Post sterilization regret in India: new evidence on trends, patterns, and determinants

Evidence on post sterilization regret in India are limited. We use data from the Indian National Family Health Surveys (NFHS) conducted in 2005-06 and 2015-16 to examine trends, patterns, and determinants of post sterilization regret in India. We use a multivariable binary logistic regression model, propensity score matching, and multivariate decomposition to analyze the data. Post sterilization regret has increased from 5% in 2005-06 NFHS to 7% in 2015-16 NFHS. The mean age at sterilization remained unchanged during this period. Women who report poor quality of service during and immediately after sterilization were more likely to regret the sterilization than those who rate the care as good. Women who do not have both sons and daughters, women who reported losing a child after sterilization, and those with lower parity were more likely to report regret compared with their counterparts. Change in the composition of 'parity at sterilization', 'sex composition of children' 'women's schooling', 'being informed that they cannot have more children after sterilization', and 'geographic region' contributed to the increase in the percentage of women reporting regret between the two surveys. Change in composition of 'experience of a child loss after sterilization' reduced post sterilization regret between the two surveys.

Key words: sterilization, regret, propensity score matching, multivariate decomposition, NFHS, India

Introduction

India is the first country in the world to launch an official family planning programme in the early 1950s (Ledbetter 1984: Srinivasan 1998). Male and female sterilization were introduced in the official family planning programme in 1966 (Gwatkin 1979). Vasectomies were more popular until the Emergency in India in the late 1970s (Basu 1985; Gwatkin 1979). This was the time when method acceptance shifted from male sterilization to female sterilization (Basu 1985). Since then female sterilization has been the dominant method of family planning in India. Recent data from the 2015-16 Indian National Family Health Survey (NFHS-4) suggest that 36% of the currently married women age 15-49 years in India are using female sterilization. Only 9%, 4%, and 2% of women are using condoms, oral pills, and intrauterine devices (IIPS and ICF 2017). Among the bigger states, the current use of female sterilization ranges between 10% in Assam and 68% in Andhra Pradesh. Moreover, there has not been any change in the current use of sterilization between the 2005-06 round of NFHS (37%) and the 2015-16 round (36%).

Recent data from the Ministry of Health & Family Welfare (MoHFW), Government of India, suggest that over 4 million sterilizations were carried out in India in 2014-15 (MoSPI 2016). If we include the sterilizations that are carried out in private facilities and are not reported, this figure is likely to increase considerably. Given the very high number of users of female sterilization in the country, the quality of care during and immediately after sterilization occupies a central place. An important issue that arises here is the post sterilization regret. A number of studies from different parts of the world have shown that a significant proportion of women who have undergone sterilization do regret sterilization in later life. Various studies in different settings have reported the sterilization regret at or around 10% (Gray 1996; Henshaw and Singh 1986; Marcil-Gratton 1988; Ramanathan and Mishra 2000; Vieira and Ford 1996). In Brazil, where the use of female sterilization is the highest in the world, the sterilization regret lies between 10-20% (Curtis Mohllajee and Peterson 2006; Gray 1996; Hapugalle et al. 1989; Henshaw and Singh 1986; Kim et al. 1997; Loaiza 1995; Marcil-Gratton 1988). India is also not far behind. The 2015-16 round of NFHS shows that 7% of the sterilized women age 15-49 years reported regret, an increase from 5% in the 2005-06 round of NFHS.

A number of studies have also highlighted the factors associated with sterilization regret. Young age at sterilization is one of the factors associated with post sterilization regret (Curtis, Mohllajee and Peterson 2006; Hardy et al. 1996; Jamieson 2007; Malhotra, Chanana and Garg 2007; McGonigle and Huggins 1990; Schmidt et al. 2000;Singh et al. 2012). Another important factor for post sterilization regret is the death of a child. Women who lose a child after sterilization are more likely to regret the sterilization compared with women who do not (Chi and Jones 1994; Hapugalle et al. 1989; Kim et al. 1997; Ludermir et al. 2009; Machado, Ludermir and da Costa 2005; Ramanathan and Mishra2000; Singh et al. 2012). Women who have a higher number of children at sterilization are found to report less regret compared with women who have fewer children (Loaiza 1995; Malhotra, Chanana and Garg 2007; Schmidt et al. 2000; Singh et al. 2012). The sex composition of children is also found to be associated with regret. Women having only male children are less likely to report regret compared with women who have only female children (Kim et al. 1997; Malhotra, Chanana and Garg 2007; Singh et al. 2012). Studies have also found an association between marital status and regret. Compared with currently married women, women who are divorced/separated/widowed report higher regret (Chi and Jones 1994; Hillis et al. 1999; Kim et al. 1997; Loaiza 1995; Ludermir et al. 2009; Machado, Ludermir and da Costa 2005; Nervo et al. 2000; Platz-Christensen1992; Vieira and Ford 1996). A number of other socio-economic variables are also associated with regret (McGonigle and Huggins 1990; Singh et al. 2012).

India has undergone tremendous socio-economic transformations since the 2005-06 NFHS. The Government of India has also launched a number of ambitious programmes to improve the health of the Indian population in general and the vulnerable population in particular. The National Rural Health Mission (NRHM), now renamed as the National Health Mission (NHM), is one of the flagship programmes of the Government of India. The 2015-16 NFHS (NFHS-4) shows tremendous improvements in female literacy, females attending 10 or more years of schooling, use of improved sanitation and clean fuel for cooking, and use of antenatal care, delivery, and postnatal care services. Studies have shown that these flagship programmes have started paying dividends in terms of improved maternal and child health in the country (Lim et al. 2010; Powell-Jackson, Mazumdar and Mills 2015; Randive, Diwan, Costa 2013). Marriage institution is also undergoing dramatic changes in the country. Although there is no systematic study that examined the trends and patterns in divorce and separation in India, the increasing number of family court cases and newspaper articles indeed suggest that divorce and separation are on the rise in India. Recent data from Azad

India Foundation suggests that Kolkata and Chennai have recorded a 200% increase in the divorce rate since the 1990s. While Kerala has seen an increase of 350%, Punjab and Haryana have registered an increase of 150% (http://www.azadindia.org/social-issues/divorce-in-india.html). Although so much has changed in India in the last two decades, female sterilization still remains the dominant family planning method in the country.

Research on post sterilization regret in India is limited and dates back to 2005-06. Most of the studies are either localized or based on small sample sizes. Only the study by Singh et al. (2012) examined the post sterilization regret using the 2005-06 NFHS. However, Singh et al. (2012) have only looked at the determinants of post sterilization regret. None of the previous studies have examined trend in post sterilization regret. Moreover, we could not come across any study that has estimated the contribution of different factors to the change in post sterilization regret. Given the dramatic changes in almost every domain of the Indian society and the availability of a more recent large-scale dataset (NFHS-4), we examine the trends in post sterilization regret in India and selected bigger states of India using the 2005-06 NFHS (NFHS-3) and the 2015-16 NFHS-4. We also investigate the reasons for the change in post sterilization regret over the two NFHS surveys. Finally, we examine the determinants of post sterilization regret among women who had undergone sterilization in the inter-survey period (i.e., between NFHS-3 and NFHS-4).

Methods

Data

We used the third and fourth rounds of the NFHS conducted in India in the years 2005-06 and 2015-16. The NFHS is a nationally representative population-based survey, which covers more than 99% of the India's population. The main objective of the NFHS is to provide estimates of various indicators of fertility, mortality, family planning, maternal and child health, nutrition, etc. The NFHS surveys have evolved over the various rounds by strengthening the existing domains and adding new relevant domains (IIPS and ICF 2017). The NFHS surveys follow a two-stage sampling design in both urban and rural areas. In rural areas, villages (PSUs) are selected in the first stage using probability proportional to size (PPS). In the second stage, households are selected from the selected PSUs using systematic sampling. In urban areas, census enumeration blocks (CEBs) are selected in the first stage using PPS and households are selected from the selected CEBs using systematic sampling. The NFHS-3 interviewed 109,041 households, 124,385 women age 15-49, and 74,369 men

age 15-54. In comparison, NFHS-4 interviewed 601,509 households, 699,686 women age 15-49, and 112,122 men age 15-54. The response rates for households, women, and men in NHFS-3 were 98%, 95%, and 87%, respectively (IIPS and Macro International 2007). The response rates for NFHS-4 were 98%, 97%, and 92% (IIPS and ICF 2017).

Sample

Since the objective of this paper is to analyze post sterilization regret, we restricted our analysis to only those women who reported using sterilization at the time of the respective surveys. We excluded the few women who reported using sterilization but have not given birth. So, the trend analysis is based on 31,019 women in NFHS-3 and 165,368 in NFHS-4. Since we wanted to examine the determinants of post sterilization regret and the reasons for an increase in regret between NFHS-3 and NHFS-4, we further restricted our analysis to women who had undergone sterilization in the past 10 years preceding NFHS-3 and NFHS-4. This yielded us a sample size of 16,579 women in NFHS-3 and 83,407 women in NFHS-4.

Variables

The dependent variable is post sterilization regret. Post sterilization regret is coded as '1' if the women reported regret at the time of survey and '0' otherwise. Existing literature suggests a number of variables that are statistically associated with post sterilization regret. Accordingly, we included a number of socio-economic, demographic, residence related, and quality of care related variables in our analysis. The independent variables included in the analysis are age at sterilization (<25, 25-29, 30 or older), whether the woman was informed that she cannot have more children after sterilization (no, yes), woman's rating of care during and immediately after sterilization (very good, alright, not so bad, bad), source for sterilization (public, private, other), sex composition of living children (only sons, only daughters, both sons and daughters), whether she experienced child loss (no loss, experienced loss before sterilization, experienced loss after sterilization), marital status (currently married, widowed/divorced/separated/deserted), geographic region (north, central, east, northeast, west, south), woman's schooling (no schooling, up to primary, up to secondary, more than secondary), parity at sterilization (1, 2-3, 4 or more), caste (scheduled caste, scheduled tribe, other backward class, others), religion (Hindu, Muslim, Christian, others), wealth quintiles (poorest, poorer, middle, richer, richest), and place of residence (urban, rural).

Analysis

We used multivariable binary logistic regression, propensity score matching, and multivariate decomposition to analyze the data. First, we pooled the two rounds of NFHS to examine whether the increase in post sterilization regret over the two surveys is statistically significant. We used a logistic regression model where the dependent variable was post sterilization regret and the independent variable was time ('0' if NFHS-3 and '1' if NFHS-4). We also used logistic regression to examine the determinants of post sterilization regret.

There is a possibility that women who report post sterilization regret may be selective on a whole set of characteristics that are associated with poor quality of care during and immediately after sterilization. We used propensity score matching (PSM) to address this potential bias in estimation. PSM is a statistical technique that estimates the effect of a treatment or intervention by adjusting for covariates that predict receiving the treatment or intervention (Rosenbaum and Rubin 1983). PSM is based on counterfactual modeling. For computing the average treatment effect (i.e., the effect of poor quality of care during and immediately after sterilization), a counterfactual model is estimated. Counterfactual is the potential outcome that we would have obtained in case the quality of care during and immediately after sterilization is good. With the help of the counterfactual model, the average treatment effect on the treated (ATT) is
estimated as

$$ATT = E(Y1/D = 1) - E(Y0/D = 1),$$

where E(Y1/D=1) gives the post sterilization regret for poor quality of care during and immediately after sterilization and E(Y0/D=1) is the expected outcome if poor quality of care during and immediately after sterilization were to become good.

Similarly, the average treatment effect on the untreated (ATU) is defined mathematically as

$$ATU = E(Y1/D = 0) - E(Y0/D = 0),$$

where E(Y1/D=0) is the expected outcome if good quality of care during and immediately after sterilization were to become bad and E(Y0/D=0) is the outcome for good quality of care during and immediately after sterilization.

The average treatment effect (ATE) is the difference between the expected outcome for poor quality of care during and immediately after sterilization and good quality of care during and immediately after sterilization. The details of PSM can be obtained elsewhere (Caliendo and Kopeinig 2005; Heckman, Lalonde, and Smith1999; Rosenbaum and Rubin 1983; Sianesi 2004; Singh et al. 2017).

We used multivariate decomposition to examine the contribution of various factors to the change in post sterilization regret between NFHS-3 and NFHS-4. Multivariate decomposition decomposes the total change in post sterilization regret between NFHS-3 and NFHS-4 into "endowments (or composition)" and "coefficients (or rate)". Endowment is that component which is accounted for by the change in composition of variables between NFHS-3 and NFHS-4. The coefficient is that component which is accounted for by the change in the effect of the variable between NFHS-3 and NFHS-4. For example, if we take post sterilization regret as an outcome of interest and parity at sterilization as a factor which affects regret and we decompose the change in regret (over time) due to parity at sterilization into 'endowment' and 'coefficient' components, then the 'endowment' component is the component that is contributed by change in the composition of parity at sterilization and the 'coefficient' component is the component contributed by the change in effect or benefit of parity at sterilization on regret. Mathematically, multivariate decomposition can be expressed as

$$Y_A - Y_B = F(X_A\beta_A) - F(X_B\beta_B)$$
$$= F(X_A\beta_A) - F(X_B\beta_A) + F(X_B\beta_A) - F(X_B\beta_B)$$

where, Y_A - Y_B represents the difference in regret between two points of time. While the first and second terms together measure endowments, the third and fourth terms together account for coefficients (Powers, Yoshioka and Yun 2011). The decomposition procedure relies on two key pieces of information: the prevalence of all selected indicators at both points in time, and the coefficients derived from multivariate regression models predicting post sterilization regret estimated separately at both time points (Winter et al. 2013).

All the statistical estimations were done using STATA15.0. Appropriate sampling weights were used in the estimations.

Results

Trends in post sterilization regret

Table 1 shows the percentage of women age 15-49 who reported post sterilization regret for India and selected states of India in NFHS-3 and NFHS-4. In NFHS-4, 7% of women reported post sterilization regret, an increase from 5% in NFHS-3. The increase in post sterilization regret was statistically significant[1]. The increase in post sterilization regret was similar in both urban and rural areas. In NFHS-4, post sterilization regret was highest in Jammu & Kashmir (14%). Twelve percent of women in Tamil Nadu also reported post sterilization regret. Post sterilization regret was also high in Kerala, Karnataka, Jharkhand, and West Bengal (8.7%, 8.5%, 8.4%, and 8.3% respectively). Between NFHS-3 and NFHS-4, post sterilization regret increased in all the states except Uttarakhand, Assam, and Goa. The maximum increase is noticed in Tamil Nadu, followed by Jammu & Kashmir.

Trends in mean age at sterilization

The mean age at sterilization was 26 years in NFHS-4 (**Table 2**). The mean age at sterilization did not vary by urban-rural residence. The mean age at sterilization was below the national average in West Bengal, Maharashtra, Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu. The mean age at sterilization was highest in Uttar Pradesh (29.3 years) and Jammu & Kashmir (29.2 years), and lowest in Andhra Pradesh (23.7 years). The maximum increase in the mean age at sterilization was noticed in Odisha (1.5 years between NFHS-3 and NFHS-4). The increase in mean age at sterilization was also considerable in Jammu & Kashmir (0.8 years), Bihar (0.9 years), Kerala (0.8 years), and Karnataka (0.7 years). In comparison, the mean age at sterilization declined by 0.8 years in Goa between NFHS-3 and NFHS-4.

Trends in socio-economic, demographic and residence related characteristics

Table 3 shows the distribution of socio-economic, demographic, quality of care, and residence related characteristics for women age 15-49 who had undergone sterilization in the past 10 years preceding NFHS-3 and NFHS-4. Thirty-six percent of women in NFHS-4 were sterilized when they were less than 25 years of age, a decline from 42% in NFHS-3. The percentage of women who underwent sterilization from age 25-29 remained unchanged

[1]We pooled the data from NFHS-3 and NFHS-4 and estimated a logistic regression model where post sterilization regret was the dependent variable and survey round was the independent variable ('0' for NFHS-3 and '1' for NFHS-4).

between NFHS-3 and NFHS-4. Seventy-nine percent of women in NFHS-4 reported that they were informed that they cannot have more children after sterilization, an increase from 66% in NFHS-3. Both NFHS-3 and NFHS-4 asked women to rate the care during and immediately after sterilization. Over 50% of women in NFHS-3 and NFHS-4 rated the care as very good. Another 44-45% rated the care as alright.

The sex composition of children at sterilization is an important determinant of regret. Sixty-nine percent of women in NFHS-4 reported having both sons and daughters. This percentage was 74% in NFHS-3. Another 22% of women in NFHS-4 reported having only sons, an increase from 20% in NFHS-3. The percentage of women reporting no child loss after sterilization has increased between NFHS-3 and NFHS-4 (from 78% in NFHS-3 to 87% in NFHS-4). The distribution of parity at sterilization changed considerably between the two NFHS surveys. Seventy-four percent of women in NFHS-4 reported the parity at sterilization as 2 or 3. This percentage in NFHS-3 was 62%. The percentage of women reporting parity as 4 or more declined from 31% in NFHS-3 to 24% in NFHS-4.

The distributions of socio-economic and residence related variables also changed over the two NFHS surveys. No schooling in women declined from 49% in NFHS-3 to 35% in NFHS-4. In comparison, up to secondary schooling increased from 31% in NFHS-3 to 42% in NFHS-4. The percentage of women belonging to scheduled castes, scheduled tribes, and other backward classes increased between NFHS-3 and NFHS-4.

Trends and differentials in post sterilization regret

Table 4 shows the trends and differentials in post sterilization regret by socio-economic, demographic, quality of care, and residence related characteristics. In both the surveys, post sterilization regret was highest in women who were sterilized before age 25. It was lowest in women who were sterilized at age 30 or later. Post sterilization regret was higher in women who were told that they cannot have more children after sterilization compared with women who were not told. Post sterilization regret also varied considerably across the woman's rating of care during and immediately after sterilization. Women who rated the care as bad had higher regret compared with women who rated the care as very good or alright.

Post sterilization regret was also associated with sex composition of children at the time of sterilization. In both the surveys, women having both son(s) and daughter(s) were less likely to regret sterilization compared with women who had only sons. Women having only daughters were more likely to regret sterilization compared with women who had only sons. Post sterilization regret was higher in women who experienced child loss after sterilization compared with women who did not experience child loss after sterilization (15.7% versus 6.9% in NFHS-4 and 11.0% versus 4.2% in NFHS-3). Post sterilization regret declined with an increase in parity of women at sterilization. In NFHS-4, 10% of women who were sterilized at parity 1 regretted sterilization compared with only 6% of women who were sterilized at parity 4 or higher. In NFHS-3, 11% of women who were sterilized at parity 1 regretted sterilization compared with only 4% of women who were sterilized at parity 4 or higher.

Post sterilization regret was high among Muslim and Christian women in both the NFHS surveys. Post sterilization regret also varied by geographic region. While the regret was highest in the south region in NFHS-4 (8.7%), it was highest in the northeast region in NFHS-3 (6.5%). The lowest regret in NFHS-4 and NFHS-3 were in the west (4.8%) and north (3.0%) regions, respectively. Post sterilization regret did not vary by woman's schooling, caste, and urban-rural residence.

Results from logistic regression analysis

Logistic regression results are shown in **Table 5**. Results adjusted for socio-economic, demographic, and region related characteristics suggests that women who were informed that they cannot have more children after sterilization were 1.4 times as likely as women who were not informed to report post sterilization regret. In both the models, women who rated the care during and immediately after sterilization as bad were statistically more likely to report regret compared with women who rated the care as alright or very good.

Sex composition of children was statistically associated with regret in both the models. Women having only daughters were 1.3 times as likely as women having only sons to report regret. Women having both son(s) and daughter(s) were less likely to report regret compared with women having only sons (Odds ratio of 0.83 in model 1 and 0.84 in model 2). Women who lost at least one child after sterilization were 2.4 times as likely as women who did not lose any child to report regret. Parity at sterilization was negatively associated with regret in

both the models. For example, women who underwent sterilization at parity 2-3 were 0.7 times as likely as women who were sterilized at parity 1 to report regret. Likewise, women who were sterilized at parity 4 or higher were 0.60 times as likely as women who were sterilized at parity 1 to report regret.

Geographic region was also associated with post sterilization regret in Model 1. Compared with women from the south region, women from the north, central, east, and west regions were less likely to report regret. State was statistically associated with regret in Model 2. Compared with women from Uttar Pradesh, women from Himachal Pradesh, Punjab, Haryana, Uttarakhand, Rajasthan, Bihar, Assam, Maharashtra, and Telangana were less likely to report regret. On the other hand, women from Jammu & Kashmir, Jharkhand, Karnataka, and Tamil Nadu were more likely to regret sterilization than women from Uttar Pradesh. Religion was also associated with regret in both the models. Muslim women were 1.3-1.4 times as likely as Hindu women to report regret. Likewise, Christian women were 1.2-1.4 times as likely as Hindu women to report regret. Age at sterilization, source of sterilization, woman's marital status, woman' schooling, caste, wealth status, and urban-rural residence were not associated with regret.

Results from the propensity score matching analysis

The results of the propensity score matching analysis are shown in **Table 6**. The unmatched sample estimates show that the difference in regret for those who rate the care during and immediately after sterilization as bad and for those who rate it as good is 3 percentage points. This indicates that those who rate care during and immediately after sterilization as bad tend to regret sterilization more than those who rate the care as good. The difference in ATT (obtained after matching using the nearest neighbor with replacement) shows that those who rate care during and immediately after sterilization as bad had higher regret than those who rate the care as good (difference of 0.03). The ATU results indicate that the regret among those who rate the care as good was 4 percentage points higher if they happened to rate the care as poor.

Results from the multivariate decomposition analysis

When limited to sterilizations done in the past 10 years preceding NFHS-3 and NFHS-4, the post sterilization regret increased by 3% between NFHS-3 and NFHS-4. The increase in regret was statistically significant. Between NFHS-3 and NFHS-4, decomposition results

show that the differences in endowment (or composition) accounted for 50% of the observed survey differential in regret. The differences in coefficients (or rate) accounted for the remaining 50% of the observed survey differential in regret. The change in sex composition of children between NFHS-3 and NFHS-4 was associated with an increase in post sterilization regret. For example, the decline in the percentage of women having both sons and daughters led to an increase in regret by 3% between NFHS-3 and NFHS-4. The decline in percentage of women undergoing sterilization at higher parity was also associated with an increase in regret between NFHS-3 and NFHS-4. The decline in the percentage of women with 5 or higher parity at sterilization was associated with a 6% increase in regret during the study period. Likewise, a decline in the percentage of women of parity 4 at sterilization was associated with a 3% increase in regret during the study period. The decline in the percentage of women who experienced child loss after sterilization was associated with a 2% decrease in regret between NFHS-3 and NFHS-4.

The change in the composition of women who were informed that they cannot have more children after sterilization was associated with an increase in regret (by 10.5%) between NFHS-3 and NFHS-4. The change in the composition of women by geographic region was also associated with a change in regret between NFHS-3 and NFHS-4. For example, a decline in the percentage of women from the west region and the northeast region led to an increase in regret by 21% and 16% respectively, between NFHS-3 and NFHS-4. In comparison, the increase in the percentage of women from the east region was associated with a decrease in regret by 8% . The change in effectiveness of geographic region and whether women were informed that they cannot have more children after sterilization was also associated with a change in regret between NFHS-3 and NFHS-4.

Discussion

This paper comprehensively examines post sterilization regret in India using data from NFHS-3 and the recently released NFHS-4. Our analysis indeed shows that post sterilization regret has increased from 5% in NFHS-3 to 7% in NFHS-4. We also find that, with few exceptions, post sterilization regret increased for almost all categories of the socio-economic, demographic, quality of family planning services, and residence related characteristics between the two survey rounds. The change in the composition of 'parity at sterilization', 'sex composition of children' 'woman's schooling', 'whether woman was informed that she cannot have more children after sterilization', and 'geographic region' contributed to the increase in

the percent of women reporting regret between the two surveys. The change in the composition of 'experience of a child loss after sterilization' contributed to a decline in the percent of women reporting regret between the two surveys. Further analysis of the data suggests that 0.04% of women in NFHS-3 and 0.05% of women in NFHS-4 became childless because of the loss of at least one child after sterilization. Moreover, 6% of women in NFHS-3 lost their son(s) because of child loss after sterilization. In NFHS-4, this percentage increased to 9%. The distribution of the sample by socio-economic, demographic, quality of family planning services, and residence related variables has changed considerably between NFHS-3 and NFHS-4. The percentage of women having both sons and daughters has decreased between the two survey rounds. The percentage of women undergoing sterilization at parity 4 or more has also declined during the study period. The composition of sterilized women by geographic region has changed considerably between NFHS-3 and NFHS-4. On the contrary, the percentage of women who experienced child loss after sterilization decreased between the two surveys.

Women's rating of care during and immediately after sterilization was negatively associated with post sterilization regret. Women were less likely to regret sterilization if the care during and immediately after sterilization was alright or very good. There is a possibility that women who report regretting sterilization are also the women who report that the care during and immediately after sterilization was bad. Binary logistic regression estimates are likely to be biased in such situations. To overcome this bias, we estimated PSM models. The PSM models indeed indicate that quality of care during and immediately after sterilization is associated with regret. The region of common support between women who reported the quality of care during and immediately after sterilization as bad and good was high. The balancing property was satisfied at $p<0.005$. The plots of propensity scores showed that the distribution of propensity scores was identical for poor and good care during and immediately after sterilization. In addition, the considerable overlap between the characteristics of women who reported poor and good care during and immediately after sterilization ensured the validity of common support assumptions. The pseudo-R^2 was significant before, but insignificant after, matching. The insignificant pseudo-R^2 after matching suggests that there was no systematic difference in the distribution of characteristics between women who reported poor and good quality of care. Our findings clearly call for improving the quality of care during and immediately after sterilization.

Another variable that was statistically associated with post sterilization regret is whether the women were informed that they cannot have more children after sterilization. Our analysis indicates that women who were informed were more likely to regret sterilization than women who were not informed. This result seems to be counterintuitive. However, it is possible that, in the absence of any other better choice, those women who opted for sterilization even after knowing that they cannot have more children regret more compared to those who did not know. We did some more bivariate analysis to check the consistency of responses on whether women were informed that they cannot have more children after sterilization. The analysis indicates that richer women, women with more schooling, and women residing in urban areas were more likely to be informed than their counterparts. Similarly, women who were informed were also more likely to receive compensation for sterilization than women who were not informed. Moreover, women who were informed were less likely to experience child loss after sterilization compared with women who were not informed. However, women who were informed were slightly more likely to have only daughters compared with only sons. Given the evidence presented above, responses of women on whether they were informed seems consistent. It is worth mentioning that many of the women who were not told that they would not be able to have more children are likely to have been the most knowledgeable about sterilization in the first place and to have gone to a health facility requesting sterilization to stop having children.

Women who experienced any child loss after sterilization were more likely to regret sterilization than women who did not experience child loss. This finding is an improvement over the findings from the previous research on India which simply relates experience of child loss (irrespective of whether the loss was before or after sterilization) with post sterilization regret (Singh et al. 2012). Another important demographic variable associated with post sterilization regret is the parity at sterilization. Our findings are consistent with the findings of previous studies in India and abroad (Loaiza 1995; Malhotra, Chanana and Garg 2007; Schmidt et al. 2000; Singh et al. 2012). In a majority of cases the sterilization is being conducted at parity 2 or 3. There is also a slight increase in the percentage of women who underwent sterilization at parity 1.

Earlier studies have shown that women having only male children are less likely to report regret than women who have only female children (Kim et al. 1997; Malhotra, Chanana and Garg 2007; Singh et al. 2012). Our study also reports that women who have only daughter(s)

regret sterilization more than women who have only sons. However, women who have both son(s) and daughter(s) regret sterilization less than women who have only sons. Our finding is consistent with the findings of several other Indian studies that show the desire of Indian women to have both sons and daughters. Indian women generally believe that sons will take care of their financial needs and daughters will look after them when they are old (Pallikadavath and Wilson 2005). Studies have also found an association between marital status and regret. Compared with currently married women, women who are divorced/separated/widowed report higher regret (Chi and Jones 1994; Hillis et al. 1999; Kim et al. 1997; Loaiza 1995; Ludermir et al. 2009; Machado, Ludermir and da Costa 2005; Nervo et al. 2000; Platz-Christensen1992; Vieira and Ford 1996). However, we did not find evidence to support the association between marital status and post sterilization regret. This could be because the divorce/separation rates are still very low in India compared with other countries. However, the recent increases in family court cases do indicate that divorces/separation are on the rise in India. In such a situation sterilization is likely to seriously hamper the prospects of remarriage for divorced/separated women leading to higher post sterilization regret.

Another important variable that was statistically associated with post sterilization regret is the geographic region. Women from the north, central, east, and west regions were statistically less likely to regret sterilization than women from the south region. This finding indicates that women from the lowest-low fertility region (i.e., the south region) are likely to regret sterilization more than women from regions that have relatively higher fertility (i.e., the central and east regions). These results might also indicate that women in the south region might be undergoing sterilization at a lower parity and at a lower age to conform to the societal norms ignoring their personal desires. NFHS-4 data indeed suggests that a high proportion of women in the south region are undergoing sterilization at parity 1 or 2. There is also a possibility that women opt for sterilization at a low parity and a younger age to achieve the social status that they otherwise achieve at older ages (Pallikadavath et al. 2015). Pallikadavath et al. (2015) report that women under age 30 who had been sterilized had higher autonomy than women who had never used any modern method of family planning. The northeast region was an exception where the post sterilization regret was high despite having higher fertility and a high average age at sterilization. This finding is also consistent with the findings of Singh et al. (2012). Urban-rural residence was not associated with post sterilization regret.

An important limitation of our study is that we could not analyze the reasons related to post sterilization regret. We could not directly analyze reasons for regret because NFHS-4 did not ask any question on reasons for regret. However, the analysis presented in the paper does indicate some of reasons for regret. Also, reporting bias related to post sterilization regret cannot be ruled out. However, it should not be a major problem as the question on post sterilization regret has been canvassed in NFHS since 1992-93 when the NFHS was implemented in India for the first time. The reporting formats have remained the same since then.

Conclusions

Over 4 million sterilizations were carried out in India in 2014-15 (MoSPI 2016). Our analysis suggests that 7% of women who have been sterilized reported regret. Converting the percentage of women reporting post sterilization regret into numbers indicates that about 3.0 million women who have been sterilized between 2005 and 2016 report post sterilization regret in India. Moreover, there are huge differentials in post sterilization regret by state and geographic region. One of the key reasons for post sterilization regret in NFHS-4 is the poor quality of care during and immediately after sterilization. Our findings call for improving the quality of services related to sterilization. The family planning programme in India should offer a full array of contraceptive choices to all women seeking advice about family planning in general, and to young women and women with lower parity in particular. Brazil, where the use of sterilization is one of the highest in the world, discourages women and men from undergoing sterilization before they have at least two children (Leone and Padmadas 2007). Brazilian law also discourages women from undergoing postpartum sterilization until the 42nd day of delivery as women may not be able to clearly figure out their fertility desires in the hospital environment. In addition, women seeking sterilization would have to go through a sixty-day counselling period during which they would be informed about the other modern family planning methods. In Colombia, Mexico, and Peru, sterilization is subject to legal regulations and requires informed, conscious, and willing consent of the couples (The Center for Reproductive Policy and Law 1997). The Indian family planning programme should also discourage postpartum sterilization and counsel couples who seek sterilization.

A significant proportion of women regretted sterilization because they lost at least one child after sterilization. This finding indicates that women might like to re-examine their fertility desires should their circumstances change over time. Another variable that is closely

associated with change in circumstance is the marital status (although not statistically significant in our analysis). Female sterilization poses a serious hindrance to remarriage of women whose marital status changes from currently married to divorced/widowed/separated. These together call for postponing sterilization to higher age by providing good mix of family planning methods. Also, more needs to be done for reducing infant and under-five mortality in India which is still very high compared with developed countries in general and neighbouring countries with similar socio-economic status in particular. The under-five and infant mortality rates were 50 and 41 deaths per 1,000 live births in five years preceding NFHS-4respectively (IIPS and ICF 2017). Reducing infant and under-five mortality further is likely to reduce post sterilization regret in India.

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Table 1: Percentage of women age 15-49 reporting regret following sterilization, by state, NFHS-3 and NFHS-4

State	NFHS-3		NFHS-4	
	Percentage reporting regret	Number of women	Percentage reporting regret	Number of women
ALL	4.6	31,019	6.9	165,368
India				
Rural	4.7	21,225	6.9	109,980
Urban	4.5	9,794	6.9	55,388
North				
Jammu & Kashmir	8.1	165	14.3	901
Himachal Pradesh	2.2	215	2.6	884
Punjab	2.7	583	3.6	3,588
Haryana	2.9	588	5.9	3,957
Uttarakhand	6.4	191	5.1	989
Rajasthan	2.9	1,610	5.5	9,759
Central				
Uttar Pradesh	4.4	2,114	6.9	10,783
Madhya Pradesh	3.7	2,306	6.7	12,149
Chhattisgarh	3.1	755	7.2	4,719
East				
Bihar	4.7	1,604	5.3	7,828
Jharkhand	7.7	529	8.4	3,573
West Bengal	4.0	2,455	8.3	11,336
Odisha	6.6	909	6.7	4,471
Northeast				
Assam	5.6	263	4.9	1,061
West				
Gujarat	5.1	1,774	7.5	7,305
Maharashtra	3.1	3,917	3.7	22,483
Goa	6.9	29	1.3	84
South				
Andhra Pradesh	4.9	4,077*	7.3	14,832
Telangana	-	-	4.6	8,426
Karnataka	7.7	2,808	8.5	11,373
Kerala	7.0	1,148	8.7	5,759
Tamil Nadu	3.3	2,641	11.5	16,918

Note: * Andhra Pradesh includes Telangana in NFHS-3

Table 2: Mean age at sterilization, by state, NFHS-3 and NFHS-4

State	**NFHS-3**	**NFHS-4**
ALL	**26.0**	**26.3**
India		
Rural	26.0	26.3
Urban	26.2	26.4
North		
Jammu & Kashmir	28.4	29.2
Himachal Pradesh	26.4	26.2
Punjab	27.3	27.5
Haryana	26.4	26.8
Uttarakhand	27.7	27.7
Rajasthan	27.3	27.3
Central		
Uttar Pradesh	28.8	29.3
Madhya Pradesh	27.1	27.1
Chhattisgarh	27.0	27.2
East		
Bihar	27.9	28.8
Jharkhand	27.2	27.7
West Bengal	25.3	25.6
Odisha	26.5	28.0
Northeast		
Assam	27.7	28.2
West		
Gujarat	26.7	27.0
Maharashtra	25.4	25.7
Goa	28.0	27.2
South		
Andhra Pradesh	23.8*	23.7
Telangana	-	24.9
Karnataka	24.5	25.2
Kerala	26.8	27.6
Tamil Nadu	25.3	25.0

Note: * Andhra Pradesh includes Telangana in NFHS-3

Table 3: Trend in select characteristics that could have influenced sterilization regret,NFHS-3 and NFHS-4

Characteristics	**NFHS-3**	**NFHS-4**
Age at sterilization		
< 25	42.0	36.4
25-29	34.2	35.4
≥ 30	23.8	28.3
Woman informed that she cannot have more children after sterilization		
Yes	66.0	79.3
No	34.0	20.7
Woman's rating of care during and immediately after sterilization		
Very good	51.7	51.0
Alright	43.5	45.0
Not so bad	4.2	3.5
Bad	0.7	0.5
Source for sterilization		
Public	80.2	80.0
Private	18.8	19.4
Others	1.0	0.6
Sex composition of children		
Only sons	19.7	22.4
Only daughters	6.6	8.4
Both sons and daughters	73.7	69.2
Experience of child loss		
No loss	78.0	86.8
Loss before sterilization	19.3	11.6
Loss after sterilization	2.7	1.6
Marital Status[1]		
Currently married	97.4	97.5
Widowed/Divorced/separated/deserted	2.6	2.5
Geographic region		
North	11.8	13.0
Central	19.3	19.5
East	17.9	18.9
Northeast	1.3	1.1
West	17.8	16.4
South	31.9	31.1
Woman's schooling		
No schooling	48.9	35.3
Up to primary	16.6	16.0
Up to secondary	31.0	42.1
More than secondary	3.6	6.7
Parity at sterilization		
1	1.2	2.2
2-3	61.7	73.6
≥ 4	37.1	24.2
Caste		
Scheduled caste	21.0	23.4

Scheduled tribe	9.0	10.9
Other backward class	44.3	46.5
Others	25.8	19.2
Religion		
Hindu	86.9	86.6
Muslim	8.0	8.1
Christian	2.3	2.3
Others	2.8	3.0
Wealth quintiles		
Poorest	18.1	20.0
Poorer	21.5	21.3
Middle	22.7	22.3
Richer	21.9	20.6
Richest	15.8	15.7
Place of residence		
Urban	29.1	30.3
Rural	70.9	69.7

Table 4: Percentage of women age 15-49 reporting regret following sterilization, by selected characteristics, NFHS-3 and NFHS-4

Characteristics	NFHS-3		NFHS-4		Difference between 2005-06 and 2015-16 significant at
	No. of women	Percentage reporting regret	No. of women	Percentage reporting regret	
Age at sterilization					
< 25	6,970	4.9	30,321	7.6	p<0.001
25-29	5,663	4.4	29,521	6.8	p <0.001
≥ 30	3,946	3.7	23,565	6.5	p <0.001
Woman informed that she cannot have more children after sterilization					
Yes	10,948	4.7	66,148	7.4	p < 0.001
No	5,628	4.1	17,259	5.4	p < 0.001
Woman's rating of care during and immediately after sterilization					
Very good	8,565	4.7	42,534	7.9	p < 0.001
Alright	7,202	3.8	37,469	5.6	p < 0.001
Not so bad	697	7.2	2,893	9.8	p < 0.116
Bad	107	10.9	411	17.0	p < 0.977
Source for sterilization					
Public	13,290	4.3	66,743	7.0	p < 0.001
Private	3,117	5.2	16,166	6.9	p < 0.001
Others	157	7.2	486	4.4	p < 0.858
Received compensation					
No	-	-	28,823	7.3	-
Yes	-	-	54,015	6.8	-
Sex composition of children					
Only sons	3,270	5.5	18,699	8.2	p < 0.001
Only daughters	1,091	9.0	6,959	10.6	p < 0.009
Both sons and daughters	12,210	3.8	3,544	6.1	p < 0.001
Experience of child loss					
No loss	12,925	4.2	72,404	6.9	p < 0.001
Loss before sterilization	3,203	4.8	9,687	6.5	p < 0.003
Loss after sterilization	451	11.0	1,316	15.7	p < 0.049
Marital Status[1]					
Currently married	16,143	4.4	81,283	7.0	p < 0.001
Widowed/Divorced/separated/deserted	432	6.6	2,089	6.8	p < 0.362
Geographic region					
North	1,960	3.0	25,984	5.6	p < 0.001
Central	3,206	3.3	10,850	7.0	p < 0.001
East	2,971	4.9	16,239	7.0	p < 0.001
Northeast	212	6.5	15,717	6.0	p < 0.001
West	2,950	3.7	917	4.8	p < 0.862
South	5,280	5.8	13,700	8.7	p < 0.001
Woman's schooling					

No schooling	8,107	4.0	29,398	6.5	p < 0.001
Up to primary	2,747	3.9	13,341	6.9	p < 0.001
Up to secondary	5,135	5.3	35,110	7.4	p < 0.001
More than secondary	590	5.4	5,558	6.9	p < 0.056
Woman's work[2]					
Not working	8,866	4.8	-	-	
Working	7,683	4.1	-	-	
Parity at sterilization					
1	201	11.1	1,835	10.4	p < 0.990
2-3	10,235	4.8	61,423	7.2	p < 0.001
≥ 4	6,143	3.7	20,148	6.0	p < 0.001
Caste					
Scheduled castes	3,366	4.1	18,959	7.0	p < 0.001
Scheduled tribes	1,441	3.9	8,844	6.8	p < 0.593
Other backward classes	7,109	4.5	37,704	7.2	p < 0.001
Others	4,134	4.8	15,573	6.3	p < 0.001
Religion					
Hindu	14,397	4.2	72,239	6.9	p < 0.001
Muslim	1,318	6.6	6,730	8.7	p < 0.001
Christian	384	7.1	1,941	8.3	p < 0.265
Others	462	4.1	2,497	4.6	p < 0.291
Wealth quintiles					
Poorest	2,997	4.1	16,694	6.5	p < 0.001
Poorer	3,570	4.2	17,770	7.2	p < 0.001
Middle	3,757	4.6	18,631	7.2	p < 0.001
Richer	3,629	4.6	17,215	7.4	p < 0.001
Richest	2,626	5.1	13,096	6.4	p < 0.001
Place of residence					
Urban	4,824	5.0	25,240	6.9	p < 0.001
Rural	11,755	4.3	58,167	7.0	p < 0.001

1. **Married but *gauna* not performed excluded from the analysis,**
2. **In NFHS-4, information on woman's work was collected in the 'state module'. Hence, this information is available for only 15% of the woman. So, woman's work not included in the analysis in NFHS-4**

Table 5: Adjusted odds ratios from logistic regressions identifying associations between sterilization regret and selected characteristics, NFHS-4

Characteristics	**Model 1**	**Model 2**
Age at sterilization		
< 25 (ref)		
25-29	0.98 (0.92,1.05)	0.97 (0.90,1.03)
>= 30	0.99 (0.92,1.06)	0.95 (0.88,1.02)
Woman informed that she cannot have more children after sterilization		
No (ref)		
Yes	1.37 (1.28,1.48)*	1.39 (1.29,1.50)*
Woman's rating of care during and immediately after sterilization		
Very good (ref)		
Alright	0.72 (0.68,0.77)*	0.74 (0.70,0.79)*
Not so bad	1.27 (1.12,1.44)*	1.27 (1.12,1.44)*
Bad	1.88 (1.40,2.52)*	1.95 (1.45,2.62)*
Source of sterilization		
Public (ref)		
Private	0.93 (0.86,1.01)	0.97 (0.89,1.05)
Others	0.73 (0.47,1.13)	0.69 (0.45,1.07)
Sex composition of children		
Only sons (ref)		
Only daughters	1.29 (1.16,1.44)*	1.30 (1.17,1.45)*
Both sons and daughters	0.83 (0.78,0.89)*	0.84 (0.78,0.90)*
Experience of child loss after sterilization		
No loss (ref)		
Loss before sterilization	1.06 (0.97,1.15)	1.07 (0.98,1.17)
Loss after sterilization	2.36 (2.03,2.74)*	2.39 (2.05,2.78)*
Marital Status[a]		
Currently married (ref)		
Widowed/Divorced/separated/deserted	0.87 (0.73,1.05)	0.89 (0.74,1.08)
Geographic region		
South (ref)		
North	0.69 (0.62,0.76)*	-
Central	0.83 (0.77,0.91)*	-
East	0.81 (0.74,0.88)*	-
Northeast	0.95 (0.82,1.10)	-
West	0.62 (0.56,0.70)*	-
Woman's schooling		
No schooling (ref)		
Up to primary	0.94 (0.87,1.02)	0.93 (0.86,1.01)
Up to secondary	0.99 (0.93,1.07)	0.98 (0.91,1.05)
More than secondary	0.88 (0.76,1.02)	0.85 (0.73,0.99)*
Parity at sterilization		
1 (ref)		
2-3	0.67 (0.56,0.79)*	0.67 (0.56,0.79)*
>= 4	0.59 (0.49,0.71)*	0.59 (0.49,0.70)*

Caste		
Scheduled castes (ref)		
Scheduled tribes	1.08 (0.98,1.18)	0.96 (0.87,1.06)
Other backward classes	0.98 (0.91,1.06)	0.98 (0.91,1.05)
Others	1.03 (0.94,1.13)	1.06 (0.97,1.17)
Religion		
Hindu (ref)		
Muslim	1.42 (1.28,1.58)*	1.26 (1.13,1.41)*
Christian	1.36 (1.17,1.57)*	1.23 (1.03,1.45)*
Others	0.96 (0.82,1.12)	1.15 (0.96,1.38)
Wealth quintiles		
Poorest (ref)		
Poorer	1.04 (0.96,1.13)	1.01 (0.93,1.10)
Middle	0.97 (0.89,1.07)	0.96 (0.87,1.05)
Richer	1.00 (0.91,1.11)	1.01 (0.91,1.12)
Richest	0.93 (0.82,1.06)	0.95 (0.84,1.09)
Place of residence		
Urban (ref)		
Rural	0.94 (0.87,1.01)	0.98 (0.91,1.05)
State[b]		
Uttar Pradesh (ref)		
Madhya Pradesh		0.94 (0.83,1.06)
Chattisgarh		1.08 (0.92,1.25)
Jammu and Kashmir		1.91 (1.56,2.33)*
Himachal Pradesh	-	0.49 (0.34,0.70)*
Punjab	-	0.43 (0.33,0.57)*
Haryana	-	0.75 (0.63,0.90)*
Uttarakhand	-	0.72 (0.58,0.91)*
Rajasthan	-	0.78 (0.68,0.90)*
Bihar	-	0.76 (0.65,0.88)*
Jharkhand	-	1.18 (1.02,1.37)*
West Bengal	-	1.02 (0.84,1.25)
Odisha	-	0.99 (0.85,1.15)
Assam	-	0.67 (0.51,0.89)*
Gujarat	-	1.08 (0.92,1.28)
Maharashtra	-	0.56 (0.47,0.66)*
Andhra Pradesh	-	0.94 (0.78,1.13)
Telangana	-	0.78 (0.62,0.98)*
Karnataka	-	1.19 (1.03,1.38)*
Kerala	-	0.99 (0.80,1.22)
Tamil Nadu	-	1.37 (1.19,1.57)*

Note: *p<0.05, Ref = reference category, 95% confidence interval shown in the parentheses
a. Married but *gauna* not performed excluded from the analysis
b. Goa excluded from the analysis due to fewer number of cases

Table 6: Results of matching estimates showing the effect of rating of care during and immediately after sterilization on regret following sterilization, NFHS-4

Rating of sterilization - good against bad	Treated	Controls	Difference	Standard error	p > z	95% Confidence interval
Unmatched	0.10	0.07	0.03			
ATT	0.10	0.07	0.03	0.007	p> 0.001	(0.02,0.04)
ATU	0.07	0.11	0.04	-		
ATE						

Table 7: Multivariate decomposition results

Characteristics	**NFHS-4 - NFHS-3**	
	Endowment (%)	**Coefficient (%)**
Age at sterilization	-0.45	6.5
Woman informed that she cannot have more children after sterilization	10.47*	-13.65*
Sex composition of children		
Only daughter (s)	0.80*	-2.13
Both sons and daughters	2.71*	-2.72
Child loss after sterilization		
Loss before sterilization	-0.41	-13.19*
Loss after sterilization	-2.39*	-1.35
Geographic region		
North	6.00*	-14.79*
Central	-0.59*	-17.94*
East	-7.85*	-1.93*
Northeast	15.95*	-14.84*
West	21.19*	-54.66*
Woman's schooling	1.93	-8.06
Parity at sterilization		
2	-6.78	23.47
3	0.55	21.50
4	3.24*	13.95
5 or more	5.68*	19.1
Wealth	0.16	1.88
Urban-rural residence	-0.18	19.55
Constant		**89.4**
Percent	**49.9**	**50.1**
Total Decline	**2.5***	

Note: * p<0.05