‘Knowledge is Power’: Ovulatory Cycle Knowledge and its Impact on Reproductive Outcomes and Empowerment

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ABSTRACT

Ovulatory cycle knowledge (OCK) is an important yet relatively unexplored component in understanding women's reproductive outcomes and empowerment. This study bridges the gap by establishing a causal relationship between reproductive knowledge and reproductive outcomes as well as empowerment. We establish causality by exploiting the nature of this knowledge and the fact that the knowledge transfer occurs from one generation to another. In our main analysis, we use the National Family Health Survey (NFHS) Round 5, and we instrument the knowledge levels of younger women by the average knowledge of older women from same district. We establish a causal link of the impact of ovulatory cycle knowledge on the (i) reproductive outcomes i.e., number of children and age at birth and (ii) empowerment. The wide-ranging implications of OCK established in this study provide the groundwork for policymakers to focus on conducting behavioural interventions to improve reproructive knowledge.

Keywords:

Ovulatory Cycles, Unplanned Pregnancy, Empowerment, Demographic and Health Survey, NFHS-5, India.

1. INTRODUCTION

Women's reproductive outcomes and their level of empowerment[1] have an important bearing on the family's well-being as well as their own health and financial outcomes (Kuipers et al., 2021; Lee-Rife, 2010; Prata et al., 2017). Multiple channels that impact these outcomes have been explored. Much emphasis has been put on the role of education itself, but as yet, little attention has been paid to the impact of reproductive knowledge. We bridge this gap by exploring the role of reproductive knowledge as measured by Ovulatory Cycle Knowledge (OCK) on outcomes related to reproductive health and empowerment decisions. Reproductive knowledge is not only a benefit to a woman's individual rights, but also her key to escaping poverty and improving the well-being of herself, and that of family (Babbar et al., 2022).

It is clear that understanding one's own reproductive system, particularly the ovulatory cycle, is crucial for women and directly makes them better equipped to make informed reproductive decisions. We also show that understanding the reproductive system leads to better empowerment outcomes. Scholars have long established that patriarchal norms are a means to control women's sexuality (Walby, 1989). On the other hand, stronger patriarchal norms are directly correlated with lower empowerment for women via restrictions on women's freedom of movement, decision making and access to financial resources (Mainuddin et al., 2015; Singh & Babbar, 2022). Consequently, there are compelling grounds to believe that a more profound understanding of one's sexuality and reproductive processes will lead to increased levels of empowerment.

Unfortunately, many women possess limited knowledge about the physiology and hormones associated with the reproductive system (Ayoola et al., 2016; Eijk et al., 2016; Garg et al., 2001). Overall, researchers have associated higher education levels (increased schooling) with

[1] For the purpose of this study, we use the definition of relational empowerment. Relational empowerment is measured as a multidimensional construct comprised of two factors: women's freedom of movement and decision-making power (Mainuddin et al., 2015; Singh & Babbar, 2022). Across the paper, we will be referring to relational empowerment as empowerment for the ease of the readers.

improved levels of reproductive knowledge (Dinçer et al., 2014; Getahun & Nigatu, 2020). In India, school curricula has been designed to ensure that girls acquire knowledge about menstruation and ovulation. Unfortunately, it has been observed that either schools just skip these topics (House et al., 2012) or these sessions are delivered with an emphasis on science-based concepts without any practical guidance (Hennegan et al., 2019; Schmitt et al., 2021; Sommer et al., 2016). In the Indian context, there are additional socio-cultural barriers to this knowledge (Lampic et al., 2006).

Since formal education channels do not effectively transmit reproductive knowledge, most girls and women acquire such knowledge is spread via the social networks where women reside (Eijk et al., 2016; Eswi et al., 2012). Mothers have been documented to be an important source of information regarding reproductive health for unmarried girls (Omidvar & Begum, 2011). After marriage women migrate to the residence of their husbands which is frequently at a distance from their natal place (Rosenzweig & Stark, 2015) changing their social context and it has been found that married women tend to share reproductive knowledge with each other (Sivaram et al., 2005)

Our first set of outcome variables are reproductive outcomes where we consider age at first birth, contraceptive usage and contraceptive decision making which are also indicators of planned pregnancies (IIPS and MacroInternational, 2022). Unplanned pregnancies are recognized as a common public health issue (Gipson et al., 2008) impacting around 85 million women worldwide (Sedgh et al., 2014) with 15% of such cases happening in India (*FP 2020 Core Indicator 2015–16 Summary Sheet*, 2020). The unavailability of accurate information around reproductive processes and sex is a significant factor leading to a higher number of pregnancies (Lampic et al., 2006). Studies have also shown that women who receive accurate information about ovulation (before they intend to get pregnant) are more likely to delay their pregnancies (Stanford et al., 2002).

Our second outcome variable is women's empowerment. United Nations have also identified empowerment as a crucial indicator as it is manifested in the Sustainable Development Goals 5 (United Nations General Assembly, 2015). The goals urged the need to end the discrimination against women and girls and empower them to ensure them their bodily autonomy, which can further help in fostering a sustainable growth and development (Duflo, 2012). A systematic review of 67 studies concluded that women's empowerment is significantly associated with mother and child outcomes in developing nations (Pratley, 2016) establishing the importance of understanding the co-variates of empowerment.

By exploring the relationship OCK and these variables, we want to emphasize that understanding the functioning of their reproductive system, i.e., the body's anatomy and ovulation, can help women mitigate unplanned pregnancies (Ayoola et al., 2016) and increased levels of empowerment.

We use the newly released round of the National Family Health Survey (NFHS-5) for our analysis. A unique feature of the NFHS is that it collects data on fertility knowledge, reproductive health and empowerment related outcomes, that we are able to exploit in our analysis. Identifying the causal effect of ovulatory cycle knowledge on the reproductive & empowerment related outcomes presents econometric challenges. The reproductive and empowerment outcomes may not be exogenous on account of omitted variable bias. Underlying social norms that are typically unobserved in survey data often determine ovulatory cycle knowledge and also the reproductive and empowerment related outcomes. In India, seeking knowledge about sexual and reproductive health is taboo and women are stigmatized by socio-cultural beliefs that consider such knowledge as impure. These taboos lead to most adolescent girls experiencing menarche with little to no information about menstruation (Eijk et al., 2016; Guterman et al., 2007). The culture of silence is maintained via prohibitions on bathing, using the kitchen, visiting the temple, and other forms of discriminatory behaviour (such as untouchability) by their family members and others (House et al., 2012; Khanna et al., 2005).

To overcome these endogeneity concerns, we use an Instrumental Variable approach where we exploit the presence of the knowledge-sharing networks, as described above, for our identification strategy. To differentiate between knowledge transmitters and recipients, we focus our attention on women younger than 35 for whom we evaluate the impact of OCK on various outcomes. We posit that women under 35 receive reproductive knowledge from older women and we use the aggregate OCK of women above the age of 35 in the neighbourhood as our instrument. To estimate our desired effect, for each household, we define its neighbourhood to include all other households in the same survey cluster[2]. Our instrument is clearly relevant given the previous research which shows how there is transfer of reproductive knowledge from mother to daughter and also within networks of married women. Our instrument satisfies the exogeneity assumption since knowledge held by older women in the cluster and with whom the respondent does not necessarily interact cannot directly impact the fertility decisions of the individual woman except via having an impact on her OCK. The First stage F-statistic & Kleibergen Paap rk-LM across all specifications are greater than 10, implying that our instrument is strong.

We find that conditional on a comprehensive set of controls and cluster-level characteristics accounting for individual and household level attributes, as well as regional fixed effectswe find a significant positive association between OCK and reproductive and empowerment outcomes. Our results suggest an increase of 2.6%, 4.8%, 4.7%, and 27.4% in age at first birth, contraceptive usage, contraceptive decision-making, and empowerment decisions, respectively for those with OCK vs for those without. Using heterogeneity analysis, our results suggest that women from disadvantaged socio-demographic backgrounds stand to gain the most from OCK education.

The paper next presents data, summary statistics for OCK, reproductive outcomes and empowerment, and socio-demographic variables in Section 2. Next, we devise an estimation strategy to establish a causal link between OCK and reproductive outcomes and empowerment.

[2] The DHS sample is usually based on a two-stage cluster design. First, primary sampling units (PSUs) are drawn from Census Enumeration Areas. Second, out of all listed households within the PSU, a fixed number of households are selected that forms the cluster. In rural areas, a cluster is usually a village whereas in urban areas it is the surrounding locality or apartment complex.

In Section 3, we present the results to establish the causal link between OCK and pregnancy outcomes. The last section presents the conclusion, and policy recommendations.

2. DATA

As a primary data source, we have used Demographic Health Survey (DHS)- India data (round 5), popularly known as National Family Health Survey-5 (NFHS-5), for the study. The NFHS-5 is a nationally representative cross-sectional survey conducted in 2019-21, which gathered information about men aged 15 to 54, women aged 15 to 49, and children below five years. Using a stratified sampling technique, the data is collected on marriage, fertility, nutrition, contraception, women's reproductive health, sexual behavior, domestic violence, and others. NFHS-5 survey data was collected in two phases (Phase I: Jun 2019 to Jan 2020, and Phase II: Jan 2020 to April 2021) from 636,699 households and includes data for 724,115 women and 101,839 men. International Institute of Population Studies (IIPS) has published a national report (IIPS and Macro International, 2022), which consists of detailed information on the study design, sampling strategy.

2.1. Ovulatory Cycle Knowledge

The following question has been considered to identify the dependent variable from the NFHS-5 questionnaire.

The question "From one menstrual period to the next, are there certain days when a woman is more likely to become pregnant if she has sexual relations? Is this time just before her period begins, during her period, right after her period has ended, or halfway between two periods?" with six response options (1= During her period, 2= After the period ended, 3= Middle of the cycle, 4= Before period begins, 5= At any time, 6= Other, 8= Don't know). The answers to this question are converted into our variable interest which is a binary variable called "ovulatory cycle knowledge" or “OCK”. It takes the value as "1" if the respondent answers "Middle of the cycle," otherwise "0". For our baseline regressions, we focus on women in the fertile age group of 15-34. NFHS-5 provides individual-level data collected from 460,608

women[3] aged 15 to 34. Only 21.5 percent of women aged 15-34 could correctly identify the ovulatory period.

Figure 1 shows the average proportion of the population with OCK by age. Overall, the OCK is low across all age groups. It starts increasing with age and remains similar after the age of 25. Figure 1 brings into stark focus the very low levels of OCK amongst adolescent girls in India. This is particularly problematic given that India has one of the highest cases of adolescent pregnancies which have an adverse impact on the mother's health. In fact, complications arising during pregnancy and childbirth have become one of the leading causes of adolescent deaths (WHO, 2020). The low levels of OCK amongst adolescent girls in India indicates that the formal channels of education are ineffective are transferring reproductive knowledge.

Insert Figure 1 about here

2.2. Reproductive Outcomes

We use three reproductive outcomes in our study i.e., age at first birth, contraceptive usage & contraceptive decision making. The first reproductive outcome considered in our study include the age of women at first birth, which is a continuous variable. The second reproductive outcome captures the contraceptive usage of women. Contraceptive usage is modelled as a binary variable takes the value 1 for the usage of any form of the contraceptives including pill, IUD, injections, diaphragm, male condom, female sterilization, male sterilization, periodic abstinence, withdrawal, other traditional, lactational amenorrhea (lam), female condom, foam or jelly, emergency contraception, other modern methods, standard days method (sdm) and 0 otherwise. The third reproductive outcome is the contraceptive decision making. Contraceptive decision is modelled as a binary variable taking takes the value 1 if the women solely or jointly

[3] We have shown data for the women from 15 to 34 years as the data for women aged 35 to 49 is used for constructing the instrumental variable.

with the husband decides to use contraceptive, 0 if she does not participate in the decision-making process.

2.3. Empowerment Outcome

Empowerment is measured as a multidimensional construct comprised of two factors: women's freedom of movement and decision-making power (Mainuddin et al., 2015; Singh & Babbar, 2022). Freedom of movement has been measured using 3 questions from NFHS survey, i.e., "Are you usually allowed to go to the following places (a) market (b) health facility (c) place outside the community" with options (1 = Alone, 2 = With someone else only, 3 = Not at all). Each individual item takes the value 1 if respondent goes alone to the market and 0 otherwise. The decision-making power of women has been measured using 4 questions from NFHS survey, i.e., "Who decides how your husband's earnings will be used?", "Who usually makes decisions about health care for yourself?", "Who usually makes decisions about making major household purchases?", "Who usually makes decisions about visits to your family or relatives?". There were four response options (1= mainly you, 2 = mainly your husband, 3 = you and your husband jointly, 4 = someone else). These items take the value 1 if the decision-making is solely by the respondent or jointly with the husband. Empowerment is measured on a continuous scale by adding all the items for the freedom of movement and decision making (Mainuddin et al., 2015; Singh & Babbar, 2022).

2.4. Empirical Strategy

To understand the causal impact of the OCK on the reproductive outcomes (number of children, age at first birth) and Empowerment, the below-mentioned model was estimated.

$$Y_{ic} = \beta_0 + \beta_1 OCK_{ic} + \theta X_{ic} + StateEF_{ic} + \varepsilon_{ic} \quad \text{--- (1)}$$

where Y_{id} denotes the outcome variable of women 'i' residing in the cluster 'c'. The outcome variable can be one of the age at first birth, contraceptive usage, contraceptive decision making and empowerment. The variable OCK_{ic} denotes the ovulatory cycle knowledge of the woman 'i' residing in cluster 'c'. Our coefficient of interest is β_1 which estimates the association between

OCK and our dependent variables. The control variables are collected in the vector X_{ic} which includes socio-demographic and mass-media control variables, *as discussed in the control variable section*. We also include state fixed effects ($StateEF_{ic}$) to control for any variability in state level health policies. Note than in the case of binary variables (contraceptive usage and contraceptive decision making) we use a linear probability model.

First, the ordinary least square (OLS) regression is implemented to obtain the parameter estimates. However, these estimates may be biased due to the endogeneity issues as it might be that OCK along with age at the first birth, contraceptive usage, contraceptive decision making, and empowerment are determined jointly via traditional norms and customs in the family. Therefore, two-stage least squares instrumental variables (IV) are carried out to attenuate such concerns and uncover the causal mechanism underlying OCK and its impact on the number of children, age at the first birth and empowerment.

To implement our IV technique, we focus our attention on women younger than 35. The instrument we use is the proportion of women above the age of 35 in a district who correctly identify their ovulatory period. The second stage regression is based on equation (1) specified above where we restrict the sample to women under the age of 35 and where we use the instrumented value of OCK. The first stage regression is computed using equation (2) as given below:

$$OCK_{ic} = \beta_2 + \beta_3 Z_c + + \theta' X_{ic} + StateEF_{ic} + \varepsilon_{ic} \qquad \text{------- (2)}$$

The instrument is represented by 'Z_c' and it is theaverage value of OCK for older women residing in the same cluster 'c' as the respondent.

2.5. IV Justification

Sexual and reproductive health have long been taboo subjects in India (Babbar, 2021; Eijk et al., 2016). The restraint around talking about sexual and reproductive health is reflected in the NFHS-3 via questions related to what respondents think should be taught to adolescents. In one question respondents are asked if boys/girls should be taught morals and an overwhelming

number say yes. At the same time there is no such approval for boys/girls being taught about the changes going in their bodies and those of the opposite sex during puberty.

Formal educational channels have faced roadblocks when trying to impart reproductive knowledge. A case in point is the Adolescent Education Program (AEP) which was introduced to facilitate sexuality education by the Department of Education (Ministry of Human Resource Development) in 2007 (*Adolescence Education Programme*, n.d.). An important objective of the program to facilitate understanding of physical changes during adolescence and also to understand issues related to gender, sexuality, and HIV/AIDS. The research clearly indicates a strong need for adolescent sexuality education in India. Yet, the AEP was met with strong opposition with some states immediately banning it and many others following suit. The critique that came from some quarters was that the material was very graphic and not suitable for Indian audiences. Educators have faced threats if they taught material from the AEP.

The discussion above makes it clear that formal education can only go so far in terms of providing comprehensive sex education and OCK. In fact, in the developing world, parents, teachers, health workers and peers are most often cited as the sources of information regarding sexual and reproductive health (Eijk et al., 2016; Sharma et al., 2020). Women repeatedly cite their female relatives and friends as trusted sources of information in these matters (Eijk et al., 2016). In fact, what has been found is that married women in a city tend to the most important sources of information for each other and form a tight network for information exchange (Juayire, 2016).

Keeping the findings from the above literature in mind, we use the knowledge of older women in the vicinity as an instrument for OCK. We use as our instrument the average OCK of women above 35 years old residing in the same cluster to explain the OCK of women below the age of 35. Our instrument satisfies the requirement of power given the literature above. In fact, our instrument easily exceeds the conventional benchmark for power of $F = 10$ in the first stage (Stock et al., 2002). Next, the instrument must satisfy validity which is equivalent to the

instrument being uncorrelated with the error term in the second stage. In our case, this means that average OCK of older women from the cluster must be uncorrelated with the respondent's reproductive outcomes and empowerment scores after controlling for predicted respondent OCK and other observed characteristics. This is likely to be the case since we do not expect the respondent to be directly in contact with all the older women in the cluster and working on their advice for her private decisions.

One channel which could bring validity into question is a common policy environment which impacts both the respondents OCK and the that of the older generation while also having an impact on reproductive outcomes and empowerment scores. Health and education policies are formulated and implemented at the state level and to control for such shocks, we include state level fixed effects. To further strengthen our results, we also conduct a **falsification** test. We include the randomly allocate the average OCK of older women to other clusters as a control for women's knowledge and as expected see that such randomly allocated average OCK of older women has no impact on women's ovulatory cycle knowledge. As additional checks for robustness, we also check if the results are different for migrant women vs non-migrant women. Women who have migrated away from their natal homes might lose their initial social network and to the extent that they do not reform a social network in their marital home, their OCK might not depend on the OCK of older women in their cluster. We find that our results hold for both migrant and non-migrant women. As a final check of robustness, we change the sensitivity of age cutoff of 35 but we find that our results continue to hold for different cutoffs.

Our variables of interest are reproductive outcomes as well as empowerment. The discussion above motivates why we think our instrument is valid. The existing work around women's knowledge sources and transfer of knowledge indicate that the knowledge of older women in the region explains the OCK of an individual woman. At the same time, the instrument must satisfy the exclusion restriction since the knowledge related to OCK held by

older women cannot directly influence the reproductive behaviour of the individual women except by influencing her OCK.

2.6. Control Variables

We use several individual and household level controls which can additionally impact OCK and reproductive behaviour. Past reports have suggested the importance of the socio-cultural factors in understanding the OCK (WHO, 2020). Pregnancies are more likely to occur in socio-economically disadvantaged families, primarily driven by the lack of education (Bunting & Boivin, 2008; Iyanda, 2020; Skirbekk & Samir, 2012; Stern et al., 2013), higher poverty levels (*Ending Child Marriage: Progress and Prospects - UNICEF DATA*, 2014; Mahey et al., 2018), area of living (Dagnew et al., 2021; Getahun & Nigatu, 2020) and age (Lundsberg et al., 2014). In India, religion and caste also play an important role in understanding the socio-cultural factors. Previous studies have also shown the importance of mass-media exposure in improving the knowledge of the ovulatory cycle (Dagnew et al., 2021; Uddin & Choudhury, 2008).

3. RESULTS

3.1. Sociodemographic characteristics of participants

The study used data of 460,608 women aged 15 to 34 who participated in the NFHS-4 survey. Descriptive statistics for OCK and OCK by socio-demographics of the women are presented in Table 1.

Insert Table 1 about here

The OCK is similar among women in urban (24.06%) and rural (20.76%). The OCK is similar across the religions i.e., Sikh (25.34%), followed by Muslims (24.26%), and 21% for Others, Christian and Hindu women. Concerning the social group affiliations of the respondents, OCK is lowest in the Scheduled Caste group (19.98%). In comparison, the highest proportion of OCK is found in the General category (24.72%). The OCK increases with the

increase in the education level of the respondents. It is observed that 28.06% of the women with higher education can correctly recognize the period of ovulation. The prevalence of OCK also increases from the bottom to the upper wealth quantile of the women. About 27% of the women in the wealthiest quantile are aware of the ovulatory cycle compared to 18% of the women in the poorest wealth quantile. OCK is higher among the women who heard/see the family planning messages via mass media, including radio, tv, newspaper, or wall.

3.2. Reproductive Outcomes

We present our baseline results for reproductive outcomes i.e., age at first birth, contraceptive usage and contraceptive decision making in Tables 2-4, respectively.

3.2.1. Age at first birth

Table 2 reports the baseline results for age at first birth. We report the OLS estimates in col (1)-(3) for comparison with our IV estimates in col (4)-(6). Column (1) presents the initial association between OCK and her age at first birth from an OLS estimation with no controls or state-fixed effects. As we move across to columns (2) and (3), we add demographic controls and state fixed effects, respectively. The estimates in column (3) with all the relevant controls and state fixed effects show that the OCK is associated with a statistically significant increase of 3.1% point (pp) in the age at first birth. While these results are not causal, they are a useful benchmark to compare with our LPM estimates.

Given that our reproductive outcome is continuous, we utilized IVREG estimation using the IV approach. The IVREG results are presented in the same progression as the OLS results. From column (4), we found an initial positive association of 9.8 pp between OCK and age at first birth. These estimates reduced to 5pp once we control for demographic characteristics, as shown in column (5). Once we control for state fixed effects, our estimates show that the OCK is associated with statistically significant increase of 2.6pp in the age at first birth. We find these effects to be consistently statistically significant.

Insert Table 2 about here

3.2.2. Contraceptive Usage

Table 3 reports the baseline results for contraceptive usage in the same progression as number of children. Contraceptive usage is a binary variable, hence, we utilized LPM estimation using the IV approach. Col (1)-(3) reports the OLS estimates followed by LPM estimates in col (4)-(6). Col (3) suggests that the OCK increases the likelihood of contraceptive usage increases by 13.9pp. Using the most preferred specification in column (6), we found that the likelihood of contraceptive usage increases by 4.8pp for women with OCK. Our results remain statistically significant across all the specifications.

Insert Table 3 about here

3.2.3. Contraceptive Decision Making

Table 4 reports the baseline OLS & IV estimates for contraceptive decision making. We see a similar pattern for contraceptive decision making as that for contraceptive usage and age at first birth. The OLS estimates from col (3) show a positive association between OCK and contraceptive decision making by the order of 13.1 pp. Using the most preferred specification in column (6), we found that the OCK is associated with statistically significant increase of 4.7 pp in the likelihood of contraceptive decision making. Our results remain statistically significant across all the specifications.

Insert Table 4 about here

3.3. Empowerment Outcomes

Table 5 reports the baseline results for the empowerment outcome. Columns (1)-(3) report the OLS estimates and columns (4)-(6) the IV results. The OLS findings in column (3) indicate a positive correlation between OCK and empowerment, with an increase of 47.4 pp. The IV results reveal that women have higher empowerment, with an increase of 27.4 pp, when they higher levels of OCK. These effects are statistically significant.

Insert Table 5 about here

Overall, we find that reproductive and empowerment outcomes are positive and statistically significant for women with OCK. Our model performs exceptionally well when subjected to diagnostic tests aimed at evaluating the effectiveness and trustworthiness of the IV. In our preferred specification, the First Stage F-statistic significantly exceeding 10 in all specifications. This high value indicates the strength of our instrument. Additionally, the Kleibergen Paap rk-LM statistic enables us to reject the null hypothesis, demonstrating that the instrument is indeed correlated with the endogenous regressor. This result underscores the relevance and correlation of our instrument with the endogenous regressor.

3.4. Robustness Checks

3.4.1. Falsification Tests

One possible concern with the estimation procedure is that the effect observed in our regressions may not necessarily be attributed to the OCK. According to our identification strategy, we anticipate that, in the absence of any meaningful OCK, we would not obtain statistically significant effect. To provide additional confidence in our identification strategy, we perform a falsification exercise, which serves as a second-best solution. In this test, we randomly assign OCK values to respondents, essentially manipulating this variable, and then run the same

regression models as in our main analysis. As expected, we do not find the estimates are significant at conventional levels in both specifications[4].

3.4.2. Migrant vs Non-Migrant Women

Past literature has shown knowledge sharing networks in which mothers and elderly figures in a woman's neighborhood are purported to be the most important source of transmission of her reproductive knowledge. However, most women move away from their family of origin upon marriage. One may argue that as the woman moves out of her natal home after marriage, the channel of transmission from older to younger women is valid only within her natal village. To improve the robustness of our results, we divide our analysis into migrant versus non-migrant women[5], as shown in Table 6.

Insert Table 6 about here

Consistent with the baseline effects, we observe statistically significant results in reproductive and empowerment outcomes as the OCK increases. Thus, our baseline results remain qualitatively unchanged and largely robust for migrant and non-migrant women. The sole exception to this pattern is the statistically insignificant result we obtained concerning the age at delivery among migrant women.

3.4.3. Sensitivity Analysis

One potential concern that one may raise is around the cut-off age of our instrumental variable i.e., 35 years. To address this concern, we re-ran our results with different cut-off age from 30 to

[4] We have run the falsification tests and results are available on request.

[5] We divide the respondents in migrant versus non-migrant. Migrant is a binary variable which takes the value 1 if the respondent is staying in the same place for less than 5 years and 0 otherwise.

45 years, as shown in Table 7(a)-(c). Our results continue to hold even with these changes. These tests clearly highlight that our results are robust to changes in data and other specifications.

Insert Table 7(a)-7(c) about here

3.5. Heterogeneity Analysis

We have documented average effects of OCK on reproductive outcomes and empowerment-related decisions. We conducted various sub-group analysis to evaluate whether our main results vary across different sub-samples i.e., area of living, caste, education levels and wealth index. We present the estimates in Table 8-11. First, we discuss the results in Table 8, which discusses the heterogenous effects by area of living. We find that women with higher levels of OCK had better reproductive outcomes and empowerment in both urban and rural areas. However, the results were statistically significant only for the women living in the rural areas. Similarly, our results were positive and statistically significant for empowerment decisions for women living in the rural areas. For contraceptive usage and decision making, statistically significant results were observed for both urban and rural areas, however, the magnitude was higher for women from the rural areas.

Insert Table 8-9 about here

Table 9 presents the results for the women belonging to the backward and non-backward castes. We note that the results are statistically significant for women from the backward castes for age at delivery and empowerment decisions. However, for contraceptive usage and decision making the estimates remains statistically significant for women from the both the groups, however, the magnitude was higher for women from backward castes. We found similar results in Table 10 and 11 for education levels and wealth index, respectively. Our results were

statistically significant for age at delivery for women with lower education. Similarly, empowerment decisions were statistically significant for women from poorer wealth index. For contraceptive usage & decision making, the estimates were positive & statistically significant for education levels as well as wealth index, however, the magnitudes were higher for women with higher education and those belonging to poor and middle class. All this evidence shows that our results were significant across the different sub-samples, however, the magnitude was higher for the women lower socio-demographics.

Insert Table 11-12 about here

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4. CONCLUSION

In this paper, we attempt to show a causal relationship between ovulatory cycle knowledge and reproductive & empowerment related decisions. While previous studies have tried to understand the associations between unintended and unplanned pregnancies and (i) the use of contraceptives (Ayoola et al., 2016; Bellizzi et al., 2020; Fotso et al., 2014; Grindlay et al., 2018; Jarolimova et al., 2018; Mayondi et al., 2016), (ii) socio-economic factors, including education levels and living area among other factors (Adhikari et al., 2009; Dutta et al., 2015; Exavery et al., 2014). Our study tries to emphasize that understanding the functioning of their reproductive system, i.e., the body's anatomy and ovulation, can help women mitigate unplanned pregnancies (Ayoola et al., 2016) and be reflected in the reproductive and empowerment related decisions.

Considering the endogeneity issues in establishing a causal link between OCK and reproductive & empowerment related outcomes, we utilize an IV approach to answer this question. Our study uses the existence of intergenerational transmission of OCK from the older women to the younger women as a potential IV. By exploiting exogenous variation in the average OCK of women aged 35 and above in the same district, we find novel estimates of the impact of OCK on her reproductive and empowerment outcomes. Our results show that

ovulatory cycle knowledge is an important predictor of the reproductive and empowerment related decisions. We found that OCK is significantly and positively associated with the age ta first birth, contraceptive usage, contraceptive decisions, and empowerment related decisions. We also document some interesting heterogeneity results, where we found that women from poorer-socio backgrounds were at a larger benefit at age at first birth and empowerment related decisions.

The results in our paper highlight the need for better reproductive knowledge via sexual education programs. In low- and middle-income countries like India, topics like sex are surrounded by multiple taboos and myths. Additionally, there have always been concerns and objections to sex education at individual, household, and community levels. At the same time, studies have established that sex education helps the women in taking their own responsibilities for consensual and safe sexual relationships (Naezer et al., 2017) and that the lack of such education makes it difficult for the women to make the right and informed decisions related to their health (Armas, 2007). Thus, it is important to design sex education modules at school level to remove the existing taboos and myths and create an open conversation about it.

The Indian government has started various initiatives like Beti Bachao, Beti Padao Abhiyaan (Ministry of Women and Child Development Government of India New Delhi, 2018) to improve girls' education and to eventually help increase their average age of getting married. Our results provides robust evidence that it is important to expand basic school education to include practical guidance related to ovulatory cycle and reproductive health (Babbar et al., 2021; Babbar & Garikipati, 2023). Our study shows how increased awareness about reproductive functions can have far reaching consequences. A reproductive knowledge session is after all a very small module of the overall education curriculum. Our study highlights that while the module is small, the consequences it has are big and thus attention needs to be paid to ensure that delivery of this module is not compromised. Additionally, it must be ensured that those who are socio-economically backward have access to this information.

OCK can be improved by starting school and community-related education programs to enhance the communication around sexual and reproductive health issues within the schools and family (Phillips-Howard et al., 2016). For school-based programs, the approach needs to go beyond just providing mid-day meals, clean toilets, providing free/subsidized sanitary napkins to including a revised curriculum and sensitization workshops for both boys and girls around sexual and reproductive health (Martin et al., 2022). The government and policymakers can do this by strengthening the existing programs like Rashtriya Kishor Swasthya Karyakram (RKSK). We suggest that the government and policymakers start focusing on improving the OCK of Accredited Social Health Activists (ASHA) and other health workers and schoolteachers. These two are the primary pillars to conduct the interventions at the school and community levels. Such programs will empower the ASHA, local health workers, and schoolteachers to educate the boys and girls in the school and community. They can help improve sex education at the grassroots, thereby reducing the high number of unplanned pregnancies.

Policymakers should provide space for strengthening the interactions between the community and health workers to emphasize the ovulatory cycles. We need more research to understand how and in what ways these government initiatives contribute to enhanced understanding of ovulatory cycles so that the awareness messages, counselling sessions, and ad campaigns can be strategically designed to address the specific needs.

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Tables & Figures

Table 1. Socio-demographic characteristics of participants

Variables	Respondent Characteristics		Ovulatory Cycle Knowledge	
	Number	Percentage (%)	Number	Prevalence (%)
Place of residence				
Urban	110345	23.96%	26554	24.06%
Rural	350263	76.04%	72730	20.76%
Religion				
Hindu	345167	74.94%	72602	21.03%
Muslim	61582	13.37%	14939	24.26%
Christian	32567	7.06%	6838	21.02%
Sikh	9728	2.11%	2465	25.34%
Others	11594	2.52%	2440	21.05%
Caste				
Scheduled Caste	91325	20.84%	18247	19.98%
Scheduled Tribe	86871	19.82%	17614	20.28%
OBC	175881	40.13%	36129	20.54%
None of them	81641	18.63%	20183	24.72%
Don't Know	2554	0.58%	384	15.04%
Education Level of Respondent				
No Education	59359	12.89%	11064	18.64%
Primary	43353	09.41%	8729	20.13%
Secondary	274931	59.69%	56207	20.44%
Higher	82965	18.01%	23284	28.06%
Wealth Index				
Poorest	97877	21.25%	17319	17.69%
Poorer	104017	22.58%	20502	19.71%
Middle	96386	20.93%	20554	21.32%
Richer	88057	19.12%	20841	23.67%
Richest	74271	16.12%	20068	27.02%
Heard Family Planning on Radio				
No	390723	84.83%	82259	21.05%
Yes	69879	15.17%	17025	24.36%
Heard Family Planning on TV				
No	190753	41.41%	34013	17.83%
Yes	269849	58.59%	65271	24.19%
Read Family Planning in Newspaper				
No	289403	62.83%	55860	19.30%
Yes	171199	37.17%	43424	25.36%
Seen family planning message on a wall or hoarding				
No	195314	42.40%	35318	18.24%
Yes	265288	57.60%	63666	24.00%

Table 2. Effect of Ovulatory Cycle Knowledge on Reproductive Outcomes- Age at first birth, NFHS-5 (2019-2021).

	OLS			IVREG		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Ovulatory Cycle Knowledge	0.051***	0.034***	0.031***	0.098***	0.050***	0.026***
	(0.004)	(0.004)	(0.004)	(0.009)	(0.009)	(0.009)
Observations	266,878	251,892	251,892	266,683	251,703	251,703
Demographic Characteristics	No	Yes	Yes	No	Yes	Yes
State FE	No	No	Yes	No	No	Yes
First Stage F Statistic				37349	32184	27040
Kleibergen-Paap rK-LM Statistic				7029	6346	5672

Col (1) – (3) present OLS estimates of the effect of ovulatory cycle knowledge on age at first birth. Col (4) – (6) present the IV results estimated using IVREG. The outcome variable is a continuous variable for the age at first birth. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 3. Effect of Ovulatory Cycle Knowledge on Reproductive Outcomes-Contraceptive Usage, NFHS-5 (2019-2021).

	OLS			LPM		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Ovulatory Cycle Knowledge	0.137***	0.140***	0.139***	0.048***	0.059***	0.048***
	(0.002)	(0.002)	(0.002)	(0.006)	(0.005)	(0.006)
Observations	488,413	461,989	461,989	488,119	461,703	461,703
Demographic Characteristics	No	Yes	Yes	No	Yes	Yes
State FE	No	No	Yes	No	No	Yes
First Stage F Statistic				32564	29024	24972
Kleibergen-Paap rK-LM Statistic				6967	6404	5689

Col (1) – (3) present OLS estimates of the effect of ovulatory cycle knowledge on contraceptive usage. Col (4) – (6) present the IV results estimated using LPM. The outcome variable is a binary variable which takes the value 1 if the respondent uses contraceptives, and 0 otherwise. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 4. Effect of Ovulatory Cycle Knowledge on Reproductive Outcomes-Contraceptive Decision Making, NFHS-5 (2019-2021).

	OLS			LPM		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Ovulatory Cycle Knowledge	0.132***	0.133***	0.131***	0.057***	0.061***	0.047***
	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)	(0.006)
Observations	488,413	461,989	461,989	488,119	461,703	461,703
Demographic Characteristics	No	Yes	Yes	No	Yes	Yes
State FE	No	No	Yes	No	No	Yes
First Stage F Statistic				32564	29024	24972
Kleibergen-Paap rK-LM Statistic				6967	6404	5689

Col (1) – (3) present OLS estimates of the effect of ovulatory cycle knowledge on contraceptive usage. Col (4) – (6) present the IV results estimated using LPM. The outcome variable is a binary variable which takes the value 1 if the respondent makes contraceptive decision solely or in consultation with husband, and 0 otherwise. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 5. Effect of Ovulatory Cycle Knowledge on Empowerment, NFHS-5 (2019-2021).

	OLS			IVREG		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Ovulatory Cycle Knowledge	0.589***	0.458***	0.474***	0.404***	0.245***	0.274***
	(0.065)	(0.066)	(0.065)	(0.065)	(0.066)	(0.068)
Observations	44,685	42,167	42,167	44,651	42,133	42,133
Demographic Characteristics	No	Yes	Yes	No	Yes	Yes
State FE	No	No	Yes	No	No	Yes
First Stage F Statistic				8649	7425	6296
Kleibergen-Paap rK-LM Statistic				1951	1786	1636

Col (1) – (3) present OLS estimates of the effect of ovulatory cycle knowledge on contraceptive usage. Col (4) – (6) present the IV results estimated using IVREG. Empowerment is measured as a multidimensional construct comprised of two factors: women's freedom of movement and decision-making power (Mainuddin et al., 2015; Singh & Babbar, 2022). Freedom of movement has been measured using 3 questions from NFHS survey, i.e., "Are you usually allowed to go to the following places (a) market (b) health facility (c) place outside the community" with options (1 = Alone, 2 = With someone else only, 3 = Not at all). Each item takes the value '1' if women are allowed to go alone, and 0 otherwise. The decision-making power of women has been measured using 4 questions from NFHS survey, i.e., "Who decides how your husband's earnings will be used?", "Who usually makes decisions about health care for yourself?", "Who usually makes decisions about making major household purchases?", "Who usually makes decisions about visits to your family or relatives?". There were four response options (1= mainly you, 2 = mainly your husband, 3 = you and your husband jointly, 4 = someone else). Each item takes the value 1, if the respondent makes sole or joint decision with the husband and 0 otherwise. Empowerment was measured on a continuous scale by adding all the items for the freedom of movement and decision making (Mainuddin et al., 2015; Singh & Babbar, 2022).
The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 6. Effect of Ovulatory Cycle Knowledge on Reproductive & Empowerment-related outcomes for Non-Migrant & Migrant women, NFHS-5 (2019-21)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Age at Delivery		Contraceptive Usage		Contraceptive Decision-Making		Empowerment	
VARIABLES	Non-Migrant	Migrant	Non-Migrant	Migrant	Non-Migrant	Migrant	Non-Migrant	Migrant
Ovulatory Cycle Knowledge	0.031***	0.017	0.043***	0.065***	0.043***	0.062***	0.290***	0.252**
	(0.010)	(0.015)	(0.006)	(0.009)	(0.006)	(0.009)	(0.074)	(0.104)
Observations	188291	63412	357934	103,769	357,934	103,769	28,471	13,662
Demographic Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic	23104	11983	20111	14393	20111	14393	4906	2790
Kleibergen-Paap rK-LM Statistic	5269	3686	5234	4307	5234	4307	1445	980.2

Col (1) – (2) and (7)-(8) present IV estimates using IVREG for the effect of ovulatory cycle knowledge on reproductive and empowerment-related outcomes for migrant and non-migrant women. Col (3) – (6) present the estimates using the LPM. The sample is restricted to women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 7(a). Effect of ovulatory cycle knowledge on reproductive and empowerment outcome via women's OCK with cut-off age as 30.

VARIABLES	(1) Age at Delivery	(2) Contraceptive Usage	(3) Contraceptive Decision Making	(4) Empowerment
Ovulatory Cycle Knowledge	0.032***	0.048***	0.048***	0.234***
	(0.007)	(0.005)	(0.005)	(0.059)
Observations	251,890	461,980	461,980	42,167
Demographic Characteristics	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
First Stage F Statistic	93155	53814	53814	15357
Kleibergen-Paap rK-LM Statistic	6723	6523	6523	1952

Col (1) & (4) present the IV estimates using IVRE for the effect of ovulatory cycle knowledge on reproductive and empowerment-related outcomes with the cut-off age for the instrument as 30. Col (3) – (6) present the estimates using the LPM. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 7(b). Effect of ovulatory cycle knowledge on reproductive and empowerment outcome via women's OCK with cut-off age as 40.

VARIABLES	(1) Age at Delivery	(2) Contraceptive Usage	(3) Contraceptive Decision Making	(4) Empowerment
Ovulatory Cycle Knowledge	0.018*	0.048***	0.047***	0.266***
	(0.009)	(0.006)	(0.006)	(0.073)
Observations	250,421	459,745	459,745	41,960
Demographic Characteristics	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
First Stage F Statistic	16941	17208	17208	4280
Kleibergen-Paap rK-LM Statistic	5224	5288	5288	1490

Col (1) & (4) present the IV estimates using IVREG command for the effect of ovulatory cycle knowledge on reproductive and empowerment-related outcomes with the cut-off age for the instrument as 40. Col (2) & (3) present the estimates using LPM. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 7(c). Effect of ovulatory cycle knowledge on reproductive and empowerment outcome via women's OCK with cut-off age as 45.

VARIABLES	(1) Age at Delivery	(2) Contraceptive Usage	(3) Contraceptive Decision Making	(4) Empowerment
Ovulatory Cycle Knowledge	0.025**	0.046***	0.042***	0.217**
	(0.011)	(0.007)	(0.007)	(0.089)
Observations	232,764	429,506	429,506	39,207
Demographic Characteristics	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
First Stage F Statistic	8899	8843	8843	2143
Kleibergen-Paap rK-LM Statistic	4151	4238	4238	1125

Col (1) & (4) present the IV estimates using IVREG command for the effect of ovulatory cycle knowledge on reproductive and empowerment-related outcomes with the cut-off age for the instrument as 45. Col (2) & (3) present the estimates using LPM. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 8. Heterogeneity Analysis- Area of Living.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Age at Delivery		Contraceptive Usage		Contraceptive Decision-Making		Empowerment	
VARIABLES	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Ovulatory Cycle Knowledge	0.024	0.019*	0.047***	0.049***	0.043***	0.049***	0.099	0.323***
	(0.017)	(0.010)	(0.011)	(0.007)	(0.011)	(0.007)	(0.131)	(0.079)
Observations	55,520	196,183	110,163	351,540	110,163	351,540	9,469	32,664
Demographic Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic	7054	19980	7400	17688	7400	17688	1619	4627
Kleibergen-Paap rK-LM Statistic	1539	4144	1625	4070	1625	4070	430.4	1195

Col (1) – (2) & (7)-(8) present the IVREG estimates of the effect of ovulatory cycle knowledge on reproductive and empowerment-related outcomes by area of living. Col (3)-(6) present the same estimates using LPM. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 9. Heterogeneity Analysis- Caste.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Age at Delivery		Contraceptive Usage		Contraceptive Decision-Making		Empowerment	
VARIABLES	Lower Caste	Upper Caste	Lower Caste	Upper Caste	Lower Caste	Upper Caste	Lower Caste	Upper Caste
Ovulatory Cycle Knowledge	0.027***	0.010	0.042***	0.070***	0.043***	0.063***	0.298***	0.110
	(0.010)	(0.019)	(0.006)	(0.012)	(0.006)	(0.012)	(0.073)	(0.142)
Observations	206,122	45,581	375,077	86,626	375,077	86,626	34,447	7,686
Demographic Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic	23660	6291	21690	6196	21690	6196	5175	1412
Kleibergen-Paap rK-LM Statistic	5004	1967	5020	1998	5020	1998	1429	472.2

Col (1) – (2) & (7)-(8) present the IVREG estimates of the effect of ovulatory cycle knowledge on reproductive and empowerment-related outcomes by caste. Col (3)-(6) present the same estimates using LPM. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 10. Heterogeneity Analysis- Education Levels.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Age at Delivery		Contraceptive Usage		Contraceptive Decision-Making		Empowerment	
VARIABLES	Low Edu	Higher Edu	Low Edu	Higher Edu	Low Edu	Higher Edu	Low Edu	Higher Edu
Ovulatory Cycle Knowledge	0.021**	0.013	0.047***	0.052***	0.047***	0.047***	0.234***	0.459***
	(0.009)	(0.020)	(0.006)	(0.010)	(0.006)	(0.010)	(0.072)	(0.129)
Observations	220,013	31,690	380,002	81,701	380,002	81,701	36,063	6,070
Demographic Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic	24448	6388	21610	8857	21610	8857	5455	1390
Kleibergen-Paap rK-LM Statistic	5197	2374	5055	3289	5055	3289	1474	576.5

Col (1) – (2) & (7)-(8) present the IVREG estimates of the effect of ovulatory cycle knowledge on reproductive and empowerment-related outcomes by education. Col (3)-(6) present the same estimates using LPM. Education Level of the respondent as defined by NFHS is into four groups i.e., No Education, Primary, Secondary & Higher. We construct it into two groups. First group comprises of individuals with secondary or lower education, whereas the other group comprises of individuals with higher education. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.

Table 11. Heterogeneity Analysis- Wealth Index.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Age at Delivery		Contraceptive Usage		Contraceptive Decision-Making		Empowerment	
VARIABLES	Poor	Rich	Poor	Rich	Poor	Rich	Poor	Rich
Ovulatory Cycle Knowledge	0.017	0.024*	0.050***	0.046***	0.046***	0.050***	0.320***	0.182*
	(0.011)	(0.013)	(0.007)	(0.008)	(0.007)	(0.008)	(0.081)	(0.104)
Observations	167,862	83,841	298,583	163,120	298,583	163,120	27,588	14,545
Demographic Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F Statistic	18230	13263	16065	13467	16065	13467	4056	2925
Kleibergen-Paap rK-LM Statistic	3983	3359	3938	3488	3938	3488	1121	880.3

Col (1) – (2) & (7)-(8) present the IVREG estimates of the effect of ovulatory cycle knowledge on reproductive and empowerment-related outcomes by wealth index. Col (3)-(6) present the same estimates using LPM. Wealth Index as defined by NFHS is into five groups i.e., Poorest, Poor, Middle, Rich, and Richest. We construct it into two groups. First group comprises of individuals from poorest, poor, and middle background, whereas the other group comprises of individuals from rich and richer wealth index. The sample is restricted to the women who are 35 years and below. Standard errors (in parentheses) are clustered at the cluster level. ***, **, and * represent significance at 1%, 5% and 10%, respectively.