) conducted a systematic review of 63 studies that attributed program exposure to changes in family planning outcomes and found both supply-side and demand-side interventions produced significant impacts.[19] Jain and Ross (2012) looked at Demographic and Health Survey (DHS) data from 40 developing countries and reached a similar conclusion – policies targeting socioeconomic conditions and family planning services have mutually reinforcing effects.[20]

In this study, we build upon the existing evidence base by looking at factors associated with differences in family planning use across 108 LMICs between 2000 and 2017. We built a comprehensive framework around what drives family planning outcomes, accounting for socioeconomic factors as well as supply-side and demand-side interventions. While past studies have relied only on point estimates directly from surveys, we modelled full time series of estimates of 11 DHS family planning indicators from 1990 to 2019 by five-year age group using spatiotemporal Gaussian process regression (ST-GPR). We used simple linear regression to calculate the effect 17 driver indicators had on family planning performance and applied Shapley decomposition to evaluate the relative importance of each indicator. To our knowledge this is the first study to investigate drivers of family planning performance in a full time series format.

Methods

Conceptual Framework

We developed a comprehensive framework of drivers of family planning outcomes (Figure 1) by reviewing the literature around what influences a woman's decision to use family planning and demand-side and supply-side factors that drive changes in contraceptive use. In order to qualify as a driver, factors needed to be on the pathway to contraceptive use. We obtained input and feedback on the framework from experts and program officers in the family planning field. This framework was developed prior to identifying available data to avoid limiting what we thought of a driver to only what is currently captured with estimates. While we hoped to include all aspects of this framework in our statistical analysis, gaps remained due to availability of indicators and statistical validity concerns.

As shown in Figure 1, enabling environment encapsulates broader drivers that affect the abilities and success of family planning interventions and indirectly affects a women's decision to use contraception. We split enabling environment into two sub-categories – boarder contextual factors and governance plus financing – to differentiate drivers that are directly in the sphere of influence of policymakers and donors versus those that represent secular trends. Following the literature, family planning interventions are divided into demand-side and supply-side activities, according to whether these activities increase desire to use contraception or improve access, respectively. We separated family planning interventions from their corresponding outputs to disentangle single interventions from their broader impacts. Desired fertility is separated from demand for family planning and service delivery outputs as we considered it to be an output of the enabling environment more than family planning interventions. Lastly, outcomes are the family planning indicators we planned to use to evaluate family planning performance.

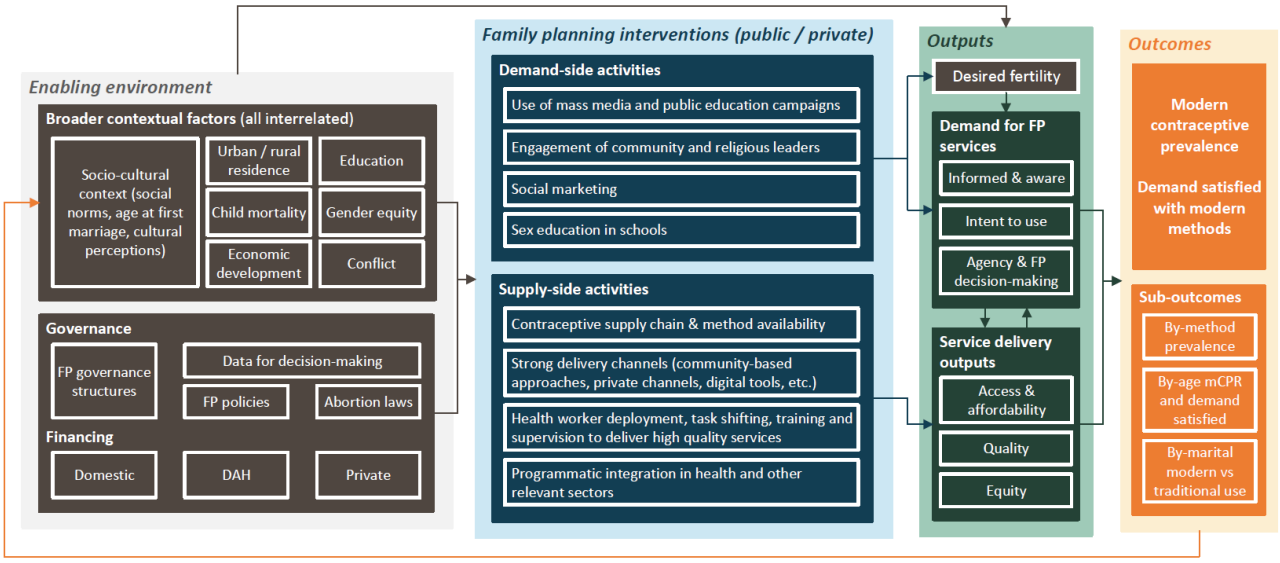

Figure 1: Conceptual framework of drivers of family planning outcomes.
Notes: The arrows reflect the main directions in which we expect drivers to influence one another, but we recognize many of these drivers are interrelated.

Family Planning Outcomes

Our primary indicators of family planning performance in this analysis were modern contraceptive prevalence (mCPR) and demand satisfied with modern methods (demand satisfied). Together these indicators capture how many women are using contraception in the general population and specifically among women who may have the most need for family planning. In addition to mCPR and demand satisfied, we explored if drivers varied across 5-year age groups, for individual methods, and between married/in-union/partnered and unmarried/unpartnered women. We used estimates available from the Institute for Health Metrics and Evaluation (IHME).

Modern contraceptive prevalence is the proportion of all women aged 15-49 who are currently using, or whose partner is current using, a modern method of contraception. Modern methods include female or male sterilization, IUDs, injections, implants, oral contraceptive pills, male or female condoms, diaphragms, spermicides and sponges, contraceptive patches and rings, plus emergency contraceptives. All other methods used to prevent pregnancy, including the lactational amenorrhea method, are classified as traditional. Abortion and complete abstinence (different from periodic abstinence) are not considered family planning methods.

Demand satisfied is the proportion of all women aged 15-49 deemed to have a need for family planning who are currently using, or whose partner is currently using, at least one modern method of contraception. Need for family planning is calculated through a complex algorithm[21] that aims to evaluate if women are at risk of pregnancy and their fertility intentions. A woman is considered to have need if (1) she is currently using contraception (modern or traditional), (2) she is married/in-union or sexually active, fecund, and does not want a child in the next 2 years, or (3) she is pregnant or post-partum amenorrheic from a birth in the last 2 years and wishes to have delayed or prevented her current or most recent pregnancy. It is important to note that demand satisfied does not capture a woman's own perceived need for family planning or her preferences for contraception use. Despite numerous critiques and proposed revisions of demand satisfied, and its counterpart unmet need, [22–29] it remains one of the most used family planning indicators.

Selection of Driver Indicators

After development of the conceptual framework to guide this analysis, we considered a list of 64 existing indicators that could quantitatively measure each driver. We considered indicators available from IHME, the Family Planning Effort Index (FPE)/National Composite Index on Family Planning (NCIFP), and Demographic and Health Surveys (DHS). We proceeded with the analysis in three phases – Phase 1 focused on enabling environment indicators available from IHME, Phase 2 involved processing the FPE indicators, and Phase 3 included extracting data and modelling estimates of relevant family planning indicators as defined and measured by the DHS. The final set of driver indicators that made it into the analysis and their definitions are presented in Table 1.

Indicator	Definition	Domain	Sub-domain	Units
Married women 15-24	Proportion of women aged 15-24 who are married, in-union, or otherwise co-habiting with a partner	Enabling environment	Socio-cultural context	Percent (%)
Mean reproductive age	Mean age of women aged 15-49 in a population	Enabling environment	Socio-cultural context	Years
Urbanicity	Proportion of population living in urban areas	Enabling environment	Urban/rural residence	Percent (%)
LDI pc	Lag-distributed income per capita; smoothed gross domestic product (GDP) per capita over the preceding 10 years	Enabling environment	Economic development	International $
Education years pc	Mean years of education per capita among women aged 15-49	Enabling environment	Education	Years
Conflict	Mean mortality rate in the previous ten years due to war and terrorism	Enabling environment	Conflict	Mortality rate (per 1 person)
Abortion legality	Legality of abortion (0 = not legal in any situation; 100 = legal on request and no restrictions)	Enabling environment	Governance: abortion laws	0-100 index
Public FP spending pc	Combined government and development assistance for health spending per capita	Enabling environment	Financing: domestic/DAH	2018 USD
Effort PCA Index	PCA-weighted index of selected Family Planning Effort Index indicators	Enabling environment, FP interventions	FP governance structures & policies, demand & supply-side activities	0-100 index
Fieldworker visits to all women	Proportion of women aged 15-49 who were visited by a fieldworker in the last 12 months who discussed family planning	Family planning interventions	Demand-side activities	Percent (%)
Not exposed via TV/Radio/Paper	Proportion of women aged 15-49 who have not been exposed to family planning messages on the radio, on television, or in a newspaper/magazine ("paper") in the last few months	Family planning interventions	Demand-side activities	Percent (%)
Desire for limiting	Proportion of women aged 15-49 who do not desire any additional children	Outputs	Desired fertility	Percent (%)
Desire for spacing	Proportion of women aged 15-49 who want (more) children, but want to wait at least 2+ years or are unsure of timing, or are unsure if they desire (additional) children	Outputs	Desired fertility	Percent (%)
Knowledge of methods	Mean number of methods known (modern or traditional) by women aged 15-49	Outputs	Demand for FP services	Number of methods
Respondent/joint decision to use	Proportion of partnered women aged 15-49 currently using a contraceptive method that say using contraception is mainly their decision or decided together with their partner/husband	Outputs	Demand for FP services	Percent (%)
Method information index	Proportion of women aged 15-49 currently using a contraceptive method who were informed of side effects, what to do in the case of side effects and told about other methods	Outputs	Demand for FP services	Percent (%)
Public source of FP	Proportion of women aged 15-49 currently using a modern method that reported mostly recently obtaining the method from a public sector source	Outputs	Service delivery outputs	Percent (%)

Table 1. Inventory of driver indicators and definitions

Phase 1 IHME Enabling Environment Indicators

In Phase 1 we decided upon 8 enabling environment indicators to include in the analysis – urbanicity, proportion of women aged 15-24 married or in-union, mean reproductive age, lagged-distributed income (LDI) per capita, public family planning spending per capita (pc), conflict, mean education years per capita (pc) among women aged 15-49, and abortion legality. The proportion of women aged 15-24 who are married/in-union was selected as a proxy for age at first marriage which we did not have readily available. Economic development is reflected by LDI per capita; we chose to use LDI rather than yearly GDP because we expect economic trends to have a cumulative effect on contraceptive use. We had access to private out-of-pocket spending estimates, but excluded it as an indicator because it is modelled using mCPR. Other indicators that were considered, but ultimately excluded due to circularity or collinearity concerns included child and neonatal mortality, labor force participation, proportion vulnerable employment, and total fertility rate under age 25.

Phase 2 Family Planning Effort Index

In Phase 2 we downloaded all of the existing Family Planning Effort Index (FPE) and National Composite Index on Family Planning (NCIFP) results (available at http://www.track20.org/pages/data_analysis/data.php). Questionnaires were administered to 10-15 key informants every 3-5 years in countries who score the performance of their national family planning programs in areas such as policies, services, evaluation, and method access.[30] One of the noted limitations of the FPE/NCIFP is that informants can be biased by their existing knowledge of key outcomes.[31] An additional concern we had when using this dataset across countries was that informants' perceptions of rankings may not be the same scale across individuals, countries, and time. To ensure data quality, we checked the correlation of each FPE/NCIFP indicator against other relevant indicators which we would expect to have some level of meaningful correlation. Examples of relevant indicators were development assistance for family planning, the World Bank government effectiveness index, mCPR, and the Socio-demographic Index. We dropped indicators that did not have at least a correlation coefficient with an absolute value of at least 0.3 with one of the validating indicators, which reduced our dataset from 56 to 19 indicators.

To avoid introducing multicollinearity into our models, we checked the correlation structure of the 19 indicators for the year 2014 as this was the only year with all 19 indicators available. A large amount of the indicators had correlation coefficients greater than 0.4, thus we decided to use principal component analysis (PCA) to reduce the dimensions of the data. We used PCA-derived weights to combine indicators into single indices on a scale of 0-100. We first tested running separate PCAs on the indicators grouped by sub-domain (FP governance structures, FP policies, data for decision-making, supple-side activities, and demand-side activities), but these still had large correlation coefficients (0.36 to 0.72). We settled upon creating a single effort PCA index comprised of all 19 indicators. To maintain the longitudinal nature of our study we also decided to run sub-analyses for two additional time periods – 2004 to 2014 and 2014 to 2017 – as these time periods had 8 and 11 indicators overlapping, respectively. We created separate effort PCA indices for these time periods only including countries that appeared in both the start and end years of each period. The composition and weight of indicators for each effort PCA index can be found in the supplementary appendix.

Phase 3 Additional Family Planning Indicators

For Phase 3 we modelled full time series of estimates from 1990 to 2019 for 11 family planning indicators – knowledge of methods, respondent/joint decision to use FP, exposure to FP messages via mass media, method information index, FP fieldworker visits, public source of contraception, desire for

limiting, desire for spacing, method-related discontinuation, future intent to use contraception among non-users, and ideal number of children. We used microdata and tabulated reports from 985 nationally or subnationally representative surveys that contained data on any subset of the indicators and matched the definitions used by DHS (available at https://dhsprogram.com/Data/Guide-to-DHS-Statistics/index.cfm). The majority of input data for the 11 indicators came from DHS, but we also relied on other major series such as the Multiple Indicator Cluster Surveys (MICS), Performance Monitoring for Action surveys (PMA), Generations and Gender Programme surveys (GGP), Reproductive Health Surveys (RHS), and Pan Arab Project for Child Development/Family Health surveys (PAPCHILD/PAPFAM), plus other country-specific family planning surveys.

We used spatiotemporal Gaussian process regression (ST-GPR) to construct full time series of estimates based on the input data extracted for each indicator. ST-GPR is a three-stage flexible estimation tool commonly used in the Global Burden of Disease (GBD) study that borrows information across locations, time, and age groups to produce estimates with uncertainty.[32] In the first stage of ST-GPR, initial estimates for each location-year-age group are predicted from a linear mixed effects regression. All stage one formulas for these indicators included fixed effects on the Socio-demographic Index (SDI) – a measure of social and economic development – and age group, plus random effects on geography (location, GBD region, and GBD super-region). In the second stage, a locally weighted polynomial regression (LOESS) function smooths the residuals between the linear predictions and input data over space, time, and age. This step ensures our estimates follow the data and, when there is no data in particular locations, age groups, or years, estimates are informed by points in nearby geographies. Lastly, the second stage trends are used as the mean model in a Gaussian process regression which accounts for input data variance and model uncertainty. From the third stage, we obtained 1000 draws for every location-year-age group and took the mean across draws as our point estimates and calculated the 2.5th and 97.5th percentiles to produce 95% uncertainty intervals.

After modelling and vetting of the 11 additional indicators, we checked the indicators for collinearity. Desire for limiting and ideal number of children were highly correlated (r=-0.707); we would expect a smaller ideal number of children to correspond to a higher proportion of women wanting to limit childbearing. We chose to drop ideal number of children from the analysis because desire for limiting is a more commonly used indicator in family planning and the two indicators capture the same concept. Next we decided to drop method-related discontinuation as this indicator encompasses all episodes of contraceptive use in the preceding 5 years making it particularly difficult to interpret and translate into action. The last indicator we dropped was future intent to use a method among current non-users of contraception. Intent to use is a marker of future use and the outcomes of interest for this analysis focused on current use. Plus, non-users are asked about use at any point in the future, so there was not a set time lag we could have applied to the indicator.

Statistical Analysis

The main time period for our analysis was 2000 to 2017; we initially planned to run the analysis through 2019, but family planning spending estimates were only available through 2017. In order to include the effort PCA indices constructed in Phase 2, we also ran a cross-sectional analysis on 2014 and two longitudinal analyses for 2004-2014 and 2014-2017. In total, 108 LMICs were represented in this analysis; all 108 in the 2000-2017 time period, 68 in the 2014 cross-sectional analysis, 62 in the 2004-

2014 longitudinal analysis, and 58 in the 2014-2017 longitudinal analysis. China was not included in this analysis as family planning spending estimates were not available.

We ran a series of 19 linear regressions adding the groups of indicators from each phase of the analysis to assess the effects and relative importance of each indicator on mCPR and demand satisfied. We dropped conflict and abortion legality from both of the longitudinal analyses as the majority of countries in these time periods experienced no change in these indicators. We also dropped exposure to mass media messages and fieldworker visits from the 2004-2014 analysis because these indicators were captured by FPE/NCIFP variables in the effort PCA index. Fixed effects on locations were tested in the models to explore isolated changes within countries. There was too few data to include fixed effects in any of the longitudinal models, so we ran regressions on the change in indicators to look at within country trends.

We used the R package *relaimpo* to perform a Shapley decomposition of the relative contribution of each indicator to the R-squared of each model.[33] Shapely decomposition is a technique that attributes a proportion of the model-explained variability in the data to each predictor.[34] Essentially it tells us how well predictors can explain the differences we see in the data, or for the sake of our analysis, which indicators best explain varying levels of family planning performance. We performed 100 bootstraps of the Shapley decomposition and took the 2.5% and 97.5% percentiles to construct 95% uncertainty intervals.

Additionally, we reran the regressions with standardized independent and dependent variables to make the regression coefficients comparable across the different indicator units. The regression coefficients were used to check if there was a positive or negative correlation between each predictor and outcome and the magnitude of that relationship. All analyses were ran in R version 4.1.3.

Results

Descriptive Statistics

Between 2000 and 2017, average mCPR across 108 LMICs increased from 20.6% to 28.3% while demand satisfied increased from 42.9% to 55.7% (Table 2). This time period is characterized by shifts in the enabling environment such as increases in the proportion of the population living in urban areas (+5.07 percentage points [p.p.]), fewer women getting married at a young age (-4.18 p.p.), an increase in the average years of education among women aged 15-49 (+1.94 p.p.), growth in income per capita (+2740 USD), and further legalization of abortion (+3.02 p.p.). In terms of family planning interventions, we estimated less exposure to family planning messages via mass media (+3.48 p.p. of those who have not been exposed), a slight increase in family planning fieldworker visits (+1.92 p.p.), and improvements in the efforts of national family planning programs during both of the 2004-2014 and 2014-2017 time periods. The mean number of methods known by women increased from 5.48 to 7.82, plus more women were told about side effects and other methods when they began using their current method (+4.57 p.p. in the method information index). Fertility preferences also changed with more women wanting to space their next birth (+7.57 p.p.) or limit childbearing completely (+2.47 p.p.).

	Full Time Period 2000-2017			Cross-sectional 2014	Longitudinal 2004-2014			Longitudinal 2014-2017		
	2000	2017	Change	2014	2004	2014	Change	2014	2017	Change
mCPR	20.6 (13.2)	28.3 (14.5)	7.76 (6.23)	28.3 (14.3)	23.9 (13.7)	29.2 (13.9)	5.24 (4.63)	26.7 (13.2)	28.2 (13)	1.57 (1.18)
Demand Satisfied	42.9 (21.6)	55.7 (19.9)	12.8 (9.72)	56.1 (20.3)	49 (21.7)	57.4 (19.4)	8.37 (7.06)	54.2 (19.2)	56.8 (18.5)	2.54 (1.99)
Urbanicity	26.4 (14.5)	31.5 (15.3)	5.07 (3.53)	33.4 (14.1)	31 (13.1)	34.1 (13.1)	3.17 (2.03)	31.6 (14.4)	32.8 (14.5)	1.16 (0.534)
Married/in-union women 15-24	35.7 (12.6)	31.6 (11)	-4.18 (3.95)	33.8 (10.7)	35.7 (11.6)	33.4 (10.2)	-2.26 (3.07)	35.2 (10.5)	34.2 (10.4)	-0.996 (0.692)
Mean reproductive age	28.8 (1.19)	29.6 (1.42)	0.775 (0.669)	29.3 (1.31)	28.9 (1.19)	29.3 (1.3)	0.436 (0.368)	29.1 (1.24)	29.3 (1.36)	0.194 (0.173)
LDI per capita (1000's)	3480 (2300)	6230 (5170)	2740 (3510)	5280 (4220)	3590 (2480)	5450 (4180)	1860 (2190)	4440 (3740)	4840 (4120)	396 (504)
Public FP spending pc (2018 USD)	1.65 (2.25)	2.09 (2.9)	0.445 (3.03)	2.39 (2.57)	0.818 (1.2)	2 (1.79)	1.19 (1.43)	2.47 (2.68)	2.07 (1.76)	-0.402 (1.81)
Conflict (mortality rate per 100,000)	15.4 (74.7)	4.34 (20.2)	-11 (77.5)	2.62 (8.6)	6.45 (28)	0.801 (2.22)	-5.65 (26.1)	3.02 (9.34)	2.89 (9.43)	-0.126 (2.98)
Education years per capita	5.55 (3.13)	7.49 (3.06)	1.94 (0.68)	6.91 (3.1)	6.01 (3.15)	7.08 (3.06)	1.07 (0.339)	6.6 (3.1)	6.96 (3.08)	0.359 (0.126)
Abortion legality (0-100)	55 (22.1)	58.1 (23.4)	3.02 (12.2)	54.6 (23.9)	57.1 (23.9)	58.2 (25.3)	1.09 (11.5)	53.5 (24.1)	53.5 (24.1)	0 (0)
Effort PCA index (0-100)	--	--	--	53.5 (14.6)	47.2 (11.6)	52.1 (12.6)	4.91 (12)	54.8 (16.5)	73 (14.6)	18.2 (13.5)
Recent public source	59.4 (20.7)	60.1 (19.4)	0.741 (7.96)	59.8 (18.5)	58.3 (19.9)	59.5 (18.6)	1.2 (7.65)	61.6 (17.7)	62.1 (17.8)	0.525 (1.67)
Knowledge of methods	5.48 (1.97)	7.82 (2.33)	2.34 (1)	7.39 (2.14)	6.15 (1.87)	7.55 (1.91)	1.4 (0.795)	7.19 (2.09)	7.73 (2.15)	0.538 (0.305)
Respondent/joint decision to use	86.4 (7.64)	89.9 (5.26)	3.54 (4.3)	89.7 (5.15)	87.5 (7.25)	89.9 (5.17)	2.43 (3.92)	89.4 (5.27)	89.8 (5.29)	0.475 (0.65)
None of TV/Radio/Paper	47.2 (17.2)	50.7 (16.9)	3.48 (14)	51.1 (17.3)	47.8 (15.7)	50.3 (16.2)	2.43 (10.8)	52.4 (18.1)	52.6 (18.1)	0.162 (4.33)
Method information index	42.4 (12.7)	47 (13.5)	4.57 (6.69)	46.2 (14.7)	44 (14.9)	47.5 (15.7)	3.55 (4.72)	46.4 (15.7)	47.2 (16)	0.787 (1.24)
Fieldworker visits to all women	7.67 (4.54)	9.59 (5.22)	1.92 (3.01)	9.25 (5.45)	7.96 (4.67)	9.47 (5.23)	1.5 (2.52)	9.71 (5.74)	9.87 (5.86)	0.153 (0.864)
Desire for limiting	28.7 (11.3)	31.1 (11.4)	2.47 (4.9)	29.7 (10.4)	29.8 (11.5)	30.6 (10.5)	0.73 (3.99)	28.7 (10.4)	29.6 (10.9)	0.883 (1.65)
Desire for spacing	35.8 (12.7)	43.4 (14.8)	7.57 (6.95)	44.5 (13.9)	39.3 (14.2)	44 (14.2)	4.73 (5.82)	45.5 (14.1)	45.6 (14.6)	0.0849 (3.24)
TOTAL LOCATIONS		**108**		**68**		**62**			**57**	

Table 2. Descriptive statistics of outcomes and driver indicators by time period of the analysis

Notes: Values presented are the mean with the standard deviation in parentheses. The effort PCA index is not comparable across time periods.

mCPR Standardized Regressions

The standardized regression coefficients from the 19 regressions with mCPR as the dependent outcome are displayed in Figure 2. Statistically significant coefficients are highlighted with a yellow outline. The majority of models were significant ($p<0.05$) except for the 2004-2014 and 2014-2017 change models (11-13 & 17-19). We are most interested in the Phase 3 model results that contain the full range of indicators we aimed to compare in each time period (models 3, 4, 7, 10, 13, 16 & 19), specifically those without a location effect or in change-space presented in Table 3, but have still provided the full range of models we evaluated for this study.

In the main 2000-2017 model without a fixed effect on location (3), all indicators except fieldworker visits and desire for spacing were statistically significant and hence correlated with changes in mCPR. Knowledge of methods had the largest positive coefficient ($\beta=0.38$) followed by desire for limiting ($\beta=0.35$), recent public source ($\beta=0.19$), and LDI ($\beta=0.18$). The indicators with the largest negative coefficients were the method information index ($\beta=-0.16$), conflict ($\beta=-0.15$), and mean reproductive age ($\beta=-0.09$). The addition of a fixed effect in model 4 flipped the direction of the relationships between mCPR and the proportion of women aged 15-24 married/in-union, conflict, abortion legality, the method information index, and desire for limiting. It should be noted conflict, abortion legality, and desire for limiting lost their significance. Only knowledge of methods ($\beta=0.25$), education ($\beta=0.23$), public source of contraception ($\beta=0.19$), married/in-union women aged 15-24 ($\beta=-0.15$), exposure to family planning messages via mass media ($\beta=-0.07$), plus the method information index and LDI were significant.

The effort PCA index was statistically significant in the 2004-2014 longitudinal analysis (model 10), but not in the 2014 cross-sectional analysis (7) nor the 2014-2017 longitudinal analysis (16). Knowledge of methods had the largest coefficient in every model, except the 2014-2017 change model (19). The most prominent and only statistically significant variable in the 2014-2017 change model (19) was public family planning spending.

mCPR Shapley Decompositions

The Shapley decomposition results of the R-squared for each mCPR model are presented in Figure 3. The numbers reflect the ranking of each predictor in a model from greatest to smallest contribution to the overall model R-squared. Predictors with larger negative or positive coefficients are more likely to have a higher ranking, thus we see many of the same patterns seen among the standardized regression coefficients. Knowledge of methods ranked first in every model it was present except for the 2014-2017 change model (19), responsible for 21-25% of the explained variation in mCPR captured by the main Phase 3 models (Table 3). Desire for limiting was the second most important indicator in the 2000-2017 model (3), 2014 cross-sectional model (7), and 2014-2017 longitudinal model (16), explaining 19%, 14%, and 25% of the variation, respectively. LDI, conflict, and education were some of the most important enabling environment variables across all of the models except for the change models that were not significant.

In the yellow box of Figure 3, we rank indicators by their average scores across all 19 models and grouped by the three phases. Phase 1 rankings pertain to models 1, 2, 5, 8, 11, 14, and 17; Phase 2 includes models 6, 9, 12, 15, and 18; Phase 3 captures models 3, 4, 7, 10, 13, 16, and 19. Lastly, the overall rankings look at how indicators preformed in all 19 regression models. These average score rankings are intended as a tool to summarize patterns across the models and to demonstrate how rankings changed with the addition of indicators. Models should still be examined individually in the context of their corresponding time period and model parameters.

Among only the Phase 1 enabling environment variables, we found that, on average, LDI ranked highest, followed by conflict second and education third. Abortion legality and public family planning spending ranked last and second to last in importance, respectively. Conflict, income, and education remained in the top three rankings with the addition of the effort PCA indices in Phase 2; the effort indices ranked third to last. The inclusion of the Phase 3 indicators produced a different set of most important indicators – knowledge of methods, conflict, and desire for limiting. Education and LDI tied for sixth in importance, surpassed by exposure to family planning messages via mass media and respondent/joint decision to use contraception as well. While there was some discordance between the top indicators in Phase 3 versus overall, there were indicators that had low relative importance in Phase 3 and throughout the analysis – fieldworker visits, the method information index, desire for spacing, abortion legality, the effort PCA indices, and if women obtained their current method from a public source.

Demand Satisfied Standardized Regressions

We reran the same 19 regressions with demand satisfied as the dependent variable instead of mCPR. The standardized regression coefficients for demand satisfied are presented in Figure 4. All models were statistically significant at the 95% significance level. mCPR and demand satisfied are highly correlated (r=0.945 for 2000-2017) leading to quite similar regression results between the two outcomes. In the demand satisfied model for the 2000-2017 time period (3), all variables were significant except the proportion of young women married/in-union. In model 3 without a location effect, knowledge of methods had the largest coefficient (β=0.36), followed by the method information index (β=-0.23) and public source of contraception (β=0.21) in terms of absolute effect size. Adding a fixed effect on location (model 4) to test within country changes caused public source to lose significance (β=0.0048), while the proportion of young women married/in-union had the second largest effect size (β=-0.18) behind knowledge of methods (β=0.4).

In the 2014 cross-sectional analysis (7), the only statistically significant variables were education (β=0.38), knowledge of methods (β=0.35), public source of contraception (β=0.25), and conflict (β=-0.19). This varies from the mCPR results for this model in Figure 2 in which desire for limiting had the third largest significant effect size (β=0.35) and the method information index was also significant (β=-0.21). The effort PCA index was significant in the 2004-2014 Phase 3 model (10), but not for the 2004-2014 change model (13) or either types of the 2014-2017 models (16 & 19). The variables with the strongest effects on demand satisfied in the 2004-2014 time period (model 10) were knowledge of methods (β=0.4), education (β=0.33), and the effort PCA index (β=0.25). For the 2014-2017 time period these variables were desire for limiting (β=0.35), knowledge of methods (β=0.34), and public source of contraception (β=0.32). Mean reproductive was the single significant variable in the 2014-2017 change model (19) with a strong negative beta coefficient of -0.31.

Demand Satisfied Shapley Decompositions

The relative importance results of the Shapley decompositions for demand satisfied are displayed in Figure 5. Based on the Phase 3 rankings, knowledge of methods was the most explanatory predictor accounting for 16-21% of the variation seen in demand satisfied across countries in each of the time periods (Table 3). The second and third most important predictors varied depending on the time period analyzed. In our main time period, 2000-2017, respondent/joint decision to use contraception ranked second (10.5% of R-squared attributed) followed very closely by LDI (9.97%). Desire for limiting was the second most important indicator in the 2014 cross-sectional analysis (11%) and 2014-2017 longitudinal analysis (19%), while the effort PCA index in the 2004-2014 model came in second (13%).

Education and LDI consistently ranked in the top 5 indicators of all non-change models, plus conflict when included.

Amongst the models with only the enabling environment indicators, on average LDI, education and urbanicity ranked the highest. Urbanicity lost importance with addition of new indicators and fell to second to last in the Phase 2 and 3 rankings. In similar fashion to mCPR, there is a consistent of indicators with low relative importance such as abortion legality, public family planning spending, the method information index, fieldworker visits, and desire for spacing.

Additional Analyses of Sub-outcomes

As part of our original framework, we explored how drivers changed according to age group, marital/partner group, and the prevalence of individual methods for the 2000-2017 time period. The results of these analyses are provided in the supplementary appendix. We found the relative importance of indicators did not vary greatly by age group except for desire for limiting and spacing. In the mCPR Phase 3 model, desire for limiting had the highest importance for the 15-19, 20-24, and 25-29 age groups, while desire for spacing had the second highest importance for the older 30-34, 35-39, 40-44, and 45-49 age groups only behind knowledge of methods. Demand satisfied produced similar results in that desire for limiting mattered greatly for the younger age groups and less so for the older ones versus desire for limiting which had the inverse relationship with age group.

We ran Phase 1 models with married/partnered and unmarried/unpartnered estimates of mCPR and traditional contraceptive prevalence as the dependent variables. There were similar results across sub-groups in terms of importance, while the directions of the coefficients varied. The standout indicators were public family planning spacing for reducing unpartnered traditional use and contributing to more than 50% of the explained variation for this model. Additionally, conflict had a strong negative effect on unpartnered mCPR and accounted for slightly under 50% of the R-squared. The by-method models revealed a myriad of positive and negative relationships with the enabling environment indicators that require additional research to fully understand. It is also important to know that the sample size groups for less common methods become very small, so we are cautious of drawing any strong conclusions from these initial results.

Figure 2. Standardized regression coefficients for mCPR

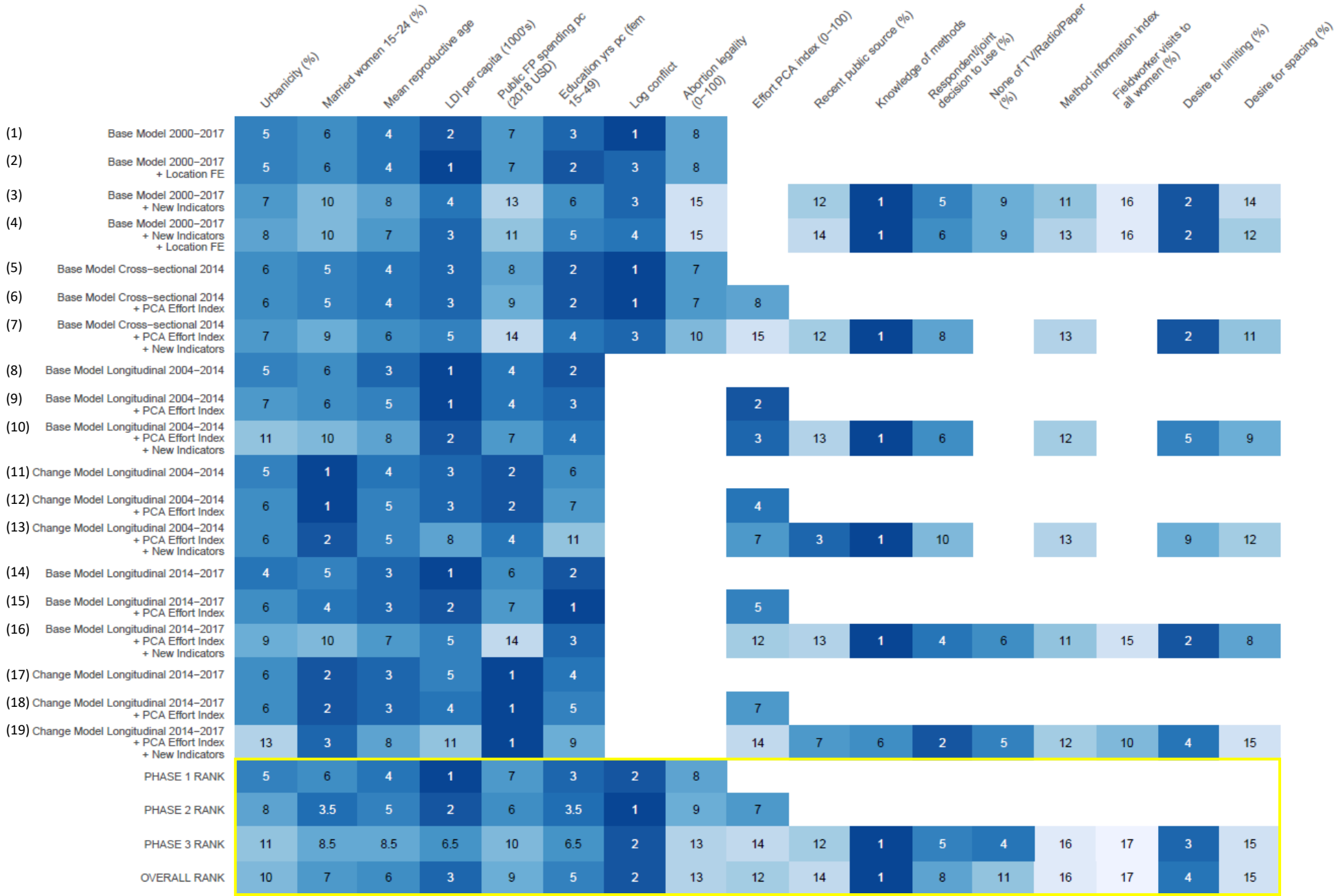

Figure 3. Shapley decomposition rankings for mCPR

Notes: Indicators are ranked from largest to smallest contribution to the model R^2. Overall rank is the average of rankings across all models. The phase-specific rankings are averages of within each phase (Phase 2 models = "+ PCA Effort Index", Phase 3 models = "+ PCA Effort Index + New Indicators").

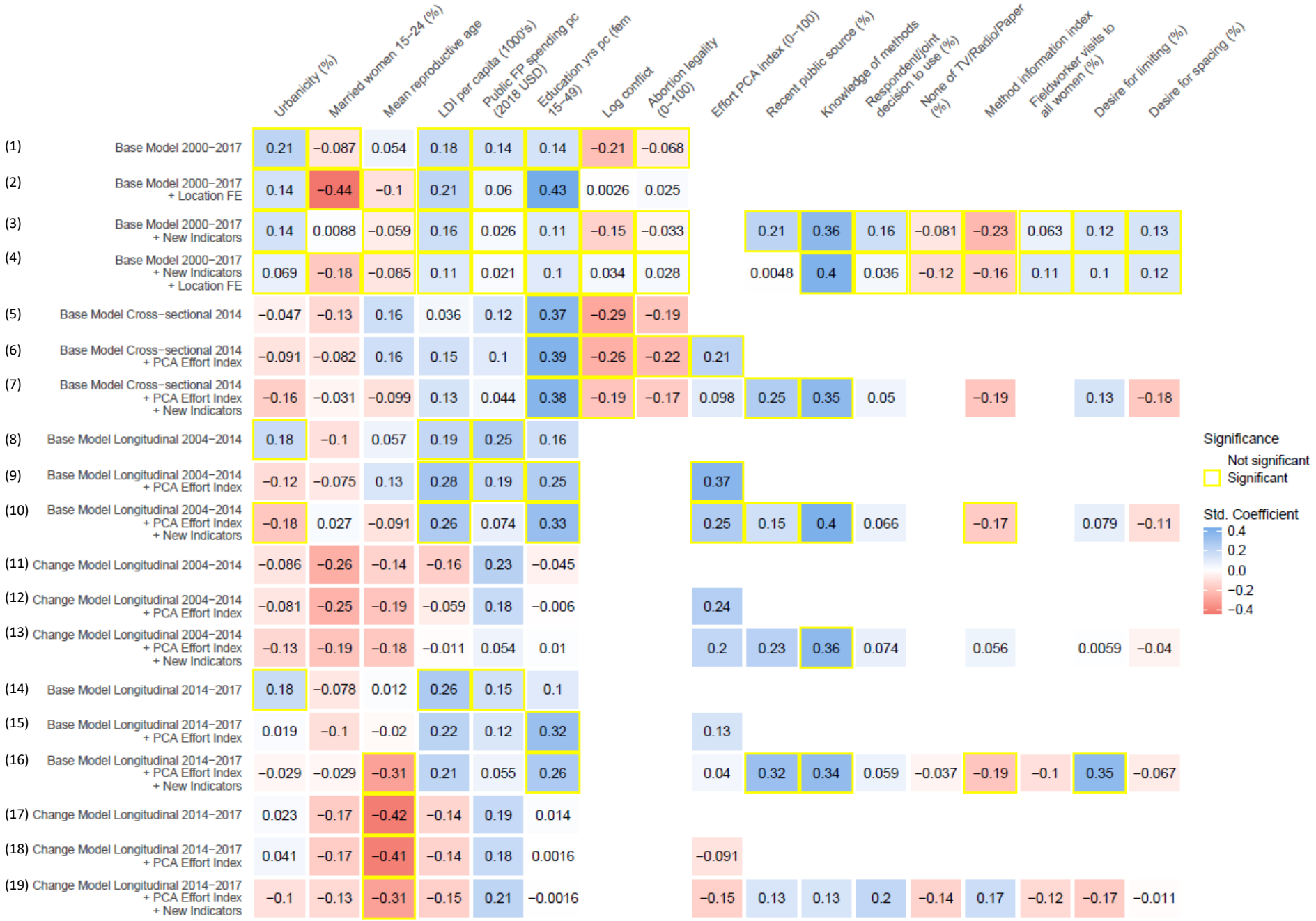

Figure 4. Standardized regression coefficients for demand satisfied

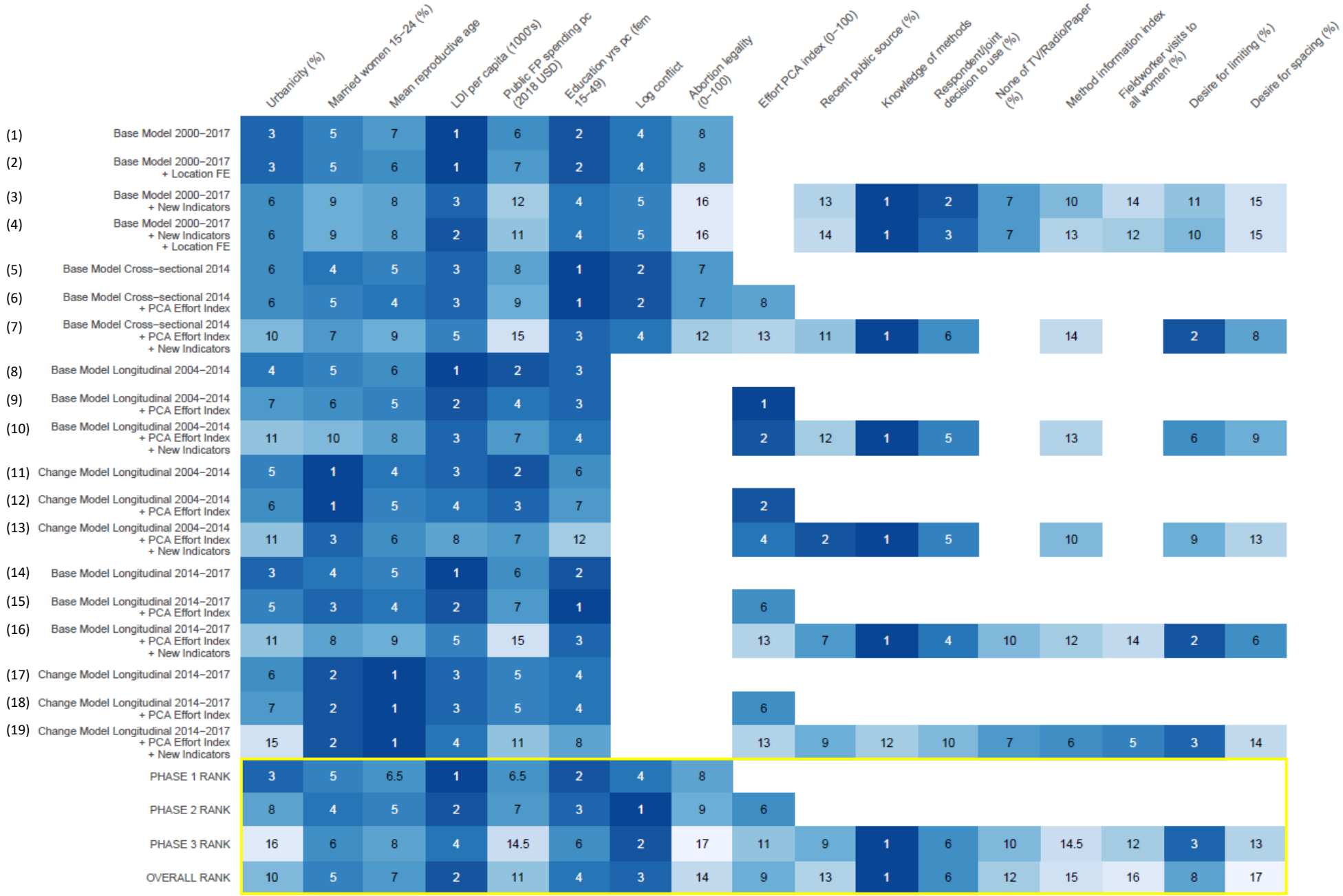

Figure 5. Shapley decomposition rankings for demand satisfied

Notes: Indicators are ranked from largest to smallest contribution to the model R^2. Overall rank is the average of rankings across all models. The phase-specific rankings are averages of within each phase (Phase 2 models = "+ PCA Effort Index", Phase 3 models = "+ PCA Effort Index + New Indicators").

	mCPR				Demand Satisfied			
	2000-2017 (Model 3)	2014 (Model 7)	2004-2014 (Model 10)	2014-2017 (Model 16)	2000-2017 (Model 3)	2014 (Model 7)	2004-2014 (Model 10)	2014-2017 (Model 16)
Urbanicity (%)	5.3 (4.1-7)	4.1 (2-7.1)	3.6 (2.3-5.3)	3.3 (1.9-5.7)	7 (6.5-7.7)	4.4 (2.5-7.4)	3.8 (2.5-5.3)	3.8 (1.8-6.5)
Married women 15-24 (%)	3.3 (2.8-3.8)	3.9 (1.7-6.8)	3.7 (2.1-6)	3 (1.3-5.1)	4.8 (4.4-5.2)	5.4 (2-10)	4.3 (2.2-7.1)	4.4 (1.7-8.4)
Mean reproductive age	5.2 (4.4-6.6)	4.8 (2.4-9.5)	6.1 (3.6-11)	4 (2.2-5.9)	5 (4.6-5.4)	5.1 (2.5-9)	6.3 (3.5-10)	4.3 (2.7-6.1)
LDI per capita (1000's)	8.7 (7.4-10)	7.7 (3.2-14)	13 (8.3-19)	5.8 (2.4-9.2)	10 (9.2-11)	8.5 (3.6-17)	12 (7.7-19)	7 (3.3-13)
Public FP spending pc (2018 USD)	2 (1.3-2.6)	2.3 (0.58-6.4)	6.4 (2.2-12)	1.7 (0.48-4.1)	3.2 (2.8-3.7)	1.8 (0.37-6.3)	6.4 (1.5-13)	1.4 (0.29-5.1)
Education yrs pc (fem 15-49)	7.1 (6-8.2)	11 (4.9-16)	9.4 (5.6-14)	9.8 (5.5-15)	8 (7.5-8.6)	11 (5.9-17)	10 (6.7-14)	9.7 (5-15)
Conflict	8.9 (6.9-11)	13 (6.3-22)	--	--	7.7 (7-8.2)	9.9 (3.8-19)	--	--
Abortion legality (0-100)	1.1 (0.84-1.5)	3.1 (0.75-7.9)	--	--	0.68 (0.58-0.82)	3.4 (0.56-9.7)	--	--
Effort PCA index (0-100)	--	2.2 (0.52-7.9)	9.5 (3.8-17)	2 (0.48-5.1)	--	2.8 (0.75-7.8)	13 (6.6-21)	2.1 (0.57-5.9)
Recent public source (%)	2 (1.2-2.9)	2.9 (0.82-8.1)	2.1 (0.6-5.1)	1.7 (0.34-5.1)	2.8 (2.4-3.3)	4.4 (0.62-12)	3 (0.84-6.5)	4.6 (1.2-12)
Knowledge of methods	22 (19-25)	21 (13-29)	23 (16-32)	25 (15-36)	24 (23-25)	17 (9.1-29)	16 (9.2-23)	21 (11-31)
Respondent/joint decision to use (%)	7.3 (6.1-8.5)	4 (0.94-9.3)	7.7 (4.8-12)	6.1 (2.4-9.8)	10 (9.8-11)	6.6 (1.8-14)	10 (5.7-15)	9.4 (5.1-15)
None of TV/Radio/Paper (%)	3.8 (2.7-5.3)	--	--	5.5 (1.5-11)	5.6 (5-6)	--	--	3.9 (0.73-9.8)
Method information index	2.5 (1.8-3.2)	2.6 (1-5.3)	2.9 (0.96-6.2)	2.6 (0.77-5.1)	4.2 (3.7-4.7)	2.6 (0.7-5.7)	2.9 (1-7)	3.4 (0.97-7.4)
Fieldworker visits to all women (%)	0.4 (0.14-0.72)	--	--	1.4 (0.32-3.3)	1.9 (1.6-2.2)	--	--	1.5 (0.49-3.5)
Desire for limiting (%)	19 (16-22)	14 (5.7-25)	9.2 (3.9-19)	25 (13-33)	3.3 (2.9-3.7)	11 (4.3-20)	7.2 (3.4-12)	19 (13-28)
Desire for spacing (%)	1.8 (1.2-2.5)	3.1 (1.2-7.4)	3.7 (1.4-7.7)	3.6 (1.3-8.2)	1.3 (1.1-1.4)	5.3 (1.6-12)	5.4 (2.3-11)	4.7 (2.1-8.7)
MODEL R-SQUARED	**0.622**	**0.777**	**0.724**	**0.698**	**0.637**	**0.732**	**0.737**	**0.662**

Table 3. Portion (%) of R-squared attributable to each independent variable in main Phase 3 models
Notes: The variable values in each column sum to 100% as they reflect a proportion of the overall model R-squared.

Discussion

Between 2000 and 2017 differential changes in mCPR and demand satisfied in LMICs were largely explained by knowledge of methods, in addition to desire for limiting, conflict, respondent/joint decision to use contraception, lagged-distributed income per capita, and education. Direct family planning interventions such as fieldworker visits and using mass media outlets to spread family planning messages had very small associations with average changes in family planning outcomes and consequently low importance compared to other indicators. Based on where these indicators fit into our conceptual framework, outputs in the form of desired fertility and demand for family planning services, plus broader contextual factors in the enabling environment, best explain why family planning performance varies across LMICs. This would further suggest that demand-side factors play a bigger role in driving contraceptive use than supply-side, however, our analysis lacked supply-side indicators.

Knowledge of methods could be reflective of general contraceptive knowledge and family planning education efforts, or expanded availability of methods. The Narongo Project in Northern Ghana during the 1990's successfully increased contraceptive knowledge and reduced desired fertility by providing convenient family planning service delivery and education.[35] Ross and Stover (2013) found that availability of 1 more method to a majority of the population could lead to a 4-8 percentage point increase of contraceptive use.[36] The method information index was typically negatively correlated with mCPR and demand satisfied in this analysis which suggests women may choose not to use contraception after being told of side effects, despite also being told about other methods. New methods or a wider range of options can help increase the likelihood that women have access to a method that meets their preferences.

When deciding to use contraception, the proportion of women that decide for themselves or with their partner did not have large effects on increasing mCPR or demand satisfied, but did carry importance in contributing to variation of these across LMICs. Autonomy in decision-making may be reflective of gender equity in a society, or that contraceptive uptake is easier with the support of a partner.[37] Desire for limiting was one of the most important variables while desire for spacing was one of the least important. Women who are unsure about the want for or timing of their next pregnancy are grouped into spacing, while limiting captures women who know they do not want to become pregnant. It is likely that a women with desire for limiting will feel more compelled to use contraception than a woman unsure of her current fertility preferences. If desire for limiting more directly translates into current contraceptive use than spacing, then that may explain why only one dimension of desired fertility strongly explained differing outcomes among countries.

Out of all the enabling environment variables included in this analysis, conflict, education and income were the most important, while the two governance and financing variables – abortion legality and public family planning spending – were some of the least important. Conflict is negatively associated with contraceptive use as we expect there are disruptions to access during times of war and terrorism. Integration of sexual and reproductive health services into humanitarian aid and the promotion of long-acting reversible contraceptives (LARCs) can ensure continuity of contraceptive coverage during conflict. In the Democratic Republic of Congo, service statistics in 2008 and 2010 revealed that contraceptive use including LARCs continued to increase and demand for family planning persisted despite crises.[38] The relationship between education and contraceptive use, particularly among young women,[39] is well documented and reaffirmed by this analysis.[40,41] More educated women choose to delay childbirth to pursue employment opportunities, which leads to eventual increases in LDI and drives down desired fertility.

Our findings would suggest that abortion legality is not a strong driver of family planning outcomes. Public family planning spending, as measured by development assistance for health and government expenditure, was also not important among the host of indicators considered. It's highest importance was during the 2004-2014 time period, although those models did not include fieldworker visits nor mass media exposures which are possible channels of spending and might have better explained variations. Overall, it seems broader contextual factors drive family planning performance more than enabling environment factors directly within the control of policymakers and donors.

Limitations

There are a number of limitations to be aware of during the interpretation of this analysis. Most importantly, this analysis only estimates associations between indicators; it is not causal. Additionally, we were not able to capture all aspects of the conceptual framework through indicators in the statistical analysis. We lacked estimates for supply-side interventions such as supply channels and health worker availability for family planning services, private family planning spending, sex education in schools, and service delivery outputs. Second, we had to restrict the time period of our analysis to accommodate certain indicators such as public family planning spending and the effort PCA indices. The FPE/NCIFP data only covered a subset of years in our analysis and trends within countries over time were inconsistent eliminating the option of modelling full time series of variables. As a result, we ran the 2014 cross-sectional analysis and two longitudinal analyses with half of the countries supposed to be in the analysis. While these analyses provide insights to the impact and importance of national family planning program efforts, the models are not directly comparable. Third, there are a number of concerns around the demand satisfied metric which are referenced in the family planning outcomes section of the methods. Due to indicator definitions and data collection, family planning estimates tend to reflect cisgender females in heterosexual relationships, and as such, gender non-conforming, intersex, and transgender individuals in need of contraceptive services are missing from our analysis. Lastly, this analysis was done at the country-level and does not capture inequalities within countries. Indicators such as income are not evenly distributed within countries; individual-level analyses within countries should be conducted to further understand how these indicators manifest in individuals and their resulting decision to use or not use contraception.

Conclusions

Exemplary family planning performance across LMICs is driven by a mix of broader contextual factors such as conflict, education, income, plus women's own desired fertility and most importantly – their knowledge of contraceptive methods. To close gaps in mCPR and demand satisfied among LMICs, policymakers should invest in expanding method availability and awareness, ensure continuity of family planning services during times of conflict, and continue to prioritize the education and economic well-being of women. Future areas of exploration are to conduct similar analyses within countries to capture inequalities across sociodemographic characteristics and geographies, plus account for country-specific cultural influences and programs.

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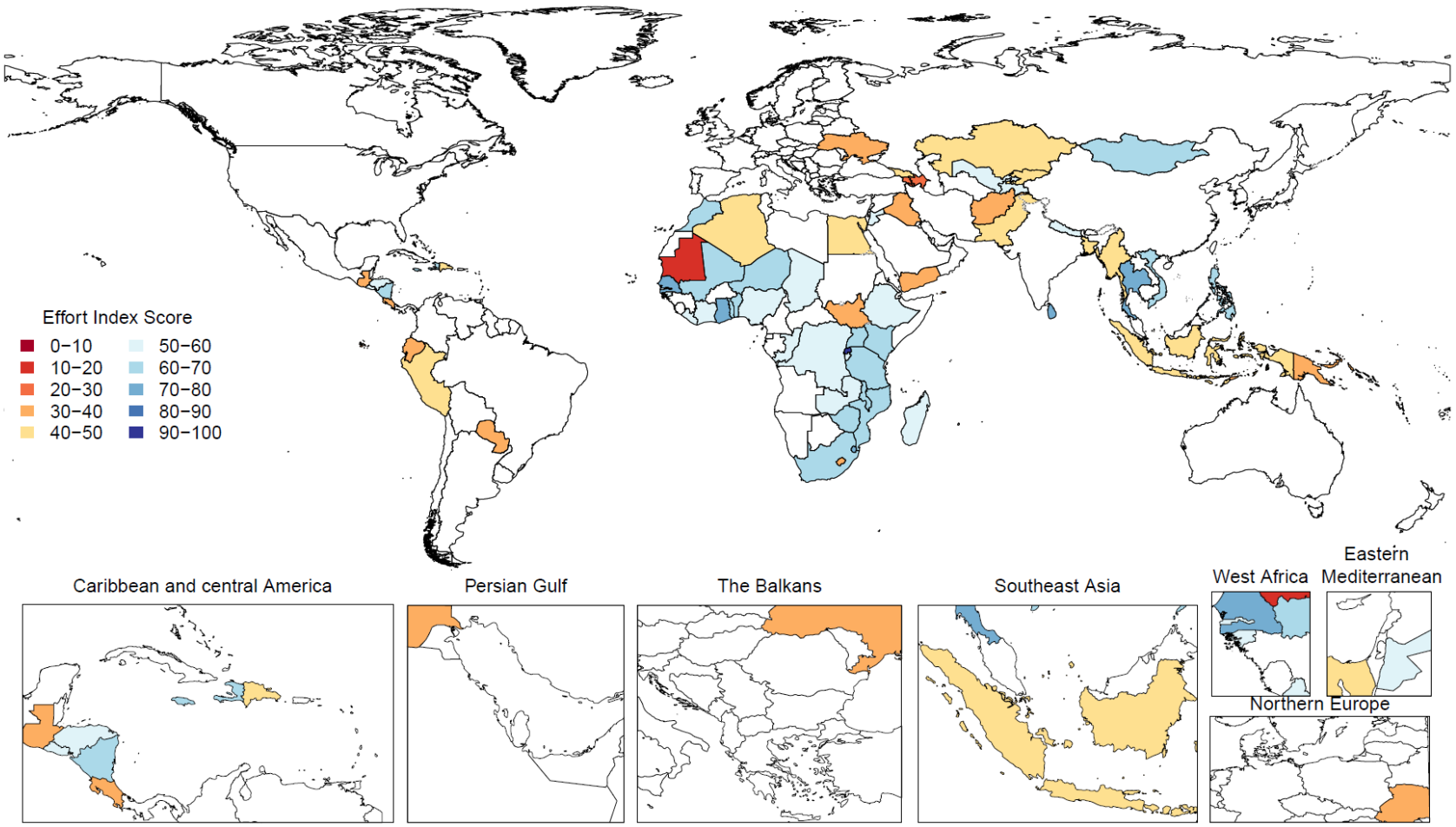
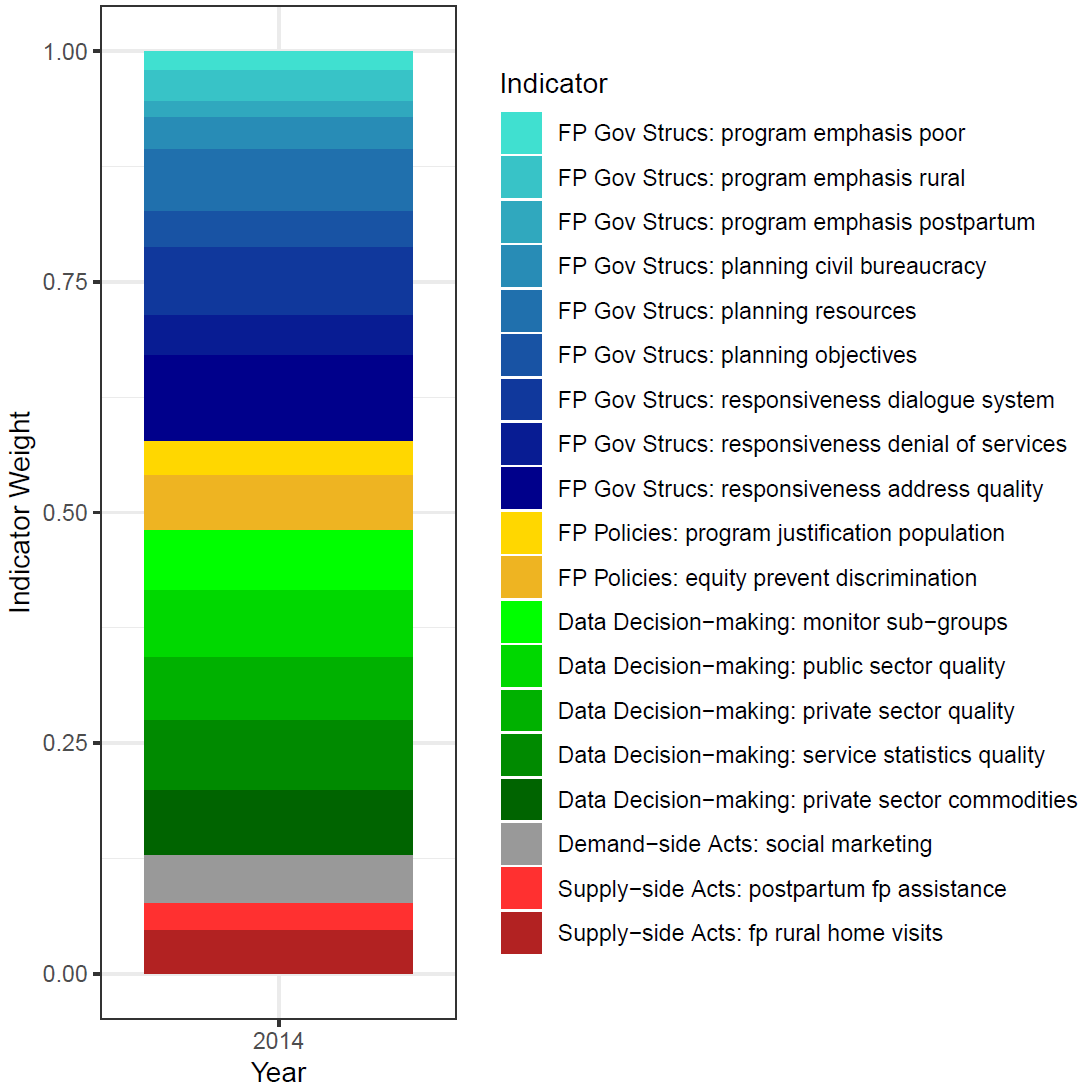
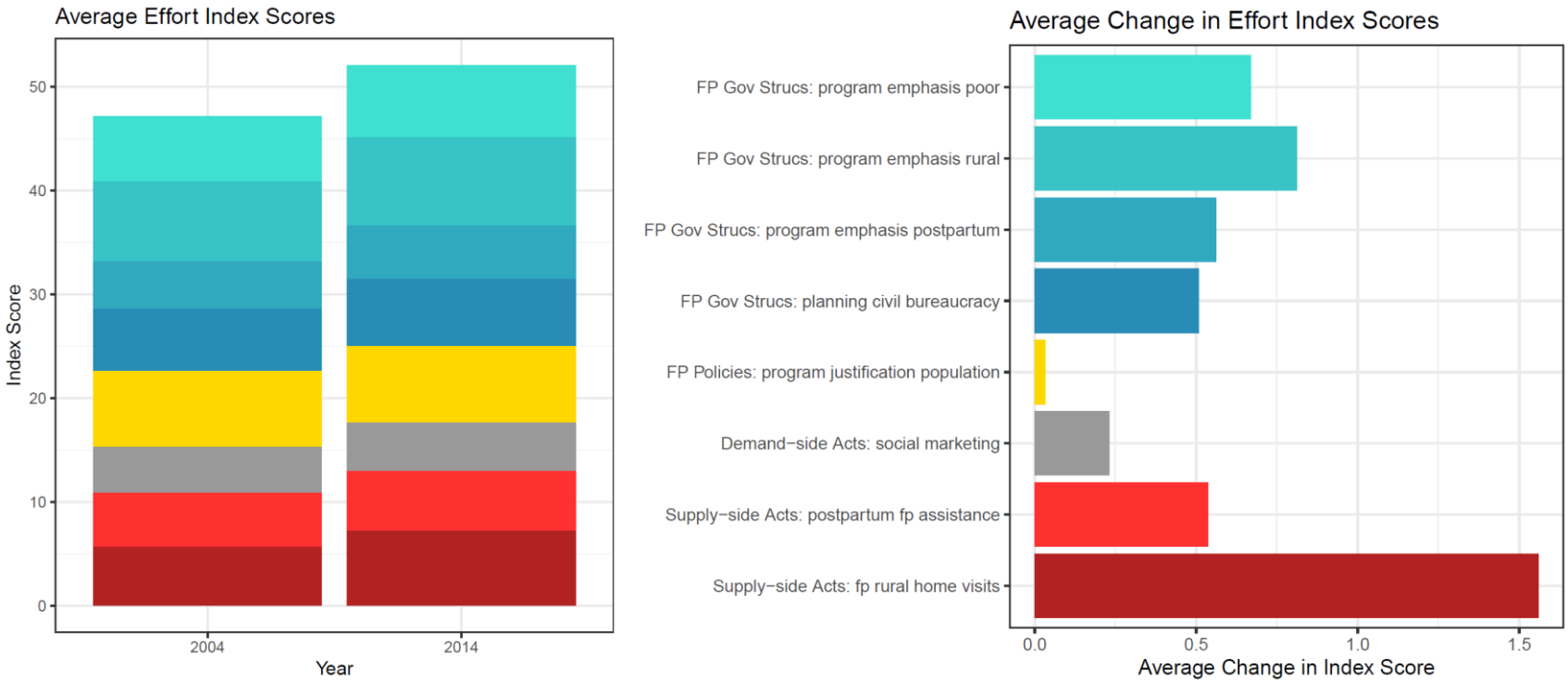
Supplementary Appendix



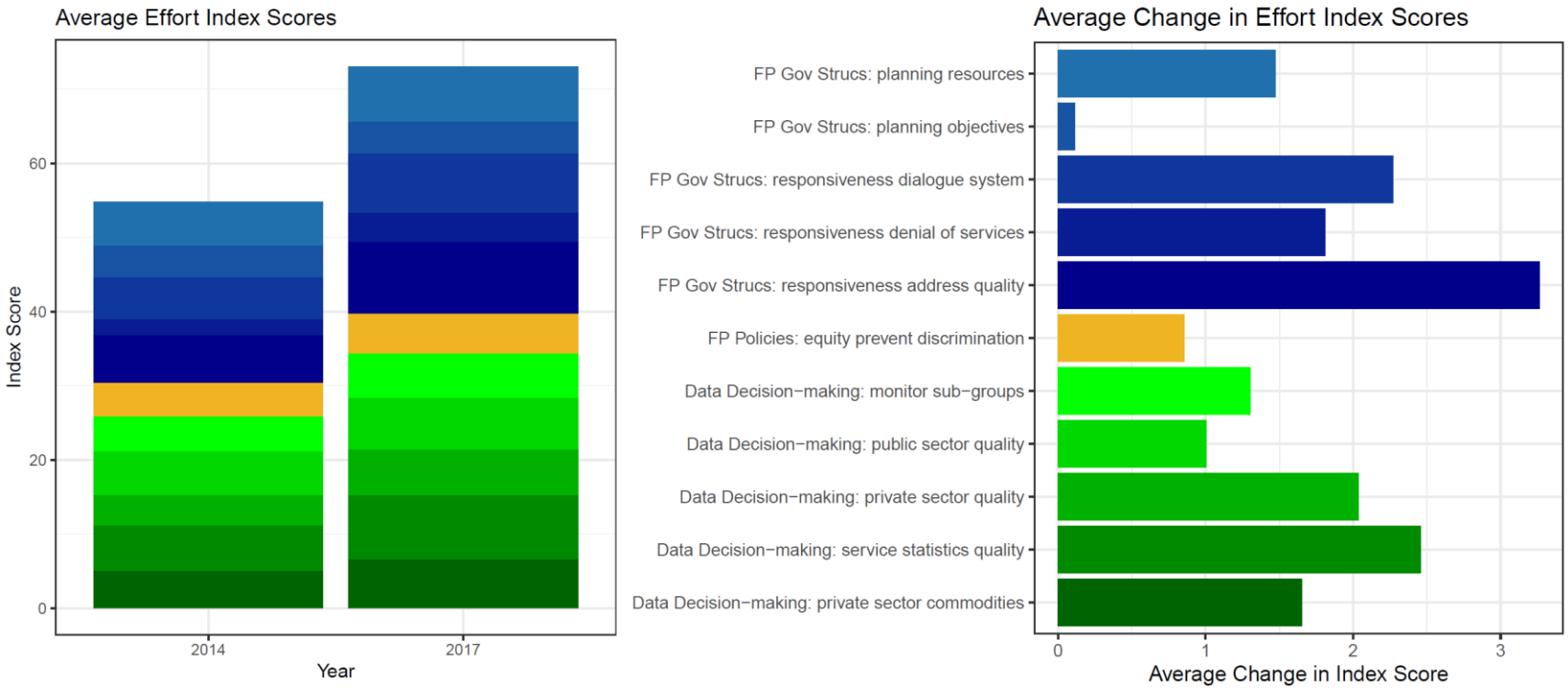
Supplementary Figure 1. Map of 2014 effort PCA index for 2014 cross-sectional analysis



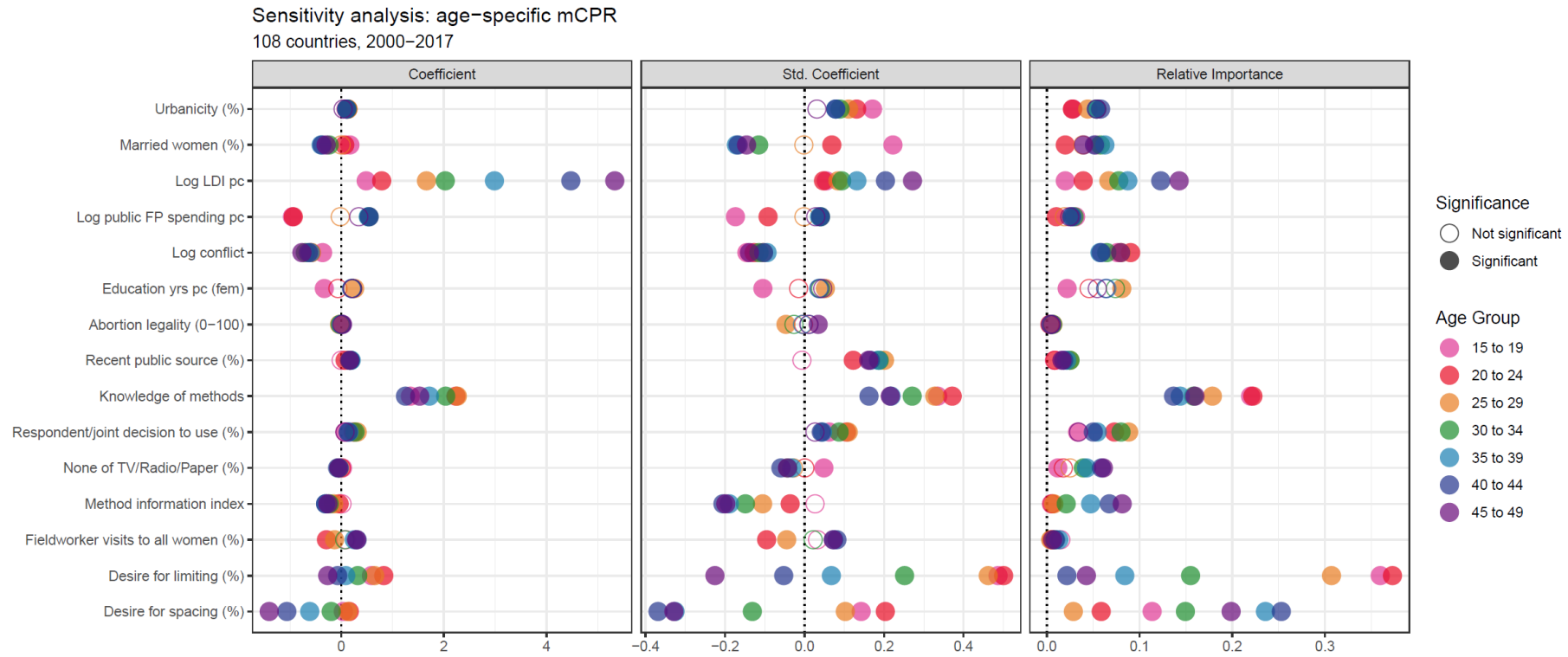
Supplementary Figure 2. PCA-derived weights used to create the 2014 cross-sectional effort index



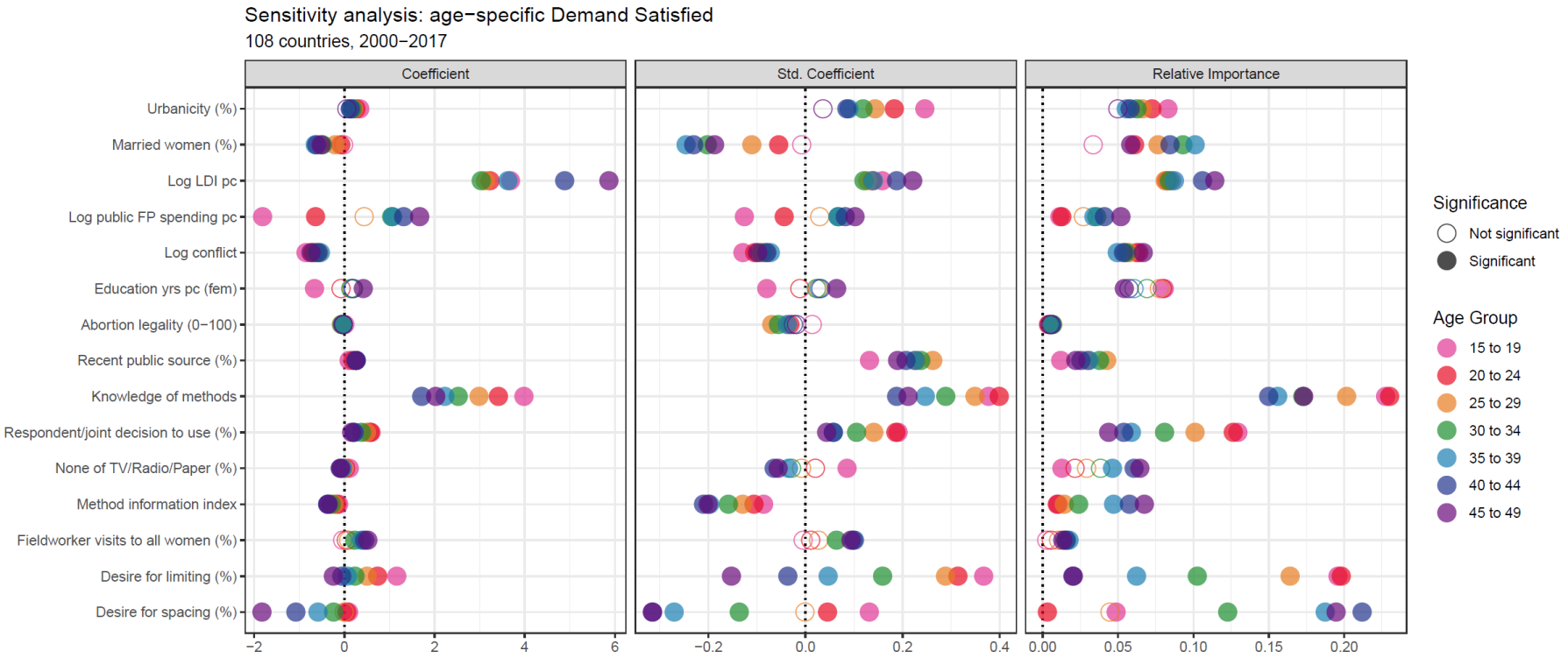
Supplementary Figure 3. Average scores of 2004-2014 effort PCA index and change in components



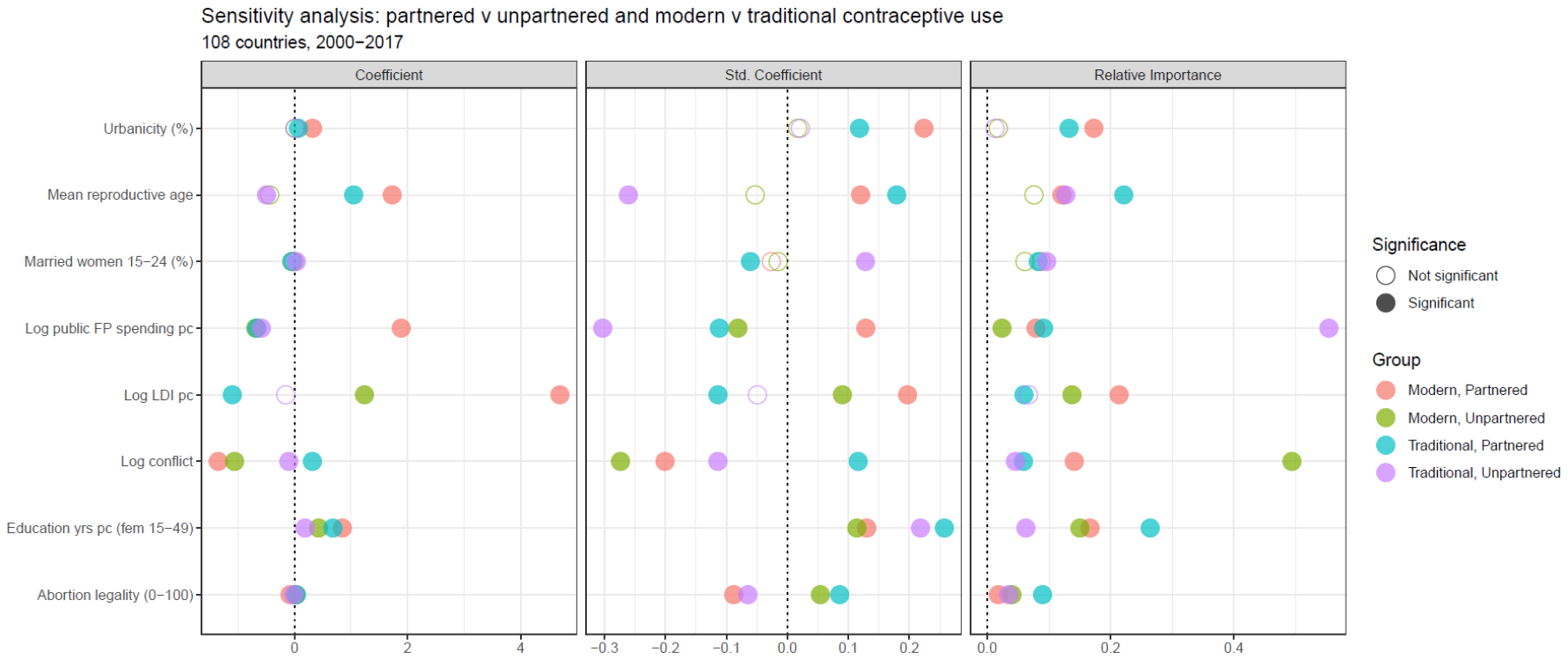
Supplementary Figure 4. Average scores of 2014-2017 effort PCA index and change in components



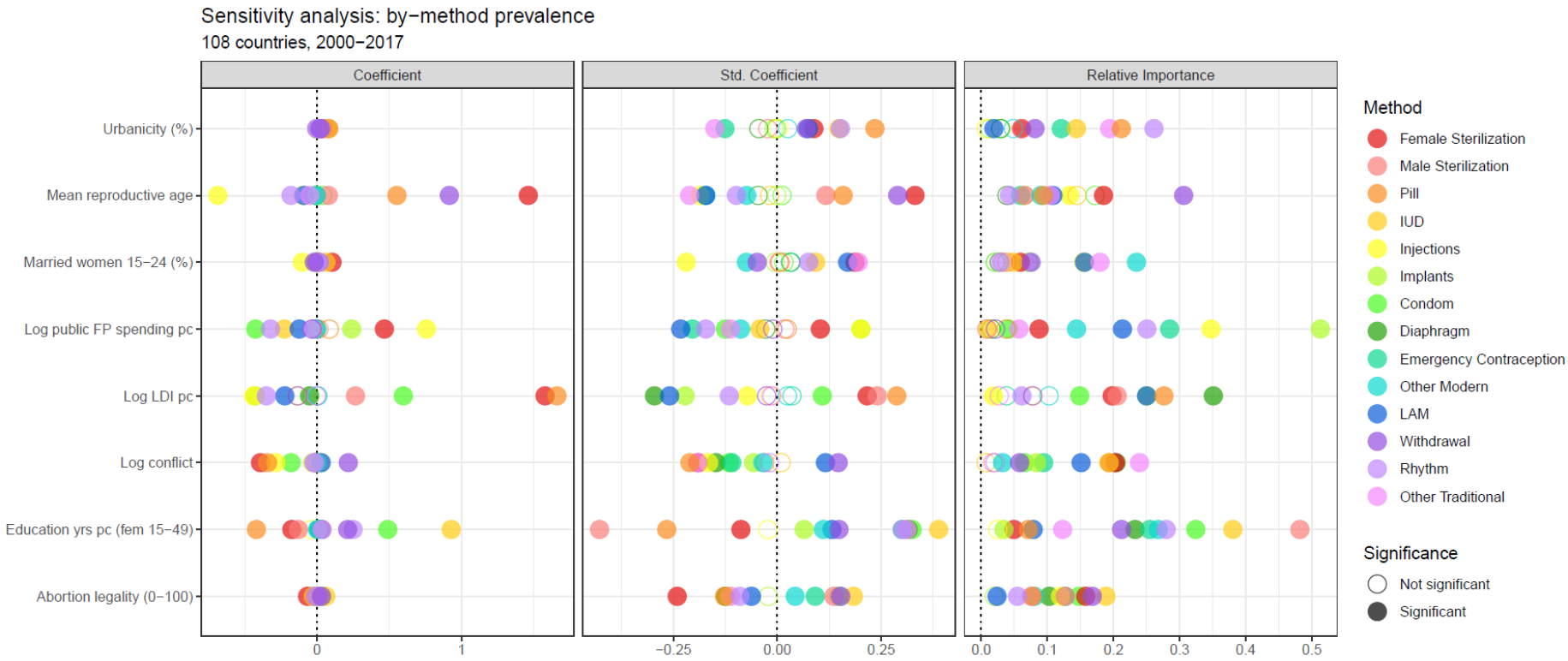
Supplementary Figure 5: Results of age-specific mCPR analysis, 2000-2017



Supplementary Figure 6: Results of age-specific demand satisfied analysis, 2000-2017



Supplementary Figure 7: Results of partnered versus unpartnered modern and traditional contraceptive prevalence analysis, 2000-2017



Supplementary Figure 8: Results of by-method prevalence analysis, 2000-2017