Appropriate Methods for Analyzing the Effect of Method Choice on Contraceptive Discontinuation

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Introduction

Contraceptive discontinuation is a topic that has received increasing attention in recent years for several reasons. First, increased attention to the quality of family planning services has lead to interest in outcomes that might be associated with the quality of services. Jain (1989) argues that the quality of services increases contraceptive prevalence through increased adoption of contraceptives but more significantly through improved continuity of use. Although there is relatively little empirical evidence to date to support the theoretical link between the quality of services and contraceptive discontinuation, the interest in contraceptive discontinuation as an outcome associated with the quality of services remains. Second, as contraceptive use rises throughout the world, contraceptive continuation becomes an increasingly important determinant of contraceptive prevalence and unwanted fertility. For example, Blanc and Curtis (1999) find that in 15 countries with Demographic and Health Surveys (DHS) total unwanted fertility rates would be between 44 percent and 81 percent lower in the absence of contraceptive discontinuation and failure. Similarly, in Turkey 78 percent of induced abortions in the three years preceding the 1998 DHS survey were preceded by a contraceptive failure or discontinuation (Senlet et al. 2001). Finally, the increasing availability of contraceptive history data, such as that collected through the DHS program, has provided increased opportunities to study contraceptive discontinuation in more depth and across more countries.

Studies of contraceptive discontinuation consistently show contraceptive discontinuation rates vary substantially by method used. Typically, method-specific discontinuation rates are lowest among IUD users and highest among users of condoms and, to a lesser extent, injectables (Ali and Cleland 1995; Blanc and Curtis 1999). Reasons for discontinuation also vary substantially by method; DHS surveys typically find side effects and health concerns are the main reasons for discontinuing hormonal methods and IUDs, inconvenience and partner's disapproval are the main reasons for discontinuing condom use, and contraceptive failure and desire for a more effective method are the main reasons for discontinuing traditional methods. Multivariate analyses of the determinants of contraceptive discontinuation find that the method used is strongly associated with contraceptive discontinuation after controlling for other factors (Curtis and Blanc 1997; Koenig et al. 1997; Steele, Diamond and Wang 1996; Steele and Diamond 1999), although the pattern by method depends on the type of discontinuation being studied. However, as Curtis and Blanc (1997) note, the relationship between the method used and contraceptive discontinuation is complicated by the fact that method choice is determined by women's balancing of a number of factors including ease of continuation, risk of failure, intended length of use, and other characteristics of the woman that might also affect her risk of discontinuing use. These factors could lead to selection of women at high risk of discontinuation to use certain methods, which in turn would lead to bias in the determinants of contraceptive discontinuation. In other words, method choice is potentially an endogenous variable. The direction of the selection effects resulting from method choice is difficult to predict. For example, a woman may choose to use the IUD because she intends to use for a long time and believes the IUD to be an easy method for long-term use because it requires no ongoing action on her part once it is inserted. Such selection may overstate the difference between the discontinuation rates of IUD and other methods. Alternatively, women who have difficulty continuing use of methods may choose the IUD again because of the lack of ongoing action required to continue use. Such selection would lead to understatement of the contraceptive method differentials.

We are aware of no studies to date that have explicitly addressed the issue of the potential endogeneity of method choice in the discontinuation process. Most authors have either ignored the problem and used conventional modelling techniques (Curtis and Blanc 1997; Koenig et al. 1997; Pariani et al. 1991; Steele et al. 1996; Steele and Diamond 1999) or have fitted method-specific models (Ali and Cleland 1999; Ping 1995; Steele et al. 1999). The objective of this paper is to explore whether method choice is endogenous in the discontinuation process, and if so, to explore what effect that has on the estimates of method effects on discontinuation. To do this, we utilize multilevel multiprocess models to simultaneously model the processes of contraceptive method choice and contraceptive discontinuation using data from the 1997 Indonesia DHS. We focus on one particular type of contraceptive discontinuation, abandonment of contraceptive use while in need of contraception.

Data and Methods

The DHS program has been collecting contraceptive histories in countries with high contraceptive prevalence (approximately 40 percent of married women or more) since 1990. The contraceptive histories are collected through a "calendar" which records monthly contraceptive/pregnancy status and reasons for discontinuing contraceptive methods for the five calendar years before the survey (Macro International Inc 1995). These contraceptive histories provide a good source of data for examining the role of contraceptive method choice on contraceptive discontinuation. For this study, we chose to use the 1997 Indonesia DHS[1]. Indonesia was chosen because of the wide range of contraceptive methods used and the low level of female sterilization. Table 1 shows the percentage of married women of reproductive age using contraception by method and the 12-month method-specific discontinuation rates. Overall, 57 percent of married women were using a method of contraception at the time of the survey. The most popular methods are injectables and pills. First-year discontinuation rates are highest for condoms followed by pills, and lowest for implants. The method-specific first-year discontinuation rates observed in Indonesia are relatively low compared to those observed in other countries (Blanc and Curtis, 1999).

In this analysis, we build on previous work by Curtis and Blanc (1997). While some other studies have distinguished between different reasons for stopping use or 'competing risks', we focus on a single end event: abandoning use of contraception while in need of family planning. A woman is considered to have abandoned use while in need of contraception if she is not using a contraceptive in the month immediately following a discontinuation and the main reason for discontinuation was not any of the following: failure, to get pregnant, menopause, marital separation, or infrequent sex. This type of discontinuation is particularly important because it leads to immediate risk of unintended pregnancy. Using data from the 1994 Indonesia DHS, Curtis and Blanc (1997) found a strong effect of method used on contraceptive abandonment while in need of contraception. The risk was lowest for users of traditional methods, and highest

[1] Details of the design and implementation of the 1997 Indonesia DHS can be found in CBS [Indonesia], NFPCB, MOH, and MI. (1998).

for users of pills, injectables, and condoms, who all had similar risk. The risk for users of IUDs was between that of users of traditional methods and that of users of the other modern methods studied. Figure 1 shows the gross life table cumulative probabilities of abandoning use while in need of contraception during the first 36 months of use for each modern method based on the 1997 Indonesia DHS. Abandonment rates are very high initially for the condom and then level off. Abandonment rates of the pill and injectables both show a fairly steady increase throughout the first 36 months of use with rates for the injectable falling slightly below those of the pill. After the first few months of use, abandonment rates are similar for pills, injectables and condoms. The rates of abandonment are much lower for IUDs and implants.

For this analysis, contraceptive methods are grouped into three categories: pills and injectables, IUD and implants, and other modern methods (mainly condoms). Traditional methods and sterilization were excluded from this study. Pills and injectables are grouped together because they are both short-term hormonal methods. IUDs and implants are both longer-term reversible methods that require a health worker to remove them. As such, they are fundamentally different from other reversible methods in that they require the user to be proactive to discontinue use and to have contact with the health system at the time of discontinuation. The analysis is based on 16,937 episodes of reversible modern contraceptive method use contributed by 12,101 women. The pill was used in 36.2 percent of these episodes, injectables in 45.6 percent, implants in 8.2 percent, IUDs in 8.1 percent, condoms in 1.8 percent, and other methods in 0.2 percent. An episode of contraceptive use is defined as a continuous period of use of a specific contraceptive method. Breaks of even one month are treated as discontinuations of the original episode of use. The analysis is based on all episodes of use that began during the calendar period. Episodes of contraceptive use that began before the start of the calendar (i.e. left-censored episodes of use) are excluded from the analysis. Episodes of use that are still in progress at the time of the survey, and episodes of contraceptive use that end for reasons other than abandonment while in need of contraception (e.g. contraceptive failures, switches to other methods, discontinuation to get pregnant, etc.) are treated as censored observations.

The covariates used in the analysis are a subset of those used by Curtis and Blanc (1997). They are: woman's education (none, primary, secondary or more), household socio-economic status (low, medium, high)[2], area of residence (urban, rural), and age of woman at the start of the episode of use (under 25, 25-34, 35-49). These covariates are theoretically associated with method choice and/or contraceptive abandonment while in need of contraception and are exogenous to both the method choice and method abandonment processes. Some of the other variables used by Curtis and Blanc (1997) are theoretically associated with method choice and discontinuation but are potentially endogenous (e.g. number of living children at the start of the episode of use and spacing versus limiting intention).

A multilevel event history or hazards model is used to determine the factors associated with contraceptive abandonment, and in particular the impact of method choice. A multilevel model is used since many women contribute more than one episode of contraceptive use over the

[2] Socio-economic status is based on a simple household possessions score. Households receive one point for each of the following: household has piped or bottled drinking water, household has flush toilet, household has bicycle, motorcycle, or car, household has radio, household has a floor that is not dirt. The total score ranges from 0 to 5 and is grouped as low (0-1), medium (2-3), or high (4-5).

observation period, leading to a two-level hierarchical structure with episodes nested within women. We begin with a description of standard multilevel hazards models, which have been used in several previous studies of contraceptive use dynamics (Curtis and Blanc 1997; Steele et al. 1996; Steele et al. 1999; Steele and Diamond 1999). This is followed by a description of an extension of this model, the multilevel multiprocess model, which allows for the potential endogeneity of method choice with respect to contraceptive abandonment.

<u>Multilevel hazards model for contraceptive abandonment</u>

We denote the duration of an episode of contraceptive use by a random variable *T*. The hazard function for episode *i* of woman *j* is denoted by $h_{ij}(t)$ and is defined as

$$h_{ij}(t) = \lim_{\delta t \to 0^+} \frac{\mathrm{P}(t \le T < t + \delta t)}{\delta t}.$$

There are several ways in which the hazard may be modelled as a function of covariates. For example, some studies use a discrete-time logit-hazard model (Steele et al. 1996; Steele, Curtis and Choe 1999; Steele and Diamond 1999) while others use a continuous-time log-hazard model (Curtis and Blanc 1997). In both types of model, the dependence of the hazard function on time (the baseline hazard) may be specified in a number of ways. For example, the logit-hazard or log-hazard may be assumed to be a quadratic function of time, or time may be treated as a categorical variable leading to the familiar piecewise-constant model. In this paper, we use a continuous-time log-hazard model where the baseline hazard is represented by a piecewise-linear spline.

The conventional hazards model is extended to allow for potential correlation between durations of episodes contributed by the same woman. Correlated durations may arise as a result of unobserved individual characteristics that influence the duration of each of a woman's episodes of contraceptive use. A model that allows for such correlations is a multilevel hazards model, a method that has been applied in several earlier studies of contraceptive use dynamics (Curtis and Blanc 1997; Steele et al. 1996; Steele et al. 1999; Steele and Diamond 1999). In a multilevel hazards model for a two-level structure with episodes of contraceptive use nested within women, random effects are incorporated to allow for unobserved heterogeneity between women. These random effects are defined at the woman level and represent unobserved woman-level characteristics that influence the hazard of abandoning use at each month of a given episode, and for each episode. The multilevel hazards model used in this study has the following form:

$$\ln h_{ij}(t) = f(t) + \boldsymbol{\beta}^A \mathbf{X}_{ij}^A + \boldsymbol{\gamma}\mathbf{C}_{ij} + u_j^A, \qquad (1)$$

where $f(t)$ is the baseline hazard which is represented by a continuous, piecewise-linear spline with nodes at 12, 24 and 36 months:

$$f(t) = \alpha_0 + \alpha_1 \min[t, 12] + \alpha_2 \max[0, \min[t-12, 12]] \\ + \alpha_3 \max[0, \min[t-24, 12]] + \alpha_4 \max[0, t-36].$$

The coefficients α_1, α_2, α_3 and α_4 are the slopes of the lines within each time segment. Method choice is represented by a vector of dummy variables, $\mathbf{C}_{ij}$, with coefficient vector $\boldsymbol{\gamma}$. $\mathbf{X}_{ij}^{A}$ is a vector of exogenous covariates, with coefficient vector $\boldsymbol{\beta}^{A}$. In this specification, the covariates are assumed to be time-invariant since longitudinal information on the variables considered here is unavailable. However, the model may be extended to incorporate time-dependent covariates. Woman-level unobserved variables are represented by a woman specific random effect, u_j^A, which is assumed to follow a normal distribution with mean zero and standard deviation σ_A.

The problem with the model in (1) is that it assumes that $\mathbf{C}_{ij}$ is uncorrelated with u_j^A. In other words, method choice is assumed to be exogenous. This assumption may be invalid since there are potentially unobserved individual characteristics that influence both method choice and the outcome of interest, abandonment of contraceptive use. In that case, $\mathbf{C}_{ij}$ is endogenous which leads to a non-zero correlation between $\mathbf{C}_{ij}$ and u_j^A.

<u>Multilevel multiprocess model</u>

To allow for the potential endogeneity of method choice with respect to contraceptive abandonment, a multilevel multiprocess model is used. The multiprocess model is a generalisation of the multilevel hazards model above in which the processes of contraceptive abandonment and method choice are modelled jointly. Individual random effects are incorporated in each process and are permitted to correlate across processes to allow for unobserved individual-level factors that influence both contraceptive abandonment and method choice.

Multiprocess models, otherwise known as simultaneous equations models, have been used extensively in econometrics (see Greene (2000) for a detailed account). Multilevel versions of these models have been proposed by several authors (Angeles, Guilkey and Mroz 1998; De Graff, Bilsborrow and Guilkey 1997; Lillard, Brien and Waite 1995; Panis and Lillard 1994). De Graff et al. (1997) use a system of three equations involving a mixture of continuous and binary outcomes relating to fertility and contraceptive use. Each equation incorporates individual- and community-level random effects, which are allowed to correlate across equations. In each of the other studies referred to above, the outcome of interest is a duration variable and the endogenous covariate(s) is binary. Angeles et al. (1998) use a multilevel multiprocess model to allow for non-random family planning programme placement when evaluating programme impact on the hazard of conception. Panis and Lillard (1994) use a system of four equations to allow for the endogeneity of prenatal medical care and institutional delivery with respect to the hazards of foetal and postneonatal mortality. Lillard et al. (1995) apply a similar model to assess whether the impact of premarital cohabitation on subsequent marital dissolution is real or due to selection of people with a lower commitment to marriage into cohabitation. The model that we propose may be considered as an extension of that used by Lillard et al. (1995) where the endogenous covariate is polychotomous rather than binary.

In the multilevel multiprocess model, equation (1) is combined with a model for choice of contraceptive method. Since method is classified into three categories, either a multinomial logit or multinomial probit model may be used. Although the logit model is considerably easier to estimate than the probit model, a problem with the logit model is its independence of irrelevant alternatives (IIA) assumption. In the context of contraceptive method choice, for example, the logit model assumes that the odds of choosing an IUD over the pill would be the same whether or not condoms were available. However, pills and condoms might be perceived as more similar than IUDs and condoms. In that case, if condoms were unavailable, would-be condom users might prefer to use pills rather than an IUD. If a pair of methods is perceived as more similar than another method then the logit model tends to lead to overestimates of the joint probabilities for the similar methods. For this reason, we use the multinomial probit model.

Let $U_{ij,m}$ denote the utility function for woman *j* in episode *i* corresponding to method choice *m* (*m* = 1, 2, 3). The utility is assumed to take the following form:

$$U_{ij,m} = \boldsymbol{\beta}_m^C \mathbf{X}_{ij}^C + u_{j,m}^C + \varepsilon_{ij,m}^C, \quad m = 1,2,3 \qquad (2)$$

where $\mathbf{X}_{ij}^C$ is a vector of exogenous covariates with coefficient vector $\boldsymbol{\beta}_m^C$, and $u_{j,m}^C$ and $\varepsilon_{ij,m}^C$ are woman and episode specific random effects respectively.

A woman chooses method *m* for which $U_{ij,m}$ is greatest. However, we do not observe $U_{ij,m}$. We observe only the choice for which the utility is highest. That is, we observe the trinomial outcome $Y_{ij} = m$ if $U_{ij,m} = \max(U_{ij,1}, U_{ij,2}, U_{ij,3})$, *m* = 1, 2, 3. Therefore we can model only differences in utilities. Denote the differences between the utilities for *m* = 2,3 and *m* = 1 by $V_{ij,21} = U_{ij,2} - U_{ij,1}$ and $V_{ij,31} = U_{ij,3} - U_{ij,1}$. Then from (2) we obtain, for *m* = 2 or 3:

$$\begin{aligned} V_{ij,m1} &= (\boldsymbol{\beta}_m^C - \boldsymbol{\beta}_1^C)\mathbf{X}_{ij}^C + (u_{j,m}^C - u_{j,1}^C) + (\varepsilon_{ij,m}^C - \varepsilon_{ij,1}^C) \\ &= \boldsymbol{\beta}_{m1}^C \mathbf{X}_{ij}^C + u_{j,m1}^C + \varepsilon_{ij,m1}^C \end{aligned} \qquad (3)$$

Equation (3) defines a multinomial probit model with the first category of Y_{ij} taken as the reference category.

The combination of (1) and (3) define a multilevel multiprocess model. (1) and (3) are linked by allowing for correlation between woman-level random effects across equations. We assume that $(u_j^A, u_{j,21}^C, u_{j,31}^C)$ follow a multivariate normal distribution with mean $\mathbf{0}$ and variance $\boldsymbol{\Sigma}$, where $\boldsymbol{\Sigma}$ takes the form

$$\boldsymbol{\Sigma} = \begin{pmatrix} \sigma_A^2 & & \\ \sigma_{AC,21} & \sigma_{C,21}^2 & \\ \sigma_{AC,31} & \sigma_{C,21,31} & \sigma_{C,31}^2 \end{pmatrix}.$$

The episode-level random effects, $\varepsilon^C_{ij,21}$ and $\varepsilon^C_{ij,31}$ are assumed to be uncorrelated and to follow standard normal distributions. The unknown parameters to be estimated are the standard deviations σ_A, $\sigma_{C,21}$ and $\sigma_{C,31}$, and the correlations $\rho_{AC,21}$, $\rho_{AC,31}$ and $\rho_{C,21,31}$. The estimates of $\rho_{AC,21}$ and $\rho_{AC,31}$ are of particular interest since they provide a test of the exogeneity of method choice. If $\rho_{AC,21}$ and $\rho_{AC,31}$ are both equal to zero, then the likelihood for the multiprocess model factors into two components: one for method choice and the other for contraceptive abandonment. In that case, method choice may be considered exogenous and the two processes may be modelled independently.

Identification of a simultaneous equations model usually requires finding at least one variable (an instrument) that on theoretical grounds is a predictor of the endogenous variable but not of the outcome variable of interest. In our case, a suitable instrument would be a variable that affects method choice but not the hazard of contraceptive abandonment. Such instruments are difficult to find. However, due to some women contributing two or more episodes of contraceptive use, instruments are not required for identification of the multiprocess model described above. Lillard et al. (1995) and Lillard and Panis (2000) argue that if there are repeated observations, and no additional correlation is assumed between error components at the replication level, then identification restrictions are not formally necessary. For a particular episode, the other episodes serve as instruments. After accounting for the individual random effects and their correlation, the remaining variation in $\mathbf{C}_{ij}$ from episode to episode within a woman represents the true effect of the method chosen in a given episode on the hazard of abandoning contraceptive use during that episode. This true effect is the effect of method choice net of the selection effect. Lillard et al. (1995) and Brien, Lillard and Waite (1999) present analyses of data where there are replications for each individual. To assess whether instruments are required when correlation is assumed only between error components at the individual level, they conducted sensitivity analyses in which estimates from models with instruments were compared to those from models with the same set of covariates in each equation. In each case, the main conclusions were found to be robust to these changes in the model specification.

The multilevel multiprocess model described above is estimated using full information likelihood, implemented in the *aML* software (Lillard and Panis 2000). Details of the estimation procedure are given in Lillard et al. (1995) and Lillard and Panis (2000).

Results

We fit a multinomial probit model for method choice with pills and injectables as the reference category and a hazards model for contraceptive abandonment while in need of contraception. Estimates for the hazards model of contraceptive abandonment are shown in Table 2, estimates for the multinomial probit model of method choice are shown in Table 3, and the estimated error structure of the two models is shown in Table 4. Two models are presented in Table 2. In Model 1, $\rho_{AC,21}$ and $\rho_{AC,31}$ are constrained to equal zero. This is equivalent to fitting (1) and (3) independently and ignoring the potential endogeneity of method choice (i.e. the standard multilevel model fitted in previous research). Model 2 is a multilevel multiprocess model in which $\rho_{AC,21}$ and $\rho_{AC,31}$ are freely estimated. Thus Model 2 allows for the endogeneity of method choice. Table 2 allows us to see what happens to the estimated effect of contraceptive method used on contraceptive abandonment when the endogeneity of contraceptive choice is controlled for. The estimates in Tables 3 and 4 are based only on the multilevel multiprocess model (i.e. Model 2).

The statistically significant, positive estimate for $\rho_{AC,21}$ (Table 4) suggests that there is a moderate positive correlation between the unobserved factors affecting contraceptive abandonment and the propensity to choose IUD/implants over pill/injectables. That is, women with an above-average probability of choosing an IUD or implant rather than the pill or injectable tend also to have an above-average probability of abandoning contraceptive use. If this selection effect is ignored, the difference in the probability of contraceptive abandonment between users of IUD/implants and users of pill/injectables is substantially understated (see Table 1). This finding supports the hypothesis that women may choose the IUD or implants because they find it difficult or inconvenient to maintain use of a method that requires continuing action on their part rather than the alternative hypothesis that women who are highly motivated to avoid pregnancy would tend to choose methods such as IUD or implants and would also be less likely to discontinue use. If this second hypothesis had been true a *negative* value for $\rho_{AC,21}$ would have been found.

The relationship between method choice and contraceptive abandonment is complicated by the presence of two statistically significant interactions between method used and area of residence and between method used and age. To aid interpretation, predicted probabilities of contraceptive abandonment within the first 12 months of use have been calculated by method used and area of residence (Figure 2) and by method used and age (Figure 3). In the calculation of the predicted probabilities all covariates other than those which interact with method are fixed at their sample mean values. The woman-level random effects are fixed at their means of zero. Only predictions based on Model 2 are shown since the pattern of the interaction effects is broadly the same for both the conventional multilevel hazards model and the multilevel multiprocess model. In both urban and rural areas, and for the two younger age groups, IUD and implant users are less likely to abandon contraceptive use while in need of contraception than users of other methods. The difference between users of pills and injectables and users of implants and IUDs is smaller in urban areas than in rural areas (Figure 2). Figure 2 suggests that condom/other method uses are more likely to abandon use than are users of pill/injectables in urban areas but are less likely to do so in rural areas. However, this difference is not statistically significant (Table 2). The difference in the contraceptive abandonment rates between users of pills and injectables and implants and IUDs does not depend on the age at the start of the episode (Table 2 and Figure 3). However, the difference between users of pills and injectables and condoms and other methods varies according to age. Among young users (under 35), there is no significant difference in the probability of abandoning contraception between users of pills and injectables and users of condoms and other methods. However, the oldest users (35-49) of condoms are significantly less likely to abandon use than are the oldest users of pills and injectables. The interaction coefficients are not substantially affected by controlling for the endogeneity of method choice suggesting that the selection effects do not vary by age or area of residence.

The other coefficients in the model show that the hazard of contraceptive abandonment declines in the first year, then remains constant thereafter (Table 2). Somewhat surprisingly, more educated women are more likely to abandon contraception. This contrasts with the findings of Curtis and Blanc (1997) who found no effect of education on contraceptive abandonment while in need of contraception in any of the six countries studied. Women of lower socio-economic status are more likely to abandon contraceptive use, consistent with the findings of Curtis and Blanc (1997).

All of the characteristics examined influence method choice (Table 3). Table 5 shows the predicted percentages of episodes for which each method category was chosen by type of area, education level, age, and socio-economic status. The effects of each variable are considered separately while all other variables are fixed at their sample means. Details concerning the calculation of predicted probabilities from a multilevel multinomial probit model are given in the Appendix. Urban women are more likely to choose condoms and other modern methods than are rural women. However, they are slightly less likely to choose IUD/implants than are rural women. Education generally reduces the probability of choosing IUD and implants and increases the probability of using other modern methods relative to pills and injectables. The effect of socio-economic status is very similar to that of education. Older women are more likely to choose both IUD and implants and other modern methods and are less likely to choose pills and injectables than are younger women. This probably reflects reduced preference for the hormonal methods as women get older.

Finally, the highly significant estimates of σ_A, $\sigma_{C,21}$ and $\sigma_{C,31}$ (Table 4) suggest that there are strong unobserved woman-level factors that influence method choice and contraceptive abandonment while in need of contraception.

Conclusions

The objective of this paper was to determine whether method choice is endogenous in the contraceptive discontinuation process. Our results show that method choice is endogenous in the case of contraceptive abandonment in Indonesia. Failing to control for the endogeneity of method choice leads to substantial underestimation of the effect of IUD/implants on contraceptive abandonment. The positive correlation between the unobserved factors affecting contraceptive abandonment and the propensity to choose IUD/implants over pill/injectables suggests that women who choose the IUD/implants over pills and injectables are those who are at high risk of abandoning use. The effects of other factors on contraceptive abandonment are not affected by the endogeneity of method choice.

This analysis confirms that the observed differences between the method-specific abandonment rates reflects genuine differences in the propensity to discontinue methods that cannot be explained by the characteristics of women who choose them. In particular, abandonment rates for the IUD and implants are significantly lower than those of pills and injectables, particularly in rural areas. There are many possible reasons why abandonment of IUDs and implants is relatively low. As noted earlier, discontinuation of these methods requires a health provider to remove the device. Thus, a proactive decision is required by the user to discontinue use, which may discourage discontinuation. In addition, the need for a health worker to remove the device provides an opportunity for the client and the health provider to discuss the reasons for discontinuation, which may in turn lead to improved management of side effects and longer use, or to method switching (rather than abandonment). On the negative side, clients who wish to have their IUD or implants removed may face problems scheduling appointments, shortages of staff trained to remove devices, resistance from health workers to remove the device, or high removal fees. In depth interviews in East Nusa Tenggara Timur province in Indonesia revealed that some women had problems getting implants and IUDs removed in health centres, especially if they requested removal before the device had expired (Hull 1998). However, removal could usually be obtained in private clinics, often by the same staff who dissuaded clients from removal in the health centre. In a representative survey of Norplant acceptors, Fisher et al. (1997) found that only nine percent of acceptors reported that they were unable to get a removal on request. Of these nine percent, 27 percent reported that no staff were available to remove the device and 14 percent said that they were persuaded not to have the implants removed. Seventy-eight percent of these clients had to wait less than one week for removal, although about half reported that they had to request removal multiple times.

Given the low overall discontinuation rates for IUDs and implants shown in Table 1, satisfaction with the method is also likely to be a factor in the relatively low levels of abandonment. Hull (1998) reports that many women in East Nusa Tenggara province like implants because of their ease of use, long-term effectiveness, reversibility, and the fact that no pelvic exam is required for insertion (unlike IUD). However, method switching is not examined here. Methods with low levels of abandonment while in need of contraception could also have high switching rates suggesting low user satisfaction. For example, although the risk of abandoning use of condoms is low among older users, overall discontinuation rates for the condom in Table 1 are higher than for other methods. Therefore, a full understanding of the low abandonment rates among older users cannot be achieved without also looking at method switching. Fisher et al. (1997) found that, although continuation rates for Norplant were very high for the first four years of use (66 percent), only 27 percent of Norplant acceptors accepted a second Norplant when their first one was removed compared to 41 percent who accepted another method and 25 percent who stopped using contraception. However, these figures could at least in part reflect misperceptions among both providers and clients about the need for a break from implants when they are removed (Hull 1998).

A secondary aim of this analysis was to explore whether multilevel multiprocess models can easily be applied to study the role of contraceptive methods on contraceptive discontinuation while controlling for the potential endogeneity of method choice. Our experience is that these models are very useful in this context and can be fitted relatively easily using the *aML* software. Since this was our first attempt to fit these models, the current study was limited in its focus. The analysis can now be extended to examine other types of contraceptive discontinuation (e.g. contraceptive failure and switching), and to examine the role of method choice on contraceptive discontinuation in other settings where selection effects may operate differently.

Appendix: Calculation of Predicted Probabilities from the Multilevel Multinomial Probit Model

The predicted probabilities of choosing methods 1,2 and 3 are calculated as follows. The *ij* subscripts are omitted for convenience.

The predicted probability of choosing method 1 is

$$\begin{aligned} \mathrm{P}_1 &= \mathrm{P}(V_{21} < 0 \quad \& \quad V_{31} < 0) \\ &= \mathrm{P}(u_{21}^C + \varepsilon_{21}^C < -\boldsymbol{\beta}_{21}^{\mathbf{C}}\mathbf{X}^{\mathbf{C}} \quad \& \quad u_{31}^C + \varepsilon_{31}^C < -\boldsymbol{\beta}_{31}^{\mathbf{C}}\mathbf{X}^{\mathbf{C}}) \\ &= \int_{-\infty}^{-\boldsymbol{\beta}_{21}^{\mathbf{C}}\mathbf{X}^{\mathbf{C}}} \int_{-\infty}^{-\boldsymbol{\beta}_{31}^{\mathbf{C}}\mathbf{X}^{\mathbf{C}}} g(u_{21}^*, u_{31}^*)\, du_{21}^*\, du_{31}^* \end{aligned}$$

where $u_{21}^* = u_{21}^C + \varepsilon_{21}^C$, $u_{31}^* = u_{31}^C + \varepsilon_{31}^C$ and $g(\cdot)$ is the probability density function of a bivariate normal distribution with mean **0** and covariance matrix

$$\Omega_1 = \begin{pmatrix} \sigma_{C,21}^2 + 1 & \sigma_{C,21,31} \\ \sigma_{C,21,31} & \sigma_{C,31}^2 + 1 \end{pmatrix}.$$

u_{21}^* and u_{31}^* may be standardised so that g(.) becomes the density function of a standard bivariate normal distribution. The resultant integral may then be evaluated using, for example, the `binorm` function in Stata (StataCorp 1999).

The predicted probability of choosing method 2 is

$$
\begin{aligned}
P_2 &= P[V_{21} > 0 \quad \& \quad V_{23} > 0] \\
&= P[V_{21} > 0 \quad \& \quad (V_{21} - V_{31}) > 0] \\
&= P[-(u_{21}^C + \varepsilon_{21}^C) < \mathbf{\beta_{21}^C X^C} \quad \& \quad -\{(u_{21}^C - u_{31}^C) + (\varepsilon_{21}^C - \varepsilon_{31}^C)\} < \mathbf{\beta_{21}^C X^C} - \mathbf{\beta_{31}^C X^C}] \\
&= \int_{-\infty}^{\mathbf{\beta_{21}^C X^C}} \int_{-\infty}^{\mathbf{\beta_{21}^C X^C} - \mathbf{\beta_{31}^C X^C}} g(u_{21}^*, u_{23}^*)\, du_{21}^*\, du_{23}^*
\end{aligned}
$$

where $u_{23}^* = (u_{21}^C - u_{31}^C) + (\varepsilon_{21}^C - \varepsilon_{31}^C)$ and the covariance matrix of $(-u_{21}^*, -u_{23}^*)$ is

$$
\Omega_2 = \begin{pmatrix} \sigma_{C,21}^2 + 1 & \sigma_{21}^2 + 1 - \sigma_{C,21,31} \\ \sigma_{21}^2 + 1 - \sigma_{C,21,31} & \sigma_{C,21}^2 + \sigma_{C,31}^2 + 2 - 2\sigma_{C,21,31} \end{pmatrix}.
$$

The predicted probability of choosing method 3 may calculated in a similar way to P_1 and P_2 above, or alternatively as $P_3 = 1 - P_1 - P_2$.

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Table 1. Contraceptive prevalence among married women age 15-49 and 12-month method-specific discontinuation rates, Indonesia, 1997.

Method	% married women using method	12-month method-specific discontinuation rate
Pill	15.4	33.9
Injectable	21.1	23.5
IUD	8.1	12.3
Implants	6.0	2.9
Condom	0.7	37.7
Sterilization	3.4	0.0
Other method	2.7	29.4
Total	57.4	24.1

Source: CBS [Indonesia], NFPCB, MOH, and MI. 1998.

Table 2. Estimated coefficients and standard errors for hazards model of contraceptive abandonment

	Model 1		Model 2	
	Coefficient	(SE)	Coefficient	(SE)
Constant	-5.883***	(0.197)	-5.994***	(0.223)
Duration (months)				
0-12	-0.046***	(0.010)	-0.044***	(0.010)
12-24	-0.005	(0.011)	-0.003	(0.011)
24-36	0.014	(0.014)	0.015	(0.015)
36+	0.015	(0.012)	0.016	(0.012)
Method				
Pill/injectables[a]	0.000	-	0.000	-
IUD/implants	-1.418***	(0.145)	-1.935***	(0.196)
Condom/other	1.111*	(0.643)	0.826	(0.807)
Type of region				
Rural[a]	0.000	-	0.000	-
Urban	0.205**	(0.083)	0.249***	(0.087)
Education				
None[a]	0.000	-	0.000	-
Primary	0.257*	(0.145)	0.268*	(0.150)
Secondary +	0.404***	(0.153)	0.408**	(0.159)
Age at start of use (years)				
<25[a]	0.000	-	0.000	-
25-34	-0.015	(0.074)	0.025	(0.077)
35-49	0.336***	(0.106)	0.399***	(0.110)
Socio-economic status				
0-1 (low)[a]	0.000	-	0.000	-
2-3 (medium)	-0.206**	(0.097)	-0.219**	(0.102)
4-5 (high)	-0.436***	(0.112)	-0.462***	(0.117)
Method by region interaction				
IUD/implants + urban	0.552**	(0.230)	0.496**	(0.236)
Condom/other + urban	0.484	(0.591)	0.468	(0.622)
Method by age interaction				
Condom/other + 25-34	-1.188**	(0.544)	-1.181**	(0.560)
Condom/other + 35-49	-2.658***	(0.780)	-2.676***	(0.810)
S.D. of woman-level random effect, σ_D	1.269***	(0.086)	1.445***	(0.110)

[a] denotes reference category.

* $0.05 < p \le 0.1$; ** $0.01 < p \le 0.05$; *** $p \le 0.01$.

Table 3. Estimated coefficients and standard errors for multinomial probit model of contraceptive choice (Model 2)

	IUD/implants vs.		Condom/other vs.	
	Coefficient	(SE)	Coefficient	(SE)
Constant	-1.075***	(0.069)	-8.718***	(0.790)
Type of region				
Rural[a]	0.000	-	0.000	-
Urban	-0.091**	(0.036)	1.252***	(0.168)
Education				
None[a]	0.000	-	0.000	-
Primary	-0.128**	(0.058)	0.406	(0.481)
Secondary +	-0.133**	(0.062)	1.624***	(0.491)
Age at start of use (years)				
<25[a]	0.000	-	0.000	-
25-34	0.260***	(0.032)	0.367***	(0.137)
35-49	0.343***	(0.047)	1.032***	(0.195)
Socio-economic status				
0-1 (low)[a]	0.000	-	0.000	-
2-3 (medium)	-0.146***	(0.042)	0.996**	(0.400)
4-5 (high)	-0.117**	(0.048)	1.716***	(0.411)

[a] denotes reference category.

* $0.05 < p \leq 0.1$; ** $0.01 < p \leq 0.05$; *** $p \leq 0.01$.

Table 4. Estimated standard deviations and correlations for woman-level random effects (Model 2)

Equation	Hazard	IUD/implants vs. pill/injectables	Condom/other vs. pill/injectables
Hazard	1.445*** (0.110)	-	-
IUD/implants vs. pill/injectables	0.358*** (0.093)	0.695*** (0.050)	-
Condom/other vs. pill/injectables	0.065 (0.141)	-0.341*** (0.063)	2.368*** (0.181)

Note: values on diagonal are standard deviations; values on off-diagonals are correlations.

* $0.05 < p \leq 0.1$; ** $0.01 < p \leq 0.05$; *** $p \leq 0.01$.

Table 5. Predicted percentages choosing modern reversible methods by background characteristics (Model 2)

	Method		
	Pill/injectables	IUD/implant	Condom/other
Type of region			
Rural	82.0	17.4	0.6
Urban	82.5	15.4	2.1
Education			
None	80.2	19.4	0.3
Primary	82.8	16.7	0.5
Secondary+	81.7	16.5	1.9
Age at start of use (years)			
<25	85.7	13.6	0.6
25-34	80.2	18.8	0.9
35-49	77.6	20.7	1.8
Socio-economic status			
0-1 (low)	80.4	19.3	0.3
2-3 (medium)	83.1	16.1	0.8
4-5 (high)	81.7	16.7	1.7

Figure 1. Gross life table cumulative probabilities of abandonning use while in need of contraception, modern reversible methods

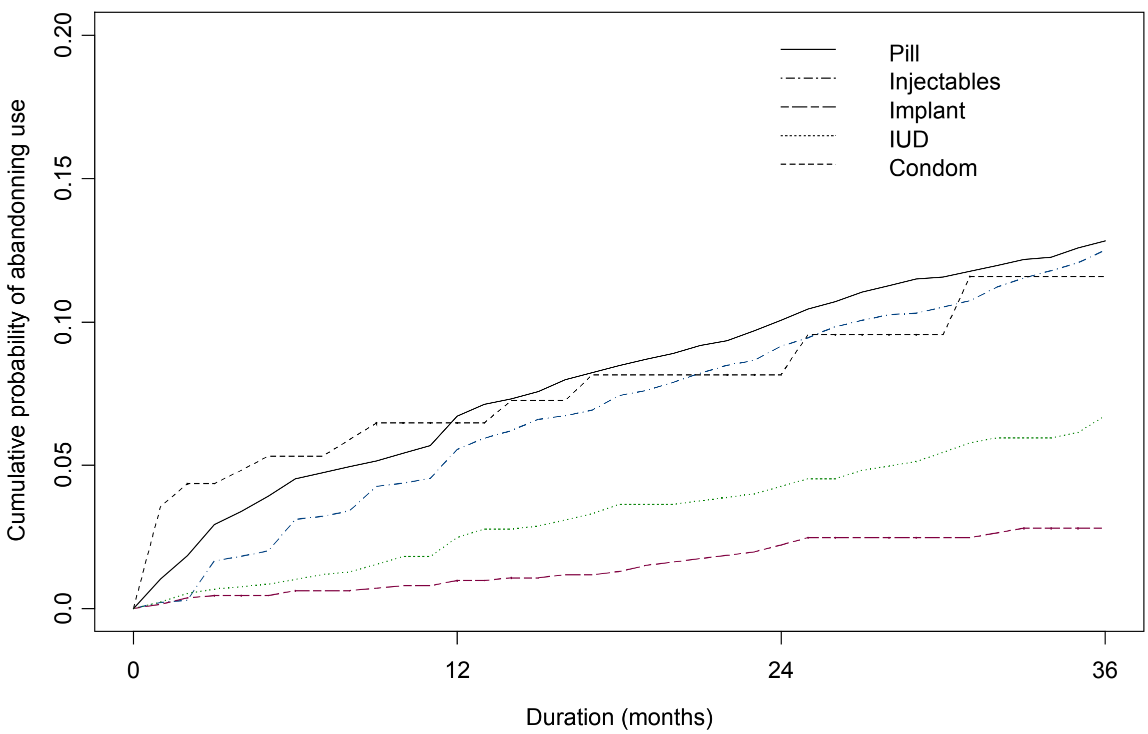
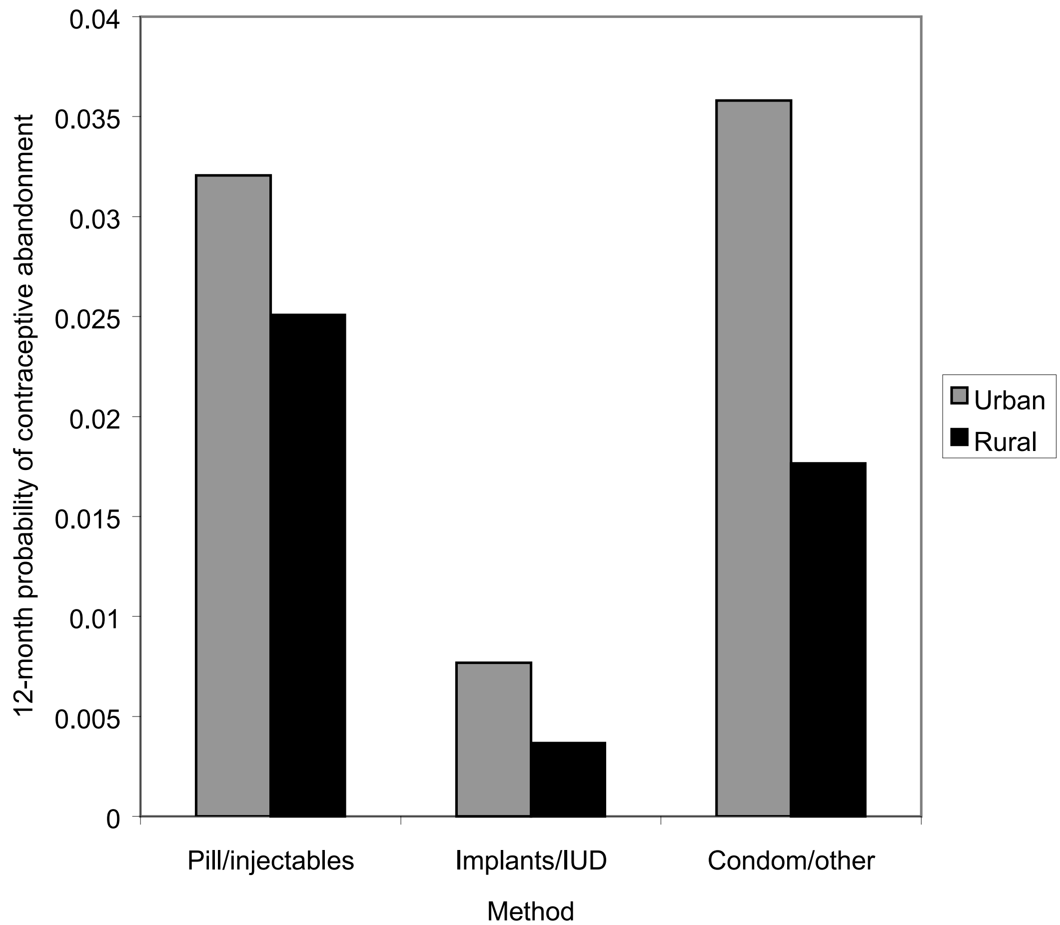
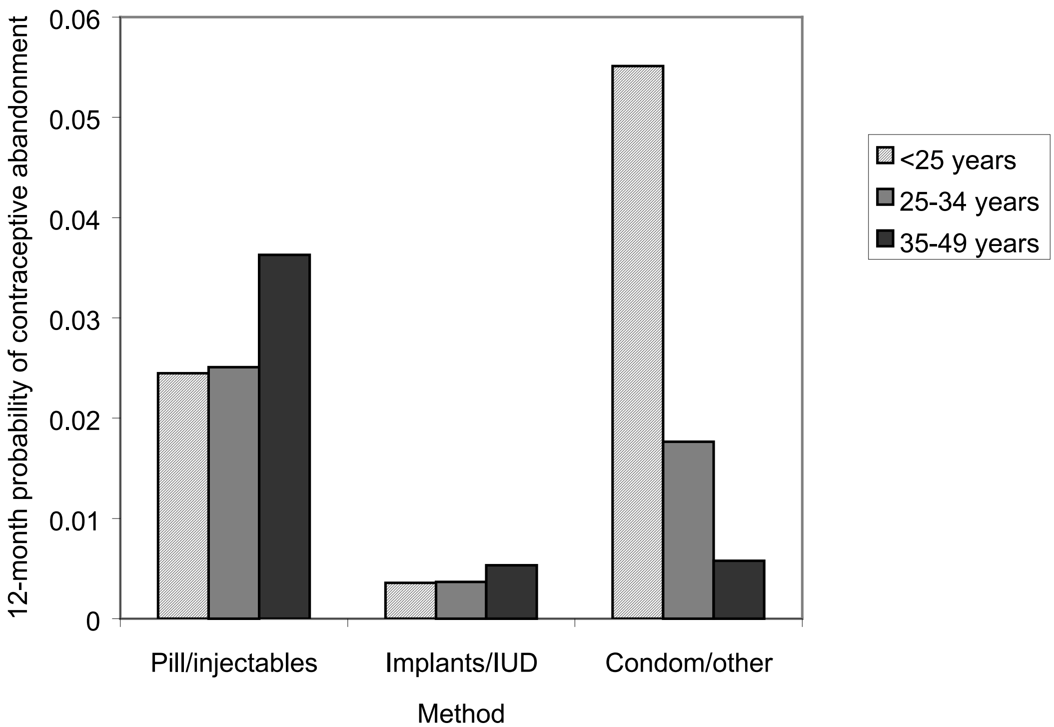


Figure 2. Predicted cumulative probabilities of abandoning use while in need of contraception within first 12 months, by method and type of region of residence (Model 2)



Note: These probabilities are estimated for women aged 25-34.

Figure 3. Predicted cumulative probabilities of abandonning use while in need of contraception within first 12 months, by method and age at start of use (Model 2)



Note: These probabilities are estimated for rural women.