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INCORPORATING COMPLEX SURVEY DESIGN FOR ANALYSING THE DETERMINANT OF WOMEN IN REPRODUCTIVE AGE PARTICIPATION IN FAMILY PLANNING PROGRAM IN INDONESIA

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ABSTRACT

Data generated from complex surveys are often treated as unweighted simple random samples by analysts. This is unfortunate because everyone has a different probability of being selected as a sample in each stage of the complex survey design. Failure to take it into account will have a serious impact on parameter and variance estimation. This paper aims to examine the relationship between participation in family planning programs and the socio-demographic status of women of reproductive age in Indonesia using data from the latest Indonesian Demographic and Health Survey (IDHS). IDHS employs a multi-stage stratified sampling design. Thus, there are a number of weights included in public-use IDHS datasets to account for this complex sample design. We found that the complex design features of the IHDS increased the variance estimates of the estimated parameters in the logistic regression models by about 1.325 – 1.88 times compared to simple random sampling. Therefore, using variance estimated from unweighted simple random samples would lead to a wrong conclusion of the significance parameter suggested by the model. The result also found that all of the socio-demographic variables used as predictors are significant. Thus, women with moderate education, unemployment, exposed by media, living in rural communities and are wealthy, have spouses that have moderate education, and have a job tend to participate in family planning programs.

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1. INTRODUCTION

Being considered as the world's 4th most populous country with a population exceeding 270 million in 2020, Indonesia is still struggling with many demographical issues that increase the population [1]. Due to the Indonesia Population Projection 2020-2050, Indonesia's population is predicted to increase at about 294,1 million people, with the population growth of about nearly 0,99 percent per year and a predicted birth rate's will experience an increase in 2025 at about 4,473.5 thousand and incrase again in 2023 reaching 4,483.0 thousand birth [2]. This means that Indonesia needs more effort to control population increase. Unable to control the population increase can raise severe social and economic problems due to overpopulation.

The family planning program is a decades-old strategy of the government of The Republic of Indonesia started with the establishment of the National Population and Family Planning Board (BKKBN) in 1970. This board, which prioritizes family planning to control population expansion, has implemented a family planning program of "dua anak cukup" (two children are enough). Many actions and funds had been implemented for supporting this program. However, the slogan constitutes only a recommendation and has been largely ignored. According to the latest Indonesian's Demographic and Health Survey (IDHS, 2017), the total fertility rate is 2.4 children born/woman. The participation in family planning programs indicated by the contraceptive prevalence rate is only 62 percent for all married couples in Indonesia. Moreover, the use of modern contraceptive methods among married women stayed the same from the 2002-2003 IDHS to the 2017 IDHS (57-58 percent) below the expected target (61.1 percent). These statistics reflected that the family planning program in Indonesia does not run smoothly.

There are many factors that can cause couple, especially the women for taking part in family planning program. Women's education, experience of child mortality, women's age, husband education, husband occupation have significant effect on the family planning contribution [3]. Respondent's residence, reading message on radio, wealth index had significant association with utilization of family planning program methods [4]. Income, marital status had significant effect on knowledge of family planning [5].

The 2017 IDHS was selected using two-stage sampling. On the first state, a number of block census were selected with systematic proportional to the number of households listed in the 2010 population census. The Census blocks were ordered by its wealth index category. In the second stage, 25 ordinary household were selected systematically from each census block. The 2017 IDHS sample includes 1,970 census blocks, 1,012 in urban areas and 958 in rural areas. The sample is aimed at providing reliable estimates of key characteristics for women age 15-49 and married men age 15-54 in Indonesia as a whole, in urban and rural areas, and in each of the 34 provinces. The sample weights for IDHS have been constructed to make the IDHS weighted sample representative of all women under reproductive age (15-49 years) in Indonesia. Baseline weights account for the differential selection probabilities by incorporating the inverse of the probability of selection for the household unit and for the individual women and for non-response to the baseline IDHS survey. Each follow up wave has a unique sample weight which adjusts the baseline sample weight to account for a non-response adjustment factor [6].

Because the IHDS employs a multi-stage sampling design, households and individuals have differential probabilities of being selected into the sample. Thus, there are several weights included in public-use IDHS datasets to account for this complex sample design. Moreover, applying clustering, observations form the same cluster were correlated and in order to obtain unbiased estimators, the sample weighting need to be considered. Ignoring the sampling weight in data analysis could lead to incorrect or inaccurate result.

Previous studies in some topics analyzed complex survey data [7]–[9]. Most of the study presented the result on classification table. Our study presented the analysis initiated by identification of independency in two-way cross tabulation using statistic which considering the complex survey. We also presented the design effect (DEFF) in order to compare Simple Random Sampling (SRS) and the complex survey design.

2. RESEARCH METHODS

In this paper we use datasets from the latest Indonesian's Demographic and Health Survey (IDHS) in 2017. The 2017 IDHS provides updated estimates of basic demographic and health indicators covered in previous IDHS surveys. In a departure from past DHS surveys in Indonesia, which covered ever-married women age 15-49, the 2017 IDHS included never-married women age 15-49 (reproductive age). All women were asked questions about their background, the children they had given birth to, their knowledge and use of family planning methods, the health of their children, reproductive health, knowledge of HIV and other sexually transmitted infections, and other information that policymakers and administrators in the health and family planning fields may use in their respective programs. Related to the problem, this research described in this paper will explore the relationship between participation in a family planning program and demographic and socio-economic characteristics of the survey respondents.

2.1 Measure

The response variable is participation in family planning program (FPP) among reproductive-age married or in-union women in Indonesia. Women were asked whether ever use any method, modern method, traditional method, or specific method [10]. This response variable was categorized into two categories and measured as "yes" if participate (ever use any method, modern method, traditional method, or specific method) and "no" if not participate. Following previous studies [3]–[5], [11], some predictor variables that are expected to have relationships with the response are: age, education level, spouse education level, working status, spouse working status, media exposure, wealth index, and type of residence. The categories of these variables were presented in Table 1.

Table 1. Measure of The Study Variables

Variables	Category	
Response Variable		
Participate in FPP	0	No
	1	Yes
Predictor Variable		
Age	0	15-24
	1	25-34
	2	35-49
Education	0	No Education/ Incomplete Primary
	1	Complete Primary
	2	Complete Secondary
	3	Higher
Spouse's Education	0	No Education/ Incomplete Primary
	1	Complete Primary
	2	Complete Secondary
	3	Higher
Working Status	0	No
	1	Yes
Spouse's Working Status	0	No
	1	Yes
Media Exposure (TV or Radio)	0	Not Exposed
	1	Only One
	2	Both
Wealth Index	0	Poorest
	1	Poorer
	2	Middle
	3	Richer
	4	Richest
Type of Residence	0	Rural
	1	Urban

2.2 The unit of Analysis

The unit of analysis covers women in reproductive age who were married or living with partner (34,467). The observation with missing data were excluded. Hence the number of subpopulations with no missing data are 27,490 as illustrated in Figure 1.

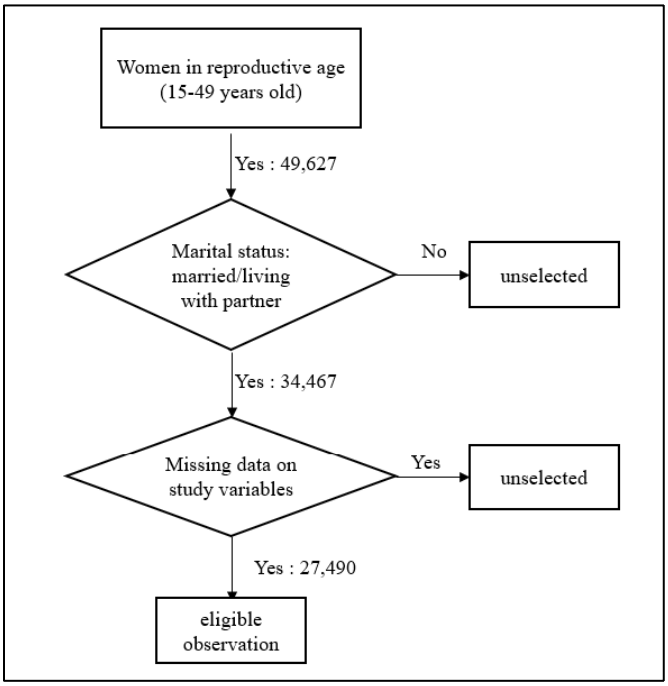

Figure 1. Flowchart selection of unit of analysis

2.3 Statistical Analysis

The *Rao-Scoot F*-Test

The initial process in specifying logistic regression model was performing initial bivariate analysis of the relationship between response and each predictor candidate. Generally, under the SRS, the formal testing of independency of two categorical variable was done by *Pearson Chi-Square* test statistic $\left(\mathrm{X}^2\right)$ or *Likelihood ratio* test $\left(G^2\right)$. Ignoring the complex survey design underlining the data sets could lead to bias in the estimated values of these statistics. To correct this bias, *Rao and Scoot* proposed the design-adjusted Rao-Scoot Pearson and Likelihood ratio Chi-Square test statistics which formulated as follow [12]:

$$\begin{aligned} \mathrm{X}^2_{R-S} &= \mathrm{X}^2_{Pearson} \big/ GDEFF \\ G^2_{R-S} &= G^2_{Pearson} \big/ GDEFF \end{aligned} \tag{1}$$

GDEFF was the generalized design effect factor. Thomas and Rao (1987) proposed the transformation of the design-adjusted X^2_{R-S} and G^2_{R-S} value that produced a more stable test statistics closely approximated an *F* distribution (**Table 2**) **[12]**.

Table 2. *F*-Transformation of the *Rao-Scott* Chi-Square Test Statistics

***F*-transformed Test Statistics**	***F* Reference Distribution under H₀**
$F_{R-S,Pearson} = \mathrm{X}^2_{R-S} \big/ (R-1)(C-1)$	$F_{(R-1)(C-1),(R-1)(C-1)df}$
$F_{R-S,LRT} = G^2_{R-S} \big/ (R-1)(C-1)$	$F_{(R-1)(C-1),(R-1)(C-1)df}$

R : the number of row, C: the number of column
df: design degree of freedom

The Logistic Regression Model

Logistic regression model was generalized linear model which appropriate for modelling the relationship of the binary survey response and a collection of predictors.

For logistic model, the link function was *logit*:

$$\pi(\boldsymbol{x}) = \frac{e^{B_0 + B_1 x_1 + \ldots + B_p x_p}}{1 + e^{B_0 + B_1 x_1 + \ldots + B_p x_p}}$$
$$\ln\left(\frac{\pi(\boldsymbol{x})}{(1-(\pi(\boldsymbol{x}))}\right) = B_0 + B_1 x_1 + \ldots + B_p x_p \tag{2}$$

where:

$\pi(\boldsymbol{x}_i)$: $P(y=1|x)$ for $0 < \pi(x) < 1$

B_j : the j-th parameter of regression coefficient of finite survey population $j = 1, 2, \ldots$ p

The finite population model parameter was denoted by the standard alphabetic B to distinguish them from superpopulation denoted by β **[12].**

The Parameter Estimation: Pseudo Maximum Likelihood Estimation

As it known that the estimation method for logistic regression for SRS of n observations was based on the maximum likelihood estimation (MLE) **[12], [13]**:

$$L(\boldsymbol{B}|\boldsymbol{x}) = \prod_{i=1}^{n} \pi(\boldsymbol{x}_i)^{y_i} [1 - \pi(\boldsymbol{x}_i)]^{1-y_i} \tag{3}$$

where $L(\boldsymbol{B}|\boldsymbol{x})$ is the Likelihood function and $\pi(\boldsymbol{x}_i) = \exp(\boldsymbol{x}_i \boldsymbol{B}) / (1 + \exp(\boldsymbol{x}_i \boldsymbol{B}))$. When the complex sample design is implemented on the survey data collection, the application of MLE in the parameter estimation is no longer possible due to some reasons. First, the probabilities of selection for n observations are unequal. The sampling weights play an important role in the parameter estimation. Second, the assumption of independence of observations can be violated due to the existence of stratification and clustering of complex sample design **[12]**. Considering these issues, Binder (1983) proposed the pseudo maximum likelihood estimation (PMLE). The PMLE approach was combined with a linearized estimator of the variance-covariance matrix for the parameter estimates, considering the features of complex survey design **[12]**:

$$PL(\boldsymbol{B}|\boldsymbol{x}) = \prod_{i=1}^{n} \left\{ \pi(\boldsymbol{x}_i)^{y_i} [1 - \pi(\boldsymbol{x}_i)]^{1-y_i} \right\}^{w_i} \tag{4}$$

As in the MLE principle, to obtain the value of $\boldsymbol{B}$ which maximize the PLME function, the **Equation (4)** was differentiated respect to $\boldsymbol{B}$ and set the resulting expressions equal to zero (**Equation (5)**). The solution of **Equation (5)** was done by Newton Raphson iteration.

$$\frac{\partial PL(\boldsymbol{B}|x)}{\partial B} = S(\boldsymbol{B}) = \sum_h \sum_\alpha \sum_i w_{h\alpha i} (y_{h\alpha i} - \pi_{h\alpha i}(\boldsymbol{B})) \boldsymbol{x}'_{h\alpha i} = 0 \tag{5}$$

where:

$w_{h\alpha i}$: sampling weight for the h^{th} stratum, α^{th} cluster, i^{th} unit observation

$y_{h\alpha i}$: response variable of the h^{th} stratum, α^{th} cluster, i^{th} unit observation

$\boldsymbol{x}'_{h\alpha i}$: predictor variables vector of in the h^{th} stratum, α^{th} cluster, i^{th} unit observation

The variance estimation was calculated by applying *Taylor Series Linearization (TSL)* with *sandwich variance estimator* formulated as:

$$\operatorname{var}(\hat{\boldsymbol{B}}) = (\boldsymbol{J}^{-1}) \operatorname{var}[S(\hat{\boldsymbol{B}})](\boldsymbol{J}^{-1}) \tag{6}$$

$\boldsymbol{J}$ was a matrix of second derivatives with respect to the $\hat{\beta}_j$ of the PMLE in **Equation (4)** and $\operatorname{var}[S(\hat{\boldsymbol{\beta}})]$ is the variance-covariance matrix of **Equation (4)**.

$$\boldsymbol{J} = -\left[\frac{\delta^2 \ln PL(\boldsymbol{B})}{\delta^2(\boldsymbol{B})}\right] | \boldsymbol{B} = \hat{\boldsymbol{B}}$$
$$= \sum_h \sum_\alpha \sum_i x'_{h\alpha i} x_{h\alpha i} w_{h\alpha i} \pi'_{h\alpha i}(\boldsymbol{B})(1 - \pi_{h\alpha i}(\boldsymbol{B})) = 0 \tag{7}$$

The Design Effect Ratio

Relative to SRS, the stratification, clustering, and weighting influenced the standard errors for survey estimate. For any chosen sample, the stratification generally reduced the estimated standard error relative to SRS, while the clustering and design that require weighting for unbiased estimation generally increased the estimated standard error [12]. The complex survey effect of stratification, clustering, and weighting in standard error, relative to SRS, from the available survey data were formulated as [12]:

$$d^2(\theta) = \frac{se(\theta)^2_{complex}}{se(\theta)^2_{srs}} = \frac{\text{var}(\theta)_{complex}}{\text{var}(\theta)_{srs}} \tag{8}$$

where:

$d^2(\theta)$: the estimated design effect for the sample estimate θ

$\text{var}(\theta)_{complex}$: the estimated complex survey design variance of θ

$\text{var}(\theta)_{srs}$: the estimated simple random sample variance of θ

The value of $d^2(\theta) > 1$ meant that the complex survey design performed better than SRS, while the value of $d^2(\theta) < 1$ meant the SRS was more effective and appropriate to be applied. Finally, the value of $d^2(\theta) = 1$ meant that there was no different in standard error estimation both in complex survey design and SRS design.

2.4 Statistical Software

The data study was analyzed using STATA 14. We used command svy:tab for examining the independency of response variable with each predictor variables. In the next step, to specify the logistic model we used command svy:logistic. This command provided the estimates and 95% confidence interval for adjusted odds ratio. Complex sample design effects for variance estimates were calculated using the estat effects command.

3. RESULTS AND DISCUSSION

3.1 Summary Statistics

Result showed about 84,68 percent of living with partner/married women participated in FPP. Out of the women, the majority were at age 35-49 years (48.06 percent), lived in rural area (51.26 percent), exposed to one media, Tv or radio (71.77 percent). However, 7.11 women were not exposed to both Tv and Radio. The women education level is low: 10.18 percent had no education/incomplete primary, 49.56 percent were complete primary, 27.36 percent had completed secondary and only 12.91 percent attained higher education. The spouse education level also dominated by complete primary education level (46.12 percent). About 59.28 percent women were not working, most women referred to working spouse (98.79 percent). Most of the household were distributed evenly in five level wealth status: poorest (18.18 percent), poorer (19.76 percent), middle (20.68 percent), richer (21.44 percent) and richest (19.96 percent).

Table 3 presents the results of these initial bivariate analysis, including the *Rao-Scott F* test of association and the adjusted degrees of freedom. Based on these initial tests of association, all the predictors appear to have significant association with participation in FPP. Hence, all predictors appear to be good candidates for inclusion in the logistic regression model.

Table 3. Initial Bivariate Design-Based Tests Assessing Potential Predictors of Married Women/Living with Partner Participation in FPP

Categorical Predictor	*Rao-Scoot F-Test*	df
Age	444.6625*	(2.00, 3805.73)
Education	543.1173*	(2.78, 5295.87)
Spouse Education	359.4337*	(2.99, 5683.04)
Working Status	93.1053*	(1, 1903)

Categorical Predictor	*Rao-Scoot F-Test*	df
Spouse Working Status	71.1708*	(1, 1903)
Media Exposure	146.2563*	(1.93, 3664.21)
Wealth Index	103.3328*	(3.86, 7344.93)
Type of Residence	14.2067*	(1, 1903)

*Statistically significant (p-value < 0.05)
***Data source**:* IDHS, 2017

3.2 Logistic Regression Models of Participation in Family Planning Program

The estimation for the logistic regression model obtained from STATA formulated as:

$$\begin{aligned} g(\pi(\boldsymbol{x})) = & -0.8477 + 1.1133 Age_1 + 0.9619 Age_2 + 0.6312 Edu_1 + 0.2263 Edu_2 - 0.2680 Edu_3 \\ & + 0.2298 PartEdu_1 + 0.0613 PartEdu_2 - 0.3089 PartEdu_3 - 0.2751 Work \\ & + 0.8978 PartWork + 0.55161 Media_1 + 0.4833 Media_2 + 0.2648 WI_1 + 0.2721 WI_2 \\ & + 0.2475 WI_3 + 0.3906 WI_4 - 0.1658 \mathrm{Re}\,sidence \end{aligned} \tag{9}$$

where:

Age_1	: Dummy for Age 25-34
Age_2	: Dummy for Age 35-49
Edu_1	: Dummy for Education level Complete Primary
Edu_2	: Dummy for Education level Complete Secondary
Edu_3	: Dummy for Education level Higher
$PartEdu_1$	: Dummy for Spouse’s Education level Complete Primary
$PartEdu_2$	: Dummy for Spouse’s Education level Complete Secondary
$PartEdu_3$	: Dummy for Spouse’s Education level Higher
$Work$	: Dummy for Working Status
$PartWork$	: Dummy for Spouse’s Working Status
$Media_1$	: Dummy for Media Exposure Only possessing one
$Media_2$	: Dummy for Media Exposure Possessing both TV and radio
WI_1	: Dummy for Wealth Index Poorer
WI_2	: Dummy for Wealth Index Middle
WI_3	: Dummy for Wealth Index Richer
WI_4	: Dummy for Wealth Index Richest
$\mathrm{Re}\,sidence$	: Dummy for Type of Residence

Table 4 presented the design based of logistic regression results. As could be seen, all the design effect on coefficient estimates values were higher than 1. It means that the complex design features of the 2017 IHDS increased the variance estimates of the estimated parameters in the logistic regression models by about 1.3195 – 1.8777 times, compared to a simple random sample. This result shows that considering the weight in complex survey design is more appropriate in data analysis.

Table 4. Estimates of Odds Ratios for Participation In FPP, Design-Based 95% CI, and Design Effects on The Coefficient Estimates, for Each Categorical Predictor

Variables	Category	Odds Ratio 95% CI	Design Effect on Coefficient Estimates
Age	15-24	-	-
	25-34	3.11 (2.75, 3.51) *	1.62205
	35-49	2.61 (2.32, 2,96) *	1.64282
	No Education/ Incomplete Primary	-	-

Education	Complete Primary	1.88 (1.59, 2,22) *	1.87769
	Complete Secondary	1.25 (1.04, 1.51) *	1.81064
	Higher	0.76 (0.62, 0,95) *	1.65383
Spouse Education	No Education/ Incomplete Primary	-	-
	Complete Primary	1.25 (1.09, 1.46) *	1.35374
	Complete Secondary	1.06 (0.90, 1,26)	1.39243
	Higher	0.73 (0.60, 0.89) *	1.31948
Working Status	No	-	-
	Yes	0.76 (0.69, 0.83) *	1.48685
Spouse Working Status	No	-	-
	Yes	2.45 (1.83, 3.29) *	1.45051
Media Exposure	Not Exposed	-	-
	Only One	1.68 (1.41, 1.98) *	1.65879
	Both	1.62 (1.33, 1.97) *	1.70526
Wealth Index	Poorest	-	-
	Poorer	1.30 (1.12, 1.50) *	1.41142
	Middle	1.31 (1.12, 1.54) *	1.67287
	Richer	1.28 (1.08, 1.53) *	1.81267
	Richest	1.47 (1.22, 1.79) *	1.70697
Type of Residence	Rural	-	-
	Urban	0.85 (0.76, 0.94) *	1.86147

*Statistically significant (p-value < 0.05)
***Data source**:* IDHS, 2017

And for the age of the participants, compared to the 15-24 age group, the participation in FPP of participants aged 25-34 years old is 3.11 higher. Meanwhile, participant aged 35-49 years old has tendency of 2.61 times higher to participate in FPP. Focusing in education level of respondents, holding other predictors constant, there were significant differences across level of education of individuals in their attributions of participating in FPP. Relative to individuals that have “no education or incomplete primary” the odds of participation in FPP increase by factors of 1.88 (complete primary education level), 1.25 (complete secondary education level) and 0.76 (higher education level). For spouse education level, relative to spouse’s individuals that has “no education or incomplete primary” the odds of participation in FPP increase by factors of 1.25 for primary education level, but there is no significant difference between no education and complete secondary education. The pattern of association between participants education and participation in FPP show that the higher the level of education, the lower the odds of FPP participation. This finding is similar with previous study **[14]. However, this result still in lined and agreed that education had contribution in women’s empowerment and decision making in FPP **[3]**, **[5]**, **[11]**.

Likewise, a similar pattern was true for the odds of participation in FPP to respondent’s working status and respondent spouse’s working status as well. Relative to individuals that unemployment, the odds of odds of participation in FPP for individuals that has a job (employment) is 24% lower, adjusting other predictors as constant. The reverse of relationships shown for spouse working status, where comparing to unemployment husband/partner, the odds of participation in FPP for employment husband/partner is 145% higher. For media exposure variable, relative to individuals that has no media exposure, the odds of participation in FPP was multiplied by factors 1.68 for those who have only one (radio or televisions) and 1.62 for those who have both (radio and televisions), holding other predictors, the same. According to **[15]**, women mostly received information about family planning from TV and rarely received information from health facilities or newspaper/magazines. Having exposure to media like TV or radio make women easier to access the dissemination of health information **[16].**

In addition, compared to those with categorized as poorest class, the odds of participation in FPP increased by 30% for the poorer, 31% for the middle, 28 for the richer and 47% for the richest class. The wealthy woman were more capable to access modern contraceptive in a better way than poor women **[17]**. For the type of residence, relative to individuals living in rural area, the odds of participating in FPP for individuals living in urban area is decreased by factor 0.84.

As of now, women who are employment are tend not to participate in family planning program, and for the spouse (husband/partner) there is a reverse situation. Another interesting finding is that the rich class of individuals has no significant difference with the poorest class for taking participation in FPP. Due to the type of residence, it found that participants living in urban areas has lower tendency in FPP participation. This is in line with **[11]** which related this finding with the Midwife Program established since 1989. This program was aimed to solve the gaps of reproductive health care especially in rural areas. Findings, needs to be studied and explored in the future. Our findings emphasize the importance of education level, employment status, and socio-economic status such as wealth index and media exposure in participation in family planning program.

4. CONCLUSIONS

Even though, the proportion of participating in FPP is quite large (84.68%), but Indonesians government still need raising awareness to increase this proportion. There are some interesting findings in this study that there were still women having no access to media. This could lead to the lack of information about family planning program. Based on the complex design features of the 2017 IHDS the increased variance estimates of the descriptive statistics will also raise the value of standard error. The higher the standard error the higher the probability of do not reject null hypothesis. Refers to the result this study, the demographic and sosio-economic factors are significantly had strong relationships with the probability of women in reproductive age to take part into family planning program. Hence, the implementation of design-based analysis is fit to the data.

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