UNIVERSITY OF SOUTHAMPTON

Assessment of Family Planning Outreach Workers' Contact and Contraceptive Use Dynamics in Rural Bangladesh using Multilevel Modelling

by

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Doctor of Philosophy

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This thesis is dedicated to my parents Abdul Jabber (in memoriam) and Nabaunnesa Begum, and my beloved wife Hasina Akter, daughter Kishwar Nadia and son Maahedi Savvy

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ABSTRACT

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ASSESSMENT OF FAMILY PLANNING OUTREACH WORKERS' CONTACT AND CONTRACEPTIVE USE DYNAMICS IN RURAL BANGLADESH USING MULTILEVEL MODELLING

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In Bangladesh, the family planning services are provided by government outreach workers, the Family Welfare Assistants (FWAs). The FWAs are the main link between the program and the rural women. The role of FWAs is to provide information about family planning, motivate women to accept a method and ensure convenient contraceptive services. Research has demonstrated that a tangible demand for family planning has been met, contraceptive use has increased and fertility has started to decline.

Women living in the areas served by the same FWA may have access to similar services and demonstrate similar patterns of contraceptive use. A hierarchical structure arises if the data are collected using multistage sampling or overtime. In a longitudinal study, observations made on the same individual over time may lead a two-level hierarchical data structure in which observations for an individual at a successive point of time are nested within the individual. The data for this research come from the Sample Registration System, a longitudinal surveillance system of the Operations Research Project of International Centre for Diarrhoeal Disease Research, Bangladesh. In this research, longitudinal data for the period 1986-1992 were used.

In this research, multilevel modelling techniques are used to analyse contraceptive use dynamics in four rural areas of Bangladesh, since individual women are nested within FWA work areas (*units*) and within FWAs Supervisors' works areas (*unions*). A multilevel logistic regression and a discrete-time hazards model are used for studying the association between FWAs contact and current contraceptive use, and the association between FWA contact and contraceptive adoption respectively. Multilevel discrete-time competing risk hazard models are used for studying the association between FWAs contact and method choice, the patterns of contraceptive discontinuation and switching in Bangladesh.

The results show that the FWAs contact is associated with an increase in contraceptive use, adoption and continuation. This research clearly points out that FWA contact is associated with the increase in the risk for a woman to switch from one modern method to another modern method and decrease in the risk to discontinue using any modern method and be at risk of unintended pregnancy. These analyses for estimating the impact of FWAs contact on contraceptive use dynamics in Bangladesh provide the evidence of impact of family planning program in the demographic transition. This research suggest that, if the FWA house visits are maintained and if the FWAs are trained in managing and treating side effects, the contraceptive use and the continuity of use will be increased and will eventually have an increasing impact on fertility transition in the country.

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CHAPTER 1

INTRODUCTION

1.0 Preamble

In Bangladesh, the family planning movement began in 1953 with the establishment of a number of voluntary organizations. However, a fully-fledged independent national family planning movement organized by the government was not launched until 1960. After more than three decades, the national family planning programme was termed a “success in a challenging environment” (Cleland et al., 1994). In the past decade, in spite of its unremarkable economic development, Bangladesh has continued to achieve a decline in fertility. Recent analyses of demographic trends in Bangladesh have documented this decline in fertility and have concluded that the demographic transition in Bangladesh is fully underway and the third stage of the transition of fertility has begun (Amin et al., 1994; Cleland et al., 1994 and Mitra et al., 1997). The increased use of contraceptives is acknowledged by researchers as responsible for the decline in total fertility rates (TFR), which in turn is recognized by most commentators as a result of a strong and successful domiciliary family planning programme.

Family planning programmes have been developed and supported to provide people with a means to achieve the number of children they desire and to reduce unwanted pregnancy, as a means of improving the health of women and children, and to contribute slower population growth. But who makes the choice about which contraceptive method an individual woman uses? Ideally, the users should make the decision about the contraceptive that they use considering the feelings, thoughts, and beliefs of their partners. In some societies, the decision-maker may be the woman’s husband or even her mother-in-law. These customs have advantages and disadvantages.

However, in many health care delivery systems around the world, the family planning provider makes the decision for the client.

No one method is adequate to meet the needs of every couple. Some couples want a temporary method to space births while the others want to limit their family sizes and want a long term-method. A method that is not effective for an individual can lead to the serious consequences of unwanted pregnancy. A method that does not suit into the individual's personal lifestyle or societal norms will not likely be used correctly or consistently.

Many women find birth control pills satisfactory, while the others experience unacceptable side effects. Hence, the ability to change methods is important. The availability of a range of methods provides alternatives for couples not satisfied with their current method. As Sai (1989) says:

> "Family planning decisions should be made on a completely voluntary basis, but on the basis of thoroughly informed choice on the part of individuals and couples. A decision about childbearing cannot be called voluntary if the individuals and couples have not been previously educated and informed about the meaning of family planning to their lives and the lives of their children and about the methods of family planning that are available" (as cited by Hatcher et al., 1989:190).

In Bangladesh, contraceptive use remained at a very low level during 1969-1975. It was estimated to be three percent in 1969 and 8 percent in 1975. In 1989, nearly 33 percent of all currently married women below age 50 reported using a method of family planning (BFS, 1989). In 1993, nearly 45 percent of all currently married women below age 50 reported using a method of contraception (Mitra et al., 1994). By 1996, the use of any contraceptive method had increased to 49.2 percent (Mitra et al., 1997). Each year, there has been a steady but a consistent increase in contraceptive use of about two percentage points. The proportion of married women using the pill has increased in recent years. The pill remains by far the most popular method of contraception, accounting for half of all modern contraceptive use. The use of male and female sterilization has declined slightly since 1989. Currently sterilization accounts for only 20 percent of all contraceptive use. The use of the injectable method, which has been increasing steadily over the past decade, may become the second most popular method in Bangladesh. Thus, these shifts from permanent methods to modern reversible methods, particularly pills and injectables, have important implications for the national family planning programme in Bangladesh.

1.1 Problem statement

In Bangladesh the family planning programme initially consisted of small-scale efforts by private voluntary organizations. In 1960, the then Pakistan government treated the programme as an official government programme and as a part of the programme static family planning clinics were established in various locations. In its First Five-Year Plan (1973-78), the Government of Bangladesh gave priority to population control equal to that given to food production (GoB, 1973). In June 1976, the growth of the population was declared as the number one problem for the country and the government emphasized an urgent need to make the family planning programme an integral part of the development process. Integrating maternal and child health in the programme broadened the base of the programme. Two years later, in 1978, emergency measures were taken to strengthen the national family planning programme. One of these included the initiative of recruiting grass roots level female workers, the Family Welfare Assistants (FWAs), and another was the construction of Family Welfare Centers (FWCs) at the lowest administrative level.

During the 1978-80 period, nearly 12,000 female FWAs were recruited and trained. These female FWAs' responsibility is to visit rural Bangladeshi women in their houses, to discuss family planning and related health issues, to motivate them to use modern contraceptives and offer them a limited range of family planning commodities. Each FWA is given responsibility for a geographical area covering a population of 4,000 and each of them is expected to visit every eligible women of reproductive age in that area at least once in every 90 days. During 1985-90 10,000 additional FWAs were recruited and trained to improve outreach coverage, and to intensify the frequency of exchanges between FWAs and clients in their homes (Hasan and Koblinsky, 1991). The use of contraceptives rose dramatically in recent years. The contraceptive prevalence rate (CPR) has increased from 25.3 percent in 1985/86 to 49.2 percent in 1996/97 (Mitra et al., 1997). For this improvement, many studies have given the credit to the FWAs, whose door-to door household contact is found to be positively associated with the chance that a woman would be a contraceptive method user (Islam and Mahmud, 1995; Kamal, 1994; Kamal and Sloggett, 1996; Phillips et al., 1989a, 1989b, 1993, 1996 and Ullah and Chakraborty, 1993). Researchers have shown a strong statistical relationship between workers' visits and contraceptive adoption and continued use (Hossain and Phillips, 1996; Koenig et al., 1997). Workers' contacts are important not only because they generate demand but also they provide a wide range of family planning services to the rural women. Schuler et al. (1995, 1996), while recognizing the contribution of the outreach on the major advances in contraceptive utilization in Bangladesh, argue that family planning outreach is now contributing to the isolation and immobility of the women resulting in low status for the women. However, Phillips and Hossain (1998) show that the family planning outreach worker's visit is not causing the status of women to deteriorate in Bangladesh.

Much has been written and documented about the relationship between social and economic development and fertility decline; but the controversy about the effect of organized family planning programmes on the decline of fertility in the absence of socio-economic development remains. Pritchett (1994), a World Bank economist, concludes that fertility is primarily determined by the desire for additional children; family planning efforts have no dominant role in determining fertility differences. Pritchett argues that ninety percent of the differences across countries in total fertility rates are accounted for solely by the reported desired fertility by the women. Bongaarts (1994) refutes Pritchett's argument on the assumption that a substantial unwanted fertility exists in most societies and a well-organized family planning programme can effectively reduce this unwanted fertility. Knowles et al. (1994) also reject Pritchett's assumption on the ground that the analysis done by Pritchett is seriously flawed by the use of an essentially 'tautological' statistical model. Caldwell et al. (1999) argue that the fertility transition in Bangladesh is not only attributed to the success of the family planning programme but also attributed to the change in socio-economic development. However, no evidence of major economic development has so far been documented by any sources (a detailed description of economic condition of Bangladesh is presented in Chapter 2). Peoples' awareness about small family size, universal knowledge about modern family planning methods and the accessibility and availability of modern methods may be a result of the vigorous outreach family planning activities (Phillips et al., 1996).

As the levels of contraceptive use have increased significantly in recent years in Bangladesh, the relationship between prevalence of contraceptive use and the level of fertility has not always been consistent. In any country when levels of contraceptive use are increasing significantly, the impact of that contraceptive use on fertility depends not only on the level of use prevalence but also on both reliability and continuity of use (Jejeebhoy, 1991). Across many countries there is a reasonably strong and stable relationship between contraceptive use and fertility. However, there is evidence that the relationship between prevalence of contraceptive use and the levels of fertility is not always consistent (Bongaarts, 1987; Curtis and Diamond, 1995). For example, in Zimbabwe, in 1984 the contraceptive use rate was 38 percent and the total fertility rate (TFR) was 6.5. Bongaarts (1987) argued that contraceptive prevalence may not be the only proximate determinant of fertility rates. However, Jejeebhoy (1991) and Curtis and Diamond (1995) argue that, in addition, high levels of contraceptive use are being compensated by higher levels of discontinuation and use failure among users. Contraceptive failure and discontinuation often increase with higher levels of use. Research findings show a strong positive association between outreach workers' contact and continuity of use of modern family planning methods (Hossain and Phillips, 1996).

Therefore, it is worthwhile to investigate the impact of contact with FWAs (outreach workers), who are responsible for motivating rural Bangladeshi women and distributing non clinical methods at their doorstep, on use of contraceptives and on reasons for discontinuation and switching.

Another important issue is the quality of family planning services. Quality matters, not only because quality is an indigenous goal, but also because it enhances the credibility of the programme. Recent studies have found a direct relationship between perceived quality of family planning services and contraceptive use (Koenig et al., 1997 and Mensch et al., 1996). Quality also encourages users to continue using contraception (Koenig et al., 1997). Choice of method is considered a central determinant of quality of care, because it influences women's satisfaction, acceptance and continuation.

There has been relatively little research on the components of contraceptive use dynamics (contraceptive use, adoption, choice, continuation and switching) using appropriate data and appropriate techniques. The majority of the early studies of the components of fertility in Bangladesh are focussed on contraceptive prevalence, with regression models applied to evaluate the factors affecting use and choice of contraceptive. In relation to other components of contraceptive use dynamics, the number of studies which investigated the reasons for discontinuation and switching is very limited. In the past the calculation of rates of contraceptive discontinuation and switching were primarily based on information from prospective or retrospective clinical studies. One common major problem with clinical data is bias due to sample selectivity. For example, for understanding the reasons for contraceptive use, if we use only clinical data we will be ignoring all other women who do not come to the clinic either for getting family planning methods or for getting side effect services. Therefore, it is very unlikely that the experience of women selected in a clinical sample represent the contraceptive experience of the population as a whole. One way of avoiding such bias is to use more representative data with duration of use for each episode of use.

Another technical issue is that, for large data sets, many analysts have used life tables to derive net rates of discontinuation and switching. One drawback with this approach is that analysts consider each factor separately. This can be overcome to an extent through the use of regression techniques but, even so, until recently few researchers have accounted for the clustered nature of the data in the analysis. The structure of the cluster is expected to be related to individual behaviour. People living close together are likely to share similar norms and values in their daily lives. In recent years there has been a great interest in the literature on the relationship between the use of contraception and the contextual factors that are directly affecting individual attitudes and behaviours. Individuals are expected to share similar attitudes and values when selected from the same cluster, to show a pattern of behaviour that is much more alike than the individuals selected from different clusters. Entwisle et al. (1989) argue that the women which live in the same community often talk to each other and, hence, are more likely to have similar contraceptive use behaviour. In the presence of such variation due to clustered data the assumption of independence between observations is no longer valid. One way of overcoming such problems is to use multilevel modelling techniques where random parameters associated with the levels of analysis are included in the model.

Phillips et al. (1996) have found that outreach workers contact had a small but significant effect on whether a woman said that she wanted no additional children. However, Arends-Kuennig et al. (1999) have found that the number of visits that a woman receives from a family planning outreach worker has no statistically significant effect on the probability that a woman alters her fertility preference from wanting more children to no more children. Desire for no additional children or desire for additional children depends on a number of issues: number of living sons, number of living daughters, women's age, etc. A woman may also change her desire from not to have any more additional child to have additional number of children if she experiences a loss of her child. Conversely, a woman may change her desire from to have an additional child to no more additional child when her desired family size is fulfilled. Desire for no additional children is found positively associated with the use of contraception (Phillips et al., 1989a, 1993, 1996; Koenig et al., 1997; Ullah and Chakraborty, 1993). Thus, desire for no additional children is assumed to be a function of the number of living sons and number of living daughters that a woman has, her level of education, and her age but not the workers' contact.

1.2 Objective of the study

In demographic research, although the application of multilevel models has become increasingly popular in recent years, no studies have so far investigated the effects of contextual factors on contraceptive adoption, choice, and reasons for switching and discontinuation using longitudinal data. The aim of this research is to validate and strengthen our ideas about the contribution of family planning outreach activities on the fertility transition in Bangladesh. The overall objective of this research is to measure the impact of family planning outreach workers' contact with rural women on the components of contraceptive use dynamics controlling for the effect of the socio-demographic characteristics of the women. They are to:

1. Investigate the determinants of desire for no additional children and the determinants of perceived quality of care in rural Bangladesh

2. Conduct a thorough investigation of the relationship between the socio-demographic and programmatic factors, and the components of contraceptive use dynamics in rural Bangladesh

3. Investigate the effect of the spacial characteristics of the areas (such as, family planning outreach workers' work areas – *units* and their supervisors work areas – *unions*) on the components of contraceptive use dynamics by means of multilevel models.

1.3 Analytical framework

A conceptual framework for the study of the impact of family planning outreach worker-woman contact on contraceptive method choice, reasons for switching and discontinuation has been developed (Figure 1.1). It is posited that the outreach worker-woman contact plays a pivotal role in a woman's decision to make a choice of contraceptive method. Worker-woman contact also plays a pivotal role in a woman's decision to continue contraceptive use or to switch to a more suitable method. Discontinuation is posited as either an indication of the dissatisfaction of a woman with a particular method or the lack of availability of a suitable method to switch to. When a woman has difficulty in adjusting to a specific method of contraception because of perceived or actual side effects, worker-woman contact provides the necessary counselling to switch to a more suitable method. Absence of such contact compels a woman to discontinue a method when she hears of a the problem of any kind about the method or faces an actual problem with the method. During worker-woman exchanges, a worker maintains a woman's privacy, talks about other methods, spends reasonable time with her and advises on the woman's perceived or actual side effects. This allows a woman to make a suitable choice and eventually should allow her to become a satisfied user.

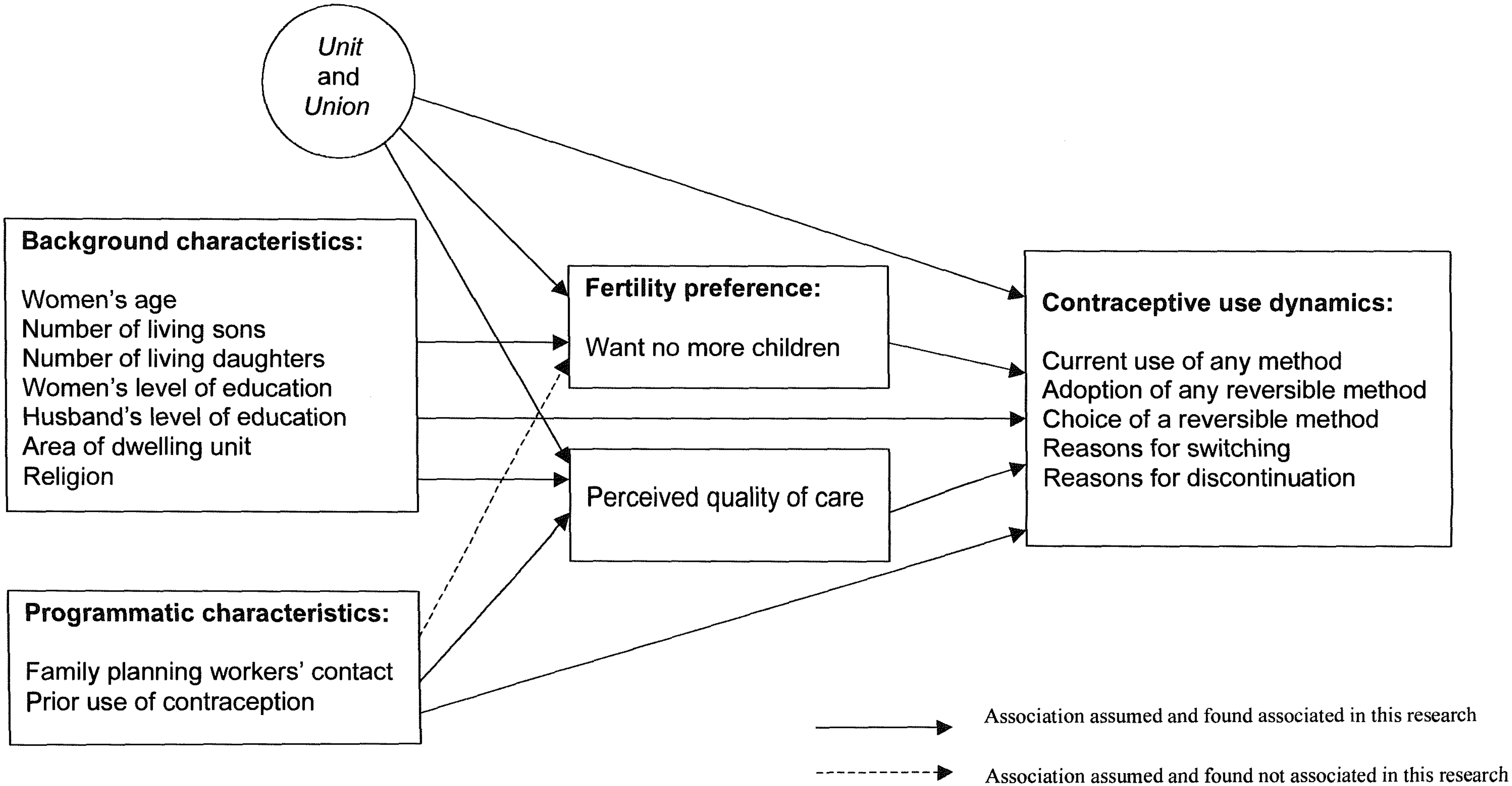
- Worker-client contact, prior use of family planning methods and the background characteristics of the women are assumed to be positively associated with perceived quality of care.

- Women's background characteristics, worker-client contact and prior use of family planning methods are assumed to be associated with desire for no additional children.

- Women's background characteristics, prior contraceptive use, perceived quality of care, fertility preference and worker-woman contacts are assumed to be associated with current use of any method of contraception.

The methodology will use a number of outcome variables. Several multilevel discrete-time competing risks hazard models will be used to measure the impact of workers' contact on contraceptive choice, reasons for discontinuation and switching. Multilevel modelling will allow the estimation of random parameters at different levels of aggregation (*unit, union* and individual level). These random parameters will permit the assessment of the variation within each level. An advantage of splitting the variation into individual and contextual components is that an estimate of the inter-community variation can be obtained. Using this approach, it will be possible to determine the amount of variation that can be explained with the observed community-level variables and the proportions that remain unexplained.

Figure 1.1: Conceptual framework for the effect of family planning outreach workers' contact on contraceptive use dynamics in rural Bangladesh using multilevel modelling



1.4 Hypotheses

(1) It is hypothesized that women's background characteristics, worker-woman contact and the prior contraceptive use affect reproductive preferences (desire for additional children), each in turn represents an independent influence on contraceptive use, adoption, choice, continuity of use and switching behaviour.

(2) It is also hypothesized that women's background characteristics, worker-woman contact and the prior use of contraception affect perceived quality of family planning services, each in turn, represents an independent influence on contraceptive choice and continuity of use.

1.5 Data

The data for this research come from the ongoing Operations Research Project (formerly called Maternal Child Health and Family Planning Extension Project), a collaborative effort of the International Center for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) and the Ministry of Health and Family Welfare of the Peoples Republic of Bangladesh to improve public-sector maternal and child health and family planning services. The data used in this research are not to be confused with the widely known demographic surveillance system of the ICDDR,B field research station in Matlab. The Matlab Family Planning and Health Services Project is described in paper by Bhatia et al. (1980). The Operations Research Project (ORP) started in 1982 in two rural *thanas* (a *thana* is a unit of local government, typically serving a population from 200,000 to 300,000) with a mandate to replicate the success of Matlab experiment in national settings (Phillips et al., 1984b). The demographic impact of Matlab Family Planning and Health Services Project is documented by Phillips and others (1982, 1988) and Menken and Phillips (1990). The Matlab Family Planning and Health Services Project (FPHSP) showed that contraceptive services can initiate a fertility change in a poor rural traditional society. Phillips and Koblinky (1984a) argue that fertility can significantly be reduced in Bangladesh by making contraceptives readily available to women. The ORP is aimed at inducing organizational change and development in the Bangladesh national family planning programme through collaborative fieldwork and research. In ORP field areas, the government's existing resources working within the constraints of the public-sector bureaucracy provide the usual family planning services. The objective of initiating ORP was to introduce a new system of management that included field scheduling, routine household visitation, record keeping, supply and logistics, supervision, and some other aspects of Matlab FPHSP not usually present in the national programme.

To monitor its impact, the ORP introduced a longitudinal surveillance system, called the Sample Registration System (SRS) that generated the data for this research. The SRS design is described in Mazumder et al. (1991). Originally established in 1982, the SRS operates in four rural *thanas* in Bangladesh. Two more rural *thanas* were added in 1986 with a baseline KAP survey. In 1989, two *thanas*, which were taken in 1982 were dropped from the surveillance. The government of Bangladesh selected these six rural thanas for the ORP. A two-stage cluster sample was drawn, with a random selection of sample *unions* at the first stage. A union is an administrative sub-unit in Bangladesh each consisting of a population of roughly 20,000. A complete household listing of all dwelling units in each sampled *union* was subsequently carried out. At the second stage, a 1/6th sample of households from seven sampled *unions* of two *thanas* (Sirajgonj *thana* and Gopalpur *thana*) and 1/5th sample of households from six sampled *unions* of two other *thanas* (Abhoynagar *thana* and Fultala *thana*) were drawn using systematic sampling, with households in each area having an equal probability of being selected in the sample. Another 1/5th

sample of households was also drawn in 1986 from four sampled *unions* of two newly selected *thanas.* (Bagherpara *thana* and Keshobpur *thana*)

Since 1982, the SRS has been collecting data on a 90-day cycle on contraceptive use dynamics from the currently married women of reproductive age in the sampled households. Questions related to government Health and Family Planning workers' service operations (contact, discussion and family planning service to the rural women, etc.) were added with the surveillance routine questions module in 1984. In addition to service operations data, the SRS also collects data on demographic events (births, deaths, migrations, marital status changes, etc). The ORP sample, which comes from a two-stage cluster design, leads to the selection of approximately one household in five at the final stage in the six *thanas.* A household is added with the surveillance when an existing sample household splits and creates a new household. The sample is continuously renewed by the registration of additional women, who join the sample households as in-migrants for reasons of marriage. All married women of reproductive age from the sample household have been followed every 90 days by well-trained and supervised female interviewers since 1982. In addition to routine data collection on demographic events and contraceptive use dynamics, the SRS has been allowed to conduct several cross-sectional surveys, such as baseline KAP surveys, fertility preference surveys, quality of care survey, etc., over the period of eleven years. The longitudinal data on contraceptive use history and the family planning workers' visitation, cross-sectional baseline data and the quality of care data are used for the analysis of the impact of workers' contact with women on contraceptive use dynamics in rural Bangladesh. The SRS has been providing a useful basis of longitudinal observation of women by recording baseline information and longitudinal information on reproductive behaviour and national family planning workers' household visits and their services.

1.6 Study area

The data from the four study areas have been used in this research. These study areas are located in two of four (recently split into six) regions of Bangladesh. The *thanas,* Abhoynagar, Bagherpara and Keshobpur are situated in Khulna region, which is about 130 kilometres southwest of Dhaka, the capital of Bangladesh. Sirajgonj *thana* is situated in Rajshahi region, which is in the north-central part of the country and is about 80 kilometres away from Dhaka (see Figures 1.2).

The Abhoynagar *thana* is located in Jessore district about 50 kilometres south of the district town. Bagherpara and Keshobpur *thanas, which* are also in Jessore district, are about 24 kilometres north of the district town and about 40 kilometres south of the district town respectively. Sirajgonj *thana* is a district headquarter *thana* located on the bank of the river *Jamuna*.

Table 1.1 shows the population size, geographical area and the population density of these four *thanas* for 1981 and 1991 censuses. In Jessore district, Abhoynagar *thana* is comparatively smaller in size than other two *thanas*– Bagherpara and Keshobpur. Though Abhoynagar *thana* is smaller in size, the population density in Abhoynagar *thana* is higher than Bagherpara and Keshobpur *thanas.* The socio-economic conditions in these three *thanas* under Jessore district are similar in nature. However, Sirajgonj is a big *thana* compared to Abhoynagar, Bagherpara and Keshobpur *thanas* in terms of geographical area. The population density is much higher in Sirajgonj compared to the other three *thanas* under study. The socio-economic conditions are a little different compared to other three *thanas* under study. The landmass of Sirajgonj *thana* keeps changing due to periodic erosion by the river. Sirajgonj *thana* has a large part of land under water and another sizeable part of land is *char* (newly formed land from the deposits of the silt of the river *Jamuna*).

Figure 1.2: Map of Bangladesh locating study thanas

Four study *thanas* are marked in boxes

Table 1.1: Population size and density in study areas, 1981 and 1991 census, Bangladesh

Region/*thana*	Area in square kms	Population (in thousands)		Population density (persons per square km)	
		1981	1991	1981	1991
Khulna region:					
Abhoynagar *thana*	247	176	205	713	830
Bagherpara *thana*	271	143	169	528	624
Keshobpur *thana*	259	171	200	660	772
Rajshahi region:					
Sirajgonj *thana*	326	369	389	1,132	1,193

Source: BBS 1991 Census

1.7 Data quality and representativeness

Table 1.2 presents the descriptive statistics of the population under study. The total number of women under study is 5,641 currently married women of reproductive age. Their average age is 28.5 years. Most of the women have no formal education. The mean number of years of formal education is 1.4. Approximately 25 percent of currently married women of reproductive age were using a method of contraception. The demand for family planning is pronounced. More than half (54.3 percent) of all married women of reproductive age stated that they wanted no more additional children. Approximately 85 percent of women under study are Muslim. Family planning outreach workers' contact rate is almost 40 percent. These characteristics are typical of data reported in national surveys. A useful indicator of household economic status is the area of dwelling units. The mean area of dwelling units is 254 square feet, which is very low. However, it is widely believed that the bigger size of dwelling units indicates higher economic status in Bangladesh.

Table 1.3 shows the rates of contraceptive prevalence by type of methods available in Bangladesh from two different sources of data. The Contraceptive

Prevalence Survey (CPS-1985) is a national representative survey conducted in 1985 throughout the country on 7,822 currently married women of reproductive age (Mitra et al., 1987). The Knowledge, Attitude and Practice (KAP) survey was conducted in 1985/86 in four rural study *thanas* of Bangladesh under Sample Registration System (SRS) framework (discussed in Section 1.4).

Table 1.2: Descriptive statistics of the study population, four rural areas of Bangladesh, 1986

Variables	Means/Percent
Background characteristics:	
Living sons	1.6
Living daughters	1.5
Desire for additional children	
Don't want any more	(54.3)
Want more	(45.7)
Age of woman (in years)	28.5
Social and economic characteristics:	
Education of woman (in years)	1.4
Religion:	
Hindu and other	(14.7)
Muslim	(85.3)
Area of dwelling unit (in square ft)	253.93
Mean women's literacy	24.4
Programmatic indicators:	
Family planning outreach workers' contact	(39.7)
Current contraceptive use	(25.4)

Figures in parentheses are the percent of study population

The overall contraceptive use rate is almost the same in both the national survey and the SRS KAP-survey. The rate of condom use is slightly higher in CPS-1985 survey than KAP-1985/86 survey. The percentage of women who use pills is also slightly higher in the CPS-1985 survey compared to the KAP-1985/86 survey. However, the use of injectables is much higher in the KAP-

1985/86 survey compared to the CPS-1985 survey. The percentage of women depending on traditional method is 6.9 in CPS-1985 survey compared to 5.2 in the KAP-1985/86 survey. Traditional methods include periodic abstinence, withdrawal, herbal methods, and others. From the comparison presented in Table 1.2 we can say that contraceptive use data reported in the KAP-1985/86 survey collected through SRS corresponds broadly with the contraceptive use data reported in national survey CPS-1985.

Table 1.3: Consistency between CPS-1985 national survey and the KAP-1985/86 SRS survey, Bangladesh

Method	Percentage of currently married women of reproductive age using contraceptives	
	CPS-1985[a] (National sample)	KAP-1985/86[b] (in four rural *thanas*)
Condom	1.8	1.5
Pill	5.1	4.7
Injectables	0.5	1.9
IUD	1.4	2.9
Female sterilization	7.9	7.1
Male sterilization	1.5	2.0
Vaginal methods	0.2	0.1
Traditional methods	6.9	5.2
Total	25.3	25.4
Total sample	7,822	5,641

[a] Mitra et al. (1997)
[b] Source: ICDDR,B Sample Registration System (SRS)

A key component of the data used in this research is the quality. Female well-trained interviewers, who are ICDDR,B paid staff and are independent of any family planning services, collect data from women of reproductive age in sample households. In the early stage of the surveillance a team consisted of one male interviewer and one female interviewer. Each sample household is visited by one female ICDDR,B interviewer once in every 90 days. Each interviewer has a fixed interviewing schedule for visiting sample households prepared at the beginning of the year. These interviewing schedules are prepared by the field supervisors with the help of the interviewer concerned and approved by the Dhaka-based supervisor. After two years or so, interviewers are transferred from one *union* to another *union* in order to maximize the quality of the data. All detected events (births, deaths, migrations, marital status change, contraceptive use status, government health and family planning workers' visits, their services, etc.) are recorded by the interviewers on the computer printed record books: household record books and service history record books. Each interviewer carries these computer-printed household record books and service record books during their household visitation. The household record books are for recording demographic events and the service history record books are for recording the contraceptive use history and the government health and family planning outreach workers' service operations. These record books are continually updated in each 90-day round and printed following the completion of six rounds. After systematic editing in the field office, these books are routinely sent to Dhaka (ICDDR,B head office) for data entry using an interactive database. These record books provide a longitudinal summary of events for each household under surveillance. Field workers are extensively trained to utilize these record books for logical consistency checks at the time of data collection.

The collection of accurate data is facilitated by a well-developed system of supervision and independent field checks. Supervisors frequently accompany field interviewers on parts of their household visitation rounds to observe data collection procedures and assess performance. Supervised interviews and spot-checks on interviewers are also each carried out on five percent of all sample households. Supervisory staff, to check on the accuracy and the validity of data collected, also carried out independent re-interviews with a random sample of five percent of all households. Monthly staff meetings are also held to review erroneous data identified by the field-based data editors and by computer edits. The meetings also discuss any field problems/instructions to standardized data collection procedures across field sites.

1.8 Outline of the thesis

This thesis consists of nine chapters. Chapter 2 provides some background information about Bangladesh and describes the history, development, successes and failures of the national family planning outreach programme. This chapter also reviews the existing research on family planning programmes and the components of contraceptive use dynamics. Chapter 3 describes the multilevel modelling techniques used in this research. Each multilevel modelling technique is presented for each kind of model used in this research. Chapter 4 describes the event-history nature of data and techniques used in this research. Chapter 5 describes the latent class analysis technique that is used for creating 'quality of care' latent class conditional probabilities. These probabilities are analogous to the factor loadings in factor analysis. Chapter 6 discusses social, demographic and programmatic factors affecting contraceptive use, adoption, and choice in Bangladesh and their implications. Three main methods of analysis are employed in this research: multilevel logistic regression models; multilevel discrete-time hazards, and multilevel discrete-time competing risk hazards model. In addition, Chapter 6 also discusses the determinants of fertility preferences and the quality of care. An Ordinary Least Squares (OLS) regression and a logistic regression are used for the analysis of the determinants of perceived quality of care and desire for no additional children respectively. Chapter 7 discusses the life table rates of contraceptive discontinuation according to social, demographic and programmatic factors by reasons for discontinuation. This chapter also discusses social, demographic and programmatic factors associated with contraceptive discontinuation due to different programmatic and non-programmatic reasons using a multilevel discrete-time competing risk hazard model. Chapter 8 discusses the social, demographic and programmatic factors associated with contraceptive switching using a multilevel discrete-time competing risk hazard model. Finally, the main results and the conclusions of all the studies are discussed in Chapter 9. The limitations of these studies are also discussed in this chapter. Some ideas for future research are also suggested.

CHAPTER 2

Fertility and Family Planning Programme in Bangladesh

2.1 Introduction

The world frequently receives bad news from Bangladesh. So adverse is the economic situation in Bangladesh that some have referred to it not as a Third World developing nation but as member of the 'fourth world', the poorest of the poor. Its population is estimated as 122.7 million in 1997, the eighth largest in the world, and lives on constricted land affected by an unkind climate (UNDP, 1999). There is relatively little industry, and most people live at the subsistence level in rural areas. The political system is unstable, characterized by military coups, dictator regimes, civil violence, and a poor human rights record. Adding to the nation's woes are natural disasters. Whipping in from the Bay of Bengal, tropical storms have repeatedly devastated the country, causing huge losses of human and animal lives. International lending and aid agencies reinforce the country, but the problems are so heavy that no one anticipates major advances in the near future.

Bangladesh was among the first Asian countries to recognize the need for reducing rates of population growth. This recognition has been an important element in the country's development planning in the last three decades. Bangladeshi women can expect to bear between three and four children, on average, if rates of child bearing observed in 1993-94 continue, a dramatic decline from a level of more than six births per woman about two decades before. The total fertility rate has declined from 6.3 births per woman in the mid-1970s to 3.3 births per woman in the mid-1990s (Mitra et al., 1997). The contraceptive use rate has increased significantly from 7.7 percent in 1975 to 49.3 percent in 1996/97.

The objective of this chapter is to give a brief description of the demographic processes that the country is currently experiencing and as well as to give a brief history and description of the national family planning programme. Additionally, the factors associated with the fertility transition are also explored. The chapter starts with a brief description of the country's setting, description of some aspects of the national family planning programme and mechanisms of how the family planning programme is associated with socio-demographic factors in Bangladesh.

2.2 Country setting

Two peculiar features symbolize the physiography of Bangladesh: a broad deltaic plain subject to regular flooding and a small hilly region crossed by speedily flowing rivers. The country has an area of approximately 144,000 square kilometres and extends about 600 kilometres east to west and 820 kilometres north to south. The country is bordered by almost 2,400 kilometre land frontiers with India on the west, north, and east and by a short land and water frontier of 193 kilometres with Myanmar in the Southwest. On the south, there is a highly irregular deltaic coastline of about 600 kilometres, fissured by many rivers and streams draining into the Bay of Bengal (Heitzman and Worden, 1989).

About 80 percent of the landmass is made up of fertile alluvial lowland called the Bangladesh plain. The plain is part of the larger Plain of Bengal, which is called the Lower Gangetic Plain. In Bangladesh, most elevations are less than 10 metres above the sea level. In the northern part of the plain, however, the altitude is up to 105 metres above the sea level in some places. The elevations lessen in the coastal south, where the domain is generally at sea level. With such low elevations and several rivers, concomitant inundating is an ascendant concrete peculiarity of the country. Almost 1/8th area of the country is blanketed with water, and vaster areas are routinely submerged during the monsoon season. The mountains in the Southeast and the mountains in Northeast are the only deviations to Bangladesh's low elevations. In Bangladesh, the highest mountain is found at *Keokradong* (about 1,000 metres) located in the southeastern region of the country (Heitzman and Worden, 1989).

Bangladesh has a subtropical monsoon climate symbolized by wide seasonal fluctuations in rainfall, tolerably warm temperatures, and high humidity. The summer, monsoon, and dry are the three main seasons generally recognized. Generally, maximum summer temperatures range between 32^{0}C and 38^{0}C. May and June are the warmest months and January is the coldest month in most parts of the country. Annually, most parts of the country receive at least 200 centimetres of rainfall. Approximately 80 percent of Bangladesh's rain falls during the monsoon season. Almost every year, the country faces natural calamities: floods, tropical cyclones, tornadoes, and tidal bores. This causes enormous loss of lives and property. India, the mighty neighbouring country, made several hydraulic dams on the two main rivers which originates from Himalaya, Nepal. As a result, in the dry season, the country does not receive enough water for its irrigation, where as in monsoon, the country receives a huge amount of water. In the dry season, India needs water and Bangladesh also needs water. As a result, in the dry season, the rivers become dry and because of mild water flow sedimentation occurs in the rivers in Bangladesh. Again, in the monsoon, India does not need water and releases a huge amount of water suddenly. Because of the monsoon, the rivers in Bangladesh are also full of water and cannot cope with the extra water burden from India. This causes sudden flooding in the country and damages crops.

Bangladesh is notable for the ethnic homogeneity of its population. Over 98 percent of the people are Bengalis, predominantly Bengali-speaking people. Bengali, which sometimes called Bangla, is the official language in Bangladesh (Heitzman and Worden, 1989).

According to the 1981 census, 86.6 percent of the population of Bangladesh is Muslim (BBS, 1983). The principle of secularism, which the country had embodied in its constitution, was subsequently replaced by a commitment to the Islamic way of life through a series of constitutional amendments. In spite of the general personal commitment to Islam by the Muslims of Bangladesh, observance of Islamic formalities and doctrines vary according to personal considerations. According to the 1961 census, the Hindu proportion of the population was approximately 18.5 percent. This proportion of Hindu population had dropped to 12.2 percent by 1981. Other religious groups counted in the 1981 census include roughly 0.6 percent Buddhists, about 0.3 percent Christians, and nearly 0.3 percent classified as 'others' (BBS, 1983). Bangladesh's tribal population was found to be less than one percent of the total population (BBS, 1983). The majority of the tribal population live in the highland valleys. They are different from the people of the rest of the country in terms of language, culture, social and marriage customs, and as well as daily lives. Half of the tribes are Buddhist and a quarter of them are Hindus (Heitzman and Worden, 1989).

Bangladesh is basically a rural and agricultural country. According to the 1981 census, about 90 percent of its population live in rural areas. Rural Bangladesh society continues to remain agrarian, traditional and conservative, although some changes are observed in recent years. Economic conditions are stagnant. Due to lack of resources for irrigation and fertilizers, which are needed for high yield crops, the efficiency in Bangladesh agricultural sectors continues to be low. However, there is a slight improvement in the agricultural productivity. Whatever improvements have occurred in agriculture, increases in agricultural productivity have not been proportionate with the pace of the population growth. Rice is the predominant crop grown, followed by wheat, jute, sugarcane, and tobacco. The land-population ratio is quite low and decreasing over time due to a persistent raise in population pressure on the fixed land. As a result, the food deficit continues to be the serious problem in the country (Khuda and Howlader, 1990). On February 11, 1998, Food and Agriculture Minister of the Government of Bangladesh told the 'Jatya Sangsad' (National Assembly of the Government of Bangladesh) that there might be a food deficit of 2.5 million tons that year (The Independent, February 12, 1998). The Finance Minister of the Government of Bangladesh said in a seminar that fifty percent of people in Bangladesh are now living below the poverty level (The Independent, February 9, 1998).

The per capita GNP in Bangladesh is the lowest among the south Asian countries. According to UNDP Human Development Report (UNDP, 1999), the per capita GNP was US$ 360 in 1997. The country has made painfully slow progress in the post independence era and remains one of the poorest countries of the world. Extremely low savings and investments also characterize its economy. About 37 percent of Bangladeshi rural households are reported as landless in 1982 (Abdullah and Murshid, 1986). However, if the definition of landless is expanded to those who own less than one half of an acre (one acre is equivalent to 100 decimals) and who are functionally landless, the figure rises to about 47 percent of the rural households in Bangladesh.

The base of the school system in Bangladesh is five years of primary education. In Bangladesh, trends in schooling have been modestly encouraging. While the literacy rates between 1974 and 1981 remained unchanged, the 1991 Census show a small increase. Recognizing the importance of education, the government of Bangladesh made universal primary education a principal objective of its educational development plans. Increasing access to school, improving training of teachers and revising the curriculum of the primary schools. By the mid-1980s, as a result, the share of primary education increased to about 50 percent of the public education expenditure. Although the entry class enrolment rose over time, the primary education sector failed to retain the students in school and could not increase the literacy rate as planned. The education system also has had a discriminatory effect on the education of women in a basically patriarchal society. The female literacy rate in 1981 was 16.0 percent and the male literacy rate was 33.0 percent (BBS, 1983). According to the 1991 census, the female literacy rate had increased to 23.4 percent, whereas the male literacy rate had increased to 35.8 percent in 1991. More recently, the male literacy rate has been estimated as 49.9 percent and the female literacy rate as 27.4 percent in 1997 (UNDP, 1999).

Traditionally, women are discouraged or prevented from participation in paid employment outside the home. The overall female labour-force participation rates are lower in Bangladesh than in the other south Asian countries, except Pakistan. There is an emerging trend of breaking *purdah* by women seeking paid employment in agriculture and industry. The economic contribution of women is significant but largely not acknowledged. Women in rural areas are responsible for most of the post-harvest work, and for keeping livestock, poultry, and small gardens. Women in cities formerly relied on domestic and traditional jobs. However, since the early 1980s, women in cities have been involved in manufacturing jobs, especially in the ready-made garment industry (BGMEA, 1995). The women are less pro-natalist than men are (Mitra et al., 1997), but their low status (Population Crisis Committee, 1988) and lack of decision making power may render them unable to implement their preference (Safilios-Rothschild, 1985). There is little evidence on the issue of increase in female status and autonomy (Population Crisis Committee, 1988). However, the government's ability to recruit and post thousands of female family planning workers is perhaps an indication of an overall change in attitude. The educated women are involved in government, health care, and teaching jobs, but their numbers are very small. In almost all aspects of their lives, women in Bangladesh remained subservient to men in custom and practice. Most women's lives remain centred on their traditional roles, and they have limited access to markets, productive services, education and health care. As long as women's access to health care, education, and training remain limited, the prospect for the improvement of productivity remains poor among the female population.

2.3 Demographic situation in Bangladesh

2.3.1 Fertility and mortality trends

Located in the North Eastern region of the subcontinent and bounded on three sides by India, Bangladesh is one of the most densely populated countries in the world. Census data compiled in 1901 indicate a total of 29 million in the then East Bengal, the region that became East Pakistan in 1947 and eventually Bangladesh in 1971. Four years after the partition from the British-ruled India, East Pakistan had 45 million people, a number that rapidly grew in the period to the first Bangladesh census conducted in 1974, which reported the population at 71.5 million. The 1981 census reported a population of 87 million and a 2.8 percent annual growth rate. Thus, the population tripled in just 80 years (between 1901 and 1981). The 1991 census shows 111.5 million people in the country. Bangladesh's population density provides further evidence of the problems that the country has been facing. In 1901, an average of 520 persons inhabited one square mile. By 1951 that number had increased to 800 per square mile and, in 1991, reached about 2,000 per square mile. By the year 2000, the population density is projected to exceed 2,500 persons per square mile. The population estimate stands at about 122.7 million in 1997 (UNDP, 1999). The crude birth rate (CBR) was about 54 per thousand in 1911 while it was 34.5 per thousand in 1991. The crude death rate (CDR) was about 46 per thousand in 1911 while it was 13.3 per thousand in 1991 (BBS, 1993). The high rate of natural increase has resulted in rapid population growth during the last three decades. With the current growth rate at 2.2 percent (as estimated in 1997) per year (UNDP, 1999), the population of Bangladesh will double in 31 years requiring the country to accommodate an additional 2.6 million new born annually to the existing population. The population growth in Bangladesh is due to the considerable amount of momentum because the population is very young.

Table 2.1 shows the population size, growth rate, density, and crude birth and death rates over a period of 90 years. During the first half of the last century, mortality declined gradually. Mortality started to decline rapidly in the 1950s and 1960s. Both crude birth rates and crude death rates remained quite high until 1951 and, therefore, the rate of natural increase remained quite low. The rate of natural increase began to rise in the 1960s. Mortality started declining quite rapidly during the 1960s. Between 1961 and 1974, the mortality decline accelerated and resulted in high growth rates. Between 1961 and 1974, crude birth rates also started declining but very steadily. This steady decline continued until 1981. The decline in crude birth rates accelerated between 1981 and 1991. The rate of population growth started declining between 1981 and 1991. However, the total population is still increasing.

Table 2.1: Population size, growth rate, population density and crude birth and death rates, Bangladesh 1901-1991

Census Year	Total Population (1,000)	Exponential rate of growth	Population density (per square mile)	Crude birth rate	Crude death rate
1901	28,928		520	-	-
1911	31,525	0.87	567	53.8	45.6
1921	33,255	0.52	598	52.9	47.3
1931	35,602	0.68	640	50.4	41.7
1941	41,997	1.65	755	52.7	37.8
1951	44,832	0.65	800	49.4	40.7
1961	50,840	1.26	914	51.9	29.7
1974	71,478	2.62	1,286	48.3	19.4
1981	87,129	2.83	1,567	43.3	16.8
1991	111,455	2.46	2,005	34.5	13.3

- Not available

Source: Bangladesh Bureau of Statistics, 1991

Table 2.2 shows the trends in estimated total fertility rates over a period of 25 years. Total fertility rates are estimated from five national surveys undertaken during 1975 and 1997. In Bangladesh, the fertility rate has declined extremely rapidly over the past 20 years, from 6.3 births per women in the mid-1970s to 3.3 births per women in the mid-1990s (Mitra et al., 1997). This is one of the steepest declines ever recorded in Asia. The total fertility rate is estimated to be 3.1 children per women in 2000 (US Bureau of the Census, 1998).

Table 2.2: Trends in total fertility rates, Bangladesh, 1971-1996.

	Survey and approximate time period				
	BFS-1975	BFS-1989	CPS-1991	BDHS-1993-94	BDHS-1996-97
Period	1971-75	1984-88	1989-91	1991-93	1994-96
Total fertility rates	6.3	5.1	4.3	3.4	3.3

Source: Mitra et al., 1997.

2.3.2 Levels and trends in infant and child mortality

Life expectancy in Bangladesh was slightly over 20 years in the early part of the last century. By 1940, life expectancy had risen to about 30 years. Life expectancy was estimated to be about 48 years in 1960 and about 58.1 among males and about 58.2 among females in Bangladesh in 1997 (UNDP, 1999). The maternal mortality rate in Bangladesh is high; estimated as 850 women per hundred thousand live births in 1990 (UNDP, 1999). The infant mortality rate was between 130 and 160 deaths per thousand live births between the mid-1950s and the mid-1970s and fell gradually during 1975-1985. The infant mortality rate was estimated as 81 per thousand live births in 1997 (UNDP, 1999). In 1997, the child mortality rate was estimated at 37 per thousand children one to four years of age (Mitra et al., 1997).

2.3.3 Abortion

In Bangladesh, existing law prohibits the termination of pregnancy except to save the life of the mother. However, the law allows menstrual regulation (MR) in the early stages of conception. In Bangladesh, MR, which refers to vacuum aspiration of the uterus, is permitted only within the first ten weeks following last menstrual period for health reasons. Although induced abortion is not legal in Bangladesh, MR has been a part of the family planning programme in the country since the mid-1970s. Since 1983, the number of illegal abortions may have risen substantially, in response to growing need to control fertility. Several studies on abortion practice have tried to estimate the number of abortions carried out annually in Bangladesh. It was found to be as high as 780,000 in 1978. This included all abortions carried out by the government service providers and by private traditional practitioners (Measham et al., 1981). A more recent study estimated 241,442 abortions in 1985 (Begum et al., 1987). The later study considered abortion performed only by providers trained under the government Menstrual Regulation (MR) training programmes and did not include those done by private practitioners and traditional abortionists. Khan et al. (1986) estimated the annual number of abortions performed nation-wide by traditional practices to be about 163,000 in 1983. Mitra et al. (1997) documented that 3.6 percent of currently married women of reproductive age reported had ever used MR. Since the lack of reliable abortion data, its role in declining fertility in Bangladesh is not clear and is difficult to quantify.

2.3.4 Breastfeeding practices

The risk of pregnancy following a birth is largely influenced by two factors: breastfeeding and sexual intercourse. Postpartum protection from conception can be extended by breastfeeding through its effect on the length of postpartum amenorrhoea. Frequency and duration of suckling as well as diurnal patterns of suckling are important factors in inhibiting ovulation. Breastfeeding is universal in Bangladesh. The median duration of breastfeeding is quite long although there is evidence of a declining trend in recent years. The median duration of breastfeeding has declined to 33 months in 1996 from 36 months in 1993 (Mitra et al., 1994 and 1997). Recent data suggest that the mean duration of postpartum infecundability and postpartum abstinence are around 11 months and 4 months respectively (Mitra et al., 1997). The mean duration of amenorrhoea calculated from BDHS-1993/94, BFS-1989 and CPS-1991 was almost 12 months, indicating that there has been no significant change overtime (Mitra et al., 1994; BFS, 1989; and Mitra et al., 1993). The decline in the length in postpartum breastfeeding could be the consequence of an increase in the use of contraceptives. To some extent, in Bangladesh, contraception is merely substituting for traditional means of fertility control.

2.3.5 Marriage patterns

Traditionally, Bangladesh has been characterized by early age at marriage for females. It was estimated that about 60 percent of Bangladeshi women were married by the time they were age 15 (Mitra et al., 1997). Recent data also show that the median age at first marriage among women aged 20-49 is 14.2 years (Mitra et al., 1997). A comparison of data from BDHS-1993/94 and BDHS-1996/97 shows that the median age at marriage among women has remained constant at age 14 over a five-year period (Mitra et al., 1994 and 1997). The BDHS data suggest that, during the past 25 years, there has been a slow but steady increase in the age at which Bangladeshi women first marry. The median age at marriage has increased from 13.3 to 15.3 during last 25 years (Mitra et al., 1997).

2.3.6 Trends in contraceptive use, discontinuation and switching

The vast majority of Bangladeshi women and men strongly favour the use of family planning and more than two thirds of ever-married women have used a method of contraception at some time (Mitra et al., 1997). Table 2.3 shows the trends in contraceptive method use over a period of 21 years. The contraceptive prevalence rate increased to 49.3 in 1996/97 from 7.7 in 1975 (Mitra et al., 1997). The majority of the increase in family planning use since the 1970s has been in use of modern methods. The oral pill remains by far the most popular method of contraception, accounting for half of all modern contraceptive use. In addition, the use of injectables has increased steadily over the last decade. Contraceptives are used at all ages: one third of young women at ages 15-19 are now using a family planning method, especially the pill, while use is highest among married women in their 30s. Unmet need for family planning in Bangladesh has declined considerably, falling to 16 percent in 1996 from 19 percent in 1993. The BDHS-1996/97 data suggest that if all women in Bangladesh who want to stop childbearing or to delay their next birth for two or more years were to use a method of contraception, the contraceptive use rate would rise to 80 percent. The contraceptive prevalence rate was 44.6 percent in 1993/94 (Mitra et al., 1994). More than 49 percent of currently married women of reproductive age are estimated as current users in 1996/97 (Mitra et al., 1997). The contraceptive use rate has increased by 10 percent between 1993/94 and 1996/97. A twenty-nine percent increase in contraceptive use rates is observed during 1989 and 1991 (Table 2.3). In Bangladesh, a large increase is observed in the number of couples using pills after the 1980s. The proportion of married women relying on the pill increased considerably in the last five years, from 13.9 percent in 1991 to 20.8 in 1996-97. Use of injectables and condoms has also increased, while the use of IUD and sterilization has declined.

Table 2.3: Trends in contraceptive method use among currently married women, Bangladesh, 1975-1996.

	BFS 1975	CPS 1983	CPS 1985	BFS 1989	CPS 1991	BDHS 1993-94	BDHS 1996-97
Any modern method	5.0	13.8	18.4	23.2	31.2	36.2	41.6
Pill	2.7	3.3	5.1	9.6	13.9	17.4	20.8
IUD	0.5	1.0	1.4	1.4	1.8	2.2	1.8
Injectables	-	0.2	0.5	0.6	2.6	4.5	6.2
Vaginal methods	0.0	0.3	0.2	0.1	-	-	-
Condom	0.7	1.5	1.8	1.8	2.5	3.0	3.9
Female sterilization	0.6	6.2	7.9	8.5	9.1	8.1	7.6
Male sterilization	0.5	1.2	1.5	1.2	1.2	1.1	1.1
Any traditional method	2.7	5.4	6.9	7.6	8.7	8.4	7.7
Any method	7.7	19.2	25.3	30.8	39.9	44.6	49.3

- Unknown (no information)
Source: Mitra et al., 1997

A key concern for the success of a family planning programme is the rate at which users discontinue use of contraceptives and the reasons for such discontinuation. The discontinuation rates are generally very high in Bangladesh. Nearly half (46.9) of users of all reversible methods combined discontinue use within 12 months of initiating a method (Mitra et al., 1997). The discontinuation rates for condoms (65 percent) and withdrawals (60 percent) are much higher than for injectables (51 percent), pills (44 percent) and the IUD (41 percent). Overall, 4 percent of the users stop using because of method failure (that is, they became pregnant while using), 7 percent because they want to become pregnant, 22 percent as a result of perceived or actual side effects or health concerns, and the remaining 15 percent because of some other reason. There has been no real reduction in discontinuation rates since 1993. The BDHS 1993/94 and BDHS 1996/97 (Mitra et al., 1994 and 1997) show that the discontinuation rates for all reversible methods combined remained almost constant between 1993-94 (48 percent) and 1996-97 (47 percent). This could be one of the reasons for the current stagnation in the fertility rates in Bangladesh.

The rate of contraceptive switching to no method is of particular interest of any family planning programme because it represents the state of highest risk of pregnancy. Many users who discontinued use do so because they no longer have a need for contraception. These users need to be separated from users who still have a need for contraception but discontinued use, therefore exposing themselves to the risk of an unwanted pregnancy. In Bangladesh, after 12 months of initiating use, about 15 percent of women of reproductive age abandon their use and move to the risk of an unwanted pregnancy (Mitra and Al-Sabir, 1996). Almost a quarter of the users of injectables abandons their method use and move to the risk of an unwanted pregnancy. Abandonment of use is highest among users of injectables, and lowest among users of traditional methods. In Bangladesh, after 24 months of use, a quarter of pill users discontinues their use and move to the risk of an unwanted pregnancy (Steele and Diamond, 1999). These suggest that the Bangladesh Family Planning Programme fails in meeting the needs of many women who discontinue use. Additionally, discontinued use of a family planning method by so many users has serious implications for fertility levels, because these women expose themselves to the risk of unwanted pregnancy.

2.3.7 Quality of family planning services

There is no universally accepted definition of quality of care. It has been defined from the perspective of providers, clients, or societies. Jain (1989) defines quality of care as "... the way individual couples (or clients) are treated by the system providing services". Bruce (1990), using this principle, elaborated a working definition of quality of services that incorporates six elements of care: choice of methods, information given to users, provider competence, client-provider relations, follow-up mechanism and appropriate constellation of services. The exchange takes place through direct contact between family planning outreach workers and clients. Phillips and his colleagues (1986) write that "If women in the villages receive frequent visits from trained, sympathetic, and committed women village workers, ... substantial effects can be achieved". Koenig et al. (1989) concluded that the frequency of contact is an important predictor of contraceptive use dynamics. Simmons and her colleagues (1986) argue that both quality and quantity of contact are important for success of a family planning programme. When a contact takes place, the flow of information between the service provider and clients becomes important and determines the levels of mutual trust and respect (Lipton et al., 1987). Quality matters, not only because quality is an indigenous goal, but also it enhances the programme credibility. Koenig et al. (1997) found a direct relationship between quality of family planning services and contraceptive use in Bangladesh. Findings show that the probability of using and adopting a family planning method is higher if the quality of care is better. Quality also encourages users to continue using a method (Koenig et al., 1997).

2.4 The Bangladesh National Family Planning Programme

The Secretary of the Ministry of Health and Family Welfare is responsible for formulating and co-ordinating the activities of the Health and Family Planning Maternal Child Health Programme in Bangladesh. A planning cell of the family planning programme in the Ministry is responsible for the preparation of plans and projects. As the Directorate of Family Planning mainly prepares the projects, the role of the planning cell in the ministry is limited in nature.

The Directorate of Family Planning is headed by a Director General (DG), who is responsible for implementing population and maternal and child health (MCH) activities throughout the country. Nine Directors assist the DG at the national level. The integrated MCH-Family Planning organization has been extended from national level to all divisions, districts, *thanas*, *unions*, *units* and *mouzas*. Each divisional office is responsible to supervise/monitor the population control programme. The District Family Planning office, which is headed by a Deputy Director (DD-FP), is responsible for co-ordinating the family planning activities within the districts. The main local point of population central programme is the *union* where a Health and Family Welfare Centre (H&FWC) exists. From each H&FWC, contraceptives are distributed among the community level workers, called Family Welfare Assistants (FWAs). In addition, the female paramedics, who are known as Family Welfare Visitors (FWVs), perform IUD insertions at the H&FWC. At the community level, the FWAs visit the rural women at their home and distribute family planning methods and refer the women to the *union* H&FWC or Thana Health Complex (THC) when needed.

Considerable progress has been achieved in establishing and maintaining a system of domiciliary family planning service delivery, despite structural problems and conflicts between the two wings of the Ministry of Health and

Family Welfare (MOHFW). The programme has neutralized conservative religious leaders' resistance to family planning in the country. The mass communication activities have contributed in improving the knowledge about family planning, its benefits both in terms of economic and health, and about contraceptive supplies and services.

In Bangladesh, family planning awareness is universal; almost all married women of reproductive age know at least one modern family planning method (Mitra et al., 1997). Through its information, motivation and communication programme, the Bangladesh family planning programme has carried out a vigorous campaign to promote birth control. Through media campaigns and programme functionaries, the programme relays the message that a smaller family is good and enhances the well being of the family. Whether or not the small family norms fit with economic reality on individual families, such messages have had some impact on fertility behaviour. Although the current use of contraception has increased since 1975, it falls short of the target set in the population policy programme. Although the effort to control the population growth of Bangladesh was initiated by voluntary organizations as early as 1953, a fully-fledged independent programme on family planning organized by the government was launched in 1965. The family planning programme suffered heavily during the 1969-72 period, due to the country's political unrest and the war of independence. The Bangladesh First Five-Year Plan (1973-78) marked the beginning of a multi-sectoral population control and family planning programme (GoB, 1973). The Second Five-Year Plan (1980-85) aimed at expanding and strengthening family planning service delivery and improving the IEC (information, education, and communication) activities in order to achieve a reduction in fertility to a replacement level by 1990 (GoB, 1980). Neither the First nor the Second Five-Year Plan has achieved their targets. However, the Third Five-Year Plan (1985-90) had shown considerable impact on contraceptive use (GoB, 1985). These efforts have led to impressive achievements for the national family planning programme in Bangladesh in an unfavourable socio-economic environment.

2.5 The role of the Family Planning Programme in Bangladesh

The Bangladesh Family Planning Programme is among the oldest in the world considering the organized efforts which started in the Pakistan era. Private agencies have offered clinical services in cities through the Family Planning Association (FPA). The Pakistan government, in 1960, launched a programme in the public sector. Since its inception, the population programme in Bangladesh has had strong political support. Initial commitment of the programme was to provide clinical services, but the programme has become a complex inter-agency programme. It was viewed that in Bangladesh, couples seek to control their fertility but could not do so because of lack of availability and accessibility of family planning methods and the cost for contraception. The subsequent Bangladesh Family Planning Programme differs from the Pakistan programme in terms of nature of distribution of services augmented with IEC and outreach activities. During the post independence period, the family planning service has been staffed by female Family Welfare Assistants (FWAs) at the grass root level and male Family Planning Inspectors (FPI) supervise their work. These family planning grass root level workers are responsible for providing information on family planning to rural women, motivating them for contraception and ensuring re-supply of contraceptive methods. These FWAs are the primary link between Bangladesh MOHFW and the rural women. One FWA is assigned in one *unit* and one FPI is assigned in one *union*. On the average, there are six *units* in each *union*. There are 900 to 1,000 currently married women of reproductive age in each *unit.* One *unit* is generally larger than a village. Every FWAs have their own service record books, on which they have reproductive histories and maternal child health and family planning services of all the women of reproductive ages in their working areas. They are assigned to visit each and every woman of reproductive age in their working areas *(units)* once in two months. These FWAs are the government outreach service providers in rural Bangladesh.

However, there are some local non-governmental organizations who are also responsible for providing family planning services in some specified (vacant areas where there is no FWAs) rural areas. Additionally, some private agencies, mainly urban based, are also engaged in providing family planning services.

2.6 The role played by private agencies

2.6.1 Family Planning Association

In family planning, the Family Planning Association of Bangladesh (FPAB) is the oldest and largest non-governmental organization in Bangladesh. The family planning movement began with the establishment of the FPAB in 1953. The association was formed with the primary objective of creating awareness of the effect of the rapid population growth on the socio-economic development of the country. The objective was also to sensitize people about the need to control the population growth in view of its harmful effects on the development of the country. The association began its activities in an atmosphere of ignorance and apathy among most people towards the concept of family planning. Currently 758 professionals and about 3,000 volunteers support the FPAB. The volunteers are attached to 20 branches and 10 special work units. The FPAB has been assigned the task of sensitizing religious leaders and providing the information, education and communication (IEC) techniques to the government field workers. The FPAB is responsible for distributing contraceptive supplies from the Government central warehouse to 178 sub-grantees of the Pathfinder International, Asia Foundation, as well as to their own projects. The FPAB has shifted their focus from a narrow emphasis on family planning services to a client-centred sexual and reproductive health approach. FPAB aims to increase male involvement, promote the community ownership of projects as well as targeting religious and community leaders with sensitization and information and education programmes. Sustainability and cost-effectiveness of projects is another focus. They also aim to meet unmet need by targeting underserved areas, such as urban slums.

2.6.2 Marie Stopes Clinic Society

In 1988, the Marie Stopes Clinic Society (MSCS) was established in Bangladesh. Since then, MSCS has operated a reproductive health network in several towns in Bangladesh. Eight clinics, mobile units and satellite health posts provide vital health care and family planning to women and men in the most needy communities in Bangladesh. MSCS also covers groups ignored by traditional family planning and reproductive programmes. They are providing essential advice and services to thousands of young factory workers through factory-based health clinics. The European Union and the British Government support the MSCS's Department for International Development in the development of a sustainable reproductive health programme in Bangladesh.

2.7 Evidence of the impact of family planning programme

The Bangladesh population programme tends to reside with problems, inter-agency conflict, failures and deficiencies. Recently such criticism has been countered with the evidence that fertility is declining as a result of an increase in contraceptive use. Therefore, the programme can no longer be discontinued because of the lack of success (Robinson, 1985). Contraceptive use is increasing and fertility is declining in a social and economic setting that is believed to be unfavourable for such changes. The level of contraceptive use in Bangladesh has risen steadily over the last two decades. The contraceptive prevalence rate for any method has increased fivefold since 1975, from 8 percent to 49 percent of married women of reproductive age (Mitra et al., 1997). These increases have led some researchers to conclude that the programme is a success. Cleland et al. (1994) and Larson et al. (1992) have documented the impact of Bangladesh family planning programme on fertility trends. Cleland et al. (1994) state that the intensification of outreach services in the period following the 1979 hiring of FWAs may explain the concomitant increase in programme outputs. However, the explicit mechanism through which Bangladesh family planning programme experiences its success lacks critical analysis. The following elements of the programme may have been pivotal to its success story.

Awareness: Knowledge of contraceptive methods and supply sources has been almost universal in Bangladesh for many years and the recent survey results confirm this fact (Mitra et al., 1997). Before their marriage, young women in Bangladesh are aware of family planning methods (especially pills and condoms). The mass media, radio and television, which is managed and controlled by the government, discuss family planning as well as advertizing family planning methods.

Outreach and interpersonal communication: Sufian (1986) has shown that women who are contacted by the outreach worker are more likely to use a method of family planning than those who are not contacted by the outreach worker. Another study has shown that the use of contraceptives is inversely related with the distance of workers residence (Phillips and Koblinsky, 1984a). Phillips et al. (1993) have shown that contraceptive use is directly related to the intensity of exchange between the woman and the outreach worker. Several studies (Islam and Mahmud, 1995; Kamal, 1994; Kamal and Sloggett, 1996; Phillips et al., 1989a, 1989b, 1993, 1996 and Ullah and Chakraborty, 1993) have documented a direct strong relationship between outreach workers' contact and contraceptive use. Koenig et al. (1997) have shown that contraceptive use and adoption are directly related with the quality of services provided by the outreach workers. A recent survey shows about 38 percent of currently married women are visited at their home by the worker in a six-month period (Mitra et al., 1997). Another recent study documented a direct relationship between outreach services and the continuity of contraceptive use (Hossain and Phillips, 1996).

Sources of family planning supplies: Non-surgical contraceptives (mainly pills, condom and injectables) are available to rural couples through the government's outreach programme. Sources of family planning methods play an important role in promoting and maintaining the levels of contraceptive use in a population. In addition to the outreach programme, an active contraceptive social marketing programme exists throughout the country. The Social Marketing Company (SMC) distributes pills and condoms through a network of some 140,000-retail outlets: including pharmacies, small shops and kiosks. A recent survey shows family planning field workers are still the largest source of supply for the modern contraceptives (Mitra et al., 1997). Thirty-nine percent of current users of modern method obtained their methods from family planning outreach workers, while thirty-five percent of modern method users obtained their methods from government facilities. Hence, in total, 74 percent of modern method users are obtaining their methods from government sources (Mitra et al., 1997). Twenty-one percent of modern method users obtain their methods from private sectors, especially pharmacies, shops, kiosks, etc.

Surgical contraception: Surgical contraception and its promotion have always been controversial in Bangladesh. For the sterilization clients, there was a system of compensation payments, which started in 1976. In 1983, the compensation was *Taka* 175 (the equivalent of about US$5.50). In addition, female clients were also provided with a *saree* and male clients with a *lungi* (Cleland and Mouldin, 1991). Both the Bangladesh government and the donors have been criticized and accused on the grounds of coercion of using compensation for men and women as an incentive (O'Reilly, 1985). After a comprehensive investigation and recommendation by Cleland and Mouldin, the system of paying the referral fees to the sterilization canvassers was removed from Bangladesh programme (Cleland and Mouldin, 1991). This change in policy may be one of the reasons for the decline in popularity of sterilization. BDHS data suggest that almost eight percent of currently married women of reproductive age in Bangladesh are sterilized (Mitra et al., 1997). Female and male sterilization together accounts for approximately 20 percent of contraceptive use in Bangladesh. These surgical contraceptives are offered in every hospital located at *thana* (a sub-district) head quarters. Each hospital, which is managed by the government, is equipped with proper instruments and trained medical officers. These medical officers are responsible to perform vasectomy and tubectomy at the hospital at thana level at no cost to the women or men. A recent study shows that during the last decade, the sterilization rate was constant or slightly declining.

Unmet need for family planning: The unmet need for family-planning services has declined considerably in Bangladesh since 1991. The desire for additional children declined noticeably in Bangladesh over the past decade. Data from 1991 show that 28 percent of currently married women were in need of family planning services, compared to 16 percent in 1996 (Mitra et al., 1993 and 1997). Half of the unmet need is comprised of women who want to space their next birth and the other half is for women who do not want any more children. The contraceptive use rate would rise to 80 percent, if all the women who want to stop childbearing or delay their next birth for two or more years were to use a method of contraception.

The mean ideal family size reported by currently married women in Bangladesh has declined from 4.1 children in 1975 to 2.9 children in 1989. The mean ideal family size further declined to 2.5 children in 1993 (Mitra et al., 1994). The mean ideal family size remained constant at 2.5 children in 1996 (Mitra et al., 1997).

CHAPTER 3

MULTILEVEL MODELLING

3.1 Introduction

Social research often concerns the relationship between individual and society. The general concept is that individuals interact within the social context to which they belong, indicating that individuals are influenced by the social communities to which they belong, and that the characteristics of those communities in turn prejudiced by the individuals who make up that community. In social sciences, many populations have an inherent hierarchical or nested pattern. People are nested within local communities which are nested within districts and countries; pupils are nested within classes which are again nested within schools. Characteristics of the context in which a person lives are likely to influence the behaviour where hierarchies exist. One may expect individuals selected from the same community to share similar attitudes and therefore to show behavioural patterns that are more similar than those of the individuals selected randomly from the population at large.

Hierarchical structures can also arise from the study design. The problem of dependencies between individual observations also occurs in survey research, when the sample is not taken at random but taken using cluster sampling from geographical areas instead. In longitudinal studies, observations are made over time on the same individual. This gives rise to a two-level hierarchical structures with repeated observations (level one) nested within individuals (level two).

Multilevel regression models are essentially multilevel versions of the familiar multiple regression models. In analysing fertility in 15 World Fertility Survey (WFS) countries, Mason et al. (1983) introduced multilevel linear models with separate error components for the individuals and the contextual levels, which takes into account extravariation at both the levels. In their analysis of linear multilevel model for the determinants of the number of children ever born, they used the characteristics of the woman as level one and the characteristics of the country as level two. Wong and Mason (1985) extended the linear model to a hierarchical logistic regression model to allow multilevel analysis using binary response. Guo and Rodriguez (1992) used a multilevel approach and developed a proportional hazards survival model. Curtis et al. (1991, 1993) and Zenger (1993) used random effects logistic models to explore the extent of familial clustering in neonatal and post neonatal mortality. A similar approach was also used by Madise and Diamond (1995) and Curtis and Steele (1996). Pebley et al. (1996) recently use a three-level multilevel logistic regression model in their research. In analysing contraceptive use dynamics, Steele (1996) and Leite (1998) use multilevel modelling in their PhD theses.

The main objective of this chapter is to describe briefly the multilevel theory used in the analysis. More detailed expositions of the theory of multilevel models can be found elsewhere, for example, Bryk and Raudenbush (1992); Goldstein (1987, 1995); Hox (1995); Kreft and Leeuw (1998); and Longford (1993). Emphasis is given to the methods of estimation consolidated in the MLwiN software (Goldstein et al., 1998) which is used in the analysis. Although, the response variables in all the analytical models undertaken in the research are discrete, for the simplicity and easy to understand, this chapter will start with a discussion on multilevel theory for the linear models. However, this chapter, before going to linear multilevel level theory, will address some of the issues related to single level approaches.

3.2 Single level approach

Until recently, before the development of multilevel modelling, researchers used two different approaches for analysing their data based on the level of aggregation. For data with a two-level hierarchical structure, there were two approaches: the individual level and the aggregate level approach.

To consider the individual level first; suppose there are two levels with *j* clusters at level 2. Let y_{ij} be the response for the individual *i* in cluster *j* of size n_j and x_{ij} is the only covariate. The individual level model then would be

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + e_{ij}, \quad i = 1,\ldots,n_j; \quad j = 1,\ldots,J \qquad (3.1)$$

where

$$e_{ij} \sim N(0,\sigma^2),$$
$$\mathrm{cov}(e_{ij}, e_{i'j'}) = 0, \quad ij \neq i'j'.$$

For the individual level analysis it is assumed that all individuals are independent even within the same cluster, which is not always a valid assumption.

The alternative approach is to analyse the data at the second level by modelling the aggregate responses for each level 2 unit. This alternative approach can be written as the following statistical model

$$\overline{y}_j = \beta_0 + \beta_1 \overline{x}_j + \overline{e}_j$$

where

$$\overline{y}_j = \frac{1}{n_j}\sum_{i=1}^{n_j} y_{ij},$$
$$\overline{x}_j = \frac{1}{n_j}\sum_{i=1}^{n_j} x_{ij}, \text{ and}$$
$$\overline{e}_j = \frac{1}{n_j}\sum_{i=1}^{n_j} e_{ij}.$$

There are problems with this approach. One problem is that the relationship at the cluster level may not be the same as the relationship at the individual level. One of the best known early illustrations, often known as the ecological fallacy, was the study undertaken by Robinson (1950) of the relationship between literacy and ethnicity in the United States. The ecological fallacy arises when the inference is made about individual behaviour from an analysis of aggregate data which does not take into account within-cluster variability. Robinson's (1950) findings showed that correlation between the mean literacy rates and the mean proportions of African Americans for each nine census divisions is very high (0.95), whereas the correlation between colour and literacy at the individual level ignoring the grouping is very low (0.20). Robinson (1950) was concerned to point out that the aggregate-level relationships could not be used as estimates for the corresponding individual-level relationship. Typically, association between aggregate responses and aggregate covariates tend to be stronger than associations between the corresponding individual responses and individual covariates which can make cross-level conclusions highly misleading. For example, in demographic research, the ecological fallacy arises when aggregated contraceptive use rate and women's age at the community level are used in standard single level regressions.

This problem can be avoided by using multilevel models which work at both levels simultaneously. The multilevel regression model is known in the research literature under a variety of names, such as 'random coefficient model' (Longford, 1993), 'variance component model' (Longford, 1993) and 'hierarchical linear model' (Raudenbush and Bryk, 1986 and Raudenbush et al., 1992). The main advantage of using the multilevel modelling approach is that it provides a better picture of the relationship of the society in which individuals are living. All unexplained variations are assigned to the individual in an individual-level model. In a multilevel model the variance is split into different components corresponding to the levels in the hierarchy. Hence, it has become possible to determine not only the differences of individual behaviour at the individual level but also the extent to which these differences are associated due to the conditions in which they live. In a single level analysis, we assume that all individuals are independent. In a multilevel model, units within a cluster are allowed to be correlated. This assumption looks more realistic than the independence assumption of a single level analysis, since there are many situations where it is expected that all individuals in the same communities follow more similar norms and values than individuals in different communities. Individuals are believed to share similar attitudes and values when represented from the same community and, therefore, to show behaviour that is much more alike than the individuals selected from a different community. In the presence of such variation due to clustered data the assumption of independence between individuals is no longer valid. This feature of multilevel modelling has proved important in educational research. The multilevel modelling facilitates comparisons in schools' performances after taking into account the socio-economic background characteristics of students within each school (Aitkin and Longford, 1986; Goldstein, 1987).

A consequence of violating the assumptions of independence in a single level analysis is that the standard error of the estimate tends to be underestimated. In the presence of clustering, to obtain an estimate of the correct standard error for the estimate of β_1 in equation (3.1), Goldstein (1995) proposed that the ordinary least squares (OLS) estimate needs to be multiplied by a function of the within-cluster correlation and the size of the cluster. If there is only one observation per cluster or if there is no within-cluster correlation this function becomes unity. In such cases the OLS estimate of the standard error will be adequate. However, if the within-cluster correlation is non-zero, the OLS estimate will underestimate the true standard error. This underestimation will increase with an increase in the size of the clusters. Hence, because of the existence of the correlation between responses within a cluster, significance tests often reject the null hypothesis. As a result, the confidence intervals based on OLS estimates tend to be too narrow. These may lead to an incorrect assessment of the significance of a variable.

3.3 The basic multilevel linear model

3.3.1 The random intercept model

The models allowing only the intercepts to vary across clusters are called random intercept models. The random intercept model, which is also called the variance component model, is the simplest form of measuring the cluster effect. In the random intercept model, regression lines for the relationship between the response variable *y* and the covariate *x* can have different intercepts for each cluster. However, each regression line shares the same slope. This means that the average response (the intercept) may differ among clusters, but the effect of covariate x is constrained to be the same for each cluster.

In measuring the multilevel effect in a model it can be assumed that each cluster has its own intercept and slope. The model can then be described by the following equation:

$$y_{ij} = \beta_{0j} + \beta_{1j}x_{ij} + e_{ij}, \; i = 1,\ldots,n_j; \; j = 1,\ldots,J. \tag{3.2}$$

Let us assume that β_{1j} is fixed across clusters (that is, $\beta_{1j}=\beta_1$). Then, from equation (3.2), we have

$$y_{ij} = \beta_{0j} + \beta_1 x_{ij} + e_{ij}, \; i = 1,\ldots,n_j; \; j = 1,\ldots,J. \tag{3.3}$$

Equation (3.3) is a single level model that describes a relationship for each cluster separately. The problem with model (3.3) is that if the number of clusters is very large, there would be a large number of parameters to estimate and hence the procedure would become inefficient. The interpretations of the results obtained from equation (3.3) are restricted to the clusters used in the model. This procedure is inappropriate to provide information for a general population of clusters as it does not recognize that clusters are a random sample.

A multilevel approach specifies a probability distribution and assumes that the

jth cluster from a sample is randomly selected from a population of clusters. Therefore, rather than estimating a series of parameters, one for each cluster, the multilevel model assumes that the cluster-specific parameters are from a distribution for which we estimate the mean and the variance.

Suppose, $\beta_{0j} = \beta_0 + u_{0j}$

From equation (3.3), we now define the random intercept model as

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + u_{0j} + e_{ij}, \quad i = 1,\ldots,n_j; \quad j = 1,\ldots,J \qquad (3.4)$$

where

$$e_{ij} \sim N(0,\sigma_e^2),$$
$$u_{oj} \sim N(0,\sigma_{u0}^2),$$
$$\text{cov}(e_{ij}, u_{0j}) = 0.$$

Equation (3.4) has two parts: the fixed part and the random part. In this case, $\beta_0+\beta_1 x_{ij}$ is the fixed part and $u_{0j}+e_{ij}$ is the random part. The coefficients β_0 and β_1 are known as the fixed parameters and σ^2_{u0} and σ^2_e are the random parameters. In contrast to the ordinary least square (OLS) models where we have only one residual term e_{ij} that measures the variation across individuals, in the multilevel random intercept model we have an additional residual term, u_{0j}. This residual term u_{0j} is assumed to capture the variation across clusters.

Observations in the same cluster are not independent since

$$\text{cov}(y_{ij}, y_{i'j}) = \sigma_{u0}^2 \qquad i \neq i'$$

but observations in different clusters are independent since

$$\text{cov}(y_{ij}, y_{i'j'}) = 0 \qquad j \neq j'.$$

The variance of y_{ij} is

$$\text{var}(y_{ij}) = \sigma_y^2$$

$$
\begin{aligned}
&= \mathrm{var}(\beta_0 + \beta_1 \mathrm{x}_{ij} + u_{0j} + e_{ij}) \\
&= \mathrm{var}(u_{0j}) + \mathrm{var}(e_{ij}) \\
&= \sigma_{u0}^2 + \sigma_e^2 .
\end{aligned}
$$

The variance of y is split into two parts, σ^2_{u0} and σ^2_e which respectively measure the variation across level 2 and level 1 units. Now, the intra-class correlation can be calculated using these two parts of the variance. The intra-class correlation is defined as:

$$
\rho = \frac{\mathrm{cov}(\mathrm{y}_{ij}, \mathrm{y}_{i'j})}{\sqrt{\mathrm{var}(\mathrm{y}_{ij})}\sqrt{\mathrm{var}(\mathrm{y}_{i'j})}} = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_e^2} \qquad i \neq i' .
$$

The intra-class correlation measures the proportion of the total variation ($\sigma^2_{u0}+\sigma^2_e$) which can be associated with between-cluster variation. When σ^2_{u0} is equal to zero, the intra-class correlation reduces to zero, which means that there is no variation across clusters. In such cases the parameter measuring the variation across level two is redundant and the multilevel linear model (3.4) reduces to the single level model (3.1).

3.3.2 The random coefficient model

The random coefficient model, which is also known as the random slope model, is an extension of the random intercept model (3.4). The random coefficient model allows the slope parameter β_1 to vary across clusters. It is possible to fit a fixed-effects model which would involve fitting separate regression lines for each cluster. It is rather unrealistic to have separate regression lines if there is a large number of clusters. It is therefore more efficient to use the multilevel approach which assumes that the cluster-specific intercept and slope come from some distributions for which we estimate the variances.

Assume

$$\beta_{1j} = \beta_1 + u_{1j} .$$

Then the multilevel model with a random slope coefficient is

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + u_{1j} x_{ij} + u_{0j} + e_{ij} \tag{3.5}$$

where

$$e_{ij} \sim N(0, \sigma_e^2)$$
$$u_{0j} \sim N(0, \sigma_{u0}^2)$$
$$u_{1j} \sim N(0, \sigma_{u1}^2)$$
$$\text{cov}(u_{0j}, u_{1j}) = \sigma_{u01}$$
$$\text{cov}(e_{ij}, u_{0j}) = \text{cov}(e_{ij}, u_{1j}) = 0 .$$

From equation (3.5), we can see that the fixed part of the model is $\beta_0+\beta_1 x_{ij}$ as before, and the random part of the model is $u_{1j}x_{ij} + u_{0j} + e_{ij}$. Hence, we can say that the random coefficient model is analogous to a random coefficient single-level model which allows interaction terms between covariates. The term $u_{1j}x_{ij}$ may be regarded as an interaction term between x_{ij} and the unobserved random effect u_{1j} in the random coefficient model. In this random coefficient model, there are in total six parameters to be estimated. Two parameters in the fixed part, β_0 and β_1, and four parameters in the random part, σ^2_e, σ^2_{u0}, σ^2_{u1} and σ_{u01}.

The models so far discussed only have covariates relating to the individuals. However, multilevel model is also can include variables from both levels. The model (3.5) can easily be extended.

Let

$$\beta_{0j} = \beta_0 + \beta_{01} x_j + u_{0j} \tag{3.6}$$

where, x_j is a contextual variable, measured at the second level. If the equation (3.6) is substituted into equation (3.2), the new equation becomes a random intercept model which can be expressed as

$$y_{ij} = \beta_0 + \beta_{01}x_j + \beta_{1j}x_{ij} + u_{0j} + e_{ij} \ . \qquad (3.7)$$

If the random coefficient's variation is to be explained by contextual variables, the model (3.7) can be extended by substituting the following into model (3.7):

$$\beta_{1j} = \beta_1 + \beta_{11}x_j + u_{1j} \ .$$

The new model becomes

$$y_{ij} = \beta_0 + \beta_{01}x_j + \beta_1 x_{ij} + \beta_{11}x_j x_{ij} + u_{1j}x_{ij} + u_{0j} + e_{ij} \ . \qquad (3.8)$$

While using a multilevel model one should not only focus on the elimination of the bias caused by the interrelation of observations but also on the analysis of a random parameter itself. While adding covariates in the model, Longford (1993) says, one should be interested in exploring whether the observations are still correlated or by how much the correlation has been reduced or increased.

3.3.3 The general form of the two-level multilevel model

We want to extend the random coefficients model to include *p* covariates in the fixed part and *q* covariates varying randomly at level 2. Hence, the general form of the two level multilevel model is

$$y_{ij} = x'_{ij}\,\beta + z'_{ij}\,u_j + e_{ij} \qquad (3.9)$$

where x_{ij} is a *p*-vector of covariates for the fixed effects; β is a vector of parameters associated with vector x_{ij}; z_{ij} is a q-vector of covariates (a subset of x_{ij}), the effects of which vary randomly at level 2; and u_j is a vector of random parameters associated with z at level 2.

In the case of the two-level random coefficient models with one level 1 covariate, we have

$$\mathrm{x}'_{ij} = (1, \mathrm{x}_{ij}),$$
$$\beta' = (\beta_0, \beta_1),$$
$$z'_{ij} = (1, \mathrm{x}_{ij}),$$
$$u'_j = (u_{0j}, u_{1j}).$$

For individuals in cluster j, the model can be written as

$$y_j = X_j\beta + Z_j u_j + e_j \tag{3.10}$$

where

$$\mathbf{y}'_j = \left(\mathbf{y}_{1j}, \mathbf{y}_{2j}, \ldots, \mathbf{y}_{n_j j}\right);$$
$$e'_j = \left(e_{1j}, e_{2j}, \ldots, e_{n_j j}\right)$$

and X_j is the $n_j x\ p$ design matrix for the fixed parameters β for the cluster *j*; and Z_j is the $n_j x\ q$ design matrix for the random effects u_j varying across level 2. Let the variance of u_j be Ω_j.

The matrix form of the general model can be written as

$$\mathrm{y} = X\beta + Zu + e \tag{3.11}$$

where X is a *n x p* design matrix for the fixed parameters; β is a vector of parameters associated with matrix X; *u* is a vector of random parameters; Z is an *n x q* design matrix for the random parameters; *n* is the number of observations ($n = \sum_{j=1}^{J} n_j$); *J* is the number of level 2 units and *q* is the number of covariates included in the random part of the model. The variance-covariance matrix for the random level 2 parameters has a block diagonal structure with a block for each cluster j, that is, var(u)= Ω = diag (Ω_1, Ω_2,..., Ω_j). The properties associated to this model are:

var(u) $= \Omega$
var(e) $= \sigma^2 I$
cov (u,e) = *0*,

where I is the identity matrix and 0 is the null matrix.

Then $$\mathrm{var}(y) = V = Z\Omega Z' + \sigma^2 I .$$

3.3.4 A three-level model

Extending the two-level random intercepts model in (3.3) to a three-level model where intercepts vary across both level 2 and level 3 units gives

$$y_{ijk} = \beta_{0jk} + \beta_1 x_{ijk} + e_{ijk} . \qquad (3.12)$$

Let $$\beta_{0jk} = \beta_0 + u_{0jk} + v_{0k} \qquad (3.13)$$

where u_{0jk} and v_{0k} are respectively level 2 and level 3 random effects. Now from equation (3.12) and (3.13), we can obtain a single equation which is

$$y_{ijk} = \beta_0 + \beta_1 x_{ijk} + u_{0jk} + v_{0k} + e_{ijk} . \qquad (3.14)$$

Let

$$e_{ijk} \sim N(0,\sigma_e^2),$$
$$u_{ojk} \sim N(0,\sigma_{u0}^2),$$
$$v_{ok} \sim N(0,\sigma_{v0}^2) \text{ and}$$
$$\mathrm{cov}(e_{ijk}, u_{0jk}) = \mathrm{cov}(e_{ijk}, v_{0k}) = \mathrm{cov}(u_{0jk}, v_{0k}) = 0 .$$

For the three-level random intercepts model (3.14), the total variance is

$$\mathrm{var}(y_{ijk}) = \sigma_e^2 + \sigma_{u0}^2 + \sigma_{v0}^2 ,$$

the level 2 variance is

$$\mathrm{var}(u_{0jk} + v_{0k}) = \sigma_{u0}^2 + \sigma_{v0}^2$$

and the level 3 variance is

$$\mathrm{var}(v_{0k}) = \sigma_{v0}^2 .$$

For a three-level model, the intra-class correlation for level 2 is

$$\rho_{0jk} = \frac{\sigma_{u0}^2 + \sigma_{v0}^2}{\sigma_e^2 + \sigma_{u0}^2 + \sigma_{v0}^2} \quad \text{and}$$

the intra-class correlation for level 3 is

$$\rho_{0k} = \frac{\sigma_{v0}^2}{\sigma_e^2 + \sigma_{u0}^2 + \sigma_{v0}^2}.$$

3.3.5 Estimation procedure for a linear multilevel model

If it is assumed that the random parameters are normally distributed, then the parameters can be estimated using the method of maximum likelihood (ML).

ML estimation provides the foundation for our approach to estimation with the logistic regression model. Generally, the method of maximum likelihood yields estimates for the unknown parameters which maximize the probability of obtaining the observed set of data. In order to apply this approach, we need to construct a function, called the likelihood function, which expresses the probability of the observed data as a function of the unknown parameters. The maximum likelihood estimators of these parameters are chosen to be those values which maximize this function.

In order to make the discussion simpler, let us use a two-level multilevel model (3.11). The log likelihood corresponding to the model (3.11) is

$$L = -\frac{1}{2}\left[C + \log_e\{\det(V)\} + \varepsilon' V^{-1}\varepsilon\right],$$

where $\varepsilon = \mathrm{y} - \mathrm{x}\beta$ and $C = n\log_e(2\pi)$.

When the number of clusters is small, the evaluation of the log likelihood is straightforward. However, computational problems may arise when the number of clusters is large, since inversion of very large matrices is required (Aitkin and Longford, 1986; and Longford, 1987). To address this problem there are three conceptually different approaches are used via likelihood maximization. They are the iterative generalized least squares (Goldstein, 1986), the EM (expectation and maximization) algorithm (Dempster et al., 1981; Mason et al., 1983), and a Fisher scoring algorithm (Longford, 1987). Since the statistical software MLwiN is used for analysing data for this research, the Iterative Generalized Least Square (IGLS) procedure used in MLwiN is discussed in the section below.

3.3.5.1 The Iterative Generalized Least Square (IGLS) procedure

Let us consider the general two-level model

$$y = X\beta + Zu + e,$$

where

$$\text{var}(u) = \Omega,$$
$$\text{var}(e) = \sigma_e^2 I \text{ and}$$
$$\text{cov}(u, e) = 0.$$

Let $\varepsilon = y - X\beta = Zu + e.$

Let $V = \text{var}(y) = \text{var}(\varepsilon) = Z\Omega Z' + \sigma_e^2 I,$

where I is the n x n identity matrix.

In a situation where V is known, the estimates of the vector of fixed parameters β could be estimated using Generalized Least Square (GLS) so that

$$\hat{\beta} = (X'V^{-1}X)^{-1}X'V^{-1}y.$$

Usually, the values of both β and V are unknown. Goldstein (1986) uses a variant of GLS, the Iterative Generalized Least Square (IGLS) procedure to estimate the multilevel fixed and random parameters. This procedure begins with an initial value of V ($V = \sigma_e^2 I$) which is then used in the above equation to obtain an estimate of β using ordinary least square estimation. Then the procedure starts alternating between the estimation of V and β, updating the estimate of one with the current estimate of the other to obtain an improved estimate of V at each iteration until convergence is achieved.

Let a_j be the $\frac{1}{2}n_j(n_j+1) \times 1$ vector containing the squares and the products of elements of the cross-product matrix $\varepsilon\varepsilon'$ for cluster j. Hence, the a_j vector is formed by stacking the columns of the lower triangle of the symmetric matrix $\varepsilon\varepsilon'$. Therefore, the a_j corresponding to the cluster j is

$$a'_j = (\varepsilon_{1j}^2, \varepsilon_{1j}\varepsilon_{2j}, \varepsilon_{2j}^2, \varepsilon_{1j}\varepsilon_{3j}, \varepsilon_{2j}\varepsilon_{3j}, \varepsilon_{3j}^2, \ldots, \varepsilon_{n_j j}^2) \ .$$

Now, if we take into account the J clusters, we have the vector

$$a' = (a'_1, a'_2, \ldots, a'_J).$$

Then $E(a) = W\gamma$ where γ is a vector containing all the elements of Ω and σ^2_e and W is known as design matrix which depends on Z. Then, we can write

$$a = W\gamma + \zeta, \qquad \text{where } \mathrm{E}(\zeta) = 0.$$

Let $\Gamma = \mathrm{var}(a) = \mathrm{var}(\zeta)$. Then Γ can be expressed as a function of the variances and the co-variances of u. If the Γ is known from the previous iteration the GLS procedure can be used and hence the estimator of γ is

$$\hat{\gamma} = (W'\Gamma^{-1}W)^{-1}W'\Gamma^{-1}a.$$

The IGLS procedure consists of three main steps. At first, the initial estimate of V is made. The second step is for estimating the fixed parameter β. The third step is for estimating the random parameter γ. Steps two and three are repeated alternatively until convergence is achieved.

For the estimation of multilevel level linear models the IGLS procedure is employed in the MLwiN software (Rasbash and Woodhouse, 1995). However, Goldstein (1995) comments that since IGLS does not account for the sampling variation of the fixed parameters, it may produce biased estimates of the random parameters if the sample size is small. However, in such situations, Goldstein (1989) suggests using restricted IGLS to obtain unbiased estimates.

3.3.6 Multilevel residual estimation

Before generalizing the residual estimation procedure, the two-level random intercepts model with one covariate x_{ij} is considered. Then

$$\mathrm{y}_{ij} = \beta_0 + \beta_1 \mathrm{x}_{ij} + u_{0j} + e_{ij},$$

where u_{0j} is the error term for level 2, and e_{ij} is the level 1 error term.

For the given x_{ij}, the predicted value of y_{ij} is

$$\hat{\mathrm{y}}_{ij} = \hat{\beta}_0 + \hat{\beta}_1 \mathrm{x}_{ij},$$

and the total residual for individual *i* in cluster *j* is

$$R_{ij} = y_{ij} - \hat{y}_{ij} = u_{0j} + e_{ij}$$

which is the sum of the residuals for level 2 and level 1 respectively. One of the primary areas of interest for multilevel analysis is to obtain these two components of the total residual separately. Hence, in a multilevel model, we require separate estimates of u_{0j} and e_{ij}. One can predict u_{0j} by the mean of R_{ij} in group *j*. Alternatively, let the predicted value of u_{0j} be proportional to the mean of R_{ij} in group *j* such that

$$\hat{u}_{0j} = c\overline{R}_j = c\frac{\sum_{i=1}^{n_j} R_{ij}}{n_j},$$

where *c* is a constant chosen to minimise $E(\hat{u}_{0j} - u_{0j})^2$.

For the two-level random intercepts model, the optimum value of c can be shown to be

$$c = \frac{\sigma_{0u}^2}{\sigma_{0u}^2 + \frac{\sigma_e^2}{n_j}}.$$

The term $\hat{u}_{0j}$ is called a *'shrunken'* residual, and c is called the *'shrinkage factor'* which is always less than or equal to one (Goldstein 1995).

Alternatively, let $\hat{u}_{0j}$ be a regression predictor of u_{0j} and therefore $\hat{u}_{0j} = c\overline{R}_j$. Now assuming a linear model, c can be estimated as

$$c = \frac{\mathrm{cov}(u_{0j}, \overline{R}_j)}{\mathrm{var}(\overline{R}_j)} = \frac{\mathrm{cov}(u_{0j}, u_{0j} + \overline{e}_{ij})}{\mathrm{var}(u_{0j} + \overline{e}_{ij})} = \frac{\sigma_{0u}^2}{\sigma_{0u}^2 + \frac{\sigma_e^2}{n_j}}.$$

As n_j increases, c tends to one and therefore u_{0j} is predicted by $\overline{R}_j$. If n_j is small, however, $\hat{u}_{0j}$ will shrink towards zero (hence the term *'shrunken'* residual). Thus for a small cluster, the cluster mean becomes close to the overall population mean as predicted by the fixed part of the model. If n_j is 1, then $c = \rho$, the intra-class correlation. If all clusters are of size unity, there will be no intra-class correlation and hence, $\hat{u}_{0j}$ will be equal to zero.

Now, let us consider the general two-level model

$$\mathrm{y}_{ij} = \mathrm{x}_{ij}'\beta + z_{ij}'u_j + e_{ij},$$

where $\mathrm{var}(u_j) = \Omega_j$ and $\mathrm{var}(e_{ij}) = \sigma_e^2$.

The predicted value of y_{ij} is $\hat{\mathrm{y}}_{ij} = \mathrm{x}_{ij}'\hat{\beta}$. The total residual is then

$$R_{ij} = y_{ij} - \hat{y}_{ij} = z_{ij}'u_j + e_{ij}.$$

Let $\overline{R}_j' = (\overline{R}_{1j}, \ldots, \overline{R}_{n_j j})$, then for given $\overline{\mathrm{R}}_j$, the regression predictor of u_j is

$$\hat{u}_j = \mathrm{cov}(u_j, \overline{R}_j{}')\,\mathrm{var}(\overline{R}_j)^{-1}\,\overline{R}_j = \mathrm{cov}(u_j, Z_j u_j + e_j)\,\mathrm{var}(Z_j u_j + e_j)^{-1}\,\overline{R}_j\,.$$

Let $$\mathrm{var}(\overline{R}_j) = \mathrm{var}(Z_j u_j + e_j) = Z_j \Omega_j Z_j' + \sigma_e^2 I_j = V_j$$

and $$\mathrm{cov}(u_j, Z_j u_j + e_j) = Z_j \Omega_j$$

Now, the estimated residuals for level 2 are

$$\hat{u}_j = Z_j \Omega_j V_j^{-1} \overline{R}_j$$

After estimating u_j, the level 1 residuals e_{ij} are estimated by

$$\hat{e}_{ij} = \overline{R}_{ij} - z_{ij}' \hat{u}_j\,.$$

The residuals from a multilevel model can also be used for diagnostic purposes as they are used for a single level model. Using estimated residuals, we can check some of the basic assumptions, such as those for normality and constant variance. To take into account differences in cluster sizes, the residuals at level 2 can be standardized by dividing the elements of estimated u_j by the estimated standard error. Normal plots of both sets of residuals can be used to check the normality assumptions. The important feature of the residual analysis is the possibility of ranking higher level residuals for further investigation. The analysis of residuals also allows identification of outlying observations. In contraceptive method use studies, for example, clusters with above average contraceptive use rates can be identified and researchers can investigate the characteristics of these clusters. It is also possible for researchers to identify communities with below average contraceptive use rates and compare their characteristics with those for clusters with above average contraceptive use rates (Aitkin and Longford, 1986; and Goldstein and Spiegelhalter, 1996). To test the difference between higher order residuals, Goldstein and Healy (1995) propose a methodology, which is based on the construction of simultaneous confidence intervals for each higher order residual.

3.3.7 Simultaneous confidence intervals for higher order residuals

Consider a simple two-level random intercepts model with a random effect. Let $\hat{u}_j$ be the estimated residual for cluster j and $\hat{\sigma}_j$ be the estimated standard deviation associated with $\hat{u}_j$. Assuming $\hat{u}_j$ is normally distributed its confidence interval for α level of significance is $\hat{u}_j \pm z_\alpha \hat{\sigma}_j$ where z_α is the $1-\frac{\alpha}{2}$ quantile of the standard normal distribution. Then the conventional 95% $(\alpha = 0.05)$ confidence interval for u_j is

$$\hat{u}_j \pm 1.96\hat{\sigma}_j .$$

Goldstein and Healy (1995) state that if the 95% confidence intervals for the means of two populations do not overlap, it does not imply that they are significantly different at 5% level of significance. When the comparison involves several means this problem of comparability becomes more serious. This is because when multiple comparisons are made the significant level α=0.05 is reduced which makes the required confidence intervals wider than the standard 95% intervals. Goldstein and Healy (1995) propose a procedure for the construction of simultaneous confidence intervals to test for differences between any pair of clusters. Goldstein and Healy's approach adjusts the value of z_α in order to achieve confidence intervals that allows simultaneous comparison of several means at α level of significance. This approach has been used by a number of authors (for example, Diamond et al., 1999)

Suppose, there are *J* independently normally distributed estimates of cluster-level residuals $\hat{u}_j$, j=1, 2 ,..., J with known standard errors σ_j. Suppose for a pair of clusters *j* and *k*, it is desired to test whether the difference between two estimated residuals $\hat{u}_j$ and $\hat{u}_k$ with standard errors σ_j and σ_k respectively are statistically significant at a level of significance *θ*. Assuming that the two residuals are normally distributed, the simultaneous 95% confidence interval for the jth cluster residual u_j is $\hat{u}_j \pm z_\theta \sigma_j$, where z_θ is selected so that the average significance level over all pairs of contrasts *(j, k)* is 5%. Assuming normality, the confidence intervals at level θ do not overlap if

$$\left|\hat{u}_j - \hat{u}_k\right| > z_\theta\left(\sigma_j + \sigma_k\right) \tag{3.15}$$

where z_θ is the (positive) normal deviate based on a two-tailed probability θ. Now the variance of the difference of the two residuals is

$$\mathrm{var}(\hat{u}_j - \hat{u}_k) = \sigma_j^2 + \sigma_k^2 = \sigma_{jk}^2$$

Now, the probability that the inequality (3.15) holds assuming $u_j = u_k$ is

$$\lambda_{jk} = 2\left[1 - \Phi\left\{z_\theta\left(\sigma_j + \sigma_k\right) / \sigma_{jk}\right\}\right]$$

where Φ is the normal integral. This varies between $2(1 - \Phi\{z_\theta\})$ and $2(1 - \Phi\{z_\theta \sqrt{2}\})$ according to the ratio σ_j/σ_k and is a minimum when this ratio is 1. In cases where there are more than two categories, Goldstein and Healy (1995) propose that the θ should be selected so that the average value of λ_{jk} over all *(j, k)* is a predetermined value, say α, typically 0.05 or 0.01. A starting point for z_θ is the average of $z_\alpha \sigma_{jk} / (\sigma_j + \sigma_k)$ based on all pairs *(j, k)*. If there are J clusters, there are *J(J-1)/2* possible different pairs and this starting point is

$$z_\theta = z_\alpha \frac{2}{J(J-1)} \sum_{j<k} \frac{\sigma_{jk}}{\sigma_j + \sigma_k}.$$

Then z_θ is adjusted until the average of the λ_{jk} is α. Then the simultaneous confidence interval for the j^{th} cluster is

$$\hat{u}_j \pm z_\theta \sigma_j.$$

3.3.8 Hypothesis testing for model selection

For any regression model, it is desired to have a simple parsimonious model by excluding all unnecessary extra parameters. In order to arrive at such a situation, it is necessary to test whether a parameter or a set of parameters should be excluded from the model. This process of inclusion or exclusion of a parameter or a set of parameters from the model involves statistical techniques. These test whether the parameter estimates or a set of parameter estimates is zero or not. This section describes how to perform a hypothesis test for both fixed and random parameters in multilevel models.

3.3.8.1 Fixed parameters

Define a *r x p* contrast matrix *H.* This contrast matrix *H* is used to form linearly independent functions of the *p* fixed parameters in the model which assumes the form $f=H'\beta$ so that each row of matrix *H* defines a particular linear function. Hence, the parameters which are not involved in the test of hypothesis have their corresponding elements set to zero. Suppose, we want to test a hypothesis that the two coefficients β_j and β_{j+1} are jointly zero. Therefore, in our situation, the matrix of contrast *H* and function *f* is defined as

$$H' = \begin{bmatrix} 0\ 0 \ldots .0\ 1\ 0\ \ldots .\ 0 \\ 0\ 0 \ldots .0\ 0\ 1\ \ldots .\ 0 \end{bmatrix} \text{ and } f = \begin{bmatrix} \beta_j \\ \beta_{j+1} \end{bmatrix}.$$

The general null hypothesis is

$$\mathrm{H}_0 : f = j, \text{ where in our special case } j = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

Now, let $$R = (\hat{f} - j)'\{H(X'\hat{V}^{-1}X)^{-1}H'\}^{-1}(\hat{f} - j)$$

where $$\hat{f} = H'\hat{\beta}.$$

It can be proved, when the null hypothesis is true, that R is approximately distributed as chi-squared with r degrees of freedom (Cox and Hinkley, 1974). The term $(X'\hat{V}^{-1}X)^{-1}$ is the estimated covariance matrix of the fixed parameters.

For multilevel linear models, the likelihood ratio test can also be used for testing hypotheses concerning fixed parameters. To test a null hypothesis H_0 against an alternative H_1 involving the fitting of additional parameters we form the log likelihood ratio or the deviance statistic as

$$D_{01} = -2\log_e(\theta_0 / \theta_1) \tag{3.16}$$

where, θ_0, θ_1 are the likelihoods maximised under the null and the alternative hypotheses. The statistic D_{01} is referred to the chi-squared distribution with degrees equal to the difference in the number of parameters fitted under the two models.

3.3.8.2 Random parameters

The likelihood test approach is used to test the significance of adding a random parameter in a multilevel linear model. Let assume that H_0 is a model to be tested and H_1 is the extended model with a random parameter. The likelihood ratio statistic or the deviance statistic is the same that defined in (3.16). However, Self and Liang (1987) state that the deviance statistic in this situation is not distributed as chi-square with one degree of freedom. Since under the null hypothesis the true value of the random parameter is on the boundary of the parameter space, that is zero. The asymptotic distribution of the likelihood ratio test in this case is believed to be an equal mixture of a chi-square random variable with one degree of freedom and a point mass at zero. According to Maller and Zhou (1996), the 95th percentile $c_{0.95}$ of the distribution of such a random variable is given by

$$\frac{1}{2} + \frac{1}{2} P\left(\chi_1^2 \le c_{0.95}\right) = 0.95$$

So $c_{0.95}$ satisfies $P(\chi_1^2 \le c_{0.95}) = 0.90$.

From standard tables of χ_1^2 we obtain $c_{0.95}$=2.71.

3.4 Multilevel logit model

In the previous section, only linear multilevel models for continuous response data are discussed. In this section non-linear multilevel models for binary response data are considered. The response variable for convenience can be denoted by 0 and 1. In contraceptive use analysis, the binary response is using a contraceptive method or not using a contraceptive method.

Let y_{ij} be the binary response for individual *i* in cluster *j* for a multilevel logit model. Let $p(y_{ij}=1) = \pi_{ij}$ be the probability of 'success'. Then the multilevel logit model can be defined as

$$y_{ij} = \pi_{ij} + e_{ij} \,, \tag{3.17}$$

where $\log_e\left(\dfrac{\pi_{ij}}{1-\pi_{ij}}\right) = \eta_{ij} = x'_{ij}\beta + z'_{ij}u_j$ and $\pi_{ij} = \dfrac{e^{\eta_{ij}}}{1+e^{\eta_{ij}}}$.

The model can be written using matrix notation as

$$y = \pi + e \tag{3.18}$$

where $$\eta = \log_e\left(\frac{\pi}{1-\pi}\right) = X\beta + Zu \,. \tag{3.19}$$

Like the linear model, *u* is assumed to be normally distributed with variance Ω. The response variable y_{ij}, conditional on the random effects, is a Bernoulli trial specified by a single parameter π_{ij}. Hence, the conditional likelihood function for this model has the form

$$L(\beta|u) = \prod_{j=1}^{J}\prod_{i=1}^{n_j}\pi_{ij}^{y_{ij}}\left(1-\pi_{ij}\right)^{1-y_{ij}}$$

$$= \prod_{j=1}^{J}\prod_{i=1}^{n_j}\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)^{y_{ij}}\left(1-\pi_{ij}\right). \tag{3.20}$$

Since the random parameter is not known, it is necessary to obtain the unconditional likelihood. The unconditional likelihood may be obtained by multiplying the conditional likelihood (3.20) by the density function of u and then 'integrating out' the random effects *u*:

$$L(\beta,\Omega) = \int \ldots \int L(\beta|u)\,\Phi(u)\,du \qquad (3.21)$$

where Φ(.) denotes the probability density function of the multivariate normal distribution.

The unconditional likelihood (3.21) is mathematically intractable and hence some approximation needs to be used. Anderson and Aitkin (1985) and Im and Gianola (1988) use some form of numerical integration to obtain the unconditional likelihood using Gaussian quadrature for a relatively simple model. Wong and Masson (1985) use the application EM algorithm. Zeger and Karim (1991) and Prevost (1996) use Gibbs sampling to estimate the parameters. The Gibbs sampling approach is computationally intensive, despite the evidence of its appropriateness (Prevost, 1996). Considering all these problems for parameter estimation in multilevel logit model, many researchers have opted to use the marginal quasi-likelihood approximation (Goldstein, 1991; Longford, 1994) as well as the penalized quasi-likelihood approximation (Breslow and Clayton, 1993; Goldstein and Rasbash, 1996). As these last two procedures are implemented in MLwiN, the software used for the analyses present in this thesis, they are described in the next sections.

3.4.1 Marginal quasi-likelihood (MQL)

Goldstein (1991) proposes an approach for estimating the parameters of non-linear multilevel logit models. His approach for estimating the parameters first linearizes the model by using a first-order Taylor series expansion and then applies Iterative Generalized Least Squares (IGLS) as for the linear models.

Let $\pi = \pi(\eta)$. Then from equation (3.19) we get

$$y = \pi(\eta) + e = \pi(X\beta + Zu) + e$$

Goldstein (1991) uses a first-order Taylor series expansion for each element of $\pi(\eta)$ around the trial values $\beta=\beta^{(0)}$ and $u=0$ to give the following approximation:

$$y \approx \pi(\eta^{(0)}) + \sum_{k=1}^{p} \frac{\partial \pi(\eta^{(0)})}{\partial x_k \beta_k} x_k(\beta_k - \beta_k^{(0)}) + \sum_{k=1}^{q} \frac{\partial \pi(\eta^{(0)})}{\partial z_k u_k} z_k u_k + e \qquad (3.22)$$

where $\eta^{(0)} = x'\beta^{(0)}$ and $\frac{\partial \pi(\eta^{(0)})}{\partial x_k \beta_k}$ and $\frac{\partial \pi(\eta^{(0)})}{\partial z_k u_k}$ are the first derivatives of the function $\pi(\eta) = \pi(X\beta + Zu)$ with respect to *k*-th fixed parameter β_k and *k*-th random term u_k evaluated at $\eta^{(0)}$.

For the logit link,

$$\frac{\partial \pi(\eta^{(0)})}{\partial x_k \beta_k} = \frac{\partial \pi(\eta^{(0)})}{\partial z_k u_k} = \pi(\eta^{(0)})[1 - \pi(\eta^{(0)})] \quad .$$

Let $\pi(\eta^{(0)})[1 - \pi(\eta^{(0)})] = w^{(0)}$.

Now, using matrix notation we can write

$$y \approx \pi(\eta^{(0)}) + W^{(0)}X(\beta - \beta^{(0)}) + W^{(0)}Zu + e \qquad (3.23)$$

where $W^{(0)} = \text{diag}[\pi(\eta^{(0)})\{1 - \pi(\eta^{(0)})\}]$ and X and Z are the design matrices respectively for parameters β and u.

After rearranging the equation (3.23), we can write

$$y^* = X^*\beta + Z^*u + e \qquad (3.24)$$

where $y^* = y - \pi(\eta^{(0)}) + W^{(0)}X\beta^{(0)}$, the working dependent variable and $X^* = W^{(0)}X$ and $Z^* = W^{(0)}Z$ are the working design matrices respectively for the fixed parameters and the random parameters.

Approximating the variance of the error term by using var(e) $\approx W^{(0)}$, gives

$$\text{var}(y) \approx Z^{*}\Omega Z' + W^{(0)}.$$

The structure of this model is that of a linear multilevel model which provides an approximation to the non-linear multilevel logit model. Now, the linear approximation can be fitted by using the Iterative Generalized Least Squares (IGLS) for linear models proposed by Goldstein (1986).

Alternatively, instead of applying the linearization using initial values and then iterating until the estimation converges, Goldstein (1991) proposes the use of an Iterative Re-weighted Least Squares (IRLS) algorithm. This algorithm, at each iteration, updates $W^{(0)}$ and hence X^*, Z^* and y^*. The approximation at iteration *m* is given by

$$y^{(m)} = \pi\left(\eta^{(m-1)}\right) + \sum_{k=1}^{p} \frac{\partial\pi\left(\eta^{(m-1)}\right)}{\partial x_k \beta_k} x_k\left(\beta_k - \beta_k^{(m-1)}\right) + \sum_{k=1}^{q} \frac{\partial\pi\left(\eta^{(m-1)}\right)}{\partial z_k u_k} z_k u_k + e \,. \qquad (3.25)$$

This MQL approach proposed by Goldstein (1991) produces biased estimates towards zero for the fixed and random parameters (Rodriguez and Goldman, 1995; Breslow and Clayton, 1993). The main reason for these biases is that the Taylor series expansion is evaluated around a trial value u=0 (Goldstein and Rasbash, 1996). Hence, the MQL approximation, according to Goldstein (1996), should perform well when the random effect is small.

When fitting the model, the level 1 variance is usually constrained to be purely binomial (σ^2_e=1). Alternatively, the constraint on σ^2_e can be relaxed to allow for extra-binomial variation (Goldstein, 1991). One advantage of Goldstein's procedure is that it can easily be extended to entertain extra-binomial variation (Williams, 1982).

After finding that the estimation of the multilevel logit model using Goldstein IGLS approach leads to a substantial downward bias in the estimation of the random parameters, as proposed by Goldstein (1991), Rodriguez and Goldman

(1995) applied a quadratic approximation in which a second-order Taylor series expansion is used. The approximation (3.25) is extended to incorporate second order terms corresponds to each individual random parameter while ignoring the second order terms for the fixed effect, to give the following approximation at iteration *m*

$$y^{(m)} = \pi\left(\eta^{(m-1)}\right) + \sum_{k=1}^{p} \frac{\partial \pi\left(\eta^{(m-1)}\right)}{\partial x_k \beta_k} x_k \left(\beta_k - \beta_k^{(m-1)}\right) + \sum_{k=1}^{q} \frac{\partial \pi\left(\eta^{(m-1)}\right)}{\partial z_k u_k} z_k u_k + \frac{1}{2} \sum_{k=1}^{q} \sum_{l=1}^{q} \frac{\partial^2 \pi\left(\eta^{(m-1)}\right)}{\partial z_k u_k \, \partial z_l u_l} z_k z_l u_k u_l + e \tag{3.26}$$

where $\frac{\partial^2 \pi\left(\eta^{(m-1)}\right)}{\partial z_k u_k z_l u_l}$ is the second derivative evaluated at $\eta^{(m-1)}$.

For the logit link

$$\frac{\partial^2 \pi\left(\eta^{(m-1)}\right)}{\partial z_k u_k z_l u_l} = \frac{\partial \pi\left(\eta^{(m-1)}\right)}{\partial z_k u_k z_l u_l} \left(1 - e^{\eta^{(m-1)}}\right)\left(1 + e^{\eta^{(m-1)}}\right)^{-1} \text{ for } l \neq k . \tag{3.27}$$

3.4.2 Penalized quasi-likelihood (PQL)

Although the quadratic approximation provides a considerable improvement in the estimation of the fixed parameters, the estimated random effects still shows a downward bias. Considering the Breslow and Clayton's (1993) penalised quasi-likelihood (PQL) approach, Goldstein and Rasbash (1996) propose a Taylor series expansion about the current estimates. This involves expanding the Taylor series around $u=u^{(m-1)}$ instead of $u=0$ for random part of the model. Here, $u^{(m-1)}$ is treated as the current estimates of the level 2 residuals. In this situation, the equation (3.26) becomes

$$\begin{aligned} y^{(m)} &= \pi\left(\eta^{(m-1)}\right) + \sum_{k=1}^{p} \frac{\partial \pi\left(\eta^{(m-1)}\right)}{\partial x_k \beta_k} x_k \left(\beta_k^{(m)} - \beta_k^{(m-1)}\right) + \sum_{k=1}^{q} \frac{\partial \pi\left(\eta^{(m-1)}\right)}{\partial z_k u_k} z_k \left(u_k^{(m)} - u_k^{(m-1)}\right) \\ &+ \frac{1}{2} \sum_{k=1}^{q} \sum_{l=1}^{q} \frac{\partial \pi\left(\eta^{(m-1)}\right)}{\partial z_k u_k z_l u_l} z_k \left(u_k^{(m)} - u_k^{(m-1)}\right) z_l \left(u_l^{(m)} - u_l^{(m-1)}\right)\left(1 - e^{\eta^{(m-1)}}\right)\left(1 + e^{\eta^{(m-1)}}\right)^{-1} + e . \end{aligned} \tag{3.28}$$

The current estimate of the random part of the model is added to the fixed part at each iteration. The first order PQL omits the second derivative term.

Goldstein (1995) and Goldstein and Rasbash (1996) compare simulation results for the first-order MQL with second-order PQL approximations and find that the second-order PQL substantially improves the estimation of the fixed and random parameters. Goldstein (1995) says, 'It is clear that the MQL first-order model underestimates all the parameter values, whereas the second-order PQL model produces estimates close to the true values' (page 101). Rodriguez and Goldman (1995) find that MQL produces severely biassed estimates for any unbalanced designs with small cluster sizes. However, in such situations, PQL performs well. Breslow and Clayton (1993) articulate that the PQL method is a method of choice for estimating parameters in the hierarchical model, especially when attention is given on random parameters. Goldstein and Rasbash (1996) mention that the first-order PQL approximation nearly always converges, but the second-order PQL does not always do so. However, both the MQL and PQL approaches with first- and second-order approximations have been incorporated in MLwiN software. One major distinction between PQL and MQL is the fact that the regression coefficients of the PQL but not of the MQL, even in the large samples, depend heavily on the estimated variance components when the link function is not the identity.

3.5 Multilevel multinomial logit model

For clustered data, if the response variable is discrete, unordered and has more than two categories, a multilevel multinomial logit model is appropriate. In the contraceptive choice analysis, the response variable has more than two categories. A woman may adopt the pill, condom, injectable, IUD, traditional method or remains a non-user. For clustered data, in that situation, a multilevel multinomial logit model is used. In this section the multilevel multinomial logit model is discussed following a description of the fixed effect multinomial logit model.

Let y_i, which has more than two categorical non-ordered responses, be the response variable for individual *i*. Now, generalize the binomial logit model to define the multinomial logit model. Assuming that the response variable y_i has *s* categories, define the probability that the response variable is equal to *r* by

$$\pi_{ri} = \Pr(y_i = r), \text{ where, r=1,2,..., s,}$$

$$\text{such that } \sum_{r=1}^{s} \pi_{ri} = 1.$$

Now, the multinomial logit model can be written as

$$y_{ri} = \pi_{ri} + e_{ri} \tag{3.29}$$

where $$\log_e\left(\frac{\pi_{ri}}{\pi_{si}}\right) = \eta_{ri} = \mathrm{x}'_{ri}\beta_r, \quad r = 1,2,\ldots,s-1 .$$

A set of covariates (β_r) needs to be estimated for different contrast, since the effect of the covariates is likely to vary separately across the categories of the response variable. For the fixed effect multinomial logit model, generally the maximum likelihood method is used for estimating the parameters. It is needed to create a number of r-1 binary variables coded as 1 or zero such that

$$y_{ri} = \begin{cases} 1 \text{ if } y_i = r, & r = 1,2,\ldots,s \\ 0 \text{ else} . \end{cases}$$

Since the observations are assumed to be independent, the likelihood function in this situation can be written as

$$L(\beta) = \prod_{i=1}^{n} \left[\left\{ \pi_1(x_i)^{y_{1i}} \right\} \left\{ \pi_2(x_i)^{y_{2i}} \right\} \ldots \left\{ \pi_s(x_i)^{y_{si}} \right\} \right]. \tag{3.30}$$

The principle of maximum likelihood states that we use as the estimate of β the value which maximizes the expression in equation (3.30). It is however, easier mathematically to work with the log of equation (3.30). Now, taking the logarithm and given that $\sum_{r=1}^{s} y_{ri} = 1$, the log-likelihood function is defined as

$$\begin{aligned} 1(\beta) = \log_e[l(\beta)] = \sum_{i=1}^{n} \{ & y_{1i}\eta_1(x_i) + y_{2i}\eta_2(x_i) + \ldots + y_{s-1i}\eta_{s-1}(x_i)\} \\ & - \log_e(1 + e^{\eta_1} + e^{\eta_2} + \ldots + e^{\eta_{s-1}}) . \end{aligned} \quad (3.31)$$

Now, the probability that a response category is *r* for an individual *i* is calculated as

$$\pi_{ri} = e^{\eta_{ri}}\left(1 + \sum_{k=1}^{s-1} e^{\eta_{ki}}\right)^{-1} \qquad \text{where } r = 1,2,\ldots,s-1$$

and the probability that a response category is *s* (the reference category) is

$$\pi_{si} = 1 - \sum_{r=1}^{s-1} \pi_{ri} = \left(1 + \sum_{k=1}^{s-1} e^{\eta_{ki}}\right)^{-1} .$$

The multilevel multinomial logit model can easily be shown by extending the multinomial logit model (3.29) with the help of incorporating the random part in the model. After incorporating the random part, equation (3.29) can be written as

$$y_{rij} = \pi_{rij} + e_{rij} \quad (3.32)$$

where $$\log_e\left(\frac{\pi_{rij}}{\pi_{sij}}\right) = \eta_{rij} = \mathbf{x}'_{rij}\beta_r + \mathbf{z}'_{rij}u_{rj}, \qquad r = 1,2,\ldots,s-1 . \quad (3.33)$$

Here x_{rij} is a vector of covariates in the fixed part of the model with associated parameters β_r. The z_{rij} is a vector of covariates in the random part of the model at level 2 with associated random parameters u_{rj}. The random parameters u_{rj} are assumed to be normally distributed with mean zero and variance Ω_{rj}.

The probability that the response category is *r* for an individual *i* in cluster *j* can be written as

$$\pi_{rij} = e^{\eta_{rij}}\left(1+\sum_{k=1}^{s-1} e^{\eta_{kij}}\right)^{-1} \qquad r = 1,2,\ldots,s-1\ .$$

Hence, the probability of the response category *s* (the reference category) is

$$\pi_{sij} = 1-\sum_{r=1}^{s-1}\pi_{rij} = \left(1+\sum e^{\eta_{kij}}\right)^{-1}\ .$$

Goldstein (1995) illustrates how a multilevel multinomial logit model can be expressed and formulated as a multilevel multivariate model, where $y_{ij}=(y_{1ij},y_{2ij},\ldots,y_{sij})$ is the multivariate response for individual *i*. With the help of Goldstein's idea, the two-level model described in (3.32) can be fitted as a three-level model treating the multivariate response as level 1, the individual as level 2 and the cluster as level 3.

3.5.1 Estimation of the multilevel multinomial logit model

As for the multilevel binomial logit regression model, a Taylor series expansion is needed in multilevel multinomial logit regression (Goldstein, 1995). Expanding about $\beta_r=\beta_r^{(m-1)}$ and $u_r=0$, at the m-th iteration of the IGLS algorithm, the approximation can be written as

$$y_r^{(m)} \approx \pi_r\left(\eta_r^{(m-1)}\right)+\sum_{k=1}^{p}\frac{\partial\pi_r\left(\eta_r^{(m-1)}\right)}{\partial x_{rk}\beta_{rk}}x_{rk}\left(\beta_{rk}^{(m)}-\beta_{rk}^{(m-1)}\right)+\sum_{k=1}^{q}\frac{\partial\pi_r\left(\eta_r^{(m-1)}\right)}{\partial z_{rk}u_{rk}}z_{rk}u_{rk}+e_r\,, \qquad (3.34)$$

where $\quad \eta_r^{(m-1)} = x_r'\beta_r^{(m-1)}\ .$

For the logit link, $\quad \dfrac{\partial\pi_r\left(\eta_r^{(m-1)}\right)}{\partial x_{rk}\beta_{rk}} = \dfrac{\partial\pi_r\left(\eta_r^{(m-1)}\right)}{\partial z_{rk}u_{rk}} = \pi_r\left(\eta_r^{(m-1)}\right)\left[1-\pi_r\left(\eta_r^{(m-1)}\right)\right].$

Let $\quad \pi_r\left(\eta_r^{(m-1)}\right)\left[1-\pi_r\left(\eta_r^{(m-1)}\right)\right] = w_r^{(m-1)}\ .$

The approximate model can be written as

$$y_r^{(m)} \approx \pi_r\left(\eta_r^{(m-1)}\right) + w_r^{(m-1)}\mathrm{x}_r'\left(\beta_r - \beta_r^{(m-1)}\right) + w_r^{(m-1)}z_r'u_r + e_r\,. \qquad (3.35)$$

After rearranging equation (3.35), we can write

$$y_r^* = x_r^*\beta_r + z_r^* u_r + e_r$$

where

$$y_r^* = y_r^{(m)} - \pi_r\left(\eta_r^{(m-1)}\right) + w_r^{(m-1)}\mathrm{x}_r'\beta_r^{(m-1)},$$
$$\mathrm{x}_r^* = w_r^{(m-1)}\mathrm{x}_r \quad \text{and} \quad z_r^* = w_r^{(m-1)}z_r\,.$$

In this case, y_r^* is the working dependent variable and x_r^* and z_r^* are the working design matrices respectively for the fixed and random parameters.

If we assume that the observed response proportion for the i[th] individual in the j[th] cluster follows a multinomial distribution then the level 2 covariance matrix has the form

$$n_{ij}^{-1}\begin{bmatrix} \pi_{1ij}\left(1-\pi_{1ij}\right) & & \\ -\pi_{1ij}\pi_{2ij} & \cdot & \\ \cdot & \cdot & \\ \cdot & \cdot & \\ -\pi_{1ij}\pi_{(s-1)ij} & \cdots & \pi_{(s-1)ij}\left(1-\pi_{(s-1)ij}\right) \end{bmatrix} \qquad (3.36)$$

where n_{ij} is the total number of responses for this individual. Typically, this is equal to one as each individual responds just once.

An extra set of covariates needs to be defined at level 1 and level 2 to specify a multinomial covariance matrix (3.36). Suppose there are three categories (s=3) of the response variable. Define the explanatory variables as

$$z_{1rij} = \sqrt{\pi_{rij} / n_{ij}} = \sqrt{\pi_{rij}}$$
$$z_{2rij} = \pi_{rij} / \sqrt{2n_{ij}} = \pi_{rij} / \sqrt{2}$$
$$z_{3rij} = -\pi_{rij} / \sqrt{2n_{ij}} = -\pi_{rij} / \sqrt{2}$$

and specify Z_1 to have a random coefficient at level 1 with variance constrained to unity and Z_2, Z_3 to have random coefficients at level 2 constraining their variances to zero and their covariance to unity. This produces the covariance matrix (3.36) and extra multinomial variation can be achieved by allowing the variance and covariance to be different from unity but constraining them to be equal (for details see Goldstein, 1995).

MLwiN macros are available for fitting the multilevel multinomial logit model using both first- and second-order approximations for both MQL and PQL estimation procedures.

The data used in this research were collected longitudinally with an equal interval of time. The data have a longitudinal record of when the events of interest occurred to an individual. The aim of event history analysis is to study the patterns and causes of these events. In the event history analysis, the length of time to the occurrence of an event of interest is analysed. A detailed description of the event history analysis technique is discussed in the next chapter.

CHAPTER 4

EVENT HISTORY ANALYSIS

4.1 Introduction

In social science, increasing attention is being given to the collection and the analysis of event history data. Compared to traditional panel data, event histories, which are a longitudinal record of events happening to a sample of individuals, are often better suited to the dynamic nature of pragmatic occurrences (Blossfeld et al.,1989). Panel data are obtained by investigating the sample units at different but fixed points in time. Panel data thus provide information on the values of the variables of interest at particular points in time. Event history data are more informative than panel data since they contain information on the timing of changes, transitions or events. Event histories provide information about the exact duration until a state alteration as well as the incidence and course of events. In order to understand the nature of event history data and the purpose of the event history analysis, it is important to understand the four elementary concepts: state, events, duration and risk period (Yamaguchi, 1991). The states are the categories of the 'dependent' variable the dynamics of which we want to explain. An event is a transition from one state to another. The period that someone is at risk of a particular event or exposed to a particular risk, is called the risk period. Using these elementary concepts, event history analysis can be defined as the analysis of the duration of the non-occurrence of an event during the risk period (Yamaguchi, 1991). In event history analysis, we analyse the length of the duration to the incidence of the event. The data collected longitudinally once every three months between 1986 and 1992 under the SRS (Sample Registration System) illustrate a case of event history data where the woman's history of use of contraception and the family planning worker's contact data with the woman are gathered.

Although event histories are ideal for studying the potential causes of events, they typically possess two special features– inclusion of censored observations and use of time-varying explanatory variables– which need to be taken into account in the analysis. An observation is called censored if the event of interest did not occur before the end of the observation period. Censoring is, in fact, a form of partially missing information: on the one hand it is known that the event did not occur during a given period of time, but, on the other hand, the time at which the event occurred is not known. Time-varying covariates are covariates that may change their value during the observation period. The possibility of including covariates which may change their values in the regression model makes it possible to perform truly dynamic analyses. The time varying explanatory variables create major problems for standard statistical procedures such as multiple regression. Attempting to apply such methods can lead to severe bias (Allison, 1984). These two problems– censoring and time-varying explanatory variables– are quite typical of event history data.

In conceptualizing the duration of the nonoccurrence of an event, an important concept is the risk period. The distinction between the risk period and non-risk period always requires an assumption. The assumption may be implicit– assuming that individuals are at risk throughout the period of time. The risk period, however, often requires a more explicit assumption. We, for example, may not know exactly the beginning of the risk period for the event. We may assume that all individuals entered at the same time. Given the distinction between the risk and the non-risk periods, Allison (1984) defines event history analysis either as the analysis of the duration for the nonoccurrence of an event during the risk period or as the analysis of rates of the occurrence of the event during the risk period.

To analyse event history data, a large number of statistical techniques are available. Event history models can be classified according to different types of dimensions. The first distinction that can be made is based on the nature of the dependent variable which is being modelled. The dependent variable may either be discrete or continuous. Event history models for discrete dependent variables can be subdivided into two subgroups: continuous-time methods or discrete-time methods. Continuous-time methods assume that events may occur at any point in time, while discrete-time methods assume that changes occur at certain discrete time points.

In studies of contraceptive discontinuation and failure (Curtis and Hammerslough, 1995; Potter, 1960; and Trussell and Menken, 1982), life-table techniques have been widely used. The discrete time hazard model is useful when the duration until the occurrence of an event is measured at regular intervals. The rate of occurrence of an event usually varies with time and among groups. The rate, when attached to a particular moment in time, is often referred to as the hazard rate or transition rate. Compared with some conventional methods such as linear regression analysis, one major beauty of using hazard-rate models for the analysis of duration data, is their ability to deal with certain types of censored observation. For analysing event history data, two types of statistical techniques– life table techniques and discrete time hazard are discussed in this chapter.

4.2 The life table technique

The life table method is one of the most commonly used methods for analysing waiting times and life expectancies. The method is basically a non-parametric method and has been applied in demographic studies in the form of a population life table. Compared to conventional linear regression analysis, one major advantage of the hazard rate model is its capacity to deal with certain types of censored observations (Yamaguchi, 1991). Life table analysis can handle right censoring for the analysis of event history data. Life table analyses were initially developed for studying mortality and the length of life. However, for studying the length of time to the occurrence of any event (such as contraceptive adoption, contraceptive discontinuation, etc.) the life table can also be used. In life table analysis the duration is broken into equal intervals of time. The number of individuals at risk, the number of events and the number of censored observations is observed in each interval of time. Using these, the probability of an event occurring in a given time interval can be calculated. The intervals need to be equidistant. The life table method is a technique for studying "grouped" time periods without explicit considerations of covariates (Blossfeld et al., 1989). For contraceptive use the interval can be monthly, two monthly, three monthly or six monthly (Trussel and Menken, 1982). When there is only one event of interest, the single decrement life table is applied. When there is more than one event, a multiple decrement life table is used. In this section, both single and multiple decrement life tables are discussed.

4.2.1 The single decrement life table

In single decrement life table analysis, we have only one event of interest. The technique is examined for the situation where observations are measured at an intervals of three months. Let n be the total number of individuals at the outset of analysis; d_t the number of individuals encountering the event during the t-th interval; and c_t the number of individuals who are censored in the t-th interval.

For the "risk set" W_t, that is, the number of individuals who had no event until the beginning of the t-th interval and have not been censored, we have

$W_1 = n$ and
$W_t = W_{t-1} - d_{t-1} - c_{t-1}$ for t=2,3,...

Let T denote the random length of time to the event. The hazard rate of the t-th interval is $\lambda_t = \Pr(\text{event occurs in } [t, t+1) | T \geq t)$. This represents the conditional probability that in the t-th time interval an event occurs given that the beginning of the interval has been reached. If during the t-th interval no censoring has occurred, then the hazard rate λ_t may be estimated directly by the relative frequency d_t / W_t. Since, usually the exact timings of events and the censoring within the interval [t, t+1) are not known, the number of individuals exposed to the risk of an event needs to be estimated. However, the value of W_t is not exactly the number of individuals who are exposed for the full time interval. This is due to inclusion of censored individuals as exposed for the full time interval. In reality, the censored individuals are exposed to the risk of experiencing the event for just a fraction of a period. The life table method thus corrects the risk set W_t through reducing it by $c_t/2$ (Potter, 1960). Hence, the estimated hazard rate can be written as

$$\hat{\lambda}_t = \frac{d_t}{W_t - c_t / 2} \quad . \tag{4.1}$$

The probability of 'surviving' to time t which is also referred to the probability of the event not occurring before time t can be defined as

$$\begin{aligned} S_t &= \Pr(T \geq t) \\ &= \prod_{k=1}^{t-1} (1 - \lambda_k) \, . \end{aligned}$$

The unconditional probability of the occurrence of the event is

$$f_t = \Pr(\text{event occurs in } [t, t+1)) \, .$$

Hence the cumulative probability that an individual experiences the event before time t is given by

$$\begin{aligned} F_t &= \Pr(T < t) \\ &= \sum_{k=1}^{t-1} f_k = 1 - S_t \, . \end{aligned} \tag{4.2}$$

By estimating the hazard rate λ_t , the other functions S_t and F_t are estimated.

4.2.2 The multiple decrement life table

Multiple-decrement life tables were originally used to study mortality by several alternative causes of death. A single-decrement life table can easily be extended in order to include multiple events. A multiple-decrement life table is also useful in the study of contraceptive discontinuation when different reasons such as side effects, method failure, etc., cause the disruptions. Suppose that there are s-1 different possible events and let r be a variable indicating the particular event that occurs (r=1,2,...,s-1) and the state s represents right-censored cases for whom the event r has not yet occurred. Let d_{rt} be the number of events of type r in interval t and $t+1$, where r=1,2,...,s-1. Now, the hazard rate of an individual experiencing an event r during the interval t and t+1 can be defined as

$$\lambda_{rt} = \Pr(\text{event of type } r \text{ occurs in } [t, t+1) | T \geq t), \qquad r=1,2,...,s-1.$$

As with the single-decrement life table the estimated hazard rate can be defined as

$$\hat{\lambda}_{rt} = \frac{d_{rt}}{W_t - c_t / 2}.$$

The overall hazard rate for an event of any type is $\lambda_t = \sum_{r=1}^{s-1} \lambda_{rt}$ and the probability that no event of any type occurs before time t is $\lambda_{st} = 1 - \lambda_t$.

The unconditional probability of event occurrence for each type of event is

$$f_{rt} = \Pr(\text{event of type } r \text{ in } [t, t+1)) .$$

The overall probability of survival to time t is

$$\begin{aligned} S_t &= \Pr(T \geq t) = \Pr(\text{no event of any type before } t) \\ &= \prod_{k=1}^{t-1} (1 - \lambda_k) \ . \end{aligned}$$

The cumulative probability that an event of type r occurs before time t is given by the sum over k of product of the overall probability of surviving to time k and then experiencing the event r before time k+1 and can be written as

$$F_{rt} = \sum_{k=1}^{t-1} \lambda_{rk} S_k \ .$$

As for the single-decrement case, the estimate of λ_{rt} can be used to derive an estimate of S_t and, therefore, an estimate of F_{rt}.

In the presence of all other competing risks, the multiple-decrement life table yields the hazard of an event of type r. Since, in most situations, an individual is simultaneously at risk of experiencing a number of different types of event the multiple-decrement life table rates reflect the actual rates. The probabilities calculated from the multiple-decrement life table are called net rates because they represent the probability of the specific event occurring in the presence of other competing risks of events.

4.2.3 The associated single-decrement life table

The associated single-decrement life table is another type of life table used mainly in the analysis of the discontinuation of contraceptive use. They are used to calculate underlying rates of discontinuation for a particular reason in the absence for other reasons for discontinuation.

Rates computed from different multiple-decrement life tables may be misleading in some situations. This may be because the risk of the occurrence of one type of event is not independent of the frequency with which the other events occur. For an example, suppose there are two different subgroups within a sample: S1 and S2. Let, for any given time period, the net rates in subgroup S1 be lower than the rates in subgroup S2. If the competing risks are also lower in subgroup S1 than in S2, it is possible for subgroup S1 to show higher net cumulative rates despite its lower rates of experiencing the event (Potter, 1969). For example, suppose we wish to compare use failure rates of two contraceptives, say injectables and traditional methods. For the two methods, in the multiple-decrement life tables, the risk of failure will depend upon the number of discontinuations for reasons other than failure. Therefore, the failure rates can be very different for injectables and traditional methods, not necessarily because one method is more effective than the other, but because one method has a higher rate of discontinuation due to other reasons than for failure. The injectables may have a lower failure rate because the rate of discontinuation due to side effects is high for the injectables but negligible for the traditional methods. One can overcome such a problem if one constructs a life table in which all the competing risks are eliminated by censoring all the remaining events other than the event of interest. This approach is called an associated single-decrement life table. The rates obtained by using associated single-decrement life table approaches are referred to as gross rates. According to Curtis and Hammerslough (1995), the distinction between the net discontinuation rates calculated using a multiple-decrement life table and the gross discontinuation rates calculated using an associated single-decrement life table is undetectable, and sometimes it is not easily perceivable which one is the most appropriate for a particular analysis.

The associated single-decrement life table assumes that the competing risks are independent (Kalbfleisch and Prentice, 1980). This assumption does not hold in many situations and cannot be tested (Kost, 1993) and hence the associated single-decrement life table has serious drawbacks.

One of the main objectives of using the life table is to calculate the rates of occurrence of an event for subgroups of the population. Therefore, in life table analysis, the effect of one particular variable on the rate of the event occurring is computed without controlling for the effect of other variables. It is possible to examine differentials between subgroups of a population by calculating separate life tables for each sub-group. However, the life table analysis becomes infeasible when the number of subgroups increases markedly. Hazard models allow us to measure the effect of one variable on the occurrence of an event after controlling for the effect of the other variables. We can also incorporate random parameters into the hazard models. These are the advantages of using the hazard models over life tables.

4.3 The discrete-time hazard model

In a continuous-time model, time is assumed to be measured as a continuous variable. However, a discrete-time analysis approach is appropriate for event history analysis. When discrete time units are very small then it is generally acceptable to treat the time data as continuous ignoring the discrete nature of the data since the differences between the recorded and actual time measurements are small. However, this treatment has become problematic when the discrete time units are large (months or years). The presence of ties due to grouping time data and treating them as continuous can lead to serious biases when using a Cox proportional hazards model. This is due to assumption that one makes with the continuous-time model that the probability of the occurrence of more than one event at a time point is zero. This problem can easily be avoided by using discrete-time approach. Another advantage of using a discrete-time approach is that it allows us easily to incorporate time-varying covariates in the model.

4.3.1 The discrete-time model for one event

Discrete-time model notations are very similar to the notations used for continuous time. In a discrete-time model, time is assumed to take only positive integer values.

Let there be n individuals, indexed by i=1,2,...,n. For individual i, the observation starts at time t=1 and is followed until time $t=t_i$ at which point either the event occurs or the observation is censored. Let c_i equal 0 if individual i is censored and 1 if individual i is uncensored. Let there be a vector of possible time-varying covariates x_{ti} associated with individual i and time point t. Then the discrete-time hazard rate λ_{ti} is defined as

$$\lambda_{ti} = \Pr(T_i = t \mid T_i \geq t, \mathrm{x}_{ti})$$

where T is a discrete random variable indicating the time of occurrence of the event.

Now, we need to specify the form of the relationship between the discrete-time hazard rate, λ_{ti}, and the explanatory variables x_{ti}.

The most common choice is the logistic link and the hazard rate, therefore, can be expressed as

$$\lambda_{ti} = \frac{\exp(\alpha_t + \mathrm{x}'_{ti}\beta)}{1 + \exp(\alpha_t + \mathrm{x}'_{ti}\beta)} \tag{4.3}$$

where $\log_e(\frac{\lambda_{ti}}{1-\lambda_{ti}}) = \alpha_t + \mathrm{x}'_{ti}\beta$ and α_t is a function of time representing the baseline hazard.

The function of time α_t can be specified in number of ways. The simplest model would assume no time dependency, $\alpha_t=\alpha$. This model assumes that the hazard is constant. Other choices are: (1) a linear function of time, $\alpha_t = \alpha_0 + \alpha_1 t$, which represents a Gompertz distribution for T, (2) a function of the natural logarithm of time, $\alpha_t = \alpha_0 + \alpha_1 \log_e(t)$, which represents a Weibull distribution for T, and (3) a quadratic function of time, $\alpha_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2$, which may also be used with a time categorized in wider intervals. However, it is also possible to group the time points to make wider intervals of time. For these types of models, time may be treated as a categorical covariate where the hazards are assumed to be constant within each interval.

For the logistic-link function, the likelihood can be written as

$$L=\prod_{i=1}^{n}[\Pr(T_i=t)]^{c_i}[\Pr(T_i>t)]^{1-c_i}, \tag{4.4}$$

where $$\Pr(T_i=t)=\lambda_{ti}\prod_{j=1}^{t-1}(1-\lambda_{ji})=\frac{\lambda_{ti}}{1-\lambda_{ti}}\prod_{j=1}^{t}(1-\lambda_{ji}) \tag{4.5}$$

and $$\Pr(T_i>t)=\prod_{j=1}^{t}(1-\lambda_{ji}). \tag{4.6}$$

Substituting equations (4.6) and (4.5) into equation (4.4) and taking the natural logarithm gives the following log likelihood function

$$l=\sum_{i=1}^{n}c_i\log_e\left(\frac{\lambda_{ti}}{1-\lambda_{ti}}\right)+\sum_{i=1}^{n}\sum_{j=1}^{t}\log_e(1-\lambda_{ji}). \tag{4.7}$$

Let us define a dummy variable y_{ti} which is equal to 1 when the individual i experiences an event at time t and is equal to zero otherwise. Now, substituting y_{ti} for c_i, the log-likelihood can be written as:

$$l=\sum_{i=1}^{n}\sum_{j=1}^{t}\left[y_{ji}\log_e\left(\frac{\lambda_{ji}}{1-\lambda_{ji}}\right)+\log_e\left(1-\lambda_{ji}\right)\right]. \tag{4.8}$$

This is the log-likelihood function for the regression analysis of a binary response data, where the binary response is y_{ti} and $\lambda_{ti}=\Pr(y_{ti}=1)$. Therefore, the parameters of the discrete-time hazard model can be estimated by using programs for the analysis of binary data. If we had chosen the logistic link, the model can be fitted in any package that performs logistic regression.

Since y_{ti} is the dependent variable which assumes the value 1 if the event occurred for the individual i at time t and zero otherwise, each discrete unit for each individual can be treated as separate observation. Let, for example, an individual experience an event at time five. That individual will have five observations. The outcome (event) variable will be coded as 1 for the fifth observation. For the other four observations for that individual the outcome variable will be coded as zero. In such situations, the number of observations contributed by each individual represents the period of time that the individual was exposed to the risk of experiencing the occurrence of the event.

For any individual *i* with covariate vector x_{ti}, an estimate of the hazard λ_{ti} can be obtained directly from the fitted model. In the case of logistic link, the estimated hazard rate can be written as

$$\hat{\lambda}_{ti} = \frac{\exp(\hat{\alpha}_t + x'_{ti}\hat{\beta})}{1 + \exp(\hat{\alpha}_t + x'_{ti}\hat{\beta})} \quad . \tag{4.9}$$

The estimated hazard rate $\hat{\lambda}_{ti}$ can now be used to derive estimates of S_{ti}, the probability that no event occurs before time *t*, and F_{ti}, the cumulative probability an event occurring before time *t*:

$$\hat{S}_{ti} = \prod_{j=1}^{t-1} (1 - \hat{\lambda}_{ji}) \qquad \text{and} \qquad \hat{F}_{ti} = 1 - \hat{S}_{ti} \ .$$

4.3.2 The discrete-time competing risks model

In many situations, there may be more than one way of leaving a particular state. For example, a woman may discontinue using a contraceptive method for a variety of reasons such as, use failure, side effects, lack of supply, etc. In order to incorporate multiple outcomes (events), the discrete-time models can be extended as for the life table. Let there be *s*-1 different possible outcomes or events and let *r* be a random variable indicating the particular event type that occurs (*r*=1,2,..., *s*-1). The discrete-time hazard rate is defined as

$$\lambda_{rt} = \Pr(T = t, R = r | T \geq t) \ , \qquad r=1,2,..., s-1$$

where λ_{rt} is the probability of event of type *r* at time *t*, given survival to time *t*.

The overall hazard of an event of any type is

$$\lambda_t = \sum_{r=1}^{s-1} \lambda_{rt} .$$

Let us define an event *s* = {no event occurs before time *t*}, then the hazard that no event of any type occurs before time *t* is

$$\lambda_{st} = 1 - \sum_{r=1}^{s-1} \lambda_{rt} .$$

Let individual *i* experiences the event *r* at time *t* or is censored at time *t*. Let c_i=1, if an event occurs at time *t*, and c_i=0 otherwise. Then, the likelihood function can be written as

$$L = \prod_{i=1}^{n} \left[\frac{\lambda_{rti}}{1-\lambda_{ti}} \right]^{c_i} \prod_{j=1}^{t} \left(1-\lambda_{ji}\right). \qquad (4.10)$$

The likelihood for a continuous-time competing risk model can be factorised into separate components for each kind of event (for details, see Kalbfleish and Prentice, 1980). This enables the continuous-time model to be estimated via a series of models for single events, one for each type of event where the other events are treated as censored. Unlike the continuous-time competing risk model, the estimation for the discrete-time competing risk model must be carried out simultaneously for all types of events (Allison, 1982).

Although different kinds of link function can be applied, a generalization of the logistic function is often used based on the multinomial logistic model:

$$\log_e\left(\frac{\lambda_{rti}}{\lambda_{sti}}\right) = \alpha_{rt} + \mathrm{x}'_{rti}\beta_r , \qquad r=1,2,...., s-1 .$$

The hazard rate for an event of type r is written as

$$\lambda_{rti} = \frac{\exp(\alpha_{rt} + \mathrm{x}'_{rti}\beta_r)}{1 + \sum_{k=1}^{s-1} \exp(\alpha_{kt} + \mathrm{x}'_{kti}\beta_k)}, \qquad r=1,2,\ldots\ldots, s-1 . \qquad (4.11)$$

Substituting (4.11) into (4.10) and then taking the logarithm, the log-likelihood for a discrete-time competing risk multinomial logistic model is obtained. Similar to the binary logistic model for the discrete time, the data needs to be restructured. This is done in order to obtain a multinomial response with *s* categories for each time point. A series of *s*-1 contrasts are estimated simultaneously each one comparing the hazard of one type of event with the reference category *s* which represents 'no event'. For any individual, his/her response in the discrete time points before the occurrence of an event will be coded *s*. His/her final record will be coded as *r* (r=1,2,...*s*-1) if an event of type *r* occurs or *s* if they are censored.

As for the binomial discrete-time model, the cause-specific hazard can be estimated directly from the fitted model. For an individual *i* with covariate vector x_{rti}, based on the model estimates, the estimated hazard for an event of type *r* is given by

$$\hat{\lambda}_{rti} = \frac{\exp(\hat{\alpha}_{rt} + \mathrm{x}'_{rti}\hat{\beta}_r)}{1 + \sum_{k=1}^{s-1} \exp(\hat{\alpha}_{kt} + \mathrm{x}'_{kti}\hat{\beta}_k)}, \qquad r=1,2,\ldots,s-1 . \qquad (4.12)$$

The estimated hazard that no event occurs is

$$\hat{\lambda}_{sti} = 1 - \sum_{r=1}^{s-1} \hat{\lambda}_{rti} = \frac{1}{1 + \sum_{k=1}^{s-1} \exp(\hat{\alpha}_{kt} + \mathrm{x}'_{kti}\hat{\beta}_k)} . \qquad (4.13)$$

The estimates $\hat{\lambda}_{sti}$ can then be used to derive estimates of the probability of survival to time *t*, S_{ti}, and the cumulative probability of an event of type *r*, F_{rti}, as

$$\hat{S}_{ti} = \prod_{j=1}^{t-1} \hat{\lambda}_{sji} \quad \text{and} \quad \hat{F}_{rti} = \sum_{j=1}^{t-1} \hat{\lambda}_{rji} \hat{S}_{ji} \ .$$

4.4 Problems with the discrete-time approach

In order to fit a discrete-time model, the data need to be restructured to obtain a set of Bernoulli responses for each individual. The Bernoulli responses for an individual will be a series of zeros for each time point at which the event has not yet occurred. The final response will be coded as an unity when the event is occurred or a zero if the individual is censored. For example, an individual experiences the event of interest in the eighth month of observation, he/she will have eight data points: seven zeros followed by an unity for the eighth point. This approach can generate huge data sets depending on the size of the units of time and the number of individuals in the sample.

When the units of time are very small compared to the total period of observation the discrete-time approach may be unrealistic. This is due to the fact that a large number of observations would be contributed to the sample by each individual. One way of overcoming such problem is to consider making the discrete time units larger. For example, rather than having a Bernoulli response for every single month, it may be possible to have a response for every two months period or every three months period. Diamond et al. (1986) have found that little precision is lost when observations are aggregated into broader intervals of time. Another way of reducing the computing time of the discrete-time method is to estimate the logistic model using a log-linear model (Allison, 1984). However, the log-linear model is only possible in the case where all the variables are categorical.

4.4.1 Unobserved heterogeneity

Analogous to the continuous-time models, a major problem with the discrete-time event history model is the assumption that the covariates explain all the variations in the hazard rate. Some covariates may have been neglected because they were thought less important, or were difficult to measure or were unavailable. Hence, there is a possibility of 'unobserved heterogeneity' or 'frailty'. Unobserved heterogeneity means that a particular variable or variables which explain individual differences in the risk of experiencing the given event being studied are not included as covariates in the hazard model because they are not observed. It means that particular variables that influence the dependant variable are not measured and therefore cannot be used as covariates in the regression models (Heckman and Singer, 1984). The observed dynamics at the population level will tend to be different from those observed at the individual level, if individuals differ by some unobserved factors (Vaupel et al., 1979 and Blossfeld et al., 1989). However, if we fail to observe many of the influencing factors for the outcome variable and we do not adjust for that, the model suffers from omitted-covariates-bias. The estimates of the observed covariates, thus, are biased. A good example of unobserved heterogeneity is the analysis of fertility where fecundability is known to vary among women but difficult to measure explicitly.

The unobserved heterogeneity biases the duration dependence downward, even if it is not correlated with the observed covariates (Vermunt, 1996). If there is a selection bias, not only are the model parameters biased, but there will also be spurious time-covariate interactions. The standard approach to incorporating unobserved heterogeneity in the model is to allow for unobserved variation across the population by adding an error term or unobservable random variable with the probability density function whose variance represents the unexplained heterogeneity between individuals. Traditionally, random effects models have been used where the random effect represents unobserved heterogeneity. A good discussion of these models as well as alternative models for incorporating unobserved heterogeneity by the inclusion of an error term in the model is given by Allison (1987). The random effect can be introduced either inside or outside the linear predictor yielding an 'internal' or 'external' model. The internal models, which are commonly used, assume that the unobserved covariates are operating on the same scale as the observed covariates. The majority of the applications of the internal model appear in the econometrics literature. Since the data have a two-level clustered structure: binary responses for each discrete time unit (level one) nested within individuals (level two), random effect models are suitable for the discrete-time event history models.

Heckman and Singer (1984) raised an important issue related to the sensitivity of parameter estimates to the choice of the unobserved heterogeneity distribution. They found differences in the estimates of the covariate coefficients. These differences depend on whether the unobserved heterogeneity was assumed to follow a normal, log-normal, or gamma distribution. Heckman and Singer (1984) proposed a non-parametric approach and simulation results showed that the estimates for this model were robust to a range of 'true' heterogeneity distribution. For a discrete-time binary response event history model, Elias (1994) found parametric approaches produce robust estimates of the regression coefficients. Narendranathan and Elias (1993) and Narendranathan and Stewart (1993) used both a parametric approach (assuming normally distributed heterogeneity) and the Heckman and Singer's (1984) non-parametric approach and found that the two sets of estimates were very similar.

4.4.2 Repeated events

In event history data individuals may experience an event more than once over the observation period. This means that an individual may contribute more than one event to the sample. The presence of recurrent events raises a methodological problem since the fundamental assumption of most statistical models is that all observations are independently distributed. The repeated durations on an individual is expected to be correlated. For example, in the context of contraceptive discontinuation, a woman having difficulties with the use of the method may discontinue early, contributing a sequence of shorter lengths of use, while the other women who do not have difficulties or have fewer problems may continue using the method for a longer time and may contribute one long spell. One way of overcoming the problem related to repeated events is to extend the model to incorporate the inclusion of a random parameter at a higher level. The two level unobserved heterogeneity model can be extended to three levels: discrete time units (level one) nested within events (level two) within individuals (level three).

4.5 Multilevel discrete-time competing risk model

If there are multiple events, in order to control for unobserved heterogeneity the single-level discrete-time competing risk model discussed earlier can be extended to incorporate cause-specific random effects. This results in a multilevel multinomial logistic model for the cause-specific hazard function:

$$\log_e\left(\frac{\lambda_{rti}}{\lambda_{sti}}\right) = \alpha_{rt} + \mathrm{x}'_{rti}\beta_r + u_{ri}\ , \qquad r = 1,2,\ldots,s-1 \tag{4.14}$$

where u_{ri} is the random effect associated with event type r for individual i. The most common assumption is that the random effect u_{ri} is normally distributed with mean zero and variance σ_r^2 and $\mathrm{cov}(u_{ri}, u_{r'i}) = \sigma_{rr'}, r \neq r'$.

This model can be estimated as a multilevel multinomial model in MLwiN. The model (4.14) is a two-level random intercepts model and can be extended to further levels, for example, to allow for repeated events and heterogeneity.

As for the single-level discrete-time competing risk model, the data need to be restructured to obtain a series of multinomial responses for each discrete time unit during which an individual was at risk. For example, if the response variable has s categories, then s-1 binary indicator variables for the s-1 event types need to be generated for each multinomial response. The restructured data set can be very large depending on the number of competing alternatives. As a result, fitting a multilevel multinomial logistic model tends to be highly computer intensive.

4.6 Summary

For the analysis of event history data, two different techniques have been presented in this chapter. They are life table techniques and discrete-time event history models. In life table techniques, it is not feasible to estimate the effect of a specific variable controlling for the effect of others. The hazard model has some advantages over life table techniques. The discrete-time hazard model for the logistic link can easily be fitted by any standard software for logistic and multinomial logistic models, depending on the number of types of events of interest. To incorporate unobserved heterogeneity, the discrete-time hazard model can be extended by adding random parameters to the model. This enables discrete-time event history models with unobserved heterogeneity to be estimated using multilevel techniques. Again, discrete-time event history random effect models can further be extended by including another level in order to incorporate the repeated events for the same individuals. Further hierarchical levels can be incorporated by adding more random parameters for exploring the presence of extra variation between higher units of aggregation, such as geographical area. The MLwiN statistical software is used in this study for the estimation of both multilevel discrete-time hazard models and the multilevel discrete-time competing risk models.

CHAPTER 5

LATENT CLASS ANALYSIS

5.1 Introduction

In the social sciences, many concepts cannot be directly observed. For example, we cannot directly observe economic development, quality of health services, quality of family planning services, status of women, religious commitment, etc. For example, while we cannot directly observe the quality of family planning services, it is fair to believe that a high quality of services leads people to accept a family planning method, and to use it continuously and efficiently. It may be assumed that each of the observed indicators is caused by an unobserved, or latent variable of interest. Latent class analysis permits a characterization of unobserved categorical variables from an analysis of the structure of the relationships among several categorical manifest or observed variables (Anderson, 1990; Clogg, 1982, 1995, Clogg and Goodman, 1984; Goodman, 1974; McCutcheon, 1987). Originally conceived as an analytic method for survey data, latent class analysis is often referred to as the categorical data analogue of factor analysis, since it can be used to reduce a set of several categorical variables into a single latent variable with a set of underlying types or classes. Much of the early work on the study of latent variables used factor analysis. Factor analysis employs the general linear model to extract continuous latent variables from sets of continuous observed indicators. While the underlying assumptions of the general linear model are violated if factor analysis is employed with categorical data, social researchers have not had analogous techniques for scaling discrete data. Like factor analysis, latent class analysis assumes that the observed associations among two or more observed variables are due completely to the associations of the observed variables with one or more unobserved variables.

Latent class models are becoming widely used in multivariate categorical data analysis because the latent class model requires neither the often violated assumptions of multivariate normality nor the assumption of continuity of measurement (Dayton and Macready, 1988; McCutcheon, 1987).

Recent developments in latent class methods have demonstrated that this analytic method also provides insight into the comparative analysis of scales and typologies in different populations (Clogg and Goodman, 1984). According to Clogg (1995), latent classes are assumed to be internally homogeneous (all individuals in a given latent class have the same probability distribution with respect to outcome), and the observed variables are conditionally independent.

5.2 Latent class analysis

Consider a 3-way contingency table which cross-classifies a sample of *n* individuals with respect to three manifest polytomous variables *A, B* and *C* consisting of *I, J,* and *K* classes respectively. Let π_{ijk} denote the probability that an individual will be at level (*i, j, k*) with respect to the joint variable (*A, B, C*) (*i=1,2,...,I; j=1,2,...,J; k=1,2,...,K*). Suppose that there is a latent polytomous variable *Y*, consisting of *T* classes, that can explain the relationship among the manifest variables *(A, B, C)*. Hence, following Goodman's (1974) notation, the probability that an individual will be at level *(i, j, k)* with respect to joint variable *(A, B, C)* can be expressed as:

$$\pi_{ijk} = \sum_{t=1}^{T} \pi_{ijkt}^{ABCY} ,$$

where

$$\pi_{ijkt}^{ABCY} = \pi_{it}^{\bar{A}Y} \times \pi_{jt}^{\bar{B}Y} \times \pi_{kt}^{\bar{C}Y} \times \pi_{t}^{Y}$$

and where π_{ijkt}^{ABCY} is the probability that an individual will be at level *(i, j, k, t)* with respect to the joint variable *(A, B, C, Y)*; π_{t}^{Y} is the probability that an individual will be at level *t* with respect to variable *Y*; $\pi_{it}^{\bar{A}Y}$ is the conditional probability that an individual will be at level *i* with respect to variable *A*, given that he/she is at level *t* with respect to variable *Y*; $\pi_{jt}^{\bar{B}Y}$ is the conditional probability that an individual will be at level *j* with respect to variable *B*, given that he/she is at level *t* with respect to variable *Y*; and $\pi_{kt}^{\bar{C}Y}$ is the conditional probability that an individual will be at level *k* with respect to variable *C*, given that he/she is at level *t* with respect to variable *Y*.

The latent class probabilities describe the distribution of classes of the latent variable within which the observed measures are independent of one another. The number of classes *T* in the latent variable *Y* represents the number of latent types defined by the latent class model. The minimum number of identifiable classes in a latent variable is two (McCutcheon, 1987). The relative size of each of the *T* classes also provides significant information for the interpretation of the latent class probabilities. The sum of the latent class probabilities over all *T* latent classes of the latent variable *Y* is equal to unity. Also, within each of the *T* latent classes the conditional probabilities for each of the observed variables sum to unity. Hence, we can write,

$$\sum_{t=1}^{T} \pi_{t}^{Y} = \sum_{i=1}^{I} \pi_{it}^{\bar{A}Y} = \sum_{j=1}^{J} \pi_{jt}^{\bar{B}Y} = \sum_{k=1}^{K} \pi_{kt}^{\bar{C}Y} = 1$$

Let $\hat{\pi}_{t}^{Y}$, $\hat{\pi}_{it}^{\bar{A}Y}$, $\hat{\pi}_{jt}^{\bar{B}Y}$, $\hat{\pi}_{kt}^{\bar{C}Y}$ denote the maximum likelihood estimates (MLEs) of the corresponding parameters in the latent class model. Then we obtain

$$\hat{\pi}_{ijkt}^{ABC\bar{Y}} = \frac{\hat{\pi}_{ijkt}^{ABCY}}{\sum_{t=1}^{T} \hat{\pi}_{ijkt}^{ABCY}},$$

where

$$\hat{\pi}^{ABCY}_{ijkt} = \hat{\pi}^{\bar{A}Y}_{it} \times \hat{\pi}^{\bar{B}Y}_{jt} \times \hat{\pi}^{\bar{C}Y}_{kt} \times \hat{\pi}^{Y}_{t}$$

Let f_{ijk} denote the observed frequency of individual at level (*i, j, k*) with respect to the joint variable (*A, B, C*) and let $p^{ABC}_{ijk} = f_{ijk} / n$, where $n = \sum_{ijk} f_{ijk}$ is the total sample size. The MLEs will satisfy the following system of equations:

$$\hat{\pi}^{\bar{A}Y}_{it} = \left(\sum_{j,k} p_{ijk} \hat{\pi}^{ABC\bar{Y}}_{ijkt} \right) \Big/ \hat{\pi}^{Y}_{t} ,$$

$$\hat{\pi}^{\bar{B}Y}_{jt} = \left(\sum_{i,k} p_{ijk} \hat{\pi}^{ABC\bar{Y}}_{ijkt} \right) \Big/ \hat{\pi}^{Y}_{t} ,$$

$$\hat{\pi}^{\bar{C}Y}_{kt} = \left(\sum_{i,j} p_{ijk} \hat{\pi}^{ABC\bar{Y}}_{ijkt} \right) \Big/ \hat{\pi}^{Y}_{t} \qquad \text{and}$$

$$\hat{\pi}^{Y}_{t} = \sum_{i,j,k} p_{ijk} \hat{\pi}^{ABC\bar{Y}}_{ijkt} .$$

The exploratory latent class analysis of respondent types imposes no restrictions on the values that the conditional or latent class probabilities can take and is referred to as an unrestricted latent class model. Although all variables are treated as nominal variables in the unrestricted latent class model, restricted latent class models have been proposed which make it possible to make a priori assumptions on the distance among the categories of the latent and manifest variables. In general, there are two types of restrictions that can be placed on each of the two types of parameters: equality constraints and specific value constraints. Equality constraints require that two or more of either modelled latent class probabilities or conditional probabilities take on the same value. Specific value constraints, on the other hand require that one or more of either the modelled latent class or conditional probabilities equal a value that has an a priori specification. An unrestricted latent class model can be useful for an exploratory analysis of a multidimensional cross-classification (Heinen, 1996). However, unrestricted latent class models are not the most suitable class of models when the analysis is aimed at measurement rather than data reduction (Heinen, 1996).

In this analysis, the *LEM* software developed by Vermunt (1997) is used for latent class analysis. The MLE of the parameters of models containing latent variables are computed by means of the Expectation Maximization (EM) algorithm. The EM algorithm (Dempster et al., 1977), which is an iterative procedure with each iteration consisting of two parts: the E-step (expectation step), in which the conditional expectations of the functions of the sufficient statistics for the latent data are calculated, and the M-step (maximization step), in which the complete likelihood, with the functions of the latent data replaced by their conditional expectations is maximized. The conditioning in the E-step is on the incomplete data and the current estimates of the parameters. The estimates are updated in the subsequent M-step. The E- and M-steps are repeated alternatively until the convergence is achieved. The main advantage of the EM algorithm is that it does converge to at least a local maximum under relatively weak conditions, even with bad starting values (Wu, 1983). The EM algorithm is both conceptually and computationally very simple. With the EM algorithm it is easy to estimate the parameters (Anderson, 1990).

The underlying constructs of quality of family planning services are considered to be latent since they are difficult to measure directly and are measured most appropriately through multiple questions (see Appendix A1). In this research work, latent class models are used to create scores, with discrete data, of different indicators of perceived quality of family planning services. Each question on perceived quality of family planning services had four categories of responses. The *LEM* software (Vermunt, 1997) only handles 2 categories of responses. Considering the limitation of *LEM* software (Vermunt, 1997), four categories of responses have been categorized into two for each questions. Five variables were found significantly associated and finally used in creating the latent class probabilities. The latent class analysis probabilities for scales derived by the LEM software (Vermunt, 1997) appear in Appendix A2. Latent class analysis parameters are conceptually similar to the factor loadings in a factor analysis with metric data, as they reflect the strength of the relationship between the latent and manifest variables. However, they are probabilities rather than regression coefficients (Collins et al., 1996).

CHAPTER 6

Contraceptive Use, Adoption and Method Choice

6.1 Introduction

Choosing a contraceptive is an important decision especially from health perspectives. Couples can make their choices from a variety of contraceptive methods that are available to the community. In Bangladesh, pills, condoms, injectables, intrauterine devices (IUDs), female and male sterilization, and norplant implants are available. However, there are also some couples who are controlling their fertility by some traditional means: abstinence, withdrawal, rhythm, lactational amenorrhoea and some other herbal methods.

Recent Bangladesh data show an overall increase in the rate of contraceptive prevalence. Pill use among married women of reproductive age increased from 5.1 percent in 1985 to 20.8 percent in 1996 (Mitra et al., 1997). Injectable use among married women of reproductive age also increased from 0.5 percent in 1985 to 6.2 percent in 1996. These increases in contraceptive use have been attributed to the expansion of family planning programme by adding female family planning workers to provide information as well as delivery of contraceptives to rural women in their homes (Cleland et al., 1994; Phillips et al., 1993, 1996).

The method specific prevalence rates for male and female sterilization show a declining trend (Mitra et al., 1997). The male sterilization acceptors declined from 1.5 percent in 1985 to 1.1 percent in 1996. The female sterilization acceptors also declined from 7.9 percent in 1985 to 7.6 percent in 1996 (Mitra et al., 1997).

This chapter is divided into three main sections: current contraceptive use, post partum contraceptive reversible method adoption, and choice of method. The objective of this chapter is to analyse the effect of family planning outreach workers' contact with rural women on contraceptive use, post partum reversible method adoption and choice in four rural areas of Bangladesh. Voluntary male and female sterilization is excluded from the adoption and the choice analysis since there are very few adopters in the period of analysis.

Given the fact that the contraceptive use behaviour is influenced by a combination of factors associated with individuals, community (family planning workers' work area) and higher levels, such as *union* (family planning workers' supervisors work area), a multilevel modelling approach is used.

6.2 Contraceptive use analysis

The data for this research come from the ongoing Operations Research Project of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). A survey on Knowledge, Attitude and Practice (KAP) was conducted in 1985/86 and the data were collected from about 5,641 currently married women of reproductive age in four rural areas of Bangladesh under the Sample Registration System (SRS).The women were asked about their contraceptive use history, fertility preference, family planning outreach workers' contact in last 90 days before the survey in addition to their socio-demographic information and detailed fertility history. A detailed description of the SRS and the data are given in Section 1.5.

Current use of contraception is defined as the proportion of women who reported using a family planning method for avoiding or delaying conceptions at the time of the survey interview.

A multilevel logistic model (discussed in Chapter 3) is used, where the dependent variable is whether or not a woman *i* in *unit j* in *union k* uses a contraceptive method. The multilevel random intercept model for the current use of any method of contraception can be written as following equation:

$$\log_e\left(\frac{\lambda_{ijk}}{1-\lambda_{ijk}}\right) = \beta'\mathbf{x}_{ijk} + u_{jk} + v_k \ . \qquad (6.1)$$

Here λ_{ijk} is the probability that a woman *i* in *unit j* and *union k* uses any method of contraception, x_{ijk} is a vector of covariates and β is the vector of parameters associated with x_{ijk}. The random parameters, u_{jk} and v_k , represent the unobserved factors operating at the *unit* level and the *union* level respectively. The random parameters u_{jk} and v_k are assumed to be mutually independent and normally distributed with mean zero and variance σ^2_{jk} and σ^2_k at the *unit* level and the *union* level respectively. Family planning workers' work area– the *unit*– is the community which reflects sharing the similar local culture and as well as similar family planning service environment within the *unit*. Research has shown that women in the same community often exchanged ideas by talking to each other and, therefore, are more likely to be behaving similarly regarding contraceptive use (Entwisle et al., 1989). Estimating variances across communities allows the assessment of whether the additions of further variables at the community level explain the variation observed at the community level. *Union* reflects the larger service environment in terms of family planning programme environment. Generally each *union* has six *units*, hence, six family planning outreach workers. A supervisor, whose responsibility is to oversee the work of the outreach worker, is assigned to each *union*.

A bivariate analysis was conducted to see the relationship of the socio-economic, demographic, and programmatic variables with the outcome variable and is included in the appendix (Appendix A3). A descriptive analysis was also conducted to see the representativeness of the sample and is mentioned in Chapter 1 (see page 17, Table 1.2). The average age of the women is 28.9.

Most are illiterate, and the mean duration of schooling is only 1.4 years. More than half of the women want no more additional children. Each woman has an average of 3.1 living children. Eighty five percent are Muslim. These characteristics are typical of data reported in national surveys of married women of reproductive age in Bangladesh.

In the multivariate analysis, the model selection strategy was first to include all available explanatory variables in the model. A large number of variables were considered to assess the factors which might be associated with contraceptive use in four rural areas of Bangladesh, based on the predictors that have been found to have affect on contraceptive use in other studies. At the second phase, the variables that were statistically insignificant at 10 percent were excluded. To control for the effect of one or two variables on the outcome, they were kept in the model even if they were found statistically not significant at 10 percent. Possible two-factor interactions were tested and retained when they were found statistically significant. For the contraceptive use analysis, number of living sons, number of living daughters, desire for additional children, women's age, women's years of education, religion, and family planning outreach workers' contact are used as predictors of contraceptive use. Women's literacy rate at the community level is also included as predictor in the analysis.

6.2.1 Results of the multilevel contraceptive use analysis

6.2.1.1 Interpretation of fixed effects

Table 6.1 displays the parameter estimates and the standard errors for the selected multilevel logistic model for the use of any contraceptive method in 1986. No interaction term was found to be significant. The odds ratios can be calculated by exponentiating the parameter estimates. An odds ratio greater than one indicates a higher odds of using any method of contraception compared to the base category. Similarly, an odds ratio less than one indicates a lower odds of using any method of contraception compared to the base category. For example, the odds of using any method of contraception increases significantly by a factor of 1.69 ($e^{+0.523}$ =1.69) for a woman who belongs to Hindu religion compared to a woman who is Muslim.

Women's age is found to be significantly associated with the use of contraception. Women of ages 20-29 are more likely to use any method of contraception compared to the women of ages less than 20. Women aged above 29 are also more likely to use any method of contraception compared to the women aged less than 20. However, the relationship is significant at the 10 percent level but not at the 5 percent level. The women with 1-2 living sons are more likely to use any method of contraception compared to the women with no living sons. The women with more than 2 living sons are also more likely to use any method of contraception compared to the women with no living sons. The odds of using any method of contraception increase significantly by a factor of 2.76 ($e^{+1.014}$ = 2.76) for a woman with more than two living sons compared to a woman with no living sons. The results are consistent with the findings of Khan (1996). The odds of using any method of contraception are also higher for a woman with 1-2 living daughters compared to a woman with no living daughters. Consistent with other studies (Ullah and Chakraborty, 1993; Phillips et al., 1993, 1996), women's level of education is found to be one of the important determinants of the current use of any method of contraception. Women with above primary level of education are more likely to practice any method of contraception compared to those who do not have any education at all, which is consistent to other researches in the region and elsewhere (Kamal et al., 1999; Khan, 1996; Phillips et al., 1993, 1996; Tawiah, 1997; Ullah and Chakraborty, 1993). The odds of using any method of contraception increase significantly by a factor of 2.68 ($e^{+0.985}$ = 2.68) for the women with above primary education compared to the women who do not have any education. The desire for additional children also plays a significant role in the process of contraceptive choice and use. Women who do not want any more children are more likely to use any method of contraception. The odds of using any method of contraception are almost two and half times higher for women who do not want any more additional children compared to women who want additional children. The results are consistent with the findings from other studies conducted in the region (Khan, 1996; Phillips et al., 1993, 1996; Ullah and Chakraborty, 1993). Household dwelling unit area, which is used as an indicator of economic status in rural Bangladesh (Phillips et al., 1993; Koenig et al., 1997) is found not to be associated with contraceptive use and is excluded from the final model. Family planning workers' contact with the women is found to be positive and significantly associated with the use of any contraceptive method. The odds of using any method of family planning significantly increase by a factor of 1.62 ($e^{+0.480}$ =1.62) when a woman is contacted by the family planning outreach worker compared to a woman who is not contacted by the outreach worker. This relationship appears to be consistent with other studies conducted in Bangladesh (Hossain and Phillips, 1996; Islam and Mahmud, 1995; Kamal and Sloggett, 1996; Khan and Rahman, 1997; Phillips et al., 1993, 1996; Ullah and Chakraborty, 1993). It is likely that the family planning outreach workers' outreach activities provide opportunities to motivate women by providing them with proper counselling on various family planning methods and services and ensuring re-supplies.

Table 6.1: Parameter estimates of the use of current contraception using multilevel logistic regression among currently married women of reproductive age: four rural areas of Bangladesh, 1986

Variables[1]	Estimate	(Standard Error)
Constant	-3.914***	(0.225)
Background characteristics		
Number of living sons: (Base: 0)		
1-2	1.000***	(0.117)
3+	1.014***	(0.140)
Number of living daughters: (Base: 0)		
1-2	0.496***	(0.099)
3+	0.343**	(0.121)
Desire for any more child: (Base: Want more children)		
Don't want any more children	0.929***	(0.092)
Woman's age: (Base: < 20 years)		
20-29	0.486**	(0.166)
30+	0.359†	(0.184)
Woman's education: (Base: No education)		
Primary and below	0.400***	(0.079)
Above primary	0.985***	(0.127)
Religion: (Base: Muslim)		
Hindu and others	0.523***	(0.094)
Programmatic variables		
Family planning workers' contact: (Base: No contact)		
Yes	0.480***	(0.075)
Community level variables		
Mean women literacy: (Base: Literacy less than 21)		
Literacy 21-30	0.224*	(0.125)
Literacy 31+	0.341†	(0.147)
Random effect:		
Union level	0.207*	(0.093)
Family planning workers' work area level	0.061*	(0.026)

[1] To permit estimation, the coefficient for one category of each main effect is constrained to 0. This 'omitted category' is termed as 'Base' and is kept under parentheses.

† p<0.10, * p<0.05, ** p<0.01, *** p<0.001

6.2.1.2 Interpretation of random effects

The random effects at the *unit* and the *union* level are found to be statistically significant. Women in the same *unit* are more likely to behave similarly. This means that even after controlling for the social and demographic factors at the individual level, there still remains some unexplained variation at the *unit* level (workers' work area level) and also at the *union* level (outreach workers' supervisors' area level). This means that there are other unobserved factors operating at the *unit* level which affect contraceptive use. The possible explanation for the random effect is a measure of motivation and supply, and supervision of family planing services at the *unit* level and at the *union* level respectively.

Curtis et al. (1993) considered various values of a random parameter. However, in this analysis, to examine the extent to which variation among workers work areas affects the current use of any method of contraception, the probabilities of using a method are calculated for three levels of the *unit* (workers' work area) level random effect: one standard deviation below the mean ($-\sigma$), the mean (zero) and one standard deviation above the mean ($+\sigma$) respectively.Table 6.2 shows the estimated probabilities of current use of any method of contraception with the average characteristics by three categories of women's level of education and family planning outreach workers' contact by one standard deviation below the mean, the mean and one standard deviation above the mean *unit* effects. It can be seen from Table 6.2 that the inter cluster variation where the probabilities for women one standard deviation below and one standard deviation above the mean differ by about 0.06. The *unit* level random effect has a significant impact on the probability of current use of any method of contraception despite the effect of different level of education and family planning outreach workers' contact with women. The probability of current use of a method of contraception is 0.42 if a woman with above primary education receives a contact from the family planning outreach worker at the one standard deviation above the mean, whereas the probability of using a method of contraception is 0.34 if a woman with above primary education receives a contact from a family planning outreach worker at the one standard deviation below the mean. In case of above primary education, for a woman associated with an above average *unit* level random effect, the probability of using a method of contraception increased by at least 11 percent compared to those women associated with an average random effect when she receives a contact from the worker. In case of no education, for a woman associated with an above average *unit* level random effect, the probability of using a method of contraception increased by at least 14 percent compared to those women associated with an average random effect when she receives a contact from the worker.

The estimates of the *unit* level residuals can be used for assessing the effect of the areas, after controlling for the effect of the socio-demographic characteristics of the women. Figure 6.1 shows the estimated family planning outreach workers' work area (*unit*) effects for the use of any method of contraception with simultaneous 95 percent confidence intervals. These estimates for a *unit* with average current use of any method would lie on the line where the residuals are zero. *Units* with below average current use of any method of contraception would lie below the zero line and the *units* with above average current use of any method of contraception would lie above the zero line.

From Figure 6.1, it can be seen that some *units* had higher than average current use of contraceptives while some others had below the average current use of contraceptives within a thana. For example, *unit* number 33 in Abhoynagar *thana* has an above average rate of contraceptive use whereas *unit* number 35 in the same *thana* has below the average rates of contraceptive use.

Table 6.2: Estimated probabilities of the current use of contraception with the average characteristics by women's education and family planning workers' contact by below the mean, the mean and above the mean *unit* level effects[1]: four rural areas of Bangladesh, 1986

Variables	Below mean	Mean	Above mean
Education (No education)			
Family planning workers' contact:			
Contacted	0.163	0.184	0.210
Not contacted	0.137	0.157	0.180
Education (Primary and below)			
Family planning workers' contact:			
Contacted	0.223	0.252	0.284
Not contacted	0.192	0.218	0.247
Education (Above primary)			
Family planning workers' contact:			
Contacted	0.340	0.377	0.415
Not contacted	0.298	0.333	0.370

[1] Below the mean, the mean and above the mean refer to workers' work areas that are one standard deviation below the mean, the mean and one standard deviation above the mean respectively.

The simultaneous 95 percent confidence intervals for the *unit* level residuals are constructed in order to determine whether any pair of *units* are significantly different in terms of current use of any method of contraception. If for any pairs of *units*, the 95 percent confidence interval overlap, then there is no evidence of any difference in terms of current use of contraceptives between two *units* at the 5 percent level of significance. In Sirajgonj *thana*, *unit* number 3 and *unit* number 5 have significantly different levels of contraceptive use at 5 percent levels of significance. In Abhoynagar *thana*, *unit* number 35 and *unit* number 39 are significantly different in terms of current use of contraception at 5 percent of level of significance. Again, *unit* number 33 and *unit* number 35 in Abhoynagar *thana* are significantly different in terms of current use of contraception at 5 percent of level of significance. However, all other confidence intervals in

Bagherpara and Keshobpur *thana* overlap each other indicating that there is no significant evidence of any difference in current method use among all *units* at 5 percent levels of significance.

The variations observed between *units* may be due to the fact that the outreach workers assigned to these *units* are performing their tasks differently. Outreach workers' job knowledge and experience are not similar and hence job performance may be different. Also, each *unit* represents a community and hence a geographical area. There are significant variations across communities.

Education has an impact on contraceptive use both at the individual level and at the community level. The effect of the proportion of literate women in a community provides support for what Caldwell (1980) termed the influence of mass education on the decline in fertility. Caldwell hypothesises that mass education enhances the rate of cultural change as education leads children away from traditional beliefs. Educated parents are likely to educate their children and, because of the increased costs of rearing school children, they cannot afford to have large families. Thus, an educated society is more complying to innovative ideas such as contraception and small family size.

Individual- and the *unit*-level socio-economic and cultural factors are likely to affect not only the demand for contraception but also the supply of family planning methods. For example, in an area where women's mobility is confined or the religious conservatism is high, it may become difficult for a female outreach family planning worker to perform her regular duties and provide family panning services. In those areas, female outreach workers' mobility is also confined. For these reasons, many newly created positions of the female outreach workers in those areas were left vacant for a long period of time (Koenig and Simmons, 1992). In remote rural areas with poor transportation also makes outreach workers' regular household visitation infeasible.

Figure 6.1: Estimated family planning workers' work area effects for the use of any method with approximate simultaneous 95 percent confidence intervals: four rural areas of Bangladesh, 1986

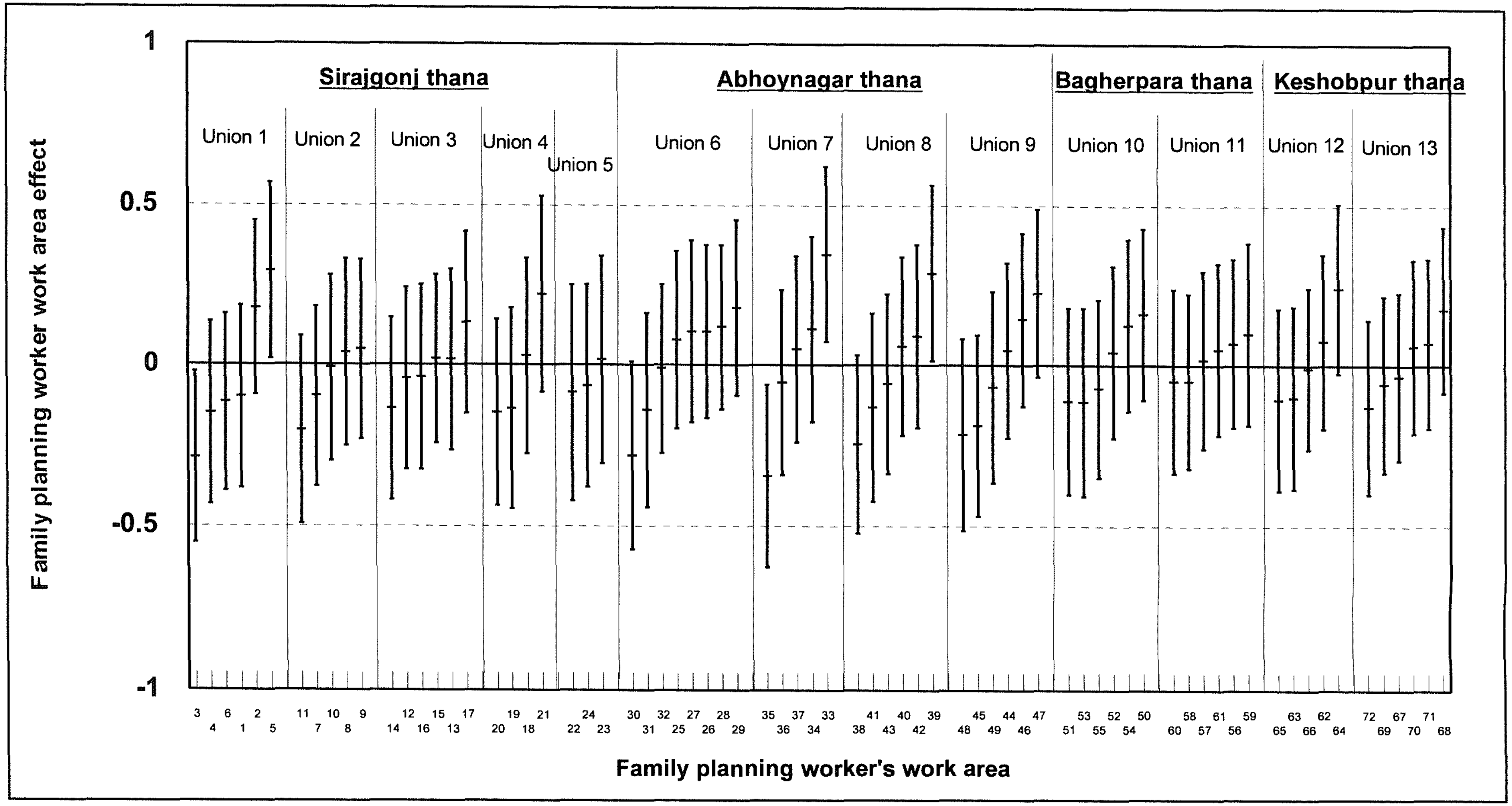
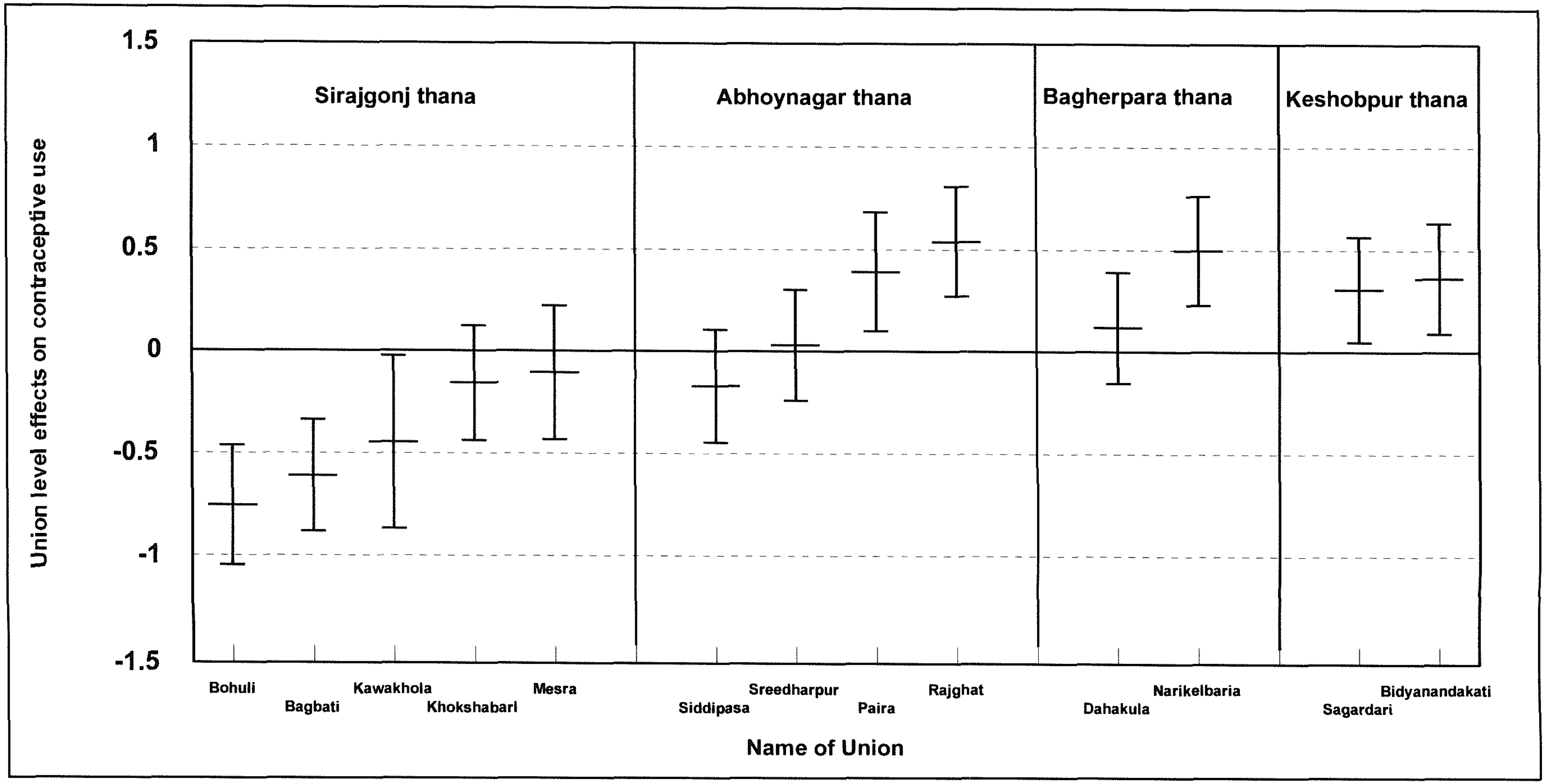


Figure 6.2: Estimated union level effects for the use of any method with approximate simultaneous 95 percent confidence intervals: four rural areas of Bangladesh, 1986



There is also evidence of a large amount of unexplained variation within *union* between *units*. Factors operating at this level may include those relating to the supervision of family planning outreach workers' work. One family planning supervisor, who is assigned to a *union*, supervises at least six family planning outreach workers' work. Some supervisors do not regularly go to visit their working areas and also do not regularly meet the outreach workers under him. Hence, there may be variations in terms of nature and the quality of supervision at the *union* level.

Figure 6.2 shows the estimated *union* level (family planning outreach workers' supervisors work area) effects for the use of any method of contraception with simultaneous 95 percent confidence intervals. From Figure 6.2, it can be seen that contraceptive use in Bohuli *union* and Mesra *union* in Sirajgonj *thana* are significantly different at a 5 percent level of significance. It also can be seen from Figure 6.2 that the contraceptive use in Bohuli *union* and Khokshabari *union* in Sirajgonj *thana* are significantly different at 5 percent level of significance. Similarly, Siddipasa *union* and Rajghat *union* in Abhoynagar *thana* have significantly different levels of contraceptive use at 5 percent level of significance. However, no significant difference of use of any method of contraception among *unions* in Bagherpara and Keshobpur *thanas* is observed.

The variations observed between *unions* in Abhoynagar *thana* and Sirajgonj *thana* may be mainly because of the lack of proper communication. Siddipasa *union* in Abhoynagar *thana* and Mesra *union* in Sirajgonj *thana* are inaccessible. In addition, supervisors assigned in each *union,* are responsible for supervising family planning outreach workers' work in Mesra and Siddipasa *unions* might have been having difficulty in performing their task because of lack of proper communication. If there is a lack of sufficient supervision, the outreach worker might have been neglecting the remote areas and might not be providing family planning services to the women residing in these areas.

6.3 Post partum contraceptive adoption analysis

The women who were included in the current contraceptive use analysis (Section 6.2) all were initially included in the adoption analysis. However, if a woman had not become pregnant before the 1986 survey and the end of the surveillance (end of 1992) she is excluded from the adoption analysis. Again, if a woman or her husband was sterilized, then she is also excluded from the adoption analysis. The remaining women were then followed to see their status of post partum adoption of reversible contraceptive methods. If a woman was pregnant during the 1986 survey or became pregnant after the 1986 survey she is followed until the conception is terminated. When a conception is terminated, the time for adoption of a method starts after excluding a period of nine months for post partum. In Bangladesh, the median duration of post partum amenorrhoea is about 8.4 months (Mitra et al., 1997). The waiting time ends when a reversible method is adopted or at the end of surveillance whichever occurs first. A woman can be in one of two mutually exclusive and exhaustive states at any time after postpartum non-use: (0) she may be a non-user or (1) she may have adopted any reversible method of contraception. Then, for example, if a woman adopts any reversible method of contraception in the seventh round, seven observations are created, one for each round and the response variable for each round assumes the values: 0,0,0,0,0,0, and 1. Here '0' stands for non-use and '1' stands for any method adoption. On the other hand, if a woman is still a non-user at the end of the observation period, there will be a number of observations depending on the length of the duration (number of rounds) that the woman was a non-user and the response variable for each round is assigned the values: 0,0,0,....,0. Only one episode of adoption is used in the analysis. A total of 2,455 currently married women of reproductive age were included in the adoption analysis which then resulted in 10,927 rounds of observations for the analysis. Very few women or their husbands had adopted sterilization during 1986-92 period and these women were excluded from the analysis of adoption. A survey of the same women on the issues of quality of family planning services was conducted in 1989. A latent class analysis (discussed in Chapter 5) is performed for generating quality of care scores from five questions (Appendix A1) of perceived quality of family planning services. These scores were then appended to the data set and used as a control for the adoption analysis. From longitudinal data prior contraceptive use status is computed and incorporated to the data set and used as a control.

A discrete-time hazard model (discussed in Chapter 4), which is essentially a multilevel random intercept logistic model and can be written as

$$\log_e\left(\frac{\lambda_{1tijk}}{\lambda_{0tijk}}\right) = \alpha_{1t} + \beta_1'\mathrm{x}_{tijk} + u_{1jk} + v_{1k}\,. \qquad (6.2)$$

Here λ_{1tijk} is the hazard of a transition from non-user to any reversible method of contraception at time t for the waiting time i of women j in *unit* k. The base category is the hazard of remaining a non-user and is denoted by λ_{0tijk}. Here the vector of covariates x_{tijk} also includes time varying covariates and β is a vector of parameters associated with x_{tijk}. A function of time α_{1t} representing the baseline hazard is also included in the model. The terms u_{1jk} and v_{1k} are the random parameters for the woman level and *unit* level effects respectively. The random parameters u_{1jk} and v_{1k} are assumed to be mutually independent and normally distributed with mean zero and variances σ^2_{1jk} and σ^2_{1k} respectively at the woman and the *unit* level. The multilevel discrete-time hazards model is fitted as a multilevel logistic model. Because one observation for each round of waiting time is created to fit the discrete-time hazards model, the sample size used in the analysis is 10,927. The model (6.2) is estimated using MLwiN statistical software (Goldstein et al., 1998). The estimates presented in this chapter are obtained by using second order PQL approximations.

6.3.1 Results of the multilevel discrete-time adoption analysis

6.3.1.1 Interpretation of the fixed effects

Table 6.3 presents the parameter estimates and standard errors from the multilevel discrete-time hazard models for post partum adoption of contraceptive reversible method during the 1986-92 period. In the discrete-time model, the conditional odds are modelled, that is, the probability of adopting a method in a particular period, given that no method has previously been adopted, is modelled. The basic model assumes that for any woman in the population the odds of having the event at each discrete-time are proportional to the odds of having the event for some specific woman who represents the set of baseline states of covariates.

The odds of post partum contraceptive adoption increase with number of living sons. The odds of adopting a reversible method of contraception increase significantly by a factor of 1.75 ($e^{+0.56} = 1.75$) for a woman who has more than two living sons compared to a woman who has no living sons. An insignificant and weak relationship between number of living daughters and contraceptive adoption is observed. The impact of the number of living sons on contraceptive adoption is as expected: the probability of adoption increases with number of living sons. A weak relationship between number of living daughters and the adoption of contraception may be because of the influence of gender preference. The preference may arise from her family or from her in-laws family. However, the effect of sex composition on the adoption of contraception was initially tested and found no significant difference when controlled for the effect of other soci-demographic characteristics of the women.

Table 6.3: Parameter estimates and standard errors from multilevel discrete-time hazard models for post partum contraceptive adoption among currently married women of reproductive change: four rural areas of Bangladesh, 1986-1992

Variables	Estimate	(Standard Error)
Constant	-5.218***	(0.230)
Background characteristics		
Number of living sons: (Base: 0)		
1-2	0.525***	(0.124)
3+	0.560***	(0.143)
Number of living daughters: (Base: 0)		
1-2	0.160	(0.105)
3+	0.050	(0.122)
Desire for any more child: (Base: Want more children)		
Don't want any more children	0.299***	(0.089)
Women's age: (Base: 35+ years)		
< 25	0.747***	(0.129)
25-34	0.531***	(0.106)
Women's education: (Base: No education)		
Primary and below	0.221**	(0.081)
Above primary	0.314*	(0.139)
Religion: (Base: Muslim)		
Hindu and others	0.383**	(0.125)
Quality of care: (Base: Low quality of care)		
Medium quality of services	0.263*	(0.106)
High quality of services	0.554***	(0.085)
Prior method use: (Base: No)		
Yes	0.919***	(0.090)
Programmatic variables		
Family planning workers' contact: (Base: No)		
Yes	1.160***	(0.082)
Time: (Base: 3 years)		
One year	1.032***	(0.113)
Two years	0.045	(0.132)
More than three years	0.211	(0.144)
Random effect:		
Family Planning workers' work area level	0.099**	(0.031)
Individual women level	0.966***	(0.013)

[1] To permit estimation, the coefficient for one category of each main effect is constrained to 0. This 'omitted category' is termed as 'Base' and is kept under parentheses.

† p<0.10, * p<0.05, ** p<0.01, *** p<0.001

As expected, the women who do not want any more children are more likely to adopt a reversible method of contraception compared to the women who want more children. The odds of adopting a reversible method of contraception increase significantly, by a factor of 1.35 ($e^{+0.299} = 1.35$), for a woman who does not want any more children compared to a woman who wants more children. The women who decided to limit their family size are likely to adopt a reversible method of contraception. This shows the success of the national family planning programme in meeting demand for contraception.

As educated women are more likely to adopt any reversible method of contraception. The odds of adopting any reversible method of contraception increase significantly, by a factor of 1.25 ($e^{+0.221} = 1.25$), for a woman with primary or below level of education compared to a woman with no education. The odds of adopting any reversible method of contraception also increase significantly, by a factor of 1.37 ($e^{+0.314} = 1.37$), for a woman with more than above primary education compared to a woman with no education. The effect of maternal education on the adoption of contraception is well established. The educated mother may have some autonomy and decision making power in the family which resulted in making decision about smaller family size.

The odds of adopting a reversible method of contraception increase significantly, by a factor of 1.47 ($e^{+0.383} = 1.47$), for a woman who is either Hindu or belong to 'other religion' compared to a woman who is Muslim.

Quality of services is very important in many settings. Better quality leads to better users' satisfaction. However, perceived quality may not depend on only one single element of the quality. In this research, the perceived qualities of family planning service scores were generated from five different indicators of quality using a latent class analysis (the latent class analysis is discussed in Chapter 5). The latent class qualities of family planning service scores (probabilities) are categorised into three categories: poor quality (0-0.25), medium quality (0.25-0.75) and high quality (0.76+). The odds of adopting a method of reversible contraception increase significantly, by a factor of 1.30 ($e^{+0.263}$ =1.30), for a woman who perceives the provided family planning services as medium (0.25-0.75) quality compared to a woman who perceives the provided family planning services as poor (0-0.25) quality. The odds of adopting a method of reversible contraception increase significantly, by a factor of 1.74 ($e^{+0.554}$ = 1.74), for a woman who perceives the provided family planning services as high (0.76+) quality compared to a woman who perceives the provided family planning services as poor (0-0.25) quality. The odds of adopting a method of reversible contraception increase, by factor of 1.34 ($e^{+0.554 - 0.362}$ =1.34), if high quality family planning services are provided compared to medium quality. These findings thus suggest that the higher quality of family planning services enhances women's satisfaction and confidence and thus increases her chance of adopting a method of contraception.

The odds of adopting a reversible method of contraception increase by a factor of 2.51 ($e^{+0.919}$ =2.51), if a woman who is a prior user of any method of contraception compared to a woman who have never used any method of contraception. If a woman is contacted by a family planning outreach worker in last 90 days, the odds of adopting a reversible method of contraception increase significantly, by a factor of 3.19 ($e^{+1.160}$ = 3.19), compared to a woman who does not receive a contact from a family planning outreach worker. The family planning outreach worker's job is to motivate women for family planning and to supply appropriate available method while visiting all women in her working area once in 60 days. These outreach workers are the main link between national family planning programme and the rural women in Bangladesh.

6.3.1.2 Interpretation of the random effects

The random effect at the *unit* level is found to be statistically significant. The random effect at the *union* level is found not to be significant and removed from the final model. Those who are in the same outreach worker's work area (*unit*) are more likely to behave similarly. This means that even after controlling for the social and demographic factors at the individual level, some unexplained variation remains at the worker's work area *unit* level. This means that there are other unobserved factors operating at the worker work area level which affects contraceptive adoption. The possible explanation for the significant random effect is due to the variation of family planing services at the *unit* level.

To examine the extent to which variation among outreach workers work areas affects the adoption of any reversible method of contraception, the probabilities of adopting a method of reversible contraception in 12 months are calculated for three levels of the *unit* level random effect. Table 6.4 shows the estimated probabilities of adopting any reversible method of contraception by women's level of education and family planning outreach workers' contact according to one standard deviation below the mean ($-\sigma$), the mean (0) and one standard deviation above the mean ($+\sigma$) *unit* random effects. It can be seen from Table 6.4 that the probabilities for women one standard deviation below and one standard deviation above the mean differ by about 0.03. The *unit* level random effect has a significant impact on the probability of adopting a reversible method of contraception despite the effect of different level of education and outreach worker contact with women in each 90-days interval. The probability of adopting a reversible method of contraception is 0.11 if a woman with above primary education receives a contact from the worker at the one standard deviation above the mean, whereas the probability of adopting a reversible method of contraception is 0.08 if a woman with above primary education receives a contact from the worker at the one standard deviation below the mean. In case of above primary education, for a woman associated with an above average *unit* level random effect, the probability of adopting a method of contraception increased by at least 17 percent compared to those women associated with an average random effect when she receives a contact from the worker. In case of no education, for a woman associated with an above average *unit* level random effect, the probability of using a method of contraception increased by at least 17 percent compared to those women associated with an average random effect when she receives a contact from the worker.

Table 6.4: Estimated probabilities of adopting a reversible method of contraception in 12 months with the average characteristics by women's education and family planning outreach workers contact by below the mean, the mean and above the mean *unit* effect[1]: four rural areas of Bangladesh, 1986-92

Variables	Below mean	Mean	Above mean
Education (No education)			
Family planning workers contact in 90 days:			
Contacted	0.059	0.069	0.081
Not contacted	0.032	0.038	0.045
Education (Primary and below)			
Family planning workers contact in 90 days:			
Contacted	0.072	0.085	0.099
Not contacted	0.040	0.047	0.056
Education (Above primary)			
Family planning workers contact in 90 days:			
Contacted	0.079	0.092	0.108
Not contacted	0.044	0.052	0.061

[1] Below the mean, the mean and above the mean refer to workers' work areas that are one standard deviation below the mean, the mean and one standard deviation above the mean respectively.

The estimates of the *unit* level residuals can be used for predicting the effect of the community, after controlling for the effect of the socio-demographic characteristics of the women. Figure 6.3 shows the estimated *unit* area effects for the adoption of any reversible method of contraception with simultaneous 95 percent confidence intervals. These estimates for a *unit* with average adoption of any reversible method would lie on the line where the residuals are zero. *Units* with below average of adoption of any method would lie below the zero line and the *units* with above average of adoption of any contraceptive method would lie above the zero line.

Figure 6.3: Estimated family planning workers' work area effects for the post partum adoption of any method with approximate simultaneous 95 percent confidence intervals: four rural areas of Bangladesh, 1986-92

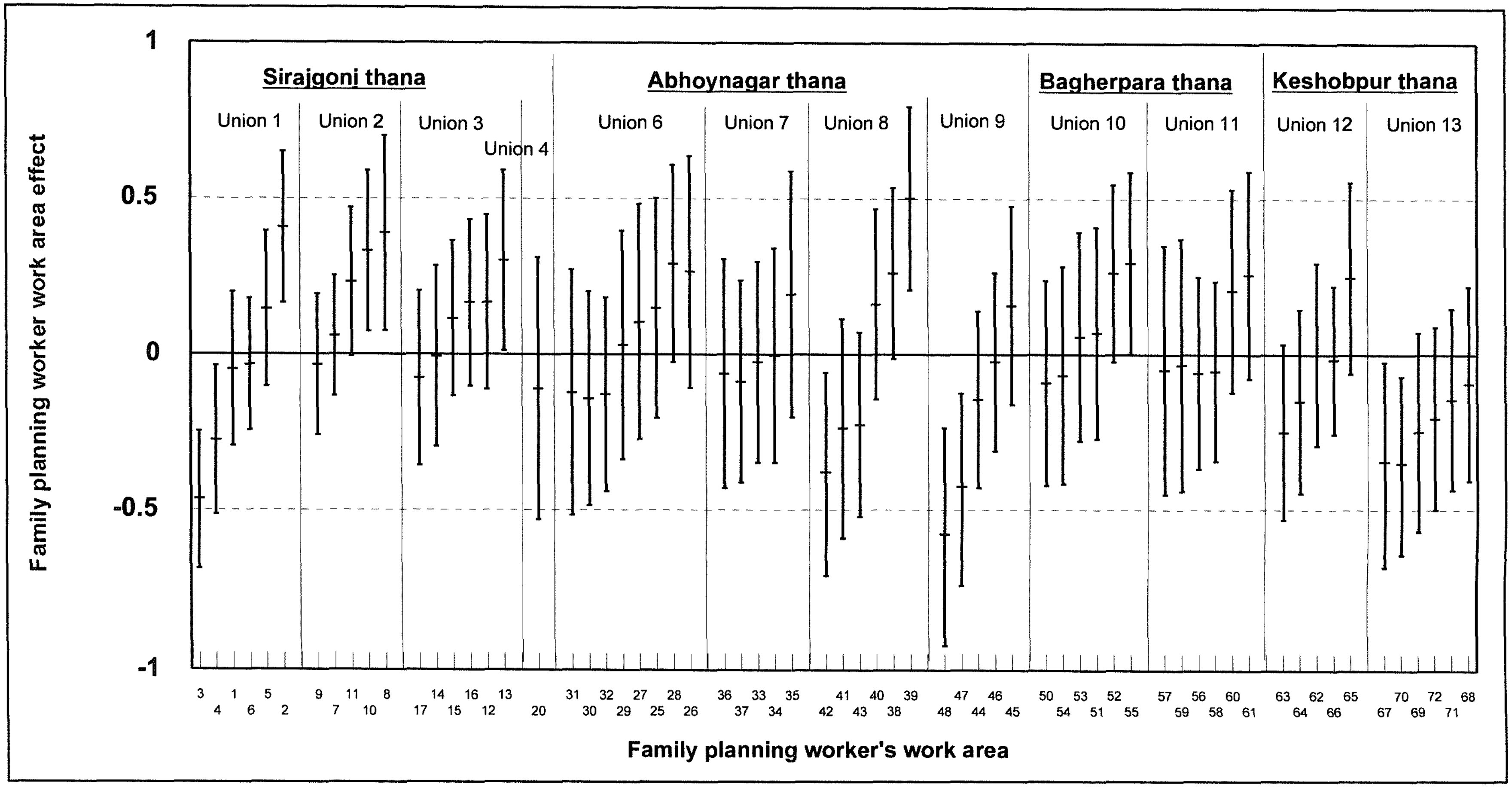


Figure 6.3 shows that *unit* number 3 and *unit* number 5 in Sirajgonj *thana* have significantly different levels of reversible method adoption at 5 percent levels of significance. Similar relationships between *units* 3 and 5 in Sirajgonj *thana* can be observed in the contraceptive use analysis (Figure 6.1). Similar relationships can also be seen between *units* 3 and 2 in Sirajgonj *thana* for the adoption analysis (Figure 6.3). In Abhoynagar *thana*, *unit* number 42 and *unit* number 39 are significantly different in terms of level of adoption of a reversible method at 5 percent of level of significance. *Unit* number 48 and *unit* number 45 in Abhoynagar *thana* are also significantly different in terms of level of adoption of a reversible method of contraception at 5 percent levels of significance. However, it can be seen that all the confidence intervals in Bagherpara *thana* and Keshobpur *thana* overlap each other suggesting that there is no evidence of any difference in adopting any reversible method of contraception among all *units* in Bagherpara and Keshobpur *thana* at 5 percent levels of significance.

The variations observed between *units* in Abhoynagar *thana* and Sirajgonj *thana* may be mainly because of the difference in job performance by the family planning outreach worker. The family planning outreach workers are assigned to each *unit* and are responsible for providing family planning services to the women in that *unit*. The level of female education in an area can also affect the implementation of family planning programme. Family planning outreach workers are recruited from the same locality and are required to possess a minimum of 10 years of school education. There are variations in terms of level of education of women between Sirajgonj and Abhoynagar *thanas*. There are also differences with regard to culture between these two *thanas*. Abhoynagar *thana* is believed to be culturally more advanced than Sirajgonj *thana*.

6.4 Post partum contraceptive choice analysis

The women who were in the contraceptive adoption analysis are used for the choice analysis. The structure of the data is very similar for adoption and choice analysis except the outcome variable. In the adoption analysis the outcome variable was binary: adopted any method or not adopted. In the choice analysis, the outcome variable is divided into six possible categories. A woman can be in one of six exclusive and exhaustive status at any time after her post partum non use: (0) she may have been remained as a non-user until the end of the period, or she may have adopted (1) pill, or (2) condom, or (3) IUD, or (4) injectables, or (5) any traditional method of family planning. Thus, for example, if a woman adopts condoms in the seventh round, seven observations are created one for each rounds and the response variable for each round assumed the values: 0, 0, 0, 0, 0, 0, and 2. Here '0' stands for non-use and '2' stands for condom adoption. On the other hand, if a woman is still a non-user at the end of the observation period, the response variable for each round assumed the values: 0, 0, 0, 0, ..., 0. As very few women were found pregnant for the second time during the study period, only one episode of post partum adoption per woman is used in the analysis.

A three level discrete-time competing risk model can be specified as the following multilevel multinomial logistic model:

$$\log_e\left(\frac{\lambda_{rtijk}}{\lambda_{0tijk}}\right) = \alpha_{rt} + \beta_r' \mathrm{x}_{tijk} + u_{rjk} + v_{rk} , \qquad r = 1, 2, 3, 4, \text{ or } 5 . \qquad (6.3)$$

This is a multilevel extension of the discrete-time competing risk hazard model, where λ_{rtijk} is the hazard of a transition from non-user to a specific method of type *r* at time *t* for the waiting interval *i* of woman *j* in *unit k*. The base category is the hazard of remaining a non-user and is denoted by $\lambda_{0tijk.}$ The vector of covariates x_{tijk} is the same for each of the six contrasts of type of method use against non-use and β_r is the vector of parameters for the contrast *r* associated with x_{tijk}. Here, the vector x_{tijk} also includes time varying variables. A function of time α_{rt} representing the baseline hazard is also included in the model. In the multinomial model, a set of random effects for each transition type *r* is included:

u_{rjk} are the woman level effects, v_{rk} are the *unit* level effects. As usual, these are assumed to be mutually independent and follow normal distributions: $u_{rjk} \sim N(0, \Omega_{ur})$ and $v_{rk} \sim N(0, \Omega_{vr})$. The multilevel discrete-time hazard model is fitted as a multilevel multinomial logistic model. Because one observation for each round of waiting time is created to fit the discrete-time competing risk hazards model, the sample size used in this analysis is 10,927.

The multilevel discrete-time competing risk model (6.3) is estimated using the MLwiN statistical software (Goldstein et al., 1998). The regression estimates are obtained by using second order PQL approximation.

6.4.1 Results of the multilevel discrete-time competing risk model analysis

6.4.1.1 Interpretation of the fixed effects

Table 6.5 presents the parameter estimates and standard errors from the multilevel discrete-time competing risk hazard models for post partum contraceptive choice during the 1986-92 period. The results show that the number of living sons, education, prior contraceptive use status, quality of family planning services, and family planning workers' contact with the rural women are associated with method choice. Number of living daughters is found not to be associated with method choice. For ease of interpretation predicted probabilities for adopting a particular reversible method after three year time periods are calculated (Table 6.6). These probabilities are calculated by transforming the estimated equations and then setting all other variables other than that of interest at their means.

Table 6.5: Parameter estimates and standard errors from multilevel discrete time competing risk model of contraceptive method choice among currently married women of reproductive change: four rural areas of Bangladesh, 1986-1992

Variables	Condom/ non-use	Oral pill/ non-use	Injectables/ non-use	IUD/ non-use	Traditional/ non-use
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Constant	-7.538***	-6.145***	-7.180***	-7.134***	-6.464***
	(0.743)	(0.370)	(0.493)	(0.830)	(0.597)
Number of living sons: 0 (Base:0)					
1-2	0.419	0.491*	0.758**	-0.135	0.692†
	(0.372)	(0.197)	(0.284)	(0.370)	(0.397)
3+	-0.509	0.500*	0.887**	-0.318	1.080*
	(0.470	(0.232)	(0.321)	(0.475)	(0.425)
Number of living daughters: (Base:0)					
1-2	-0.055	0.226	0.336	-0.369	-0.032
	(0.322)	(0.174)	(0.221)	(0.332)	(0.278)
3+	-0.202	0.124	-0.015	-0.765†	0.165
	(0.379)	(0.202)	(0.259)	(0.433)	(0.310)
Desire more child: (Base: Want more)					
Don't want more children	0.186	0.260†	0.241	0.729*	0.514*
	(0.282)	(0.144)	(0.181)	(0.333)	(0.219)
Woman's age: (Base 35+)					
< 25	0.593	0.944***	0.507*	2.049***	0.289
	(0.433)	(0.216)	(0.251)	(0.619)	(0.320)
25-34	0.463	0.696***	0.251	1.226*	0.472*
	(0.377)	(0.180)	(0.204)	(0.572)	(0.237)
Women's education: (Base: No education)					
Primary and below	0.252	0.387**	-0.093	0.159	0.303
	(0.256)	(0.129)	(0.171)	(0.295)	(0.209)
Above primary	0.872*	0.388†	-0.414	-0.475	0.961**
	(0.352)	(0.224)	(0.335)	(0.580)	(0.318)
Religion: (Base: Muslim)					
Hindu and others	0.002	0.407*	0.050	1.029**	0.254
	(0.377)	(0.194)	(0.283)	(0.345)	(0.336)
Quality of care: (Base: Low quality of care)					
Medium quality of care	0.487	0.232	0.414†	-0.289	0.246
	(0.332)	(0.172)	(0.225)	(0.429)	(0.261)
High quality of care	0.594*	0.486***	0.961***	0.389	0.441*
	(0.268)	(0.137)	(0.178)	(0.285)	(0.201)
Prior modern method use: (Base: No)					
Yes	1.344***	1.202***	0.642***	1.231***	0.769***
	(0.252)	(0.140)	(0.192)	(0.308)	(0.222)
Family planning workers' contact:(Base: No)					
Yes	1.654***	1.258***	1.882***	0.799**	0.049
	(0.317)	(0.127)	(0.200)	(0.276)	(0.172)
Time: (Base: Three years)					
One year	1.168**	0.798***	0.880***	0.606	0.926**
	(0.384)	(0.175)	(0.227)	(0.379)	(0.286)
Two year	-0.612	0.036	0.123	-0.253	0.108
	(0.522)	(0.200)	(0.256)	(0.456)	(0.331)
More than three years	-0.147	0.319	0.389	-0.580	0.394
	(0.545)	(0.219)	(0.278)	(0.607)	(0.347)
Random effect:					
Worker level random variance	0.379†	0.173*	0.391**	0.128	0.060
	(0.201)	(0.068)	(0.133)	(0.191)	(0.087)
Women level random variance	0.751	0.673***	0.857***	1.348*	0.843*
	(0.468)	(0.146)	(0.207)	(0.645)	(0.328)

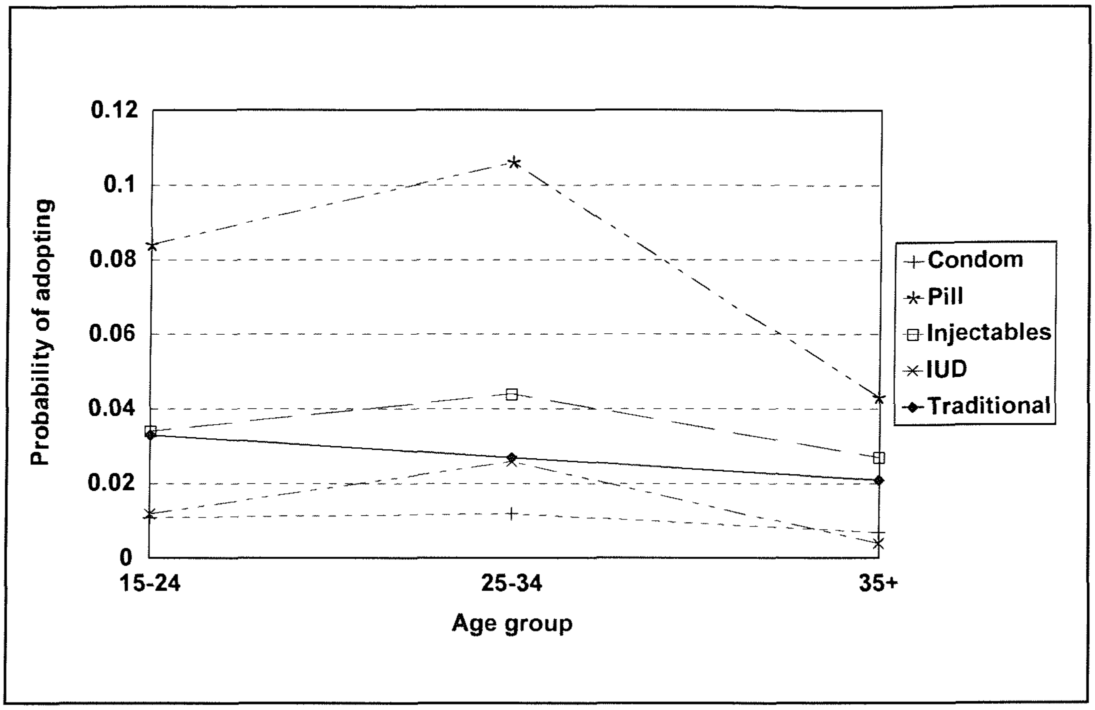
† p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 6.6: Estimated probabilities from multilevel discrete time competing risk logistic regression model of contraceptive choice in post partum period among currently married women of reproductive age: four rural areas of Bangladesh, 1986-1992

Variables	Predicted probabilities[1] at the end of three year period					
	Condom	Oral pill	Injectable	IUD	Traditi-onal	Non-adopters
Number of living sons:						
0	0.010	0.051	0.017	0.014	0.013	0.894
1-2	0.015	0.081	0.036	0.012	0.026	0.829
3+	0.006	0.082	0.041	0.010	0.038	0.822
Number of living daughters:						
0	0.011	0.065	0.029	0.019	0.026	0.849
1-2	0.011	0.081	0.041	0.013	0.025	0.829
3+	0.009	0.074	0.029	0.009	0.031	0.848
Desire for any additional child:						
Want more children	0.012	0.088	0.046	0.008	0.032	0.814
Don't want any more children	0.011	0.146	0.095	0.013	0.098	0.638
Woman's age:						
< 25	0.012	0.104	0.043	0.027	0.027	0.787
25-34	0.011	0.083	0.033	0.012	0.032	0.828
35+	0.007	0.042	0.027	0.004	0.021	0.900
Women's education:						
No education	0.009	0.069	0.036	0.012	0.025	0.849
Primary and below	0.012	0.101	0.032	0.013	0.033	0.809
Above primary	0.022	0.100	0.023	0.007	0.063	0.785
Religion:						
Muslim	0.010	0.074	0.034	0.011	0.027	0.843
Hindu and others	0.010	0.109	0.035	0.030	0.034	0.782
Quality of care:						
Low quality of care	0.008	0.064	0.024	0.011	0.023	0.869
Medium quality of care	0.013	0.080	0.036	0.008	0.029	0.833
High quality of care	0.014	0.101	0.062	0.016	0.035	0.773
Prior modern method use:						
No	0.009	0.068	0.033	0.010	0.025	0.855
Yes	0.032	0.207	0.057	0.033	0.050	0.622
Worker's contact in last 90 days:						
No	0.004	0.040	0.013	0.008	0.027	0.908
Yes	0.021	0.131	0.079	0.016	0.027	0.725

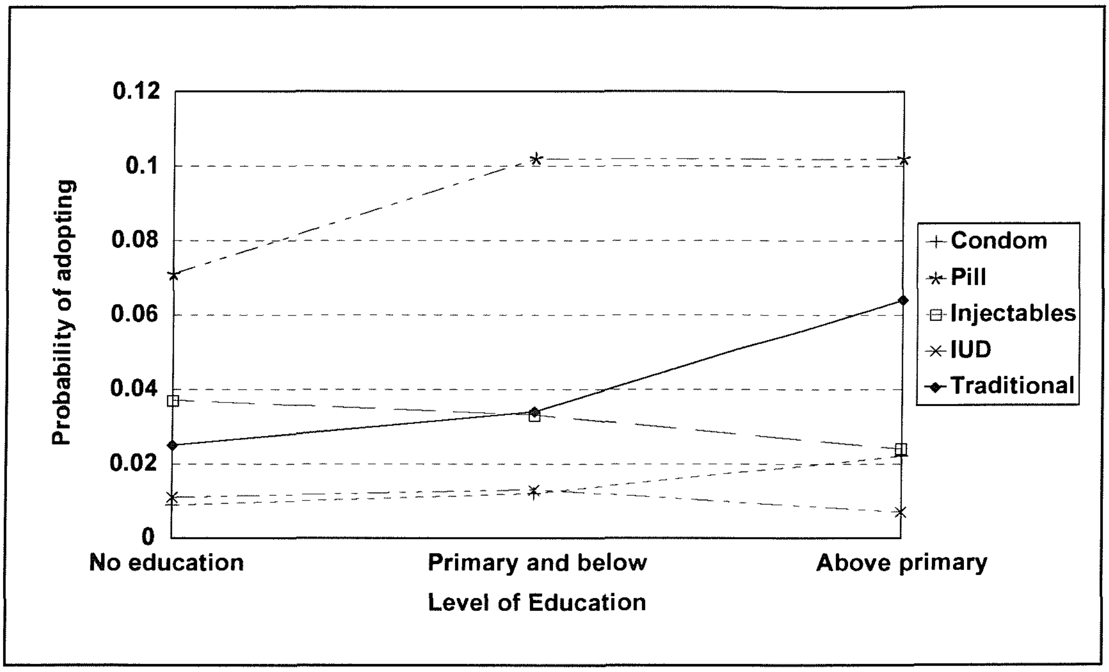
[1] Probabilities are estimated by keeping other cavariates fixed at the sample averages and the random effects are fixed at their average

Figure 6.4: Probabilities of adopting any reversible method by age: four rural areas of Bangladesh



The choice of any particular reversible method varies significantly by age as shown in Figure 6.4. In three age specific post partum periods, the probability of adopting injectables is higher for women aged 25-34 compared to the women aged 15-24 and over 34. The probability of adopting an IUD in the three age specific post partum periods is also higher for women aged 25-34 compared to the women aged 15-24 and over 34. The probability of adopting the pill in the three age specific post partum periods is 0.08 for women aged 15-24. This probability is higher for women aged 25-34 and declines sharply for women aged over 34. Pills, injectables and IUD's are the most popular methods among women aged 25-34. Pills are also popular among young women. The probability of adopting condoms or traditional methods in the post partum three year period does not vary much across age groups. The high probability of choosing injectables and pills by women aged 25-34 may be due to the fact that they adopt contraception for spacing not for limiting. Younger women were also more likely to use injectables. This may be associated with the fact that these women may be newly married and have difficulty in taking pills every day or using a condom in every episode of intercourse. This may be due, for example, to the fact that it is very difficult for rural women to hide oral pills from in-laws. The influence of service providers on method choice may have played an important role in adopting an appropriate method during the post partum period.

Figure 6.5: Probabilities of adopting any reversible method by education: four rural areas of Bangladesh

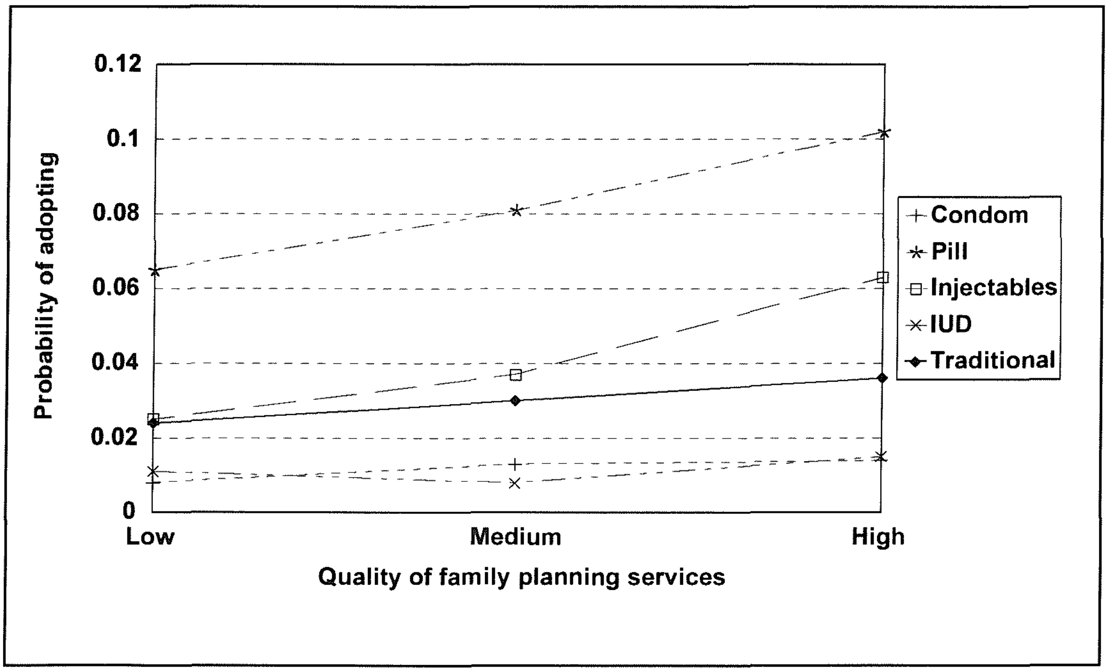


From Figure 6.5, it is observed that the probability of choosing any specific reversible method of contraception varies across different levels of education. The probability of choosing the pill increases with education level. The probability of choosing pills is higher for women with some education compared to no education (Figure 6.5). This finding is consistent with the findings observed elsewhere (Khan and Rahman, 1997; Phillips et al., 1989b and Tuoane, 1999).

The positive association between education and adoption of pills may indicate higher level communication exists between husband and wife. Furthermore, it may not be that easy for an illiterate rural woman to take pills every day.

The probability of choosing injectables, however, decreases with the increase in education (see also Khan and Rahman, 1997; Phillips et al., 1989b and Tuoane, 1999). This may be due to the fact that educated women may be more worried about the possible side effects related to injectables. The injectables DMPA (Depot-medroxy-progesterone acetate), which are available in Bangladesh, prevents a woman from conception at least for three months. A less educated woman may rely on a method which is very effective and long acting. They do not need to worry about taking the method every day, at least for three months once a DMPA injection is taken. However, Bangladeshi rural women, many of whom are illiterate, may not be aware about the possible side effects of DMPA.

Figure 6.6: Probabilities of adopting any reversible method by perceived quality of family planning services: four rural areas of Bangladesh



Similarly, the probability of adopting a traditional method is higher for women with higher levels of education. This may be due to the fact that the educated women, who are very much aware of side effects related to modern methods, will discontinue the method if they experience any side effect and switch to side effect free methods. Traditional methods are believed to be free of side effects.

The probability of adopting pills and injectables increase with the perceived quality of family planning services (Figure 6.6). The family planning outreach workers are responsible for providing mainly pills, condoms, and injectables to the rural Bangladeshi women. The probability of adopting pills is higher for women who perceive the provided family planning services are of a high quality compared to the women who perceive the service is of low quality. Similarly, the probability of adopting injectables is higher for the women who perceive the provided family planning services are of high quality compared to those women who perceive the service is of low quality.

Family planning outreach workers are not responsible for providing intrauterine devices (IUDs) to the rural Bangladeshi women. They are responsible only to motivate or recruit the prospective IUD acceptors. Quality of family planning services appears not to be associated with the probability of IUD adoption. IUD-380A, which is very effective and protects women from any unwanted conception for almost eight years, is available in Bangladesh. The IUDs are inserted by the female paramedics not by outreach workers. Once a woman has an IUD inserted, it is likely that the family planning outreach worker will make a couple of follow-up visits. The family planning outreach worker, who is not a paramedic, can only provide counselling and refer a woman having complications due to an IUD to the female paramedics. If a woman is happy with the IUD with very few or no complications, the family planning outreach worker may not visit IUD clients regularly. Hence, quality of family planning services appears not to be associated with the adoption of IUDs.

If a woman is a prior family planning method user, it is likely that she adopts a method sooner than later following the post partum period. The results show a positive significant relationship between prior use and choice of method (Table 6.6). The probability of choosing the pill is higher compared to other methods if a woman used any method in the past. Hindus experience significantly higher probabilities of use of pills and IUDs than Muslims (Table 6.6).

The probabilities of adopting pills and injectables are positively associated with family planning outreach workers' contact (Table 6.6). The probability of adopting pills is higher for women who receive contact from the outreach worker. The probability of adopting injectables is also higher for women who receive contact from the outreach worker. For adopting a family planning method, most rural Bangladeshi women depend on the family planning outreach workers' supply. Outreach workers' contacts enhance and widen women's knowledge on family planning methods and ensure resupply of contraceptives. Outreach workers are also responsible for distributing condoms. However, condoms are not as popular as pills in rural Bangladesh. In addition, condoms are also available in dispensaries and in many kiosks.

6.4.1.2 Interpretation of the random effects

To examine the extent to which the variation across women affects the choice of methods, probability of choice of condoms, pills, injectables, IUDs, and traditional methods are calculated separately by family planning outreach workers' contact for three values of the woman-level random effect: one standard deviation below the mean, the mean, and one standard deviation above the mean (Table 6.7). Other variables are held at their mean values.

When a woman receives a contact from a family planning outreach worker, the probability of adopting pills is much higher than adopting injectables. When a woman is contacted by the outreach worker and is associated with an above average random effect, her chance of choosing pills increased by at least 39 percent compared to those women associated with an average random effect. Again, when a woman is contacted and is associated with an above average random effect, her chance of choosing injectables increased by at least 49 percent, in relation to a woman associated with an average random effect.

Table 6.7: Estimated probabilities at the end of a three year period of choosing condoms, pills, injectables, IUDs or traditional methods of contraception with the average characteristics by family planning workers contact by below the mean, the mean and above the mean of women-level random effect[1]: four rural areas of Bangladesh, 1986-92

Variables	Below mean	Mean	Above mean
Condom			
Worker's contact			
No	0.002	0.004	0.008
Yes	0.011	0.021	0.040
Pill			
Worker's contact			
No	0.028	0.040	0.057
Yes	0.093	0.131	0.182
Injectables			
Worker's contact			
No	0.008	0.013	0.020
Yes	0.052	0.079	0.118
IUD			
Worker's contact			
No	0.004	0.008	0.017
Yes	0.008	0.016	0.035
Traditional methods			
Worker's contact			
No	0.016	0.027	0.047
Yes	0.016	0.027	0.045

[1] Below the mean, the mean and above the mean refer to woman-level random effects that are one standard deviation below the mean, the mean and one standard deviation above the mean respectively.

Figure 6.7: Estimated family planning workers work area effects for the choice of condom with approximate simultaneous 95 percent confidence intervals: four rural areas of Bangladesh, 1986-92

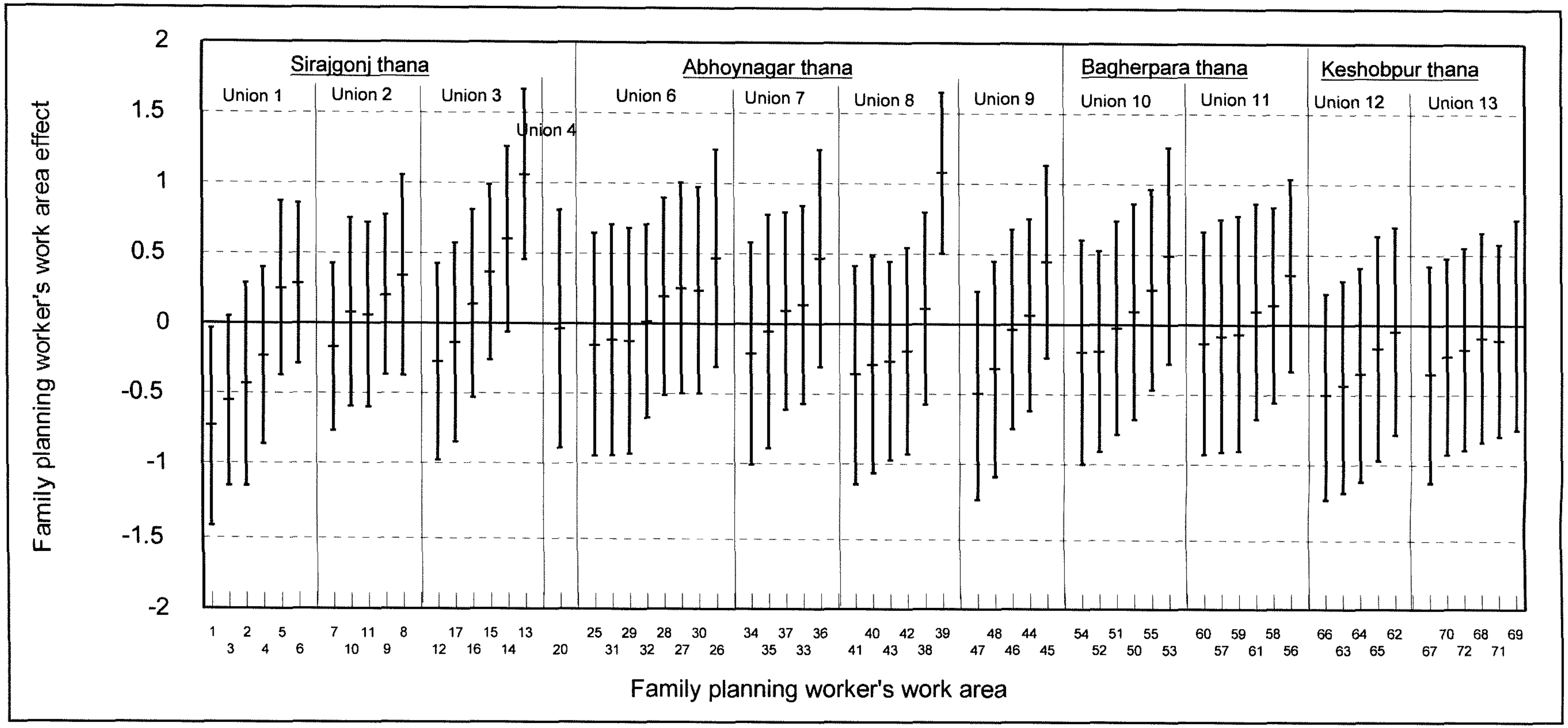


Figure 6.8: Estimated family planning workers work area effects for the choice of pill with approximate simultaneous 95 percent confidence intervals: four rural areas of Bangladesh, 1986-92

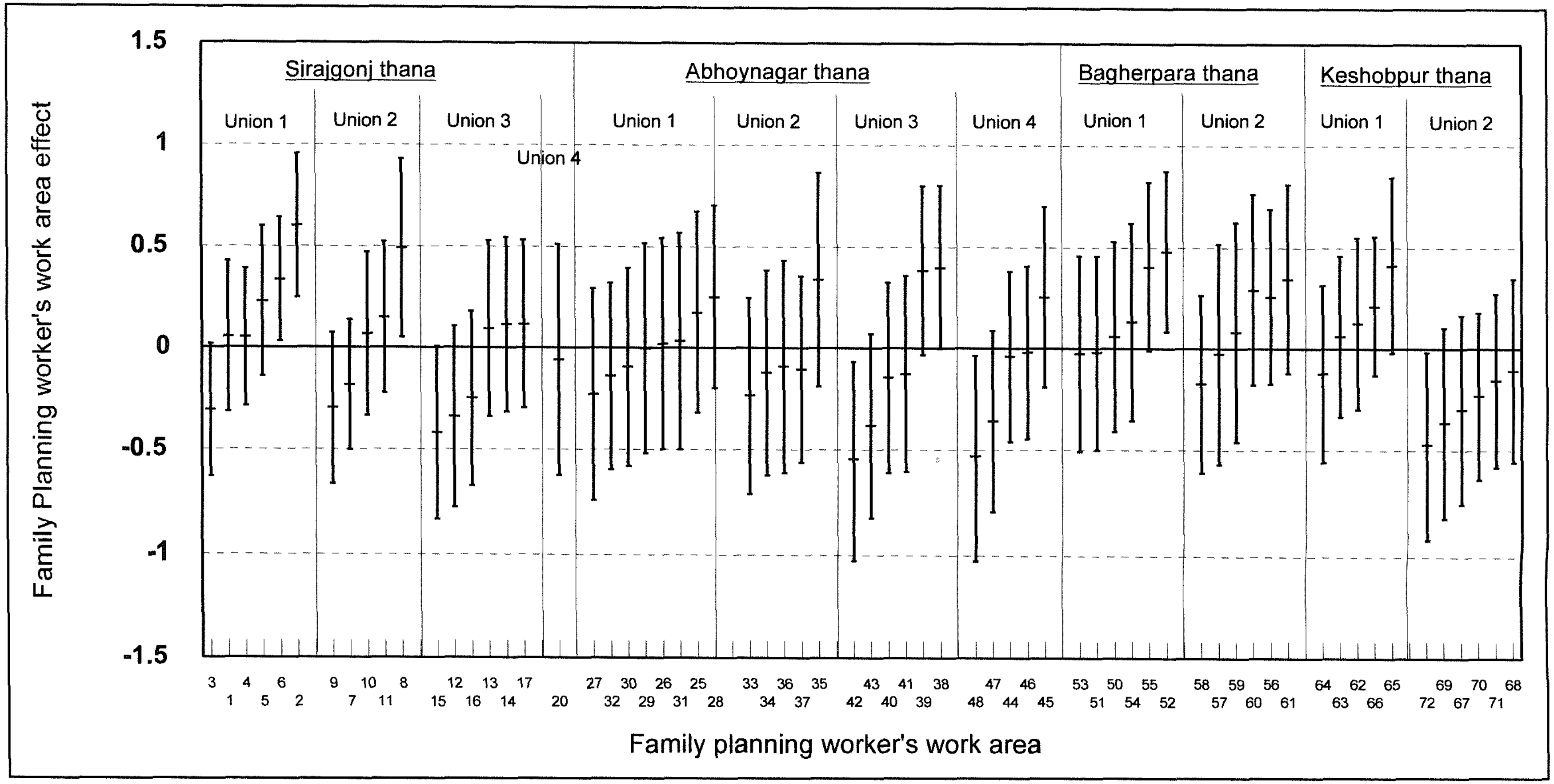
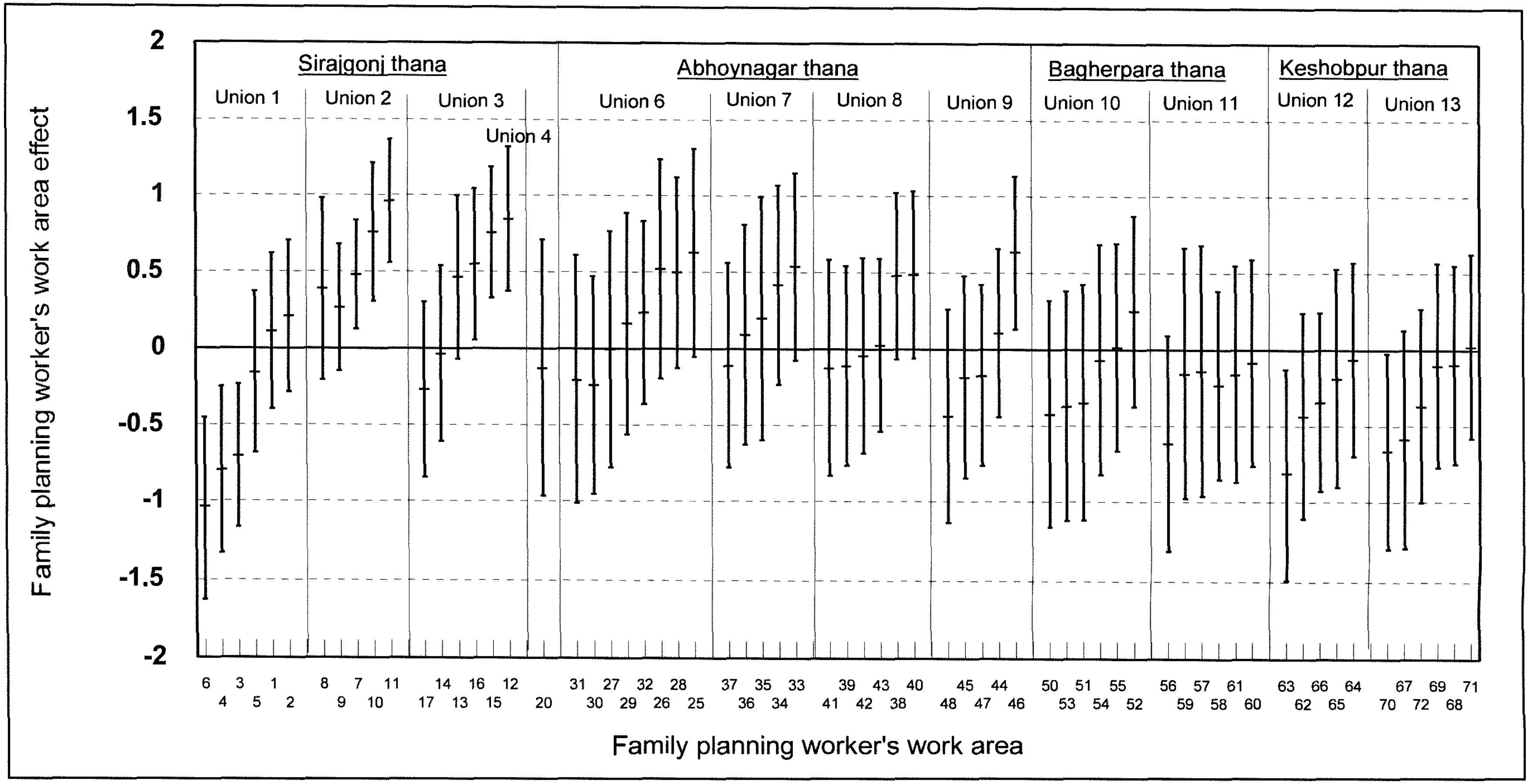


Figure 6.9: Estimated family planning workers work area effects for the choice of injectables with approximate simultaneous 95 percent confidence intervals: four rural areas of Bangladesh, 1986-92



The estimates of the *unit* level residuals can be used for predicting the effect of the community on the choice of a specific method of contraception, after controlling for the effect of the socio-demographic characteristics of the women. These estimates for a *unit* with average choice of a specific method would lie on the line where the residuals are zero.

Figure 6.7 shows the estimated *unit* level effects for the adoption of condoms with simultaneous 95 percent confidence intervals. We can see that the 95 percent confidence interval in *unit* number 1 and 13 in Sirajgonj *thana* do not overlap, suggesting that *units* 1 and 13 have significantly different levels of adoption of condoms at 5 percent levels of significance. A similar relationship can also be seen between *units* 3 and 13, and *units* 2 and 13 in Sirajgonj *thana*. In Abhoynagar thana, the *units* 39 and 41, the *units* 39 and 43 and the *unit*s 39 and 47 have significantly different levels of condom adoption at 5 percent levels of significance. However, all the confidence intervals in Bagherpara and Keshobpur *thana* overlap each other indicating that there is no evidence of any difference in choosing condom between *units* at 5 percent levels of significance.

Figure 6.8 shows the estimated *unit* level effects for the adoption of pills with simultaneous 95 percent confidence intervals. In Sirajgonj *thana*, it is observed that the 95 percent confidence interval do not overlap between *unit* number 3 and 2 suggesting that the *units* have significantly different levels of adoption of pills at 5 percent level of significance. A similar relationship is seen in Abhoynagar *thana* between *units* 42 and 38. However, all the confidence intervals in Bagherpara and Keshobpur *thanas* overlap each other suggesting that there is no evidence of any difference between *units* in adopting pills.

Figure 6.10: Estimated family planning workers work area effects for the choice of IUD with approximate simultaneous 95 percent confidence intervals: four rural areas of Bangladesh, 1986-92

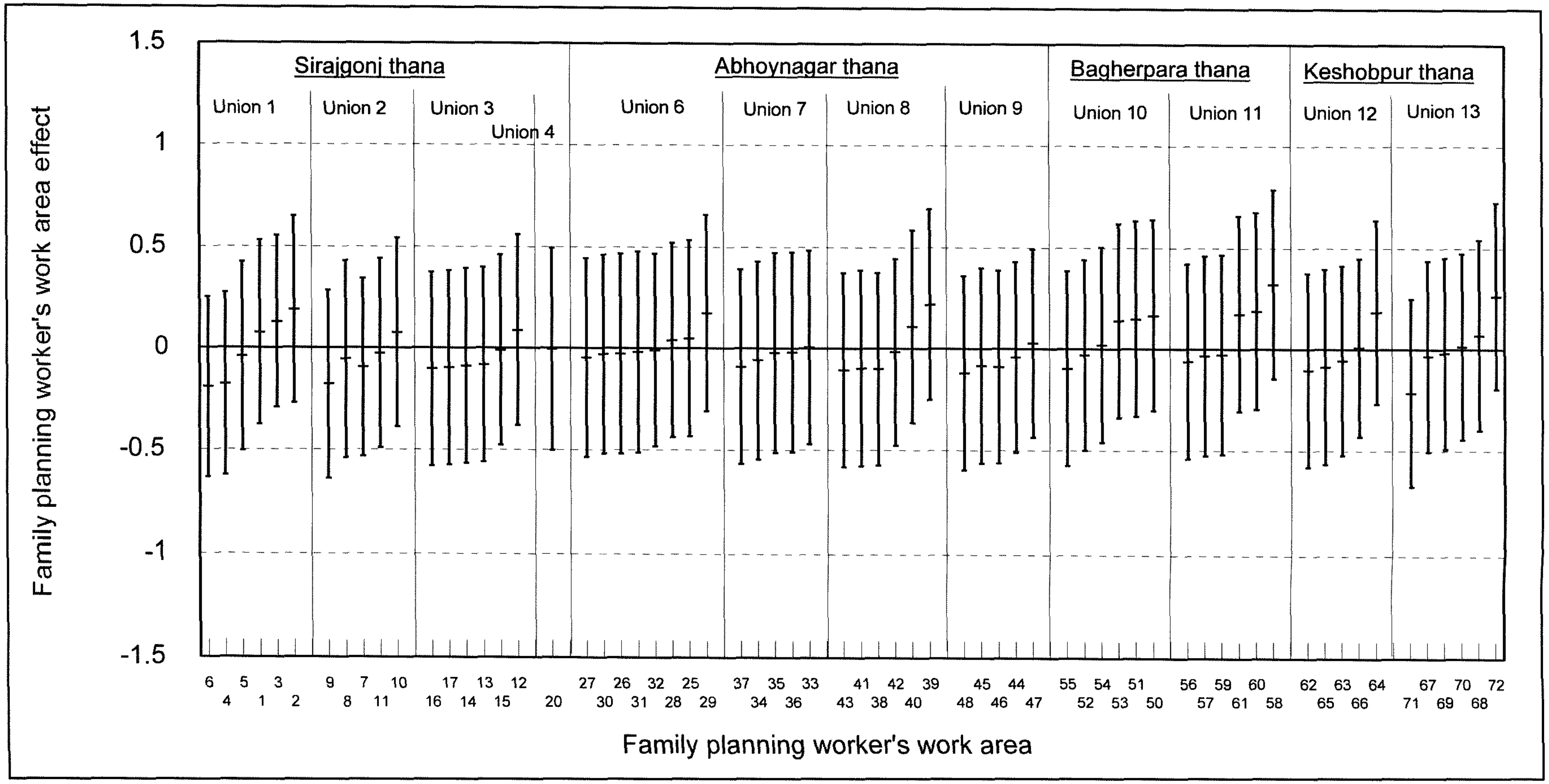


Figure 6.11: Estimated family planning workers work area effects for the choice of traditional method with approximate simultaneous 95 percent confidence intervals: four rural areas of Bangladesh, 1986-92

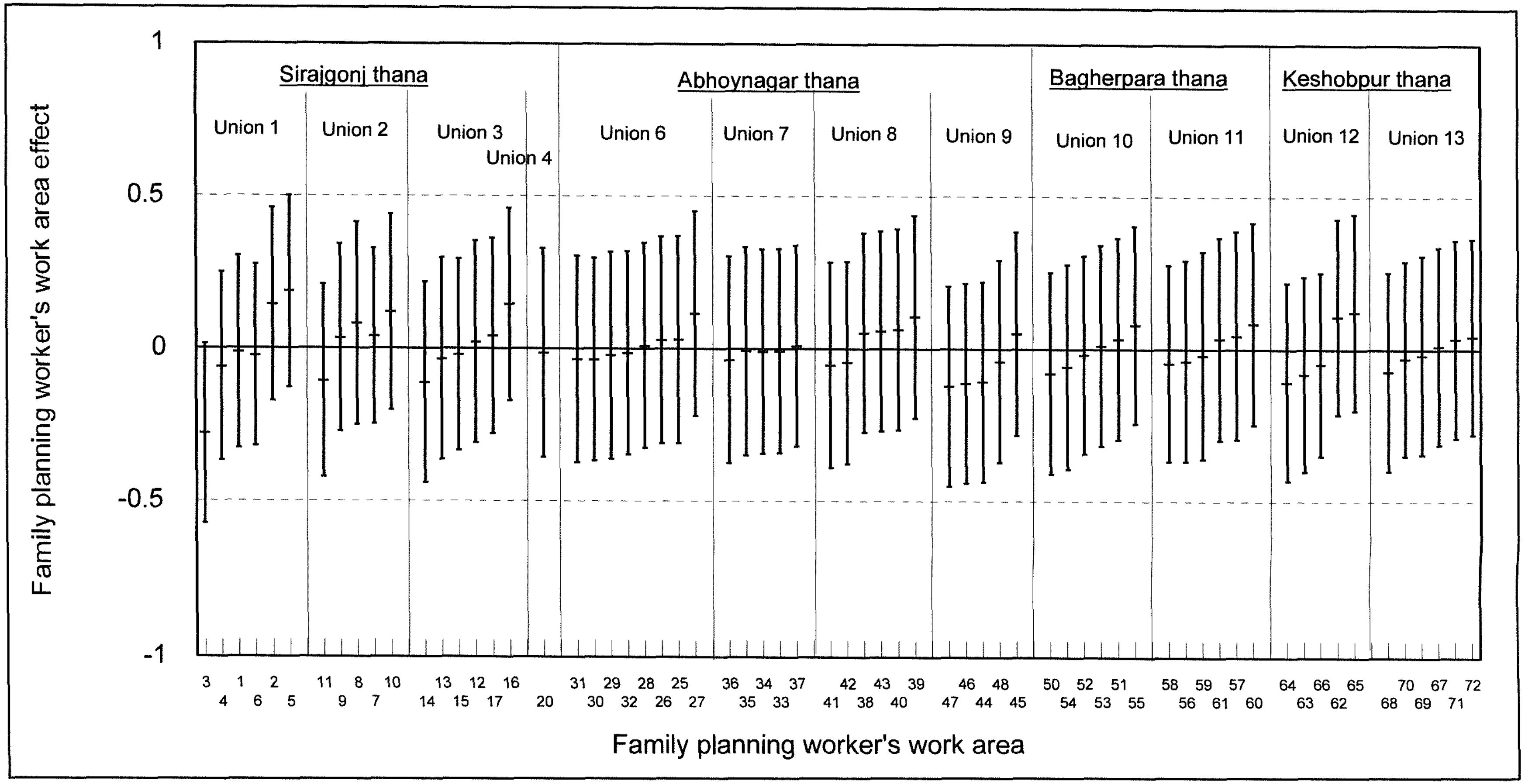


Figure 6.9 shows the estimated *unit* level effect for the adoption of injectables with simultaneous 95 percent confidence intervals. In Sirajgonj *thana*, many *units* appear to have significantly different levels of adoption of injectables. In Sirajgonj *thana* the 95 percent confidence intervals do not overlap between *units* 6 and 2 suggesting that the *units* 6 and 2 have significantly different levels of adoption of injectables at 5 percent levels of significance. *Unit* 6 and *unit* 12 also have significantly different levels of adoption of injectables. Very interestingly, all the confidence intervals in Abhoynagar *thana*, Bagherpara thana and in Keshobpur *thanas* overlap each other suggesting that there is no evidence of any difference between *units* in adopting injectables as a method of family planning.

Figures 6.10 and 6.11 show the estimated *unit* level effects for the adoption of IUD and traditional methods with simultaneous 95 percent confidence intervals. As expected, all the confidence intervals in all four *thanas* overlap each other suggesting that there is no evidence of any difference between *units* in all four *thanas* in choosing IUD or any traditional method.

6.5 Determinants of fertility preference and the quality of care

A multilevel logistic regression (discussed in Chapter 3) is used to measure the association between women's socio-demographic and programmatic characteristics, and desire for no additional children. As expected, results (Appendix B1) show a positive and statistically significant association between women's socio-demographic characteristics and desire for no additional children. However, the family planning worker's contact and prior use of any family planning method appear not to be associated with desire for no additional children. A random parameter at the *union* level (level 3) is tested and found not significant. A random parameter at the *unit* level (level 2) is finally used and found significantly associated with women's desire for additional children. A random effect OLS regression (discussed in Chapter 3) is used to measure the relationship between women's socio-demographic and programmatic characteristics, and perceived quality of family planning services. The perceived quality of family planning services scores are generated from a latent class analysis (a discussion of latent class analysis is presented in Chapter 5) using *LEM* software developed by Vermunt (1997). Results (Appendix B2) show a positive and a statistically significant relationship between family planning workers' contact and prior use of any family planning method with perceived quality of care. Women's education level appears to be associated with the perceived quality of family planning services. However, other women's socio-demographic characteristics of the women appear not to be associated with the perceived quality of family planning services. The random parameters at the *union* level (level 3) and at the *unit* level (level 2) are found to be significantly associated with women's perception about the family planning services provided by the family planning outreach worker in her community. The *unit* and the *union* respectively represent outreach workers' and her supervisors' working area.

6.6 Summary

This chapter was divided into three main sections: contraceptive use analysis, any reversible method adoption analysis and the choice analysis. Most of the findings are consistent with previous studies conducted in Bangladesh and elsewhere. The study has shown that the patterns of contraceptive use differ considerably by individual characteristics as well as programmatic characteristics and communities. It is clear that women's age, their levels of education, number of living sons and number of living daughters are positively associated with the use of any method of contraception. Husbands' level of education is found not to be associated with contraceptive use and excluded from the analysis (see also Tawiah, 1997; Ullah and Chakraborty, 1993). One may expect that the education of a husband should have significant association with the current use of contraception. The educated husbands are assumed to be more aware of the contraceptive methods and the relative advantage of smaller family size. However, I think the decision making authority of women in the household may diminish the effect of husbands' education in relationship to contraceptive use in rural Bangladesh.

If a woman does not want any additional children, the odds of using any method of contraception are significantly higher compared to a woman who wants additional children. If a woman is Hindu, the odds of using any method of contraception are significantly higher compared to the Muslim. If a woman is contacted by the family planning outreach worker in last 90 days, the odds of using any method of contraception are significantly higher compared to a woman who is not contacted by the outreach worker.

The second section mainly concentrated on the factors associated with the post partum reversible method adoption. Most of the findings are similar to the use analysis findings and are consistent with the previous studies conducted in Bangladesh and elsewhere. A woman's age, her level of education, numbers of living sons and perceived quality of family planning services are significantly positively associated with the post partum adoption of any reversible method of contraception. Women's number of living daughters is found not to be associated with the post partum adoption of any reversible method of contraception. Desire for additional children also found statistically associated with post partum reversible method adoption. Family planning outreach workers' contact with rural women is found significantly associated with post partum reversible method adoption. Prior use status is also found significantly associated with post partum reversible method adoption.

The last section mainly concentrated on factors affecting method choice. The most popular methods were pills and injectables. Women's age, education, living sons, and perceived quality of family planning services are positively significantly associated with the choice of methods. Living sons are positively associated with the choice of pills and injectables. Workers' contact also significantly associated with choice of any reversible method but traditional methods. Unexpectedly, education is found to be significantly positively associated with the choice of traditional methods. This may because educated women who are having difficulties with the modern method are be switching to traditional methods. If this is the case then we may have to conclude that family planning programme might have failed to deal with the side-effects related to a modern method which has resulted in high discontinuation and potentially unwanted child bearing. We will explore the impact of outreach workers' contact in dealing with the perceived or actual side effects in the next chapters.

In all three analyses, it is observed that while the individual characteristics explained the variation between women within *units* in contraceptive use, adoption and choice analysis, the location of *units* and the performance of family planning outreach workers explained the differences observed between *units* and hence communities. Each *unit* is assigned to a family planning outreach worker. The difference between *units* may be due to the fact that some *units* are geographically remote and also family planning outreach workers' work performances are not equivalent. In addition, the difference may be as a result of programme inputs, which are not similar across *units* as well as across *unions*. It is also observed from the estimated simultaneous 95 percent confidence intervals that the contraceptive use rate in *unit* number 3 in *union* 1 is well below the average in all three analyses: contraceptive use, adoption and the choice analysis. Conversely, the contraceptive use rate in *unit* number 39 in union 8 is well above the average in all three analyses.

CHAPTER 7

CONTRACEPTIVE DISCONTINUATION

7.1 Introduction

In the previous chapter, the effect of outreach family planning workers' contact on current contraceptive use, and post partum contraceptive adoption and choices of a reversible method were analysed. It is equally important to see the impact of outreach workers' contact on the continuity of use. The impact of contraceptive use on fertility does not depend only on the level of use of contraception but also depends upon the continuity and the reliability of use.

Women adopt contraception for a simple reason that they wish to delay or avoid pregnancy. They may abandon or suspend contraceptive use for the equally simple reason to have a child (Bracher and Santow,1992). They also may discontinue using it when they think that they are out of the risk of conception because of old age. Bracher and Santow (1992) state that the women may also abandon contraceptive use because of circumstances that are neither planned nor aimed at the time of initiating the use.

A high drop in the rate of using a method is a sign of dissatisfaction with a particular contraceptive method. Although use failure is one of the reasons for contraceptive discontinuation that is most of the interest to family planning policy makers, women may discontinue or terminate using a method of contraception for a variety of reasons. While using, they may become pregnant, may experience side effects, may not feel comfortable with their current method and may want to switch to a more suitable method, the method may be out of supply, they may have other method-related problems, may want to have a break from using contraception or may want to have a child. Within this multitude of reasons a high rate of contraceptive discontinuation is likely to suggest the failure of a family planning programmes in providing appropriate or suitable methods.

Recent data show, in Bangladesh, that almost half of the women of reproductive age are currently using a form of contraception to avoid or delay pregnancy (Mitra et al., 1997). Recent analysis also shows that half of the contraceptive users stop using a method within 12 months of initiation (Mitra and Al-Sabir, 1996). In Bangladesh, discontinuation rates vary by method– 65 percent for condoms, 60 percent for withdrawal (a traditional method), 41 percent for IUDs, and 44 percent for oral pills (Mitra and Al-Sabir, 1996). Discontinuation rates for the injectables are relatively high– fifty-one percent of injectable users discontinue their use within 12 months of initiating use. Research conducted recently in Bangladesh by Mitra and Al-Sabir (1996) suggests that side effects are the major cause of discontinuation followed by method related causes. Side effects and other method-related problems are the major cause of discontinuation among pill and injectable users. Side effects are also the major cause of discontinuation among users of IUD. However, the users of condoms and traditional methods are less likely to discontinue their use due to side effects. Other method-related reasons appear to be the main cause of discontinuation for condoms and traditional method users. Although the discontinuation rates due to method failure are generally low, women appear to become accidentally pregnant more often while relying on condoms or traditional methods than when depending on pills, IUDs or injectables.

A limited number of researchers have examined the determinants of contraceptive discontinuation in Bangladesh. For example, Ali and Cleland (1999), and Hossain and Phillips (1996) are among the recent studies. So far, no study can be found which examined the association between outreach family planning workers' contact and reasons for contraceptive discontinuation using longitudinal data. In a sense, this study is unique and is the first step in exploring the relationship between outreach family planning workers' contact and reasons for contraceptive discontinuation. The objective of this research is to investigate the impact of family planning outreach workers' contact on the reasons for contraceptive discontinuation in four rural areas of Bangladesh. In this analysis, single decrement life tables, multiple decrement life tables and multilevel discrete-time competing risks hazard models are used to derive 12-months rates of contraceptive discontinuation. These are preceded by a brief literature review on the issues related to contraceptive discontinuation and the reasons.

7.2 Contraceptive discontinuation: definition and review

The definitions of continuation/discontinuation are important when analysing the reasons for discontinuation. Jejeebhoy (1991) defines the contraceptive continuation rate as the proportion of acceptors who are still using a particular method after a given period of exposure to the risk of discontinuing. The contraceptive discontinuation rate, which is defined as a complement of the continuation rate, measures the proportion of acceptors who are no longer using a method after a period of exposure to the risk of discontinuing either because of contraceptive use failure or for any other reasons.

Contraceptive failure rates have generally been estimated by relating the numbers of accidental pregnancies to woman-years of exposure. Jejeebhoy (1991) defines contraceptive use-failure as the ratio of unintended pregnancies to the duration of contraceptive exposure (while contraception is practised). Unintentional conceptions may occur as a consequence of either method failure or failure to use the contraceptive method accurately and consistently. Three definitions of contraceptive failure are described in the literature (Bongaarts and Potter, 1983; Jejeebhoy, 1991; Trussell and Kost, 1987). The consolidated definition of contraceptive failure is theoretical failure, which attempts to measure failure under perfect use. However, theoretical failure is very difficult to assess from survey data (Grady et al., 1986).

The simple definition of contraceptive failure is extended use-failure. Extended use failure includes all accidental pregnancies following acceptance of a particular method, even if the use was interrupted or discontinued at the time of conception or if the method in use had been switched. This measure has advantages when the data do not include information on the duration and the timing of contraceptive use (Goldman et al., 1983).

Another definition of contraceptive failure is use failure, which attempts to measure failure due to inconsistent or improper use. Use failure appears to be a more appropriate definition of contraceptive failure from the viewpoint of programme evaluation. A number of studies have used this definition (Curtis, 1996; Moreno, 1993). This research also uses the use failure definition of contraceptive method failure.

Authors, in their studies, have used different assumptions in defining contraceptive discontinuation. Akbar et al. (1991) considered a woman as a continued user if she is found using the same method of contraception after the gap of non-use by allowing a period of 4 months of non-use between episodes. Pariani et al. (1991) defined a woman to be a discontinued user if she was found not using after 12 months. Izmirlian et al. (1997) estimated duration from current status data, instead of using other sources such as calendar data to obtain duration of use.

A number of studies used longitudinal prospective data (Hossain and Phillips, 1996) and retrospective calendar data (Curtis and Blanc, 1997; Mitra and Al-Sabir, 1996) for analysing contraceptive discontinuation in Bangladesh.

Few studies have examined contraceptive failure in Bangladesh using national and sub-national data. Using retrospective calendar data, Mitra and Al-Sabir (1996) estimated the 12-month cumulative contraceptive failure rate in Bangladesh to be 3.6. They estimated the 12-months cumulative failure rate to be 1.7 percent for pills, 0.3 percent for the IUDs, 1.1 percent for injectables, 6.0 percent for condoms and 9.7 percent for the traditional methods. Bairagi and Rahman (1996) investigated contraceptive failure based on the longitudinal data collected from Matlab (a rural ICDDR,B intervention *thana* in Bangladesh) during 1984-89. They estimated the 12-month cumulative failure rate in Matlab to be 1 percent for injectables, 3 percent for the IUDs, 15 percent for pills and 15 percent for 'other' methods including condom, foam tablet, periodic abstinence, withdrawal, and herbal medicines.

A number of studies have examined the determinants of contraceptive continuation in Bangladesh (Akbar et al., 1991; Akhter, 1987; Akhter and Ahmed, 1991, 1991a, 1992; Chowdhury et al., 1986; Hossain and Phillips, 1996; Salway and Hossain, 1991). Hossain and Phillips (1996) documented that there is a net positive effect of family planning outreach workers' contact on contraceptive continuation. Pariani et al. (1991), using Indonesian data and Steele et al. (1999) using Moroccan data, also have found that service delivery factors are also associated with the continuity of use.

Ali and Cleland (1999) found that the desire for another child, the number of living children and the woman's age to be significantly associated with discontinuation of use. They also found that neither the education of the women nor the education of her husband proved to exert a significant influence on the continuity of use. Salway and Hossain (1991) found that the continuation rates are similar for educated and uneducated women in Bangladesh.

Some studies have also examined the determinants of method specific continuations. In the six countries they studied, Ali and Cleland (1999) found that pill discontinuation rates vary little by education. Huezo and Malhotra (1993) found that the risks of contraceptive discontinuation increased for rural residence but decreased for IUDs and Injectables acceptors. Mitra and Al-Sabir (1996) found that discontinuation of the IUD is lower than for the traditional methods. Ali and Cleland (1999) found that the younger women are more likely to discontinue a method of contraception compared to the older women when controlling for the effect of the fertility preference. They concluded that the older women may have better tolerance than the younger women. Kost (1993) found that discontinuation rates are higher for pills than for the rhythm method. Mitra and Al-Sabir (1996) found that discontinuation rates for injectables and condoms are greater than traditional methods.

With the substantial increase in contraceptive prevalence in Bangladesh, family planning policy makers have shown their interest in the information on the effectiveness of the methods that are available in the country. Hence, the factors that are associated with discontinuation and the impact of outreach activities on the discontinuation become important. Bracher and Santow (1992) state that an unpleasant or hazardous to use method may provoke health concerns among users and should not be adopted even if the method is an effective one. In terms of a programmatic point of view one should look for a method that is not only highly effective but also provides high levels of satisfaction and continuity of use as determined by the rates of contraceptive discontinuation due to inconvenience, health concerns or side effects (Steele, 1996).

Information on the reasons for contraceptive discontinuation allows family planning policy makers to provide more efficient services. Thus, for improving the efficiency of the services and for keeping the users away from discontinuation, it is important to identify the characteristics at the individual and the programmatic level that are associated with each reasons for discontinuation. For example, a particular group of individuals are more likely to use a particular method more efficiently than the other groups. At the programmatic level, problems related to accessibility, counselling, and side effect treatment may make it extremely difficult for a woman to continue using a method of contraception. Reasons for contraceptive discontinuation are also likely to vary with the type of method. For example, injectable or pill users are more likely to discontinue their method of contraception due to health reasons or side effects than those who are relying on traditional methods. On the other hand, injectable and pill users are less likely to experience a method failure than those who are relying on traditional methods or condoms. Hence, this research investigates the effect of family planning outreach workers' contact with women, and other covariates on reasons for contraceptive discontinuation.

7.3 Methodological aspects of the study of contraceptive discontinuation

There are a number of issues associated with the analysis of contraceptive discontinuation. It is very important to decide how the reasons for discontinuation are classified. There are nine possible causes of discontinuation in these longitudinal data. It is neither feasible nor worthwhile to consider each causes separately. Thus, it is also important to be careful while merging the categories. It is also necessary to take into account duration of use of a method of contraception. It is possible that a woman is less likely to continue using the method of contraception as duration of use increases. Therefore, the methodology adopted should allow for changes in the risk of discontinuation according to duration of use. Finally, as is typically the case when analysing event histories, some of the women using a method of contraception will still be using the method at the end of the surveillance period and so the analytical method will need to incorporate right censored observations in the analysis. Life table procedures, which are discussed in Chapter 5, fulfil all these requirements and are applied considerably in fertility research.

7.3.1 The use of life tables

To derive rates of 12-month contraceptive discontinuation, Grady et al. (1983), while analysing data from the United States, used a multiple decrement life table. In order to calculate the annual rates of contraceptive discontinuation in Philippines, Choe and Zablan (1991) also used a multiple decrement life table. Choe and Zablan (1991) classified the reasons for contraceptive discontinuation as: (a) contraceptive failure; (b) desire for pregnancy; (c) switching to a different contraceptive method; (d) no longer needed to use due to spousal separation or menopause; and (e) for other reasons. Ali and Cleland (1995) applied life table techniques in their recent study to derive and compare discontinuation rates in six developing countries. They used an associated single decrement life table to calculate cause-specific discontinuation rates. They considered four causes for contraceptive discontinuation: (a) health concerns; (b) method failure; (c) desire for pregnancy; and (d) other unspecified reasons. The 'other unspecified reasons' compose of a diversified bunch of causes. The use of associated single decrement life table by Ali and Cleland (1995) raises questions around these cause specific rates. In the case of an associated single decrement life table, the cause specific discontinuation rates are computed by assuming a complete absence of other causes that are competing against each other. The rates of discontinuation computed from a multiple decrement life table are called net rates of discontinuation since these represent the rates of discontinuation, due to a particular cause, in the presence of other causes of discontinuation. The net rates of discontinuation for each cause, therefore, depend on the rates of discontinuation for the other causes. One of the useful measures obtained from multiple decrement life tables for contraceptive discontinuation is the cumulative rate of discontinuation for each cause. However, the distinction between the net discontinuation rates using multiple decrement life table and the gross discontinuation rates using an associated single decrement life table is a delicate one, and it sometimes can be difficult to know which one is the most appropriate for a particular analysis (Curtis and

Hammerslough, 1995). While analysing Chinese data, Steele et al. (1996) used three reasons for contraceptive discontinuation: (a) method failure; (b) other method-related reasons; and (c) non-method-related reasons. More recently, Steele et al. (1999) while analysing Morocco DHS data used four reasons for pills discontinuation: (a) method failure; (b) desire to get pregnant; (c) side effects and health concerns; and (d) other method-related. Leite (1998), while analysing Brazil DHS data, used five reasons for contraceptive discontinuation: (a) contraceptive method failure; (b) to get pregnant; (c) side effects; (d) other method related reasons; and (e) other reasons.

The life table approach, whether single decrement or multiple decrement, is a simple technique to apply that achieves all the necessary requirements for the analysis of discontinuation. However, despite these features, the life table approach has some limitations in its application. For example, it is not possible to sub-divide the sample into a larger number of sub-groups. Such a procedure permits analyses of even the largest surveys to control for only three or four variables simultaneously before the sizes of the subgroups become too small for reliably estimating discontinuation rates (Hammerslough, 1984; Rodriguez et al., 1984). It is also not possible simultaneously to use a number of factors in the life table. In the life table, the discontinuation rates for one factor are generally measured without controlling for the effect of other factors.

Hazard models, which allow for the estimation of rates of occurrence of the event of discontinuation during the risk period, can be used to overcome these problems. In addition, right censored data can be incorporated in hazards model analysis. Therefore, hazards models have more advantage and flexibility over the life tables.

7.3.2 Life table based on regression models

Until recently, the conventional procedure for calculating multivariate life tables had been to split the sample into many sub-groups. This had limitations of using a number of control variables that produce unreliable estimates. To overcome this problem, Schirm et al. (1982) and Hammerslough (1984) used a log-linear hazards model using the logarithm of the rate of experiencing a method failure as an outcome variable. Schirm et al. (1982) estimated discontinuation rates due to method failure for each method of contraception based on the coefficients of the statistically significant variables. Using United States National Surveys of Fertility Growth (NSFG) data for the 1973 and 1976 period, Hammerslough (1984) estimated one-year rates of contraceptive discontinuation for women who discontinued method a due to other reasons. To calculate the rates of discontinuation due to method failure, Grady et al. (1986) used a similar approach to the one applied by Schirm et al. (1982), considering the intervals that are interrupted by periods of no intercourse as continuous, even though the periods of abstinence will not have contributed to the exposure. Grady et al. (1988) used a similar approach to estimate the two destination-specific discontinuation models: switching to a different method and stopping using the method. To do this, they removed from their analysis four competing risks: (a) marital separation; (b) unintended pregnancy; (c) stopped using in order to get pregnant; and (d) contraceptive sterilization.

Bracher and Santow (1992) used continuous-time competing risks for computing the cause-specific rates of contraceptive discontinuation. The data they used had eight different reasons for discontinuation: (a) desired to have a baby; (b) accidental pregnancy; (c) side effects; (d) dissatisfaction with the method; (e) becoming sterilised; (f) end of relationship or absence of partner; (g) menopause; and (h) other reasons. They used a Cox regression model to estimate the parameters of models fitted for three different reasons for contraceptive discontinuation: side effects, contraceptive failure and other types of dissatisfaction with the method.

7.3.3 Multilevel approaches

A discrete-time competing-risks hazard model with random effects is used by Steele et al. (1996) for measuring the determinants of contraceptive discontinuation in China. They grouped the reasons for contraceptive discontinuation into three major categories: (a) method failure; (b) other method-related reasons; and (c) non-method-related reasons. The women who were still using the method at the end of the survey period are treated as the reference category. The principal non method-related reason is stopping to become pregnant; women who discontinue upon reaching menopause also fall into this category. Steele (1996) treated as right censored segments that end because a woman reaches menopause or because of the disruption of her marital life. A recent study conducted by Steele and others (1999) used a discrete-time competing risks hazards model with random effect for measuring the determinants of contraceptive discontinuation in Morocco. They aggregated the reasons for discontinuation into four categories: (a) method failure; (b) desire to become pregnant; (c) side effects/health concerns; and (d) other method-related reasons. The discrete-time competing risk model is analogous to the multiple-decrement life-table and yields net or dependent rates in which the probability that the occurrence of a particular type of event depends on the probabilities corresponding to each of the other competing risks. Sometimes women may contribute more than one episode of use. In this research, only one episode of use interval is used. A two-level model is applied where women are nested within *units*.

7.4 Data and methodology

The data for this research come from the ongoing Operations Research Project of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). A survey on fertility preferences was conducted in 1990 in four rural areas of Bangladesh under the Sample Registration System (SRS). A detailed description of the SRS is given in Section 1.5. The users and the non-users in the 1990 survey were followed until the end of 1992. When a woman in the 1990 survey is found to be a user, her pervious contraceptive use data were checked from the previous longitudinal data to find out her initiation of the use of the same method. The non-users who adopted a method of contraception after the 1990 survey were followed until the end of 1992. Sterilization (permanent method), and *kabiraji,* and *homeopathic* (so called traditional permanent methods) acceptors were excluded from the analysis. The women who were not users at the time of the 1990 survey and who did not start using any method of contraception until the end of 1992 are also excluded from the analysis. During this time, these women were asked about their contraceptive use behaviour, government family planning outreach workers' contact with women and the reasons for discontinuation (if it happened) in every 90-day cycle. In this research, only one segment of use is considered. The final sample is composed of 3,484 segments of use that also represent the total number of women in the sample. The methods of contraception included are pills, injectables, condoms, IUDs, and traditional methods. Withdrawal, rhythm and periodic abstinence are included as traditional methods. If a woman lost her eligibility (due to marital dissolution, migration or infecundability), the data are treated as right censored. If a user continues using the same method until the end of 1992, her data are also treated as right censored.

In this research, initially a single decrement life table is used for computing discontinuation rates for the different methods. Though it is not the primary aim of the analysis presented in this chapter, it seems more plausible to estimate net rates of contraceptive discontinuation. In this chapter, therefore, multiple decrement life tables are used to derive contraceptive discontinuation rates according to some selected socio-demographic, programmatic and economic characteristics of the women. In order to incorporate the dependence among different reasons for contraceptive discontinuation in a regression model, a discrete-time competing risks model is applied to estimate cumulative probabilities of contraceptive discontinuation for each factors controlling for the effect of other factors in the model.

Seven categories of reasons for contraceptive discontinuation are recorded in the SRS data base: (1) side effects; (2) desire to get pregnant/wanted child; (3) husband's objection or unwillingness to use; (4) contraceptive method failure; (5) other method-related reasons (switched, wish to switch, etc.); (6) other reasons; and (7) menopause, divorced, widowed. In this research, the reasons for discontinuation are aggregated into five categories. Husband's objection or unwillingness to use is merged with the 'other reason' category. Finally, for the analysis, a woman can be in one of the six mutually exclusive and exhaustive states: (1) experienced side effects and discontinued use; (2) desired to get pregnant/wanted child and discontinued use; (3) experienced a contraceptive use failure; (4) discontinued for other method-related reasons (switched, wish to switch, etc.); (5) discontinued for other reasons; or (6) continued use of the same method. Curtis and Hammerslough (1995) have suggested this way of aggregation for analysing the causes of contraceptive discontinuation in their model plan for analysing contraceptive discontinuation. Leite (1998) used a similar aggregation in his dissertation research. As proposed by Steele (1996) segments of use that were interrupted for causes such as menopause, widowed, or divorced were also treated as right censored.

In this chapter, any change to a more effective contraceptive method is considered as a discontinuation of the previous method. Hence, change or switch is not considered as a specific category. A more extensive analysis of contraceptive switching, therefore, is undertaken in the next chapter.

A discrete-time competing risks hazards model can be estimated as a multinomial logistic model in which the observations are repeated according to the duration of use until the event of discontinuation occurs or it is censored. In such a situation, starting with the round when a method is adopted, a multinomial response is recorded for each round until either the method is discontinued or ends of follow-up or censored, whichever event occurs first. The response variable assumes one of the following codes for the rounds in which contraceptive methods were interrupted depending on the reasons for contraceptive discontinuation: (1) side effects; (2) desire to get pregnant; (3) method failure; (4) other method-related; and (5) other reasons. For the rounds in which a contraceptive method was in use a code (6) was used. Thus, if a woman discontinues a method due to contraceptive failure in the fifth round of use, five observations will be created for this segment of use, one for each round of use and the response variable would assume the values: 6, 6, 6, 6, and 3. On the other hand, if a woman is still using the same method at the end of the observation period, the response variable would assume the values: 6, 6, 6, 6, ..., 6 and would be treated as censored.

The single-level competing risks hazard model can be specified as the following multinomial logistic model

$$\log_e\left(\frac{\lambda_{rti}}{\lambda_{6ti}}\right) = \alpha_{rt} + x'_{ti}\beta_r, \qquad r = 1, 2, 3, 4, \text{ or } 5 \qquad (7.1)$$

where λ_{rti} is the hazard of a discontinuation of type *r* at time *t* for the use interval *i*, and λ_{6ti} is the hazard of continuing use of the same method (the base category).

In Chapter 6, we found that both the *unit* level *and* the *union* level are statistically significant for the contraceptive adoption analysis. However, for the analysis of contraceptive choice, we found that the *unit* level was statistically significant but not the *union* level. In this contraceptive discontinuation analysis we have tested the *unit* level and the *union* level effect on contraceptive discontinuation. The *union* level effect is found not to be statistically significant and hence is removed from the analysis. Finally, a two-level discrete-time competing risk model is used for the analysis of discontinuation. The model is given as follows:

$$\log_e\left(\frac{\lambda_{rtijk}}{\lambda_{6tijk}}\right) = \alpha_{rt} + x'_{tijk}\beta_r + u_{rjk} + v_{rk}, \quad r = 1, 2, 3, 4, \text{ or } 5, \qquad (7.2)$$

where λ_{rtijk} is the hazard of discontinuation of type *r* at time *t* for the use interval i of woman *j* from *unit k*. The set of covariates x_{tijk} is the same for each of the five contrast of type of contraceptive discontinuation against continuing using a method. β_r is the vector of parameters for the contrast *r* associated with x_{tijk}. A function of time α_{rt}, representing the baseline hazard, is also included in the model. In the multinomial logistic model, a set of random effects for each transition of type *r* is included: u_{rjk} are the woman level effects, v_{rk} are the *unit* level effects. As usual, each random effect is assumed to be mutually independent and follow a normal distribution: $u_{rjk} \sim N(0, \sigma^2_{rjk})$ and $v_{rk} \sim N(0, \sigma^2_{rk})$. This model is called a random-intercept model or variance-component model.

The multilevel discrete-time competing risks model is analogous to a multilevel multinomial logistic regression model (Goldstein, 1995; Steele et al., 1996). The MLwiN software (Goldstein et al. 1998) is used for estimating the parameters in equation 7.2. Rodriguez and Goldman (1995) have exhibited that simple approximation to the likelihood for the above model can lead to an underestimation of the random-effect variances. However, Goldstein and Rasbash (1996) demonstrated that most of this bias could be minimized when a second order penalized quasi-likelihood (PQL) approximation is used. In this research, hence, a second order PQL approximation is used.

7.5 Descriptive analysis

Table 7.1 gives the distribution of segments of contraceptive use according to the method of contraception. Since, in this research, only one segment of use is used for a woman, the number of segments represents the total number of women in the sample. Pills are the most popular method with 49 percent of segments contributed to the study sample. After pills, injectables are the second most popular method with more than a quarter of segments contributed to the study sample. Condoms, IUDs and traditional methods are almost equal and jointly accounted for another quarter of the segments of contraceptive use.

Table 7.1 Distribution of segments of contraceptive use according to the method of contraception: four rural areas of Bangladesh, 1990-92

Methods of contraception	Number of segments	Percentage
Condoms	302	8.7
Pills	1706	49.0
Injectables	926	26.6
IUDs	272	7.8
Traditional methods	278	8.0
Total	3484	100.0

Table 7.2 gives the distribution of the number of segments of contraceptive use according to the reasons for discontinuation. The table shows that a considerable proportion of segments of contraceptive use were right censored (34.4 percent of women either lost their eligibility due to a menopause, widowed, divorced or were still using a method of contraception at the end of the follow-up period). Apart from use failure, more than 50 percent of women discontinue their use because of method-related reasons: side effects and other method-related reasons. Of these, almost two thirds discontinue using their method because of side effects. Overall, one third of all women discontinue using their method

because of side effects. This may be due to the fact that a large proportion of women depend on pills (49 percent of women) and injectables (27 percent of women) in the sample. A small proportion (1.7 percent) of women experience a method failure. Approximately 7 percent of women discontinue their use because they want to get pregnant. In addition, 5.4 percent of women discontinue their method because of other reasons.

Table 7.2 Distribution of the number of segments of contraceptive use according to the reasons for the discontinuation: four rural areas of Bangladesh, 1990-92

Reasons for discontinuation	Number of segments	Percentage
Side-effects	1147	32.9
Desire to get pregnant	235	6.7
Use failure	58	1.7
Other method related reasons	656	18.8
Other reasons	189	5.4
Continue using or censored	1199	34.4
Total	3484	100.0

7.5.1 Multiple-decrement life table discontinuation rates

In this research, multiple-decrement life tables were used to estimate the net reason-specific discontinuation rates by different demographic, socio-economic and programmatic characteristics. Table 7.3 presents 12-month cumulative probabilities of contraceptive discontinuation according to the reasons stated for discontinuation by selected demographic, socio-economic and programmatic characteristics. A range of demographic and socio-economic characteristics are considered, including the number of living sons, the number of living daughters, desire for additional children, women's age, education of women, education of her husband, area of dwelling unit, and religion. Programmatic characteristics, such as prior use of contraception, family planning outreach workers' contact and the type of method used are considered.

From Table 7.3, it is observed that almost half of all women discontinued use of a method of contraception within the first 12 months of use. This finding is consistent with findings using national samples for Bangladesh (Curtis and Blanc, 1997; Mitra and Al-Sabir, 1996). From the overall cumulative probability of discontinuation, side effects and other method-related reasons appear to be the two major reasons for contraceptive discontinuation in Bangladesh. After 12 months, the overall cumulative probabilities of contraceptive discontinuation due to side effects and other method-related reasons respectively are 0.24 and 0.14. Mitra and Al-Sabir (1996) reported that the overall cumulative probabilities of contraceptive discontinuation after 12 months in Bangladesh to be 0.19 due to side effects and 0.13 due to other method-related reasons. After 12 months, the overall cumulative probabilities of contraceptive discontinuation due to the women wanting to get pregnant, due to use failure and due to other reasons are relatively small.

The discontinuation rates due to side effects appear to be declining marginally with the number of living sons and the number of living daughters. As expected the rate of discontinuation due to the women wanting to get pregnant declines sharply with both the number of living sons and the number of living daughters. No particular pattern of relationship is observed between use failure and the number of living sons and daughters. A mild U-shaped relationship is observed between contraceptive discontinuation due to other method-related reasons and number of living daughters.

Table 7.3 Life-table cumulative probabilities of contraceptive method discontinuation within 12 months of starting of use, by reasons and selected characteristics: four rural areas of Bangladesh, 1990-92

Variables	Reasons for discontinuation					(n)
	Side effects	Get pregnant	Method failure	Other method-related	Other reasons	
Number of living sons						
0	0.278	0.117	0.016	0.130	0.054	(698)
1	0.245	0.051	0.010	0.142	0.049	(1242)
2+	0.223	0.018	0.014	0.141	0.036	(1544)
Number of living daughters						
0	0.251	0.097	0.012	0.144	0.048	(842)
1	0.251	0.039	0.014	0.133	0.047	(1253)
2+	0.229	0.029	0.013	0.142	0.040	(1389)
Desire for additional children						
Don't want more	0.220	0.019	0.014	0.135	0.044	(2285)
Want more children	0.284	0.106	0.012	0.147	0.045	(1199)
Age of women						
Less than 25	0.296	0.095	0.012	0.158	0.055	(974)
25-29	0.264	0.038	0.011	0.146	0.040	(852)
30-34	0.254	0.024	0.018	0.136	0.045	(719)
35+	0.159	0.038	0.012	0.118	0.036	(939)
Education of women						
No education	0.261	0.046	0.010	0.140	0.039	(2163)
Primary and below	0.218	0.051	0.015	0.131	0.053	(943)
Above primary	0.194	0.058	0.025	0.157	0.052	(378)
Education of husband						
No education	0.252	0.049	0.012	0.160	0.043	(1583)
Primary and below	0.235	0.055	0.017	0.118	0.037	(909)
Above primary	0.232	0.043	0.012	0.126	0.052	(992)
Area of dwelling unit						
< 200 square feet	0.275	0.047	0.014	0.156	0.035	(1776)
201+ square feet	0.208	0.051	0.012	0.122	0.054	(1708)
Religion						
Muslim	0.250	0.050	0.012	0.144	0.044	(3031)
Hindu and others	0.184	0.038	0.021	0.111	0.043	(453)
Prior use of contraception						
No	0.299	0.051	0.015	0.136	0.061	(1228)
Yes	0.213	0.048	0.012	0.141	0.046	(2256)
Family planning workers contact						
No	0.173	0.057	0.021	0.210	0.071	(843)
Yes	0.263	0.046	0.011	0.117	0.036	(2641)
Methods						
Condom	0.044	0.100	0.045	0.244	0.222	(302)
Pill	0.289	0.051	0.005	0.109	0.024	(1706)
Injectables	0.307	0.024	0.005	0.162	0.016	(926)
IUD	0.193	0.026	0.004	0.084	0.004	(272)
Traditional methods	0.000	0.084	0.065	0.196	0.108	(278)
Overall	0.242	0.049	0.013	0.139	0.044	(3484)

Discontinuation due to other method-related reasons is expected to decline with number of living children. However, it may increase again as women complete their desired family size since they are more likely to discontinue a method to switch to a long-term method. No particular pattern of relationship is observed between contraceptive discontinuation due to other method-related reasons and the number of living sons. Discontinuation due to other reasons declines with both the number of living sons and number of living daughters.

The rate of discontinuation due to side-effects declines steadily with women's age. However, a sharp decline is seen for women aged 35 and above. The cumulative probability of contraceptive discontinuation due to side effects is almost 0.30 for women ages 35 and above while the probability of contraceptive discontinuation due to side effects is 0.16 for the women aged less than 25. One plausible explanation for this is the probable rise in the woman's motivation for limiting fertility at higher ages. The low rate among women aged 35 and above may also be a reflection of declining fecundity with age. The rate of discontinuation due to the women wanting to get pregnant declines sharply with age, which also authenticates the explanation. No particular nature of relationship is observed between the age of women and discontinuation due to other reasons and method failure. However, there is a lower risk of discontinuation due to other method-related causes among older women. Older women are likely to have experienced different types of contraceptive methods and, therefore, they may continue using a method that suits their needs thus diminishing the chance of discontinuing a method of contraception because of other method-related causes.

Surprisingly, the risk of contraceptive use failure increases with the level of education of the women. Steele (1996) observed a similar finding in China. A possible explanation is the higher level of pill and condom use among educated women, as these methods have higher failure rates than injectables and IUDs. Mitra and Al-Sabir (1996) observed in Bangladesh that the risk of contraceptive failure increases with education among pill users. However, the risk of contraceptive discontinuation due to side effects decreases with the level of education of women. This indicates that women with a higher level of education are more able to choose more suitable low dose pills, which are less likely to generate an adverse reaction. The risk of contraceptive discontinuation due to the reason that the woman wants to get pregnant appears to be slightly increasing with her level of education. The rate of contraceptive discontinuation due to other method-related reasons appears to have been associated with the level of education of the husbands. As the level of husbands' education increases the rates of contraceptive discontinuation due to other reasons slightly decrease. A slight decline in the risk of contraceptive discontinuation due to side effects is observed with husbands' education.

The size of the dwelling unit is a proxy indicator of the economic condition of the rural families in Bangladesh. The higher the size of the dwelling unit the better the economic condition. The risk of contraceptive discontinuation due to side effects is lower among the more affluent. The risk of discontinuation due to other method-related reasons is also lower for the more affluent. The risk of contraceptive discontinuation due to method failure is also lower for the more affluent. These women are more likely to be pill users and are buying prescribed low-dose pills from the dispensary, which is less likely to provide adverse reactions.

The risk of contraceptive discontinuation due to side effects appears to be lower among Hindu and other religious women compared to Muslim women. Hindu and 'other religious' women have relied on traditional methods, which are believed to be free of any adverse side effects. Consequently, the risk of method failure is higher among Hindu and 'other religious' women compared to Muslim women.

To test whether the spell of current contraceptive use behaviour is influenced by the spell of past use experience, the prior use spell of any method of contraception is considered. If a woman had used a method in the past, she may be more experienced in using contraception and less likely to discontinue for any method-related reasons. The risk of contraceptive discontinuation due to side effects appears to be lower among women who have experience of using a method of contraception. However, the risk of contraceptive discontinuation due to other method-related reasons is similar for both prior users and non-prior users of any method of contraception. The risk of contraceptive failure appears to be lower for women who have experience of prior use of contraceptive methods.

The risk of contraceptive discontinuation due to other method-related reasons appears to be lower if a woman receives contact from the national family planning outreach workers. However, the risk of contraceptive discontinuation due to side effects appears to be increasing with the national family planning workers' contact. The negative association of national family planning outreach workers' contact with the risk of contraceptive discontinuation due to side effects is surprising. However, these national family planning outreach workers' main responsibility is to motivate women and provide contraceptive services. They are not trained in side effect management. When problems arise, their role is limited to persuading women to switch to a more suitable method. That is why the family planning outreach workers' contact reduces the risk of contraceptive discontinuation due to other method-related reasons.

The contraceptive failure rates among the traditional method users are higher compared to pill, condom, injectable and IUD users. Mitra et al. (1996) documented that almost 10 percent of women, after 12 months, discontinue their traditional method use because of method failure.

As expected, the main reason for discontinuation of contraception among injectable users is side effects. Side effects also appear to be the main reason for discontinuation among pill users and IUD users. Using the same technique, Leite (1998) found similar findings of discontinuation for pills and for injectables in Brazil. Similar findings are also documented by Akhter and Ahmed (1991) from a Bangladesh national sample using different techniques. Other method-related reasons account for a substantial proportion of the discontinuation among women using condoms, pills, injectables and traditional methods. Approximately 24 percent of women discontinue condom use in the first 12 months because of other method-related reasons. Inconvenient to use, supply shortage and switch to a more effective method are the main categories that constitute other method-related reasons for the condom users. Other reasons account for a substantial proportion of the discontinuation among condom users and traditional method users. The rates of discontinuation due to method failure are relatively low among IUD users. However, the rates of discontinuation due to method failure are similar for both pill and injectable users and a little higher than IUDs. The rates of discontinuation due to method failure for condom users are 4.5 percent, which is the second highest after traditional method users, 6.5 percent, after 12 months. Twenty two percent of women discontinue condom use in the first 12 months because of other reasons. Husband's absence is one of the main reasons in the 'other reason' category among condom users.

The main reasons for discontinuation among users of traditional methods appear to be other method-related reasons followed by other reasons, respectively 19.6 percent and 10.8 percent. Particularly in the case of withdrawal, inconvenience to use is the dominating reason for discontinuation due to other method-related reasons. Switching or desire to switch to a more effective method is a common cause for discontinuation due to method-related reasons among traditional method users. The three monthly method-specific discontinuation rates by reasons are shown in Figures 7.1 to 7.5.

Figures 7.1 through 7.5, show clearly that for most of the reasons, contraceptive discontinuation is more likely to occur in the early stages of use intervals. Contraceptive discontinuation due to side effects among pills and injectables users (Figures 7.2 and 7.3) is more likely to happen in first three months of use. However, there is no evidence that contraceptive failure is more likely to be occurring in the early stage of contraceptive use among traditional method users. It is also observed that some rates of discontinuation by reasons (Figures 7.1 through 7.5) show a pattern of a plateau after eighteen months of use. These patterns may be due to the fact that the number of women for some reasons of discontinuation for some methods has become very small after eighteen months.

Figure 7.1 Cumulative probabilities of discontinuation among condom users according to the reasons mentioned: four rural areas of Bangladesh, 1990

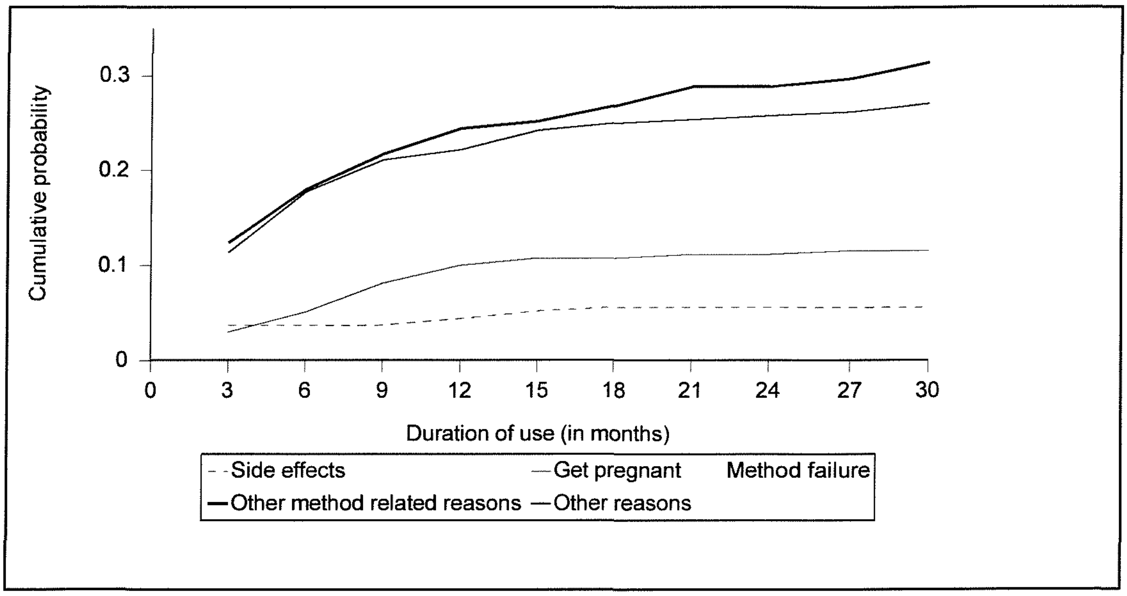


Figure 7.2 Cumulative probabilities of discontinuation among pill users according to the reasons mentioned: four rural areas of Bangladesh, 1990

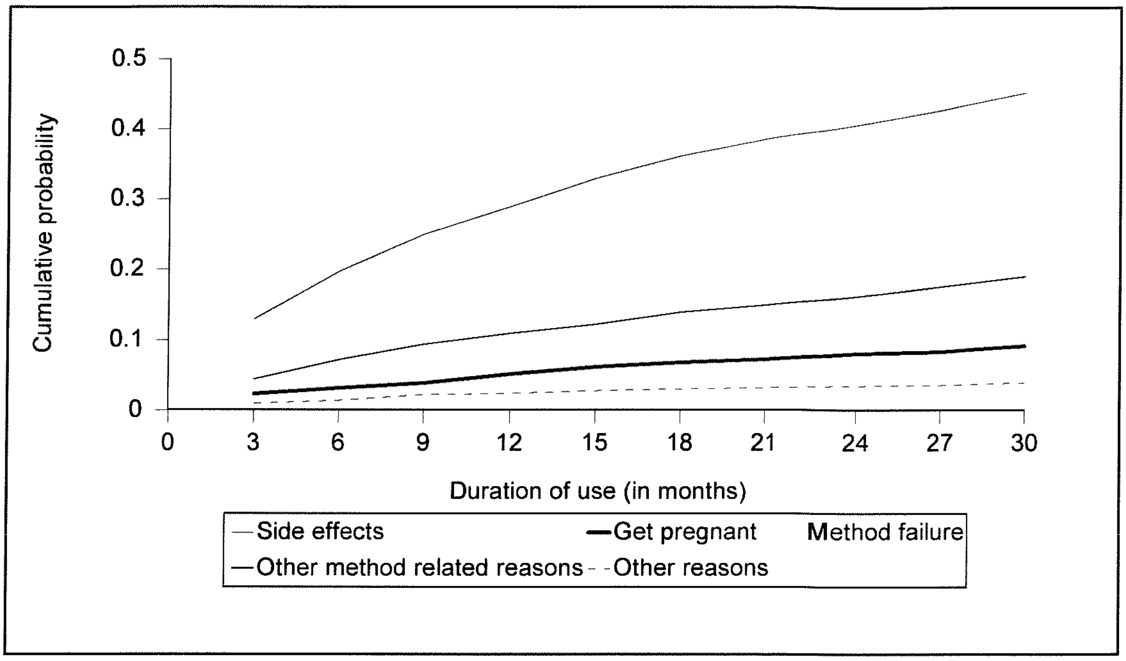


Figure 7.3 Cumulative probabilities of discontinuation among injectables users according to the reasons mentioned: four rural areas of Bangladesh, 1990

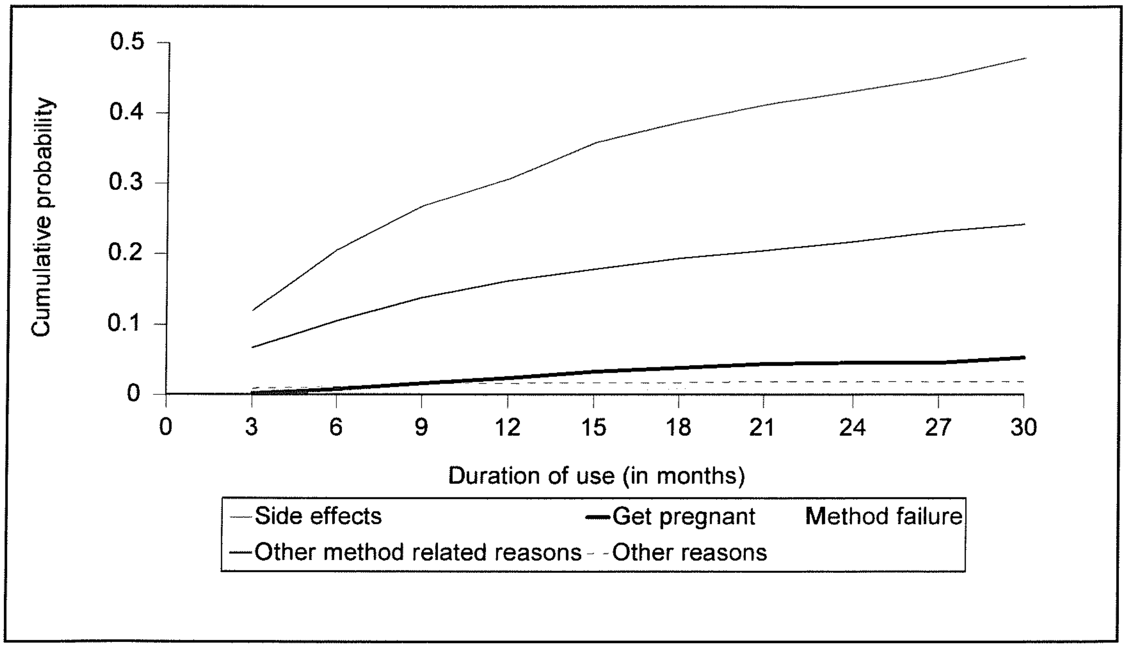


Figure 7.4 Cumulative probabilities of discontinuation among IUD users according to the reasons mentioned: four rural areas of Bangladesh, 1990

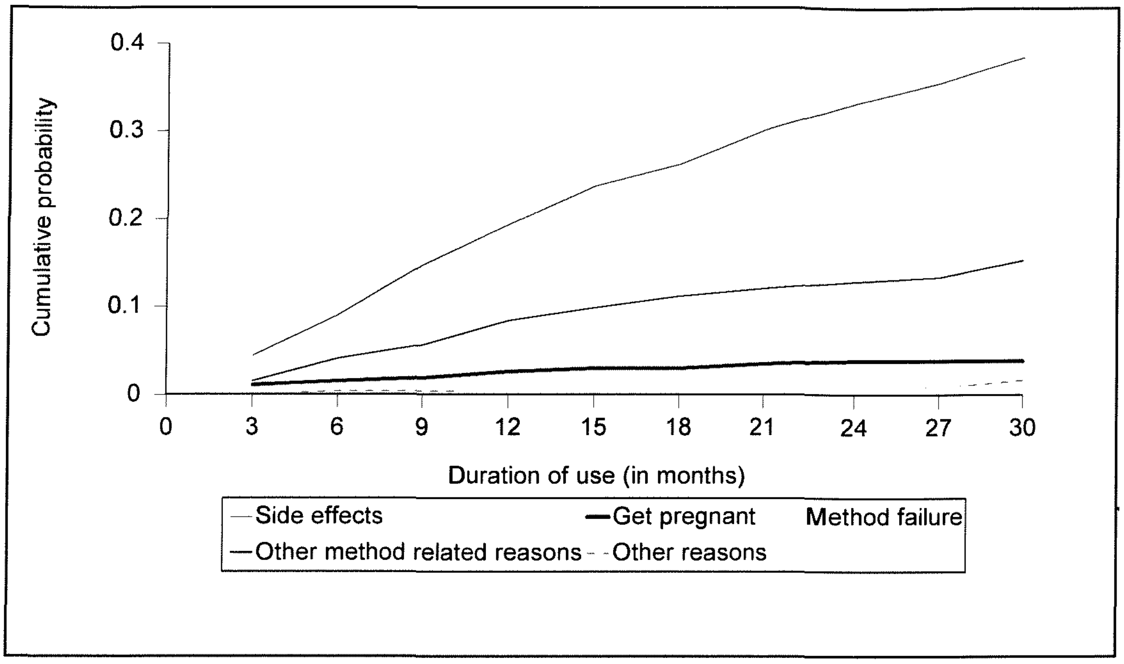
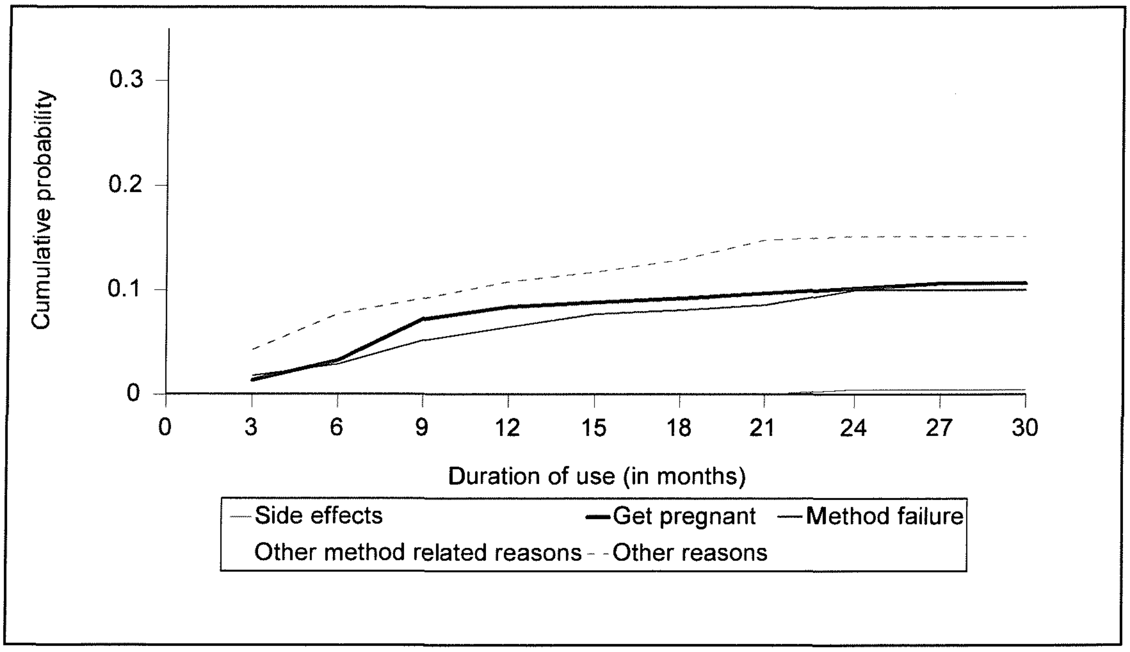


Figure 7.5 Cumulative probabilities of discontinuation among users of traditional methods according to the reasons mentioned: four rural areas of Bangladesh, 1990



7.6 Multilevel modelling using discrete-time competing risks hazards model

In a discrete-time competing risks hazards model, a function of duration of use needs to be incorporated into the model. At the initial stage, three different models for modelling duration dependence are used: (a) a linear function of the duration ($\alpha_t = \alpha_0 + \alpha_1 t$); (b) a quadratic function of duration ($\alpha_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2$); and (c) the natural logarithm of duration ($\alpha_t = \alpha_0 + \alpha_1 \ln(t)$). Only the duration function is included in the models at this stage. A Bayesian Information Criterion, *BIC* (Raftery, 1986), is used for selecting the model. Heckman and Walker (1987) have recommended the use of *BIC* for selecting models for duration data. This has proven to be very useful for model selection among contingency models (Raftery, 1995). For selecting duration dependence models, the use of *BIC* has become very popular in social science research (Yamaguchi, 1992; Wang, 1994). It is, thus, calculated using the following equation:

$$BIC = L^2 - (\log_e(N)) \times (df)$$

where L^2 is the likelihood ratio test statistic comparing the model of interest with the model with no covariates, N is the total number of observation and df is the number of parameters that the model of interest adds to the one with the only intercept model. The model that maximizes *BIC* is assumed to be the best among the models being compared. In this research, the quadratic function of duration is chosen as the best function of duration since it has the highest *BIC* value.

Along with the duration function, a series of socio-demographic variables, a limited number of economic variables and a limited number of programmatic variables are included in the model. All variables used in the descriptive analysis were included in the discrete-time competing risk hazards model analysis. As discussed in Chapter 4, one of the advantages of using a discrete-time competing risks hazards model is the scope of incorporating time-varying covariates in the model. Four variables were included as time varying in this analysis. These are the number of living sons, the number of living daughters, the age of women and the national family planning outreach workers' contact with women. While efficiently using a method of contraception, it is not possible for a woman to give birth. However, it may be possible for a woman to have experienced a death of a child while using a method of contraception. This may have an impact on her decision to continue or discontinue using the method of contraception. Family planning outreach workers' contact is measured over time once in each round (three months) for every round of contraceptive use and non-use.

Using a multinomial logistic regression model, the parameters in the discrete-time competing risks hazards model are estimated. Using one observation for each round, contraceptive use status is recorded for each interval. As a result, the data file resulted in 16,409 observations for 3,484 women. For the multinomial logistic regression, six mutually exclusive outcome categories were used. Hence, the data are arranged in such a way in order to obtain a set of five binary responses for each round of use. This approach has produced 82,045 records for the discrete-time analysis. If the data were in monthly intervals, the total number of observations would become three times 82,045. The use of such large data is computationally intensive, particularly in the case of multilevel modelling. Although the aggregated strategy throws away some information, Diamond et al. (1986) have found grouping duration into reasonably broad groups loses little accuracy. The computational time is also greatly reduced when the observations are aggregated into wider intervals of time.

In this study a two level multinomial logistic model is used with six contrasts. Multilevel multinomial models described here can be estimated by using a special macro (called *multicat*) for the MLWIN package (Goldstein et al., 1998).

In this special macro procedure, a first order Taylor series approximation is implemented to produce a linear model, which then is estimated with the algorithm of the iterative generalized least squares (IGLS). However, this procedure can produce parameter estimates which are biased towards zero when the random effects are large, especially for situations in which the level 2 units are very small (Rodriguez and Goldman, 1995). To improve the approximations used in multilevel models with discrete responses, a penalized quasi-likelihood (PQL) approach is used and higher order terms are added in the Taylor series expansion (Goldstein, 1995). The results of the multilevel discrete-time competing risks hazard model are discussed in the next sections.

7.6.1 Results of the multilevel model

7.6.1.1 Interpretation for the fixed parameters

Initially, a random effects model for each contrast of a type of discontinuation with the 'still using' group was selected. Possible two-way interactions were tested and none were found to be statistically significant. Finally, a multilevel multinomial logistic model is used where all types of contrasts of reasons for discontinuation are used. Table 7.4 displays the parameter estimates and standard errors for the multilevel discrete-time competing risks hazards model.

The fixed parameters can be interpreted in a way similar to those obtained from a standard multinomial logistic regression model. For a six-category response variable for reason for contraceptive discontinuation, the parameter estimates corresponding to the five contrasts are estimated with reference to the base category. For any contrast, the estimates of the fixed-part parameters can be exponentiated and interpreted as the average odds that the response is in the category rather than in the reference category. The actual odds of a particular response will equal the average odds plus some amount arising from the individual woman effect. However, in order to make the interpretation easier, for each covariate, 12-month cumulative probabilities of contraceptive discontinuation by reasons are computed while all other covariates are held at their mean values (Table 7.5).

After controlling for the effect of the socio-demographic, economic and programmatic variables, the overall 12-month cumulative rates of contraceptive discontinuation is reduced as compared to that obtained from multiple decrement life tables. The overall 12-month cumulative rates of contraceptive discontinuation reduced to 36.4 percent from 48.7 percent using multiple decrement life-tables. Steele (1996) and Leite (1998) also observed similar reduction in this probability in their research. However, despite the reduction in the magnitude, there is no notable discrepancy for 12-month cumulative rates of discontinuation between multiple decrement life tables and multilevel discrete-time competing risk probabilities.

The discontinuation due to side effects of contraception significantly decreases as time increases. This may not mean that the side effects due to contraceptive use decrease over time. This may be the fact that a woman tries to cope with side effects as time goes on. Discontinuations due to other method-related reasons and other reasons also significantly decrease over time.

As expected, a woman discontinues using a method to get pregnant if she has no living sons or living daughters. The low parity women appear to be more likely to stop using a contraceptive method in order to get pregnant. As soon as a woman has her first birth, her chance of discontinuing a method of contraception to get pregnant declines substantially. It is less likely that women with two or more living sons will discontinue their use for getting pregnant. It is also less likely that women with two or more living daughters will discontinue their use to get pregnant. The risk of discontinuation due to side effects appears not to be significantly associated either with the number of living sons or with the number of living daughters. Women with two or more living sons are more likely to discontinue a method because of other method-related reasons. Women with two or more living daughters are also more likely to discontinue a method because of other method-related reasons. The high rates of discontinuation due to other method-related reasons among high parity women may be due to the women switching to long term methods. Contraceptive discontinuation due to method failure appears not to be associated either with the number of living sons or with the number of living daughters.

The risk of discontinuation due to side effects of contraception increases significantly among women who want more children. A woman who uses a contraceptive method for spacing, may discontinue her use when she experiences any side effects. As expected, the women who want more children are most likely to discontinue a method to get pregnant. The 'desire for additional children' data were collected during the 1990 survey on fertility preference and are not used as time variant covariates in the regression model. One may assume that the women who do not want any more children may continue to use a method of contraception as long as they are fecund. However, there are situations where these limiters become spacers when they have lost a child during their contraceptive use period or when they changed their mind about the desired size of the family.

Women's age appears to be an important factor affecting the risk of discontinuation. The risk of discontinuation due to other method-related reasons declines with women's age. This may be due to the fact that the older women may be able to choose methods that are more likely to meet their needs. The risk of contraceptive discontinuation due to side effects increases slightly with age until age 34. However, the risk of discontinuation due to side effects declines sharply for women aged above 35. Again, the risk of discontinuation due to other reasons declines steadily with age. Women aged 35 and above may think that they are no longer capable of producing any child and they drop the method. The risk of method failure declines steadily as age increases. The decline in fecundity and in the frequency of intercourse might be one of the main reasons for lower rates of contraceptive method failure among older women. Another possible explanation for the lower failure rates among older women may be due to the fact that they might have already reached their desired family size and be more motivated to avoid conception and hence use failure.

The risk of contraceptive discontinuation due to side effects decreases with the level of education of women. More educated women appear to be less likely to discontinue using a method because of side effects. This may be because the educated women may be more aware of the merits and demerits of methods and hence may adopt a more appropriate method. More educated women may be able to use low hormone pills effectively and hence may be less exposed to side effects. Again, more educated women may have been empowered to ask the distributor about the method, whereas the less educated women may use what they receive. In addition, more educated women may also feel more confident in using traditional methods, which have very low rates of discontinuation due to side-effects. From contraceptive choice analysis presented in Chapter 6, it is observed that the more educated women are more likely to have relied on traditional methods than the less educated women.

The risk of contraceptive discontinuation due to side effects increases with the level of education of the husband. This may be due to the fact that the educated husband, when he sees his wife is facing complications/side effects while using a particular method, encourages his wife to discontinue the method. The risk of contraceptive discontinuation due to other method-related reasons appears to be declining steadily with the level of education of the husband. It appears that women of more educated husbands may be less likely to discontinue a method because of other method-related reasons. That women of educated husbands discontinue using a method of contraception may be to switch to a more suitable method.

Table 7.4: Multilevel discrete-time competing risk hazard model estimates for the effect of family planning outreach workers' contact on reasons for contraceptive discontinuation

Variables	Reasons for discontinuation (Base: Continued user)				
	Side effects	Get pregnant	Method failure	Other method related	Other reasons
Intercept	-2.330***	-7.040***	-7.063***	-2.937***	-5.482***
	(0.185)	(0.495)	(0.971)	(0.263)	(0.658)
Duration	-0.239***	0.174†	0.088	-0.239***	-0.311**
	(0.046)	(0.104)	(0.214)	(0.060)	(0.104)
Duration2	0.017***	-0.016	-0.019	0.020***	0.020†
	(0.005)	(0.011)	(0.023)	(0.006)	(0.011)
Number of living sons: (Base: 2+)					
0	0.080	1.903***	0.016	-0.416*	0.320
	(0.122)	(0.259)	(0.526)	(0.172)	(0.249)
1	-0.038	0.889***	-0.290	-0.193†	0.016
	(0.084)	(0.221)	(0.352)	(0.110)	(0.180)
Number of living daughters: (Base: 2+)					
0	-0.049	1.348***	-0.210	-0.314*	-0.076
	(0.109)	(0.232)	(0.487)	(0.150)	(0.234)
1	-0.012	0.440*	0.147	-0.224*	-0.069
	(0.080)	(0.208)	(0.342)	(0.109)	(0.177)
Desire more children: (Base: Want no more)					
Want more children	0.335***	1.279***	0.074	0.170	-0.057
	(0.090)	(0.200)	(0.433)	(0.129)	(0.203)
Age of women: (Base: 35+)					
Less than 25	0.118	-0.647*	0.730	0.693***	1.166***
	(0.133)	(0.296)	(0.596)	(0.180)	(0.292)
25-29	0.159	-0.501†	0.857†	0.558***	0.789**
	(0.109)	(0.271)	(0.457)	(0.144)	(0.245)
30-34	0.265**	-0.653*	0.656	0.341**	0.736***
	(0.099)	(0.285)	(0.401)	(0.130)	(0.213)
Education of women: (Base: No education)					
Primary and below	-0.145†	-0.183	0.250	0.060	-0.104
	(0.081)	(0.173)	(0.341)	(0.108)	(0.168)
Above primary	-0.270*	-0.374	0.744	0.277†	-0.424
	(0.134)	(0.256)	(0.494)	(0.167)	(0.261)
Education of husband: (Base: No education)					
Primary and below	0.023	-0.034	0.170	-0.199†	-0.204
	(0.079)	(0.174)	(0.337)	(0.109)	(0.179)
Above primary	0.247**	-0.119	-0.967*	-0.303*	-0.260
	(0.092)	(0.209)	(0.444)	(0.129)	(0.197)
Area of dwelling unit: (Base: 200+)					
< 200 square feet	0.145*	-0.050	0.273	0.137	-0.317*
	(0.069)	(0.148)	(0.291)	(0.094)	(0.150)
Religion: (Base: Muslim)					
Hindu and others	-0.151	-0.336	-0.033	-0.394**	-0.551*
	(0.104)	(0.225)	(0.392)	(0.150)	(0.234)
Prior use of contraception: (Base: No)					
Yes	-0.312***	0.231	-0.281	0.020	-0.250†
	(0.069)	(0.154)	(0.298)	(0.097)	(0.150)
Family planning workers contact: (Base: No)					
Yes	0.080	-0.073	0.034	-0.773***	-0.246
	(0.086)	(0.162)	(0.310)	(0.097)	(0.156)
Methods (Base: IUD)					
Traditional	-4.229***	1.723***	3.191***	1.036***	3.516***
	(1.019)	(0.391)	(0.757)	(0.225)	(0.606)
Condom	-1.198***	2.107***	2.879***	1.721***	4.185***
	(0.280)	(0.386)	(0.768)	(0.219)	(0.593)
Pill	0.454***	1.119***	-0.171	0.723***	1.792**
	(0.119)	(0.340)	(0.798)	(0.188)	(0.588)
Injectables	0.521***	0.635†	0.281	0.997***	0.848
	(0.127)	(0.370)	(0.815)	(0.198)	(0.631)
Women level random variance	0.110†	0.247	0.435	0.426***	0.273†
	(0.066)	(0.213)	(0.678)	(0.121)	(0.223)
Worker level random variance	0.022	0.044	0.347	0.166**	0.118
	(0.015)	(0.057)	(0.264)	(0.051)	(0.073)

† p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001

Table 7.5 Cumulative probabilities of method discontinuation within 12 months of starting use, by reasons and selected characteristics based on parameters estimated from the discrete-time competing risks hazards model: four rural areas of Bangladesh, 1990-92

Variables	Reasons for discontinuation				
	Side effects	Get pregnant	Method failure	Other method related	Other reasons
Number of living sons					
0	0.232	0.104	0.008	0.119	0.046
1	0.210	0.038	0.006	0.152	0.035
2+	0.217	0.016	0.008	0.184	0.034
Number of living daughters					
0	0.210	0.071	0.006	0.136	0.035
1	0.219	0.029	0.008	0.150	0.035
2+	0.219	0.018	0.007	0.186	0.037
Desire for additional children					
Want more children	0.268	0.070	0.007	0.176	0.034
Don't want more	0.199	0.020	0.007	0.155	0.037
Age of women					
Less than 25	0.212	0.023	0.009	0.217	0.060
25-29	0.223	0.026	0.010	0.191	0.042
30-34	0.249	0.023	0.008	0.155	0.040
35+	0.196	0.045	0.004	0.113	0.020
Education of women					
No education	0.232	0.032	0.006	0.153	0.039
Primary and below	0.202	0.027	0.008	0.164	0.035
Above primary	0.178	0.022	0.013	0.203	0.025
Education of husband					
No education	0.200	0.030	0.009	0.185	0.041
Primary and below	0.206	0.029	0.011	0.153	0.034
Above primary	0.256	0.027	0.003	0.137	0.032
Area of dwelling unit					
< 200 square feet	0.233	0.028	0.008	0.172	0.030
201+ square feet	0.203	0.030	0.006	0.151	0.042
Religion					
Hindu and others	0.196	0.022	0.007	0.118	0.023
Muslim	0.221	0.030	0.007	0.170	0.039
Prior use of contraception					
Yes	0.200	0.031	0.007	0.163	0.034
No	0.268	0.024	0.009	0.156	0.043
Family planning workers contact					
Yes	0.222	0.029	0.007	0.136	0.034
No	0.198	0.030	0.007	0.284	0.042
Method used					
IUD	0.248	0.011	0.005	0.074	0.007
Traditional	0.003	0.058	0.106	0.194	0.217
Condom	0.063	0.076	0.069	0.344	0.378
Pill	0.365	0.031	0.004	0.142	0.039
Injectables	0.386	0.019	0.006	0.185	0.015
Overall	0.224	0.004	0.003	0.125	0.008

As expected, the risk of contraceptive discontinuation due to side-effects decreases if a woman has prior experience of using a method of contraception. It is likely that an experienced woman may tend to continue using the method even if the method produces side effects. The risk of contraceptive discontinuation due to method failure, due to other method-related reasons and due to other reasons appears not to be statistically associated with the prior experience of using a method of contraception.

Family planning outreach workers' contact with women appears to be significantly associated with other method-related reasons. The risk of contraceptive discontinuation due to other method-related reasons declines with the family planning outreach workers' contact. This may be because the family planning outreach worker encourages women to continue using the method by providing the supply. Additionally, when a woman faces difficulties with the method and wants to discontinue using the method, the outreach worker may motivate her to switch to a more suitable method. In the absence of such a contact, the women may discontinue using the method. As anticipated, the risk of contraceptive discontinuation due to side effects appeared to be not related to the outreach family planning workers' contact. One plausible explanation may be that these outreach workers are mainly responsible for recruiting acceptors and ensuring re-supply but not for treating any side effects. These outreach workers are not paramedics. They do not have any training on treating side effects.

As in the multiple decrement life table analysis, IUDs appear to have the lowest rate of contraceptive discontinuation. Approximately 66 percent of IUD users were still using the method after 12 months of use. The main reason for discontinuing the IUD appears to be side effects. Approximately 25 percent of IUD users discontinue their method in the first 12 months because of side effects. In Bangladesh, Copper T 380A is the most widely used IUD. The Copper T 380A has the lowest failure rate of the globally distributed IUDs. IUDs may affect sperm, ova, fertilization, implantation, or the endometrium to prevent pregnancy. The exact mechanism of action of IUDs is not completely understood. The failure rate of IUDs depends on a number of administrative, client and medical variables, including ease of insertion, clinician experience, clients detection of IUD expulsion, and the clients access to the medical services (Hatcher et al., 1998). In the first year after the insertion, between 5 percent and 15 percent of women will have their IUDs removed because of bleeding or spotting (Hatcher et al., 1998). Hatcher et al. (1998) states the client may experience more days of bleeding, persistent bleeding, spotting between cycles and even pallor weakness. Approximately 2 percent to 8 percent of users spontaneously expel an IUD within the first year.

The rates of discontinuation appear to be similar for the traditional methods and pills. Approximately, 42 percent of pill users were still using the method after 12 months of use. The main reason for discontinuing the pill appears to be side effects followed by method-related reasons. Approximately 37 percent of pill users discontinue their use in the first 12 months because of side effects. Another 14 percent of pill users discontinue their use in first 12 months because of other method-related reasons. Over the past three decades, birth control pills have become an important component of most family planning programmes. Oral pills prevent pregnancy through the action of *estrogens* and *progesteins*, each acting via a different mechanism of action. In Bangladesh, pills are provided by the family planning outreach workers, generally without any physical examination or are available at pharmacies without prescription. In Bangladesh, pills containing a standard formulation of 0.5mg of *norgestrel* and 0.05mg of *ethinyl estradiol* are available. Also, a low dose pill containing 0.5mg of *norethindrone* and 0.035mg of *ethinyl estradiol* is available (Salway et al., 1994). The common side effects with the pill are: spotting, blurred vision, headaches and hypertension.

About 39 percent of injectable users were still using the method after 12 months of use. The main reason for discontinuing injectables is side effects followed by other method-related reasons. About 39 percent of injectable users discontinue their use in the first 12 months because of side effects and 19 percent of injectables users discontinue their use in the first 12 months for other method-related reasons. Family planning outreach workers distribute injectables in Bangladesh. The most commonly used injectables are *Depo-medroxy Progsterone Acetate* (DMPA) and *Norethindrone enanthate* (NET). Injectable *progestins* cause menstrual cycle irregularities for most users, principally amenorrhoea (some women prefer regular menstruation as an assurance that they are not pregnant). Excessive endometrial bleeding and amenorrhoea are the most frequent reasons for discontinuing DMPA (Hatcher et al., 1998). DMPA is very popular because it is long acting (provided at three monthly intervals). Despite the popularity and the benefits of injectable *progestins*, the possible side effects have raised some concerns.

The rates of discontinuation due to method failure for users of pills, injectables and IUDs are similar and are well below one percent after 12-months of use.

Approximately 42 percent of traditional method users were still using their method after 12 months of use. Other reasons are the major cause for discontinuation among traditional method users. Approximately 22 percent of traditional method users discontinue their method due to other reasons. As expected, discontinuation due to side effects is very low among traditional method users. The risk of method failure appears to be higher among users of traditional methods. Approximately 11 percent of traditional method users experienced a method failure in first 12 months of use. However, the second main reason reported for discontinuing traditional methods is other method-related reason (about 20 percent). Inconvenience of use and as well as desire for more efficient methods are among the main method-related reasons.

The overall discontinuation rates for the condom are the highest observed: about 89 percent of condom users discontinue using the method in the first 12 months of use. Other reasons and the other method-related reasons are the two main reasons for discontinuation of condoms. Husband's absence and unexplained causes are the main reasons for the discontinuation due to other reasons. Approximately 35 percent of condom users discontinue their use in the first 12 months because of other method-related reasons. Inconvenience of use, lack of supplies and desire to switch to a more effective method are the main reasons reported in this category. Condoms are available in Bangladesh by the family planning outreach workers and also by the pharmacies. Condoms are a safe and effective method of birth control. However, its effectiveness depends heavily on how consistently it is used. The most common error is the failure to use the condom.

7.6.1.2 Interpretation of the random parameters

A significant amount of the variation in discontinuation due to side effects and other method-related reasons still exists in spite of controlling for the effect of a wide range of socio-demographic, economic and programmatic variables in the discrete-time competing risks hazards model (Table 7.4). The random parameters for contraceptive discontinuation due to other method-related reasons are highly significant both at the women level and the worker *(unit)* level. The random parameter for contraceptive discontinuation due to side effects is significant at the women level. The random parameter for contraceptive discontinuation due to side effects at the *unit* level appears not to be significantly different from zero. The random parameter for discontinuation due to side effects and other method-related reasons may be the result of the lack of presence of some unobserved variables. For example, the opinion of husbands with regard to male dependent methods may explain a part of the unobserved variation for contraceptive discontinuation due to other method-related reasons. The random effects for contraceptive discontinuation due to side effects and due to other method-related reasons at the *unit* level may be a result of variation across the *unit*. A family planning outreach worker is assigned to each *unit*. Their role is to motivate rural women to accept family planning and to maintain supply. These outreach workers are not trained how to treat any side effects. They only pursue a woman to switch to a more suitable method if she is having problems with her current method. However, there are variations across *units* in terms of workers performance, her ability of convincing women to accept a method and her ability in providing an appropriate method to the women according to their needs. The random effects for contraceptive discontinuation due to side-effects and due to other method-related reasons at the *unit* level may be a result of the absence of some unobserved characteristics of the family planning outreach worker.

The random effects for contraceptive discontinuation due to method failure and to become pregnant at the individual level and the *unit* level is not statistically significant. The decision to become pregnant is more likely to be a function of the factors associated with women's age, her number of living sons and daughters. The lack of significance of the random effect may not be attributed to the effect of any of the variables included in the model. The method failure depends mainly on the effectiveness of the method and the consistent way of using the method. A significant random effect was expected for contraceptive discontinuation due to method failure at the women level.

One way of examining the implications of the variability across the *unit* is to use an approach adopted by Curtis et al. (1993). This approach involves estimating the probabilities of being in the response category of type *r* for different values of v_{rk}, where v_{rk} is the random effect associated with *unit* *k* for discontinuation type *r*, with a specific combination of characteristics of the women. Curtis et al. (1993) considered various values of v_{rk}. To examine the extent to which the variation across the *unit* affects the rates of discontinuation due to side effects and due to other method-related reasons, 12-month cumulative contraceptive discontinuation rates for each one of these two causes were estimated by the method of contraception for three values of the *unit*-level random effect: one standard deviation below the mean ($-\sigma_r$), the mean (zero) and one standard deviation above the mean ($+\sigma_r$) respectively (Tables 7.6 and 7.7). In addition, the 12-month cumulative contraceptive discontinuation rates due to other method related reasons were estimated by workers' contact for the same three values of the *unit* level random effect (Table 7.8). The other covariates in the model are kept fixed at their mean values.

Table 7.6 Estimated 12-month cumulative probabilities of side-effects discontinuation by method for below the mean, mean and above the mean values of the *unit* level random effect[1]: four rural areas of Bangladesh, 1990-92

	Random effect at the *unit* level		
	Below mean	Mean	Above mean
Method used:			
IUD	0.218	0.248	0.282
Traditional	0.003	0.003	0.004
Condom	0.058	0.063	0.066
Pills	0.324	0.365	0.407
Injectables	0.344	0.386	0.430

[1] Below the mean, the mean and above the mean refer to workers' work areas that are one standard deviation below the mean, the mean and one standard deviation above the mean respectively.

As can be seen from Table 7.6, the random parameter employs a moderate impact on the cumulative probabilities of discontinuation due to side effects. In case of injectables, a woman associated with an above average *unit* level random effect has her risk of discontinuing a method increased because of side effects by at least 11 percent compared to those women associated with an average random effect. In case of pills, a woman associated with an above average *unit* level random effect has her risk of discontinuing a method increased because of side effects by at least 12 percent compared to those women associated with an average random effect. A woman associated with a below average unit level random effect has her risk of discontinuation reduced a little compared to those women associated with an average *unit* level random effect.

Table 7.7 Estimated 12-month cumulative probabilities of other method-related discontinuation by method for below the mean, mean and above the mean values of the *unit* level random effect[1]: four rural areas of Bangladesh, 1990-92

	Random effect at the *unit* level		
	Below mean	Mean	Above mean
Method used:			
IUD	0.050	0.074	0.108
Traditional	0.136	0.194	0.272
Condom	0.247	0.344	0.469
Pills	0.097	0.142	0.205
Injectables	0.127	0.185	0.266

[1] Below the mean, the mean and above the mean refer to workers' work areas that are one standard deviation below the mean, the mean and one standard deviation above the mean respectively.

As can be seen from Table 7.7, the random parameter employs a strong impact on the cumulative probabilities of discontinuation due to other method-related reasons. In the case of IUDs, a woman associated with an above average *unit* level random effect has her risk of discontinuing a method because of other method-related reasons increased by 46 percent compared to those women associated with an average random effect. In the case of pills, a woman associated with an above average *unit* level random effect has her risk of discontinuing a method because of other method-related reasons increased by

44 percent compared to those women associated with an average random effect. In the case of injectables, a woman associated with an above average *unit* level random effect has her risk of discontinuing a method because of other method-related reasons also increased by 44 percent compared to those women associated with an average random effect.

In the case where there is a contact from the family planning outreach worker, a woman associated with an above average *unit* level random effect has her risk of discontinuing a method because of other method-related reasons increased by 46 percent compared to those women associated with an average random effect.

Table 7.8 Estimated 12-month cumulative probabilities of other method-related discontinuation by family planning workers' contact for below the mean, mean and above the mean values of the *unit* level random effect[1]: four rural areas of Bangladesh, 1990-92

	Random effect at the *unit* level		
	Below mean	Mean	Above mean
FP worker's contact			
Yes	0.093	0.136	0.198
No	0.196	0.284	0.406

[1] Below the mean, the mean and above the mean refer to workers' work areas that are one standard deviation below the mean, the mean and one standard deviation above the mean respectively.

7.7 Summary

Multiple decrement life tables and a multilevel discrete-time competing risks hazards model are employed in this chapter to derive cumulative probabilities of contraceptive discontinuation by reason in four rural areas of Bangladesh.

Considering the nature of the data, the discrete time-competing risks hazards model is believed appropriate to use in this research. The discrete time-competing risks hazards model used here is essentially a multinomial logistic regression model in which the women's contraceptive use status is recorded for each rounds (three months) of use. A series of socio-demographic, economic and programmatic factors are used and some are found to be statistically associated with reasons for contraceptive discontinuation. The reasons for contraceptive discontinuation are categorized as: (1) side effects; (2) wanted to become pregnant; (3) method failure; (4) other method-related reasons; and (5) other reasons.

Women's age, the number of living sons and the number of living daughters appear to have a strong effect on contraceptive discontinuation due to desire to get pregnant. In relation to discontinuation due to other method-related reasons women's age has a much stronger effect on the rates than the number of living sons and daughters. The risk of contraceptive discontinuation due to other reasons appears to be significantly associated with age of women. Interestingly, method failure was neither found to be associated with women's age nor with the number of living sons and daughters.

A weaker relationship is observed between women's level of education and contraceptive discontinuation due to desire to get pregnant. However, the level of women's education appears to have a significant effect on contraceptive discontinuation because of side effects. The higher the level of women's education the lower is the rate of contraceptive discontinuation because of side effects. However, the level of education of the husband appears to be positively associated with contraceptive discontinuation because of side effects. Which means that the risk of contraceptive discontinuation due to side effects increases with the increase in husband's education. This may be because the educated husbands are very sensitive to side effects. In a situation when there is any side effect, the educated husband may be more likely to discontinue using the current method and switch to a traditional method.

The prior use of contraception appears to have a significant impact on contraceptive discontinuation because of side effects. The risk of contraceptive discontinuation due to side effects is reduced if a woman has prior experience of using any method of contraception.

Government family planning outreach workers' contact with rural women appears to have a significant effect on the discontinuation of contraception due to other method-related reasons. It appears that the risk of contraceptive discontinuation due to other method-related reasons decreases with family planning outreach workers contact. Interestingly, outreach workers' contact shows no significant association with contraceptive discontinuation because of side effects. This may be because that the outreach workers have no training on side effect management. Their responsibility is to motivate women for contraceptive adoption and to ensure contraceptive supplies.

Few random parameters at the woman level and at the *unit* level are still significant after controlling for the effect of a range of socio-demographic, economic, and programmatic variables. Using different values at the *unit* level random effect, the estimated rates for different types of contraceptive method show that the random effect has a strong effect on the rates of contraceptive discontinuation due to other method-related reasons. Estimated rates for the government family planning outreach workers' contact using different values for the *unit* level random effect have a strong effect on the rates of contraceptive discontinuation due to other method-related reasons.

Approximately 49 percent of women discontinue their method of contraception in the first 12 months. Two major causes for contraceptive discontinuation are observed in this data: out of 49 percent, 24 percent of women discontinue their method due to side effects and 14 percent of women discontinue their method due to other method-related reasons, in first 12 months. These two major causes can be minimized if (1) side effect management and services are ensured and (2) contraceptive supply and choice are ensured. In Bangladesh, at present, female paramedics treat the side effects due to contraceptive use at the clinics. There is one female paramedic in such clinics with one clinic for each 25,000 population. When a rural woman has experienced any side effect due to method use, it is very unlikely that the woman will travel to a clinic, which may not be near to her residence. If the outreach workers are trained in managing or treating side effects the continuity of contraceptive use may increase and that will have a long term impact on the ongoing fertility transition in the country.

CHAPTER 8

CONTRACEPTIVE SWITCHING

8.1 Introduction

In the previous chapter, multilevel event history analysis was undertaken to identify the factors that are associated with the reasons for which a woman discontinues using a method of contraception. Contraceptive switching, which is another important component of contraceptive use dynamics is analysed in this chapter. The study of contraceptive switching behaviour is concerned with the behaviour following discontinuation of a method. Contraceptive switching/discontinuation and fertility are closely related since the impact of contraceptive discontinuation on fertility depends on the woman's decision whether to switch to another method or abandon use. With regard to fertility, switching between methods of the same efficiency or better is of lesser concern. Of particular concern is switching to a less effective method or abandoning use. Any switching from modern methods to less effective traditional methods or non-use may increase the risk of unintended pregnancy. Steele and Diamond (1999) observed that, in the first few months of use, women are likely to experience a method failure, as they are not fully familiar with the method. Switching to a lesser effective method or abandoning use because of side effects or other method-related reasons may suggest that the family planning programme has not been successful in meeting women's demand and needs. If a woman is able to switch immediately to another equally effective method, the implications are less problematic. Such switches may in fact be the result of a wide range of contraceptive options made available by the programme.

Contraceptive switching is the least studied component of the dynamics of contraceptive use. However, there is evidence that a large proportion of women who discontinue a method switch to another method. Using United States data, Grady et al. (1988) found that approximately fifty percent of all contraceptive discontinuation resulted in a method switch. Kost (1993) observed that women in Peru are more likely to change to another method than to discontinue use.

The analysis presented in this chapter utilizes multilevel discrete-time competing risk hazards models to study the association between the family planning outreach workers' contact and the nature of contraceptive switching using longitudinal prospective data collected in four rural areas of Bangladesh. Two multilevel discrete-time competing risk hazards models: switching from pill and switching from modern methods other than pill are used. After discontinuing a method, a woman either switches immediately to another modern method, to a traditional method, to non-use but at risk of unintended pregnancy or to non-use but not at risk of an unintended pregnancy.

8.2 Studies on contraceptive switching and definitions of switching

There are few studies in which the authors have concentrated their analysis on contraceptive switching. However, each of these analyses used different analytical approaches. Some used a life-table approach. Some used regression models. To a large extent, the approach chosen greatly depends on the nature of the contraceptive use history data available for the analysis. For example, the exact duration of use of a method in some cases is not available. Westoff and Jones (1979) analysed contraceptive switching by looking at transitions made between two defined points of time. Tsui et al. (1989) analysed contraceptive switching over a period of time defined by a calendar. The way the data are collected can play an important role in the decision of how to use them in the analytical process. For example, Westoff and Jones (1979), while using data from the United States, used a subsample of the same women interviewed in 1970 and reinterviewed in 1975. In Sri Lanka, Kane et al. (1988) used data taken from 1985 national follow-up survey of respondents who were also in the 1982 Sri Lanka Contraceptive Prevalence Survey (CPS). The 1985 survey followed a sub-sample of respondents from the 1982 survey who were currently married, had been married for three or more years and were aged between of 18 and 49 years. Haque et al. (1997) used longitudinal data for a period of eleven years. Using data from Malaysia, DaVanzo et al. (1989) looked at the change of contraceptive methods between the pair of intervals after and before the next pregnancy. Their samples were composed of ever-married women who had given at least one birth. Since it was not possible to use the duration of use data, DaVanzo et al. (1989) presented transition matrices showing the probabilities of transitions between methods. In addition, they also looked at the bivariate relationships between method switching and the woman's background characteristics.

Using multiple decrement life table, Curtis and Hammerslough (1995) classified the contraceptive use status of a woman in the month after discontinuation into one of three categories: (a) non-use because the woman has no longer need for contraception; (b) non-use (abandon use) but the woman is at risk of an unintended pregnancy and (c) switch to another method of contraception. The definitions of no longer in need of contraception were based on the reasons given for discontinuing the use: discontinued because the woman is pregnant, wants to get pregnant, or as a result of loss of eligibility due to marital separation. Similar definitions of switching behaviours are adopted and Sambisa (1996) used three types of decrement for studying contraceptive switching behaviour in Zimbabwe. However, while using similar definition of switching behaviour, Mitra and Al-Sabir (1996) use four categories of decrement for contraception in studying contraceptive switching in Bangladesh: (a) non-use because the woman has no need for contraception; (b) non-use (abandon use) but at risk of an unintended pregnancy; (c) switch to a modern method of contraception and (d) switch to a traditional method. Perez and Tabije (1996) also used four similar categories of decrement for studying contraceptive switching behaviour in the Philippines. Akhter and Ahmed (1991a) used three types of switches in their descriptive analysis of contraceptive switching: (a) discontinue using a method (non-use for any reasons); (b) switch to a modern method of contraception and (c) switch to a traditional method. The multiple decrement life table approach has also been applied in studies conducted by Kost (1993) and Steele (1996).

In order to generate switching rates, regression models have also been used to analyse contraceptive switching. To estimate the probability of a woman switching to different methods, Hamill et al. (1990) extended the descriptive analysis conducted by Tsui et al. (1989) by using a multinomial logistic regression model. The data they used only had information on contraceptive use for three years prior to the survey. While analysing contraceptive method switching using the 1987 National Indonesia Contraceptive Prevalence Survey data, Samosir (1994) extended the bivariate approach of DaVanzo et al. (1989) by using multinomial logistic regression models.

While using the United States data, Grady et al. (1989) used a competing risk hazards model in their contraceptive switching analysis. They fitted a series of models, one for each type of destination method. For analysing the changes in contraceptive behaviour in Bangladesh, Islam (1994) used a hazards modelling approach. He used a multistate proportional hazards model proposed by Kay (1982) for transitions, reverse transitions and repeated transitions.

For determining the factors associated with contraceptive switching, very few researchers have so far used multilevel models. Samosir (1994) used a multilevel multinomial logistic model while analysing contraceptive switching using 1991 Indonesian DHS data. She used random effects models to measure variation across women. To analyse contraceptive switching in Bangladesh, Steele and Diamond (1999) applied a multilevel discrete-time competing risks model with three levels: woman, cluster and district levels. They define switching as: (a) non-use but not at risk; (b) non-use but at risk of an unintended pregnancy; (c) another modern method and (d) a traditional method. In their comparative study of six developing countries, Curtis and Blanc (1997) define switching as: (a) contraceptive failure; (b) another method; (c) abandon but not in need of contraception; and (d) abandon but in need of contraception. They define contraceptive switching as episodes of use starting in the next month following discontinuation. If a woman discontinues a method and does not use any method in the month following discontinuation, Curtis and Blanc (1997) classify her as having abandoned use. Liete (1998) applied multilevel discrete-time competing risks hazards models to analyse contraceptive switching in Brazil. He used three categories of transition: (a) transitions to no method; (b) transitions to another modern method and (c) transitions to traditional methods.

8.3 Data and methodology

The data used in this chapter are the same as those used in Chapter 7. The present analysis employs three multiple decrement life tables and two multilevel discrete-time competing risk hazards models. Two separate models are used for studying transitions from the use of pill and from modern methods other than pill. The pill is the most commonly used method in Bangladesh (Mitra et al., 1997), and hence is considered separately from other modern methods. Considering the definitions used in other similar researches, a woman is categorized, after initiating a method as: (a) discontinued; (b) switched to a modern method; (c) switched to a traditional method or (d) continued using the original method. The reasons for discontinuation data are utilised to identify two broad categories of non-use: non-use but not at the risk of unintended pregnancy and non-use but at the risk of an unintended pregnancy. The first group of non-users consists of women who have discontinued use due to the reasons that they wanted to get pregnant, or are pregnant as a result of method failure. The second group of non-users consists of women who have discontinued use because of side effects and other method-related reasons.

In this research, transition from pill use is classified as one of the five types: (a) non-use but not at risk; (b) non-use but at risk of an unintended pregnancy; (c) another modern method; (d) traditional method or (e) continue using the pill. Similar definitions were used for the transition from the use of another modern method. The number of women who switched from a modern method other than pill to traditional methods was found to be very small. While performing a multivariate analysis, it was found that there were no women who have no living children and had switched from other modern method to a traditional method. In addition, only two covariates are found to be significantly associated with the transition from pill to traditional methods. Hence, the transition category from modern method other than pill to a traditional method is removed from the analysis and the transition variable ended up with four possible types of transitions from the use of modern method other than pill. An analytical approach similar to that used in Chapter 7 is employed in this chapter.

The number of women who switch from pills and from other modern methods are very small. Also, there are very few women with no living sons and no living daughters. Therefore, to overcome the problems with parameter estimation the number of living sons and daughters are added together and the number of living children is used in the analysis of contraceptive switching.

In this chapter, therefore, multiple decrement life tables are used to derive contraceptive switching rates by type of method used and by some selected socio-demographic, programmatic and economic characteristics of the woman. In order to incorporate the dependence among different transitions in the regression models, multilevel discrete-time competing risk hazards models are applied to estimate cumulative probabilities of contraceptive switching for each factor controlling for the effect of the other factors in the model.

A multilevel discrete-time competing risks hazards model is used to estimate the probability of a woman making a specific transition at a given duration of use. In the contraceptive switching analysis, to control for the effect of unobserved heterogeneity, a women-level random effect is incorporated in the regression model. The model for the analysis of switching from pill is expressed as

$$\log_e\left(\frac{\lambda_{rtij}}{\lambda_{5tij}}\right) = \alpha_{rt} + \mathrm{x}'_{tij}\beta_r + u_{rj}\,, \qquad r = 1, 2, 3, 4, \qquad (8.1)$$

where λ_{rtij} is the hazard of a switching of type *r* at time *t* for the use interval i of woman *j*. The set of covariates x_{tij} is the same for each of the four contrasts of type of contraceptive switching against continuing the same method. β_r is the vector of parameters for the contrast *r* associated with x_{tij}. A function of time α_{rt}, representing the baseline hazard, is also included in the model. In the multinomial logistic model, a set of random effects for each transition of type *r* is included: u_{rj} are the woman level random effects. As usual, each random effect is assumed to be mutually independent and follow a normal distribution: $u_{rj} \sim N(0, \sigma^2_{rj})$.

The model for the analysis of switching from modern methods other than pill is expressed as

$$\log_e\left(\frac{\lambda_{rtij}}{\lambda_{4tij}}\right) = \alpha_{rt} + \mathrm{x}'_{tij}\beta_r + u_{rj}\,, \qquad r = 1, 2, 3. \qquad (8.2)$$

Because one observation for each round of use was created to fit the discrete-time competing risks hazards model, the sample size used in the analysis was 7,986 (1,706 women) for transition from pills and 6,957 (1,474 women) for transition from other modern methods.

8.4 Descriptive analysis

8.4.1 Multiple-decrement life table switching rates by method

In the first stage of the analysis, multiple decrement life tables are used for estimating the cumulative probabilities of switching within the 12 months after a woman initiated using a method of contraception. Table 8.1 shows method-specific cumulative probabilities of switching within the 12 months of contraceptive use, calculated using multiple decrement life tables. Five possible transitions of contraceptive use are used in Table 8.1: transit to non-use but not at risk, transit to non-use but at risk of an unintended pregnancy, switch to another modern method, switch to a traditional method or continue using the same method. Switching to an alternative method of contraception or to non-use but at risk of an unintended pregnancy is the main focus of interest. Overall, more than a half of the women who discontinue their use switch to non-use but at risk of an unintended pregnancy (Table 8.1). Another one-fifth of the women who discontinue their use are switching to non-use but are not at risk of an unintended pregnancy.

The proportion of women who discontinue use and do not adopt another method of contraception is likely to have a larger impact on fertility in the country. From Table 8.1, it can be seen that the pill users who discontinue use of contraception are more likely to become non-users (40 percent out of 49 percent discontinuations) rather than switching to another modern method. It is not likely (less than 1 percent out of 49 percent discontinuations) that the pill users switch to a traditional method of contraception. The users of injectables, IUDs and condoms are more likely to switch to an alternative modern method of contraception compared to the pill users. Since the pill is the most widely used method in Bangladesh, the users who switch from injectables, IUDs or condoms may possibly switch to pills rather than any other modern method. Generally, users of injectables, IUDs, or pills are not likely to switch to a traditional method.

However, the rate of transition to a traditional method is considerably higher among users of condoms compared to the users of any other modern method. Users of traditional methods are likely to switch to a modern method of contraception. More than two-thirds of women, who discontinue using condoms or traditional methods, become non-users within 12 months of initiation of use.

Table 8.1: Percentage distribution of women surveyed who originally used a method, by whether they continued using that method, switched to another method or stopped using altogether in 12-months: four rural areas of Bangladesh, 1990-92

	Type of transition					Total %	(n)
	Non-use and not at risk [a]	Non-use and at risk [b]	Another modern method	Traditional method	Continue		
Pill	9.9	30.2	7.8	0.9	51.2	100.0	(1706)
Injectables	4.2	31.1	15.4	0.4	48.9	100.0	(926)
IUD	3.4	15.1	12.2	0.8	68.5	100.0	(272)
Condom	16.9	28.1	17.8	4.8	32.4	100.0	(302)
Traditional	17.8	14.5	15.5	-	52.2	100.0	(278)
Overall	9.2	27.7	11.7	1.0	50.5	100.0	(3843)

[a] Discontinuation due to the reasons that the woman becomes pregnant after a contraceptive method failure or the woman wanted to become pregnant

[b] At risk of an unintended pregnancy, that is, discontinuation due to side effects and other method-related causes.

Table 8.2 shows the percentage distribution of women who switch to another method of contraception by their method of origin and the method they switch to. Almost two-thirds of pill users switch to injectables. Only 8 percent of pill users switch to IUDs. However, the users of injectables, IUDs and condoms are more likely to switch to the pill. More than four-fifths of injectable users switched their method to pill within 12 months of initiating use. More than a half of IUDs and condom users switch their method to pill within 12 months of the initiation of use. Almost half of the traditional method users switch to the pill use within 12 months of the initiation of use. The rates of switching by different demographic, socio-economic and programmatic factors are analysed in the next section.

Table 8.2: Percentage distribution of women who reported switching to another method, by their original method according to the method they switched: four rural areas of Bangladesh

	Destination method						
	Pill	Injectables	IUD	Condom	Traditional	Total	(n)
Pill	-	66.8	7.8	12.9	12.4	100	(217)
Injectables	86.8	-	3.2	8.5	1.6	100	(189)
IUD	52.4	36.5	-	4.8	6.4	100	(63)
Condom	55.3	18.4	1.3	-	25.0	100	(76)
Traditional	48.1	21.2	5.8	25.0	-	100	(52)

8.4.2 Multiple-decrement life table switching rates by selected background characteristics

Differentials in the 12-month cumulative probabilities of switching by socio-demographic, economic and programmatic characteristics are shown in Tables 8.3 and 8.4 respectively for pill users and other modern method users. These probabilities are calculated using multiple-decrement life tables. A range of socio-demographic and economic characteristics are considered, including the number of living children, desire for more children, woman's age and education, husband's education, area of dwelling unit, and religion. Programmatic characteristics, such as prior use of contraception and family planning outreach workers' contacts are considered.

From Table 8.3, it is observed that, overall, 48.8 percent of the pill users discontinue their method within first 12 months of initiation of use. Mitra and Al-Sabir (1996) observed a slightly lower discontinuation rate (44.6 percent) using calendar data in Bangladesh. About 30 percent of pill users discontinue their method and risk an unintended pregnancy. From Table 8.4, it is observed that, overall, half of the modern method users other than pill users discontinue their use within 12 months of initiation of use. Twenty eight percent of modern method users other than pill users discontinue their method and risk an unintended pregnancy. Sixteen percent of modern method users other than pill users switched to other modern methods within 12 months of use.

Among the pill users, the cumulative probability of transiting to non-use but not at risk of an unintended pregnancy declines sharply with the number of living children. The cumulative probability of transiting to non-use but at risk of an unintended pregnancy declines slowly with the number of living children among the pill users (Table 8.3). Similar relationships and trends are also observed among women who are other modern method users (Table 8.4).

Among the pill users and the users of other modern methods, women who do not want more children are less likely to discontinue their use and risk an unintended pregnancy. They are also less likely to discontinue their use and become not at risk of an unintended pregnancy. Women who do not want more children are more likely to switch to a traditional method. Women who do not want more children are more likely to switch from pills to another modern method compared to the women who want more children. This may be because the women who decided to limit their family size, are more likely to switch to a long-term method, such as IUDs or sterilizations.

Among the pill users, the probability of transiting to non-use but not at risk of an unintended pregnancy decreases with the age of the woman. For both the pill users and the users of other modern methods, the probability of transiting to non-use but at risk of an unintended pregnancy declines with age of the woman. This may be due to the fact that the older women may already have completed their desired family size and may think that they are out of risk of any conception because of their older age.

Among the pill users, the educated women are more likely to transit to non-use but not at risk of an unintended pregnancy; both the educated women and their educated husbands are more likely to switch to traditional methods. This may be because the educated women and their educated husbands are more likely to move to a traditional method when there is any side effects with the pill (Table 8.3). For both the pill users and the users of other modern methods, the uneducated or less educated women appear to be more likely to discontinue their method and to become at risk of an unintended pregnancy. This may be because the uneducated or the less educated women are more likely to discontinue a method whenever they face any side effects or experience any method-related problems. However, among the users of other modern methods, it appears that the educated women and the educated husbands are more likely to switch to other modern methods (Table 8.4).

People living in a bigger dwelling unit are assumed to be richer in rural Bangladesh. Since reliable income data are not available, the size of the dwelling unit is assumed to be a proxy of the economic condition of rural Bangladeshi people. Among the pill users and the users of other modern methods, the probability of transiting to non-use both at risk of unintended pregnancy and not at risk of unintended pregnancy is lower among women who have the size of the dwelling unit larger than 200 square feet (Tables 8.3 and 8.4). Among the pill users, the cumulative probability of switching to a traditional method is higher among women who have a dwelling unit less than 201 square feet.

Table 8.3: Cumulative probabilities of switching for pill users within 12 months, by types of transitions and selected demographic characteristics: four rural areas of Bangladesh

	Types of transition					(n)
	Non-use and not at risk	Non-use and at risk	Other modern	Traditio-nal	Continue	
Number of living children						
0	0.347	0.364	0.061	0.016	0.212	(88)
1	0.144	0.328	0.057	0.003	0.468	(356)
2	0.101	0.308	0.089	0.015	0.487	(412)
3+	0.058	0.284	0.083	0.007	0.568	(850)
Desire for additional children						
Want more	0.168	0.340	0.074	0.003	0.415	(632)
Don't want more	0.059	0.279	0.081	0.012	0.569	(1074)
Age of women						
Less than 25	0.164	0.365	0.080	0.002	0.389	(518)
25-29	0.106	0.296	0.089	0.019	0.490	(442)
30-34	0.067	0.291	0.106	0.006	0.530	(345)
35+	0.041	0.240	0.041	0.008	0.670	(401)
Education of women						
No education	0.090	0.313	0.079	0.007	0.511	(1021)
Primary	0.103	0.288	0.071	0.010	0.528	(491)
Above primary	0.135	0.276	0.091	0.011	0.487	(194)
Education of husband						
No education	0.104	0.314	0.089	0.005	0.488	(763)
Primary	0.108	0.269	0.070	0.002	0.551	(445)
Above primary	0.083	0.311	0.069	0.019	0.518	(498)
Area of dwelling unit						
< 200 square feet	0.118	0.312	0.085	0.010	0.475	(863)
201+ square feet	0.079	0.291	0.071	0.007	0.552	(843)
Religion						
Muslim	0.103	0.303	0.080	0.008	0.506	(1506)
Hindu and others	0.064	0.287	0.062	0.017	0.570	(200)
Prior use of contraception						
No	0.108	0.390	0.074	0.005	0.423	(648)
Yes	0.094	0.250	0.080	0.011	0.565	(1058)
Family planning workers' contact						
No	0.098	0.376	0.039	0.015	0.472	(396)
Yes	0.099	0.280	0.090	0.007	0.524	(1310)
Overall	0.099	0.302	0.078	0.009	0.512	(1706)

Table 8.4: Cumulative probabilities of switching from modern methods other than pill within 12 months, by types of transitions and selected demographic characteristics: four rural areas of Bangladesh

	Types of transition				(n)
	Non-use and not at risk	Non-use and at risk	Other modern	Continue	
Number of living children					
0	0.180	0.471	0.170	0.178	(43)
1	0.124	0.323	0.154	0.399	(281)
2	0.047	0.263	0.184	0.506	(359)
3+	0.052	0.264	0.143	0.541	(791)
Desire for additional children					
Want more children	0.104	0.347	0.165	0.384	(494)
Don't want more	0.050	0.247	0.151	0.552	(980)
Age of women					
Less than 25	0.101	0.337	0.189	0.373	(412)
25-29	0.041	0.280	0.161	0.518	(365)
30-34	0.087	0.253	0.173	0.487	(309)
35+	0.043	0.243	0.102	0.612	(388)
Education of women					
No education	0.064	0.304	0.146	0.486	(999)
Primary	0.076	0.250	0.154	0.480	(358)
Above primary	0.071	0.168	0.240	0.521	(117)
Education of husband					
No education	0.066	0.327	0.132	0.475	(735)
Primary	0.075	0.236	0.166	0.523	(388)
Above primary	0.063	0.232	0.194	0.511	(351)
Area of dwelling unit					
< 200 square feet	0.071	0.310	0.151	0.468	(805)
201+ square feet	0.063	0.244	0.161	0.532	(669)
Religion					
Muslim	0.070	0.292	0.157	0.481	(1297)
Hindu and others	0.049	0.196	0.144	0.611	(177)
Prior use of contraception					
No	0.068	0.333	0.140	0.459	(495)
Yes	0.067	0.254	0.164	0.514	(979)
Family planning workers' contact					
No	0.084	0.391	0.084	0.441	(302)
Yes	0.064	0.254	0.173	0.509	(1172)
Overall	0.068	0.280	0.156	0.496	(1474)

Among both pill users and the users of other modern methods, a Hindu woman is less likely to transit to non-use and risk an unintended pregnancy (Tables 8.3 and 8.4). Among both pill users and the users of other modern method, a Hindu woman is also less likely to transit to non-use but not at risk of an unintended pregnancy. For pill users, the probability of switching to a traditional method is higher among Hindus compared to Muslims. This may be due to the fact that a Hindu woman, when she faces side effects with the pill, is more likely to switch to a traditional method.

Prior use of contraception appears to be related to lower rates of contraceptive discontinuation. For the pill users and the users of other modern methods, the cumulative probability of discontinuation but becoming at risk of an unintended pregnancy is higher among women who have not used any method of contraception prior to the current episode of use (Tables 8.3 and 8.4). This may be the fact that a woman who has experience of using a method is less likely to discontinue a method because of side effects or other method related reasons. Interestingly, among the pill users, the cumulative probability of switching to a traditional method is higher for a woman who has experience of using any method of contraception compared to a woman who has no experience of using any method of contraception (Table 8.3). This may be because a prior user may know the side effects related to pill and when she experiences such side effects it is likely that she moves to a side-effect free traditional method.

For the pill users and the users of other modern methods, when there is contact from a family planning outreach worker, the cumulative probability of switching to another modern method is higher, and the cumulative probability of discontinuation and becoming at risk of an unintended pregnancy is lower, compared to a situation where there is no contact from the family planning outreach worker (Tables 8.3 and 8.4). For the pill users, the worker contact reduces the chance of transiting to a traditional method. When a woman faces any side effects or any other method-related problem with the pill or any other modern method, the outreach workers' contact reduces the chance of discontinuing the method and increases the chance of switching to another suitable modern method. The family planning outreach workers' main role is to motivate and recruit family planning acceptors and on demand, distribute non-clinical family planning methods (mainly pills, condoms and injectables) to the rural women of reproductive ages. A worker contact motivates a woman to try to use another modern method if a particular method does not suit.

8.5 Multilevel discrete-time competing risks hazards models

A function of duration of use is needed to specify the discrete-time competing risks hazards model. Similar to Section 7.5, three different models for modelling the duration dependence are used. Using the Bayesian Information Criterion (*BIC*), the quadratic function of duration is chosen as the best function of duration. A description of *BIC* is given in Section 7.5.

Along with the duration function, a series of socio-demographic variables, and a limited number of economic and programmatic variables are included in the model. All the variables used in the life table analyses are also included in the discrete-time competing risks hazards model. In the discrete-time competing risks hazards regression model, three variables were included as time varying covariates: the number of living children, the age of women, and the contact from a family planning outreach worker. Two discrete-time competing risk hazards models are used: for the pill users and for the other modern method users.

The parameters in the two discrete-time competing risks hazard models are estimated using multinomial logistic regression models. For the pill users, five mutually exclusive outcome categories were used: switching to non-use but not at risk, to non-use but at risk of an unintended pregnancy, to another modern method, to a traditional method or remaining a continued user of pill. For the users of modern methods other than pills, four mutually exclusive outcome categories were used: switching to non-use but not at risk, to non-use but at risk of an unintended pregnancy, to another modern method or remaining a continuing user of a modern method other than the pill. Switching to a traditional method from another modern method was excluded because of the low number of cases.

For the pill users, initially a two level multinomial logistic model is used with five contrasts. For the users of other modern methods, another two level multinomial logistic model is used with four contrasts. A special macro, called *multicat* (Yang et al., 1999), is used for these models using the MLwiN package (Goldstein et al., 1998). As the process of estimation is iterative, each iteration took a substantial amount of time to converge. The random parameters at the *unit* level were either found zero or insignificant and hence the *unit* level random parameters are dropped and only the women level random parameters are kept in both the models. As the second order PQL fails to converge, first order PQL is used for both the models. Yang (1997) observed that a first order PQL is the best procedure in terms of convergence. The results of the multilevel discrete-time competing risks hazard models for the pill users and the users of other modern method are discussed in the following sections.

8.5.1 Results of the multilevel discrete-time hazards models

8.5.1.1 Interpretation of the fixed parameters

For comparative purposes, it was decided to use the same set of covariates in both the transitions– from pill use and from other modern method use. Possible two-way interactions were tested and none were found to be statistically significant. The parameter estimates and standard errors for the multilevel discrete-time competing risks hazards models are displayed respectively in Tables 8.5 and 8.6 for the pill users and for the users of other modern method. To make the interpretation easier, 12-month cumulative probabilities of contraceptive switching from the use of pills and the use of other modern method to different state of transitions are estimated for each covariate holding all other covariates at their mean values. The estimated cumulative probabilities are displayed respectively in Tables 8.7 and 8.8 for the pill users and the users of other modern methods.

Among the pill users, the transition from using to non-use and at risk of an unintended pregnancy significantly decreases with time. This negative effect does not mean that side effects reduce with time. This may be because the women in Bangladesh try to adjust to side effects with pills (Table 8.5). The transition from using the pill to using other modern methods also significantly decreases over time. Similar relationships between transition to non-use and becoming at risk of an unintended pregnancy and time, and between transition to other modern method and time are also observed among women who are the users of any other modern method (Table 8.6).

Among pill users, the number of living children appears to be significantly associated with the transition to non-use but not at risk of an unintended pregnancy (Table 8.5). Among the pill users, the probability of transiting to non-use and becoming at risk of unintended pregnancy declines with number of living children. Since the incidence of modern method failure is very low in these data, it can be expected that the woman in the 'non-use while not at risk of unintended pregnancy' category will highly be represented by women who discontinue using the method because they wish to get pregnant.

Among the users of other modern methods, the number of living children appears to be significantly associated with the transition to non-use but not at risk and also with the transition to non-use but at risk of an unintended pregnancy (Table 8.6). Among the users of other modern methods, the probability of transition to non-use but at risk of an unintended pregnancy also decreases with number of living children. This may be because a woman with three or more living children is less likely to discontinue the pill or other modern method in order to get pregnant. It is likely that a low parity woman, when she faces a side effect, may discontinue use and risk an unintended pregnancy. Low parity women are generally young women and are likely to be new users.

For both pill users and users of another modern method, the desire for more children is significantly associated with the transition to non-use but not at risk and also transition to non-use but at risk of an unintended pregnancy (Tables 8.5 and 8.6). As expected, the women who want more children are more likely to transit to non-use but not at risk. The reason may be that the women who want more children are likely to discontinue their method to get pregnant. The women who want more children are also more likely to transit to non-use but at the risk of an unintended pregnancy. Since these women have not completed their desired family size, they discontinue their use and risk an unintended pregnancy when they face any side effects or other method-related problems.

Among the pill users, the woman's age appears to be significantly associated with the risk of transition to other modern methods. These findings are consistent with the findings observed by Steele (1996) using Bangladeshi national data. Among the pill users, who are aged 35 and above, the cumulative probability of switching to a modern method is 0.04, while the probability of switching to a modern method is 0.10 for the women aged less than 25 (Table 8.7). Since the use of IUDs and sterilization has a declining trend in Bangladesh, these pill users who moved to another modern method are likely to move to injectables. Considering the side effects related to injectable use, these pill users may be less likely to switch to injectables. Probably they already have adjusted to any side effects of the pills and are less likely to switch to another modern method. Among the users of other modern methods, the chance of moving to another modern method decreases with age (Table 8.6). This could be due to the difficulties with the current method or because these women may want to limit rather than space their births. For the pill users, the probability of a switch to non-use but not at risk of unintended pregnancy is lower among older women.

Among the pill users, the risk of discontinuation but at risk of an unintended pregnancy declines with the level of education of the woman. However, the relationship appears not to be significant at 0.05 level (Table 8.5). Among the pill users, the cumulative probability of discontinuation but at risk of an unintended pregnancy is 0.24 for women with above primary level education, whereas, for the women with no education, the probability is 0.32 (Table 8.7). This may be because educated women try to adjust to the side effects or other method-related problems. Among the pill users, the higher educated women appear to be more likely to switch to other modern method. The relationship is not significant at 0.05 level. Interestingly, among the pill users, husbands' education appears to be significantly associated with transition to a traditional method. An educated husband, when he observes his wife faces side effects with the pill, may switch to another safe method or opt for a side effect free traditional method if no other modern methods are available.

Among the users of other modern methods, the risk of transiting to non-use but at risk of an unintended pregnancy declines with the level of education of women (Table 8.6). This may be because women with education above primary education are aware of the side effects related to other modern methods, and wanted to continue using the method even if they are having side-effects or other method-related problems.

Table 8.5: Multilevel discrete-time competing risk hazard model estimates and standard errors (SE) for the effect of family planning outreach workers' contact on the transitions from the pill use, by types of transitions and selected demographic characteristics: four rural areas of Bangladesh 1990-92

Covariates	Types of transition							
	Non-use and not at risk/continue		Non-use and at risk/continue		Other modern/ continue		Traditional/ continue	
	Est.	(S.E.)	Est.	(S.E.)	Est.	(S.E.)	Est.	(S.E.)
Constant	-4.298***	(0.355)	-1.143***	(0.183)	-3.639***	(0.382)	-5.821***	(0.999)
Duration	-0.039	(0.104)	-0.279***	(0.059)	-0.484***	(0.109)	-0.024	(0.292)
Duration squared	0.001	(0.011)	0.024***	(0.006)	0.043***	(0.011)	0.009	(0.027)
Number of living children:								
(Base: 3+)								
0	1.562***	(0.319)	0.319	(0.262)	-0.664	(0.575)	1.540	(1.304)
1	0.333	(0.268)	0.049	(0.171)	-0.657*	(0.319)	-0.072	(1.017)
2	0.246	(0.219)	0.053	(0.128)	-0.206	(0.215)	0.203	(0.564)
Desire for more child:								
(Base: Don't want more)								
Want more child	0.944***	(0.182)	0.255*	(0.116)	0.120	(0.204)	-0.817	(0.671)
Age of women: (Base: 35+)								
Less than 25	0.307	(0.315)	-0.042	(0.174)	0.840*	(0.327)	-0.378	(0.940)
25-29	0.437	(0.277)	0.034	(0.140)	0.869***	(0.258)	0.844	(0.590)
30-34	0.486 †	(0.265)	0.098	(0.128)	0.880***	(0.236)	-0.242	(0.647)
Education of women: (Base: No education)								
Primary	0.072	(0.175)	-0.065	(0.107)	0.165	(0.188)	0.096	(0.505)
Above primary	0.186	(0.254)	-0.280 †	(0.170)	0.538 †	(0.286)	-0.993	(0.780)
Education of husband:								
(Base: No education)								
Primary	-0.131	(0.178)	-0.011	(0.108)	-0.291	(0.192)	-0.987	(0.817)
Above primary	-0.059	(0.211)	0.185	(0.125)	-0.364	(0.228)	1.275*	(0.546)
Area of dwelling unit: (Base: 201+ square feet)								
< 200 square feet	0.400**	(0.151)	0.153 †	(0.090)	0.171	(0.162)	0.284	(0.450)
Religion: (Base: Muslim)								
Hindu and others	-0.396 †	(0.237)	-0.234 †	(0.137)	-0.708*	(0.290)	-0.118	(0.599)
Prior use: (Base: No)								
Yes	-0.071	(0.151)	-0.540***	(0.091)	-0.001	(0.174)	0.546	(0.582)
FP workers' contact: (Base: No)								
Yes	0.028	(0.169)	-0.431***	(0.093)	0.625**	(0.230)	-1.118**	(0.417)
Random effect variance								
Women level	0.214	(0.201)	0.310***	(0.091)	0.382	(0.264)	1.857	(1.176)

[1] To permit estimation, the coefficient for one category of each main effect is constrained to 0. This 'omitted category' is termed as 'Base' and is kept under parentheses.

Note: † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 8.6: Multilevel discrete-time competing risk hazard model estimates and standard errors (SE) for the effect of family planning outreach workers' contact on the transitions from other modern method (other than pills) use, by types of transitions and selected demographic characteristics: four rural areas of Bangladesh 1990-92

Covariates	Types of transition					
	Non-use and not at risk/continue		Non-use and at risk/continue		Other modern/ continue	
	Estimate	(S.E.)	Estimate	(S.E.)	Estimate	(S.E.)
Constant	-4.421***	(0.457)	-1.174***	(0.222)	-3.478***	(0.322)
Duration	0.223	(0.145)	-0.214**	(0.071)	-0.191*	(0.092)
Duration squared	-0.030*	(0.015)	0.015*	(0.007)	0.010	(0.010)
Number of living children: (Base: 3+)						
0	1.796***	(0.539)	1.017**	(0.352)	0.478	(0.467)
1	1.061**	(0.367)	0.141	(0.213)	-0.178	(0.266)
2	-0.048	(0.320)	0.067	(0.158)	0.119	(0.186)
Desire for additional children: (Base: Don't want more)						
Want more	0.688**	(0.254)	0.465***	(0.138)	0.249	(0.170)
Age of women: (Base: 35+)						
Less than 25	-0.145	(0.387)	-0.230	(0.203)	0.558*	(0.252)
25-29	-0.193	(0.346)	-0.133	(0.164)	0.417*	(0.210)
30-34	0.428	(0.290)	-0.046	(0.152)	0.423*	(0.195)
Education of women: (Base: No education)						
Primary	0.029	(0.227)	-0.090	(0.131)	-0.151	(0.163)
Above primary	0.031	(0.379)	-0.572*	(0.252)	0.166	(0.246)
Education of husband: (Base: No education)						
Primary	-0.017	(0.221)	-0.307*	(0.128)	0.089	(0.157)
Above primary	-0.258	(0.279)	-0.127	(0.152)	0.211	(0.183)
Area of dwelling unit: (Base: 201+ square feet)						
< 200 square feet	0.018	(0.197)	0.184†	(0.112)	-0.077	(0.137)
Religion: (Base: Muslim)						
Hindu and others	-0.762*	(0.363)	-0.312†	(0.176)	-0.089	(0.194)
Prior use of contraception: (Base: No)						
Yes	0.186	(0.209)	-0.239*	(0.113)	0.182	(0.147)
FP workers' contact: (Base: No)						
Yes	-0.186	(0.219)	-0.593***	(0.112)	0.560**	(0.191)
Random effect variance						
Women level	0.320	(0.315)	0.562***	(0.125)	0.478**	(0.184)

[1] To permit estimation, the coefficient for one category of each main effect is constrained to 0. This 'omitted category' is termed as 'Base' and is kept under parentheses.

Note: † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 8.7: Estimated cumulative probabilities of switching from pills within 12 months, by types of transitions and selected demographic characteristics: four rural areas of Bangladesh

	Types of transition				
	Non-use and not at risk	Non-use and at risk	Other modern	Traditi-onal	Continue
Number of living children					
0	0.276	0.363	0.043	0.018	0.299
1	0.090	0.308	0.049	0.004	0.550
2	0.081	0.307	0.076	0.005	0.531
3+	0.064	0.292	0.094	0.004	0.546
Desire for additional children					
Want more child	0.118	0.335	0.098	0.002	0.448
Don't want more	0.048	0.274	0.091	0.006	0.581
Age of women					
Less than 25	0.076	0.283	0.096	0.003	0.542
25-29	0.085	0.301	0.097	0.010	0.506
30-34	0.089	0.319	0.098	0.003	0.490
35+	0.057	0.302	0.042	0.004	0.594
Education of women					
No education	0.072	0.316	0.069	0.005	0.538
Primary	0.077	0.296	0.082	0.006	0.539
Above primary	0.087	0.240	0.119	0.002	0.552
Education of husband					
No education	0.079	0.285	0.093	0.004	0.538
Primary	0.070	0.286	0.071	0.002	0.572
Above primary	0.074	0.339	0.064	0.015	0.509
Area of dwelling unit					
< 200 square feet	0.091	0.320	0.083	0.005	0.500
201+ square feet	0.063	0.283	0.072	0.004	0.577
Religion					
Muslim	0.078	0.308	0.084	0.005	0.525
Hindu and others	0.055	0.255	0.043	0.004	0.642
Prior use of contraception					
No	0.075	0.421	0.074	0.003	0.427
Yes	0.074	0.261	0.079	0.006	0.580
Family planning workers' contact					
No	0.071	0.410	0.046	0.011	0.462
Yes	0.076	0.277	0.088	0.004	0.555
Overall	0.031	0.500	0.031	0.007	0.432

Table 8.8: Estimated cumulative probabilities of switching from modern methods (other than pills) within 12 months, by types of transitions and selected demographic characteristics: four rural areas of Bangladesh

	Types of transition			
	Non-use and not at risk	Non-use and at risk	Other modern	Continue
Number of living children				
0	0.207	0.567	0.197	0.029
1	0.121	0.288	0.124	0.467
2	0.041	0.272	0.170	0.516
3+	0.043	0.258	0.153	0.546
Desire for additional children				
Want more children	0.067	0.343	0.174	0.416
Don't want more children	0.036	0.231	0.145	0.588
Age of women				
Less than 25	0.044	0.237	0.193	0.527
25-29	0.042	0.261	0.168	0.529
30-34	0.076	0.279	0.165	0.479
35+	0.051	0.299	0.111	0.539
Education of women				
No education	0.050	0.288	0.156	0.506
Primary	0.053	0.267	0.136	0.545
Above primary	0.054	0.168	0.190	0.589
Education of husband				
No education	0.054	0.300	0.141	0.504
Primary	0.055	0.226	0.157	0.562
Above primary	0.042	0.266	0.175	0.517
Area of dwelling unit				
< 200 square feet	0.051	0.292	0.147	0.510
201+ square feet	0.050	0.246	0.161	0.542
Religion				
Muslim	0.056	0.279	0.154	0.510
Hindu and others	0.027	0.213	0.147	0.613
Prior use of contraception				
No	0.044	0.319	0.133	0.504
Yes	0.054	0.254	0.161	0.531
Family planning workers' contact				
No	0.057	0.422	0.093	0.427
Yes	0.050	0.244	0.170	0.536
Overall	0.039	0.518	0.053	0.389

Among pill users, Hindu and 'other religious' women are significantly less likely to switch to other modern methods (Table 8.5). Hindu women are more likely to continue using the pill. Among the pill users, the cumulative probability of discontinuation but not at risk of an unintended pregnancy is lower for Hindu and others compared to Muslim women. Among the pill users, the cumulative probability of discontinuation and at risk of an unintended pregnancy for Hindu and others is also lower compared to the Muslims (Table 8.7). However, these relationships are not significant at the 0.05 level. Among other modern method users, a Hindu or 'other religious' woman is less likely to discontinue her method and become not at risk of an unintended pregnancy (Table 8.6). Among the users of other modern methods, the cumulative probability of discontinuation but not at risk of an unintended pregnancy is 0.03 for Hindus and others, whereas, for Muslims, the probability is 0.06 (Table 8.8). A Hindu woman, who uses another modern method, almost always discontinues using only when she wants to get pregnant. For the users of other modern methods, the risk of discontinuation and becoming at the risk an unintended pregnancy is lower among Hindu and other religious women. However, the relationship is not significant at the 0.05 level.

A variable relating to a woman's experience of using any method prior to the use episode of the current method is included in the regression model. Because of the lack of information about the reasons for the discontinuation for the previously used method, the reasons for discontinuation for a previously used method could not be used. Hence, only a dichotomous response is used indicating whether the woman had used any method of contraception in the past prior to the current episode of use.

Among the pill users, if a woman has used a method in the past, the risk of transiting to non-use and becoming at risk of an unintended pregnancy declines significantly (Table 8.5). Among other modern method users, the risk of transiting to non-use but at risk of an unintended pregnancy declines significantly for women who have used any method of contraception prior to the current episode (Table 8.6). Since a prior user may know of the problems or may have experience with the problems, it is likely that the prior user may tend to continue using the pill even if she experiences side effects or other method-related problems with the pill. These findings suggest that the current use behaviour is indeed linked to the past experience.

Among the pill users, family planning outreach workers' contact with rural women appears to be significantly associated with the transition to non-use but at risk of an unintended pregnancy, transition to other modern method and transition to a traditional method (Table 8.5). The risk of transition from pill use to non-use but at risk of an unintended pregnancy declines significantly when there is a contact from the family planning outreach worker. This may be because the worker-woman contact may lead to a wide choice of contraceptives and hence may lead to low transition rates to non-use and becoming at risk of an unintended pregnancy. If there is any contact from the family planning outreach worker, the risk of transition from pill use to another modern method increases significantly. It is also likely that when a woman faces problems with pills, the family planning outreach worker may offer the woman another modern method instead of allowing her to become a non-user but at risk of an unintended pregnancy. In the absence of such worker-client contact, these women may either drop use or may switch a traditional method. The finding in this research validates this assumption. If there is any contact from the outreach worker, the probability of switching from pill use to a traditional method declines significantly.

Similar findings are also observed for the users of other modern methods. The probability of transiting from other modern method use to non-use but at risk of an unintended pregnancy declines significantly when there is contact from a family planning outreach worker (Table 8.6). The probability of switching from 'other' modern method use to another modern method increases significantly with the contact of a family planning worker. This shows that worker-woman contact may reduce a woman's risk of discontinuing and becoming at risk of an unintended pregnancy, and may also reduce the risk of a woman's transition to a traditional method. However, the worker-women contact may increase a woman's chance of transiting to a modern method of contraception.

8.5.1.2 Interpretation of the random parameters

A large amount of variation in transiting risks from pill use and the use of other modern methods remains unexplained even after controlling for a wide range of socio-demographic, economic and programmatic factors. The random parameter estimates at the woman level are shown in Tables 8.5 and 8.6 respectively for the pill users and the users of other modern methods. The random parameter at the woman level is highly significant only for transitions from pill to non-use but at risk of an unintended pregnancy (Table 8.5). However, for the users of other modern methods, the random parameter at the woman level is also highly significant for transitions to non-use but at risk of unintended pregnancy and transitions to another modern method (Table 8.6).

The large amount of unexplained variation at the woman level indicates that unobserved factors at the individual level have an important impact on contraceptive switching behaviour. Unobserved individual-level factors which may potentially influence the switching behaviour include the level of dedication and enthusiasm to continue using a method of family planning.

In order to evaluate the impact of the unobserved woman level variation on the transition rates, 12 months cumulative probabilities of switching are calculated for transitions from pill use and from other modern method use by family planning outreach workers' contact for three values of the woman-level random effect: one standard deviation below mean ($-\sigma_r$), the mean (zero) and one standard deviation above the mean ($+\sigma_r$). Table 8.9 presents the cumulative probabilities of transiting from pill use to non-use but not at risk, to non-use but at risk of unintended pregnancy, to a modern method and to a traditional method by family planning outreach workers' contact at different levels of the woman-level random effect. Table 8.10 presents the probabilities of transiting from other modern method use to non-use but not at risk, to non-use and at risk of an unintended pregnancy and to a modern method by family planning outreach workers' contact at different levels of the woman-level random effect.

Table 8.9 Estimated 12-month cumulative probabilities of switching from the use of pills by family planning outreach workers' contact for below the mean, mean, and above the mean values of the women-level random effect[1]: four rural areas of Bangladesh, 1990

Types of transition	Family planning outreach workers' contact	Random effect at the women's level		
		Below mean	Mean	Above mean
Non-use and not at risk	Not contacted	0.049	0.071	0.099
	Contacted	0.051	0.076	0.108
Non-use and at risk	Not contacted	0.254	0.410	0.629
	Contacted	0.169	0.277	0.435
Other modern method	Not contacted	0.027	0.046	0.074
	Contacted	0.051	0.088	0.147
Traditional methods	Not contacted	0.003	0.011	0.037
	Contacted	0.001	0.004	0.013

[1] Below the mean, the mean and above the mean refer to workers' work areas that are one standard deviation below the mean, the mean and one standard deviation above the mean respectively.

As can be seen from Tables 8.9 and 8.10, the transition probabilities are greatly influenced by the value of the woman-level random effect. In the case where there is contact from an outreach worker, a woman associated with an above average woman-level random effect has her risk of switching from pill to other modern methods increased by 67 percent compared to those associated with an average random effect (Table 8.9). In the case where there is contact from an outreach worker, a woman associated with an above average woman-level random effect has her risk of switching from other modern method to another modern method increased by 72 percent compared to those associated with an average random effect (Table 8.10).

Table 8.10 Estimated 12-month cumulative probabilities of switching from the use of modern methods other than pills by family planning outreach workers' contact for below the mean, mean, and above the mean values of the women-level random effect[1]: four rural areas of Bangladesh, 1990

Types of transition	Family planning outreach workers' contact	Random effect at the women's level		
		Below mean	Mean	Above mean
Non-use and not at risk	Not contacted	0.036	0.057	0.084
	Contacted	0.030	0.050	0.076
Non-use and at risk	Not contacted	0.221	0.422	0.742
	Contacted	0.125	0.244	0.445
Other modern method	Not contacted	0.052	0.093	0.154
	Contacted	0.093	0.170	0.292

[1] Below the mean, the mean and above the mean refer to workers' work areas that are one standard deviation below the mean, the mean and one standard deviation above the mean respectively.

8.6 Summary

The aim of the analysis presented in this chapter is to investigate and analyse the changes in contraceptive use behaviour in four rural areas of Bangladesh using longitudinal data for a period of three years. Steele and Diamond (1999) recently published an article on the issues of contraceptive switching in Bangladesh using retrospective calendar data. However, this research on the issues of contraceptive switching in Bangladesh using longitudinal data is in a sense unique and a first step in this manner. In this research, initially multiple decrement life tables are used for estimating the cumulative probabilities of switching from the use of pill, condom, IUDs, injectables and traditional methods to another method of contraception. Multiple decrement life tables are also used for estimating the probabilities that a woman switches her use from pills and from other modern methods. Of most interest to family planning managers and the policy makers is the degree of switching from efficient methods to inefficient methods or to non-use where the woman is at risk of an unintended pregnancy and to evaluate the impact of the family planning programme in these transitions.

Two multilevel discrete-time competing risk hazards models are used for estimating the cumulative probabilities of switching from pill and from modern methods other than pills. A series of socio-demographic, economic and programmatic variables are used as independent variables in the regression models. The results show that the number of living children, age and education of woman, education of husband, religion, prior use status and family planning outreach workers' contact have an influence on switching patterns in Bangladesh. Results show that family planning outreach workers' contact with women significantly decreases the risk of transiting to non-use and at risk of an unintended pregnancy. The outreach workers' contact also decreases the risk of switching to a traditional method and increases the risk of switching to another modern method. The family planning outreach workers' contact is by far the most important variable in the analysis. Interestingly, husband's education increases the chance of switching from the pill to a traditional method. This raises an important issue of involving males in reproductive health. In Bangladesh, the family planning programme should initiate taking steps to involve males in reproductive health issues.

An important result is the high rates of transitions to no method, which considerably increases a woman's chance of having an unintended pregnancy.

Results show that a high proportion of pill, injectable and condom users switch to non-use and remain at a risk of unintended pregnancy.

Although a large number of background characteristics are considered in the analysis of contraceptive switching, there are likely to be some important factors which may have been overlooked. Quality of family planning service may be one of them. Although some indicators of perceived quality of family planning services are available, that were collected by conducting a special survey in 1988/89 prior to the data used in this. Hence, they are excluded from the analyses of discontinuation and switching. The analysis of contraceptive discontinuation and switching is carried out using longitudinal data for the period 1990-92. To allow for these unobserved factors, a woman-specific random effect is included in the model for the switching. The results show a large and significant amount of unobserved heterogeneity remain between women in the risk of switching from a modern method to non-use but at risk of an unintended pregnancy and also risk of switching from one modern method to another modern method. The results also show a large and significant amount of unobserved heterogeneity between women in the risk of switching from the pill to non-use but at risk of an unintended pregnancy.

CHAPTER 9

SUMMARY AND CONCLUSIONS

9.1 Introduction

Bangladesh has been experiencing a substantial decline in fertility since the late 1980s which resulted in a debate about the impact of the national family planning programme in the process of fertility decline. It can be argued that this decline in fertility has been achieved by means of a large increase in the use of modern methods of contraception during this period. In the last decade, the annual rate of increase in contraceptive use has been around 7 percent, with the 1993-94 Bangladesh Demographic and Health Survey (BDHS) reporting that about 45 percent of currently married women were using some method of contraception for avoiding or delaying pregnancy (Mitra et al., 1994). Some researchers, including Cleland et al. (1994), recognize the decline in fertility as a result of the organized family planning programme. However, Caldwell et al. (1999) believe that improved education and changing social and economic structures played an important role in reducing fertility in Bangladesh. The research presented in this thesis did not aim to be involved in this debate. However, since a huge amount of donors' money is spent (Cunnane, 1995) in the field of family planning programme, this research is an attempt to examine the impact of family planning outreach workers' contact on contraceptive use dynamics in rural Bangladesh.

Apart from the prevalence of contraception and the rates of contraceptive discontinuation, very little is known about the determinants of different reasons for contraceptive discontinuation and switching. Also little is known about the association between socio-demographic, economic and programmatic factors and the different reasons for contraceptive discontinuation and switching. This research investigates the association between family planning workers' contact and contraceptive use dynamics in four rural areas of Bangladesh using multilevel techniques.

Most populations in the social sciences have a hierarchical structure. For example, individuals live in households which may be nested within communities, within *thanas*, within districts, even within countries. If such hierarchies exist, it is likely that other individuals in the community or in the group may influence the attitudes of an individual. Members in the same community or group may share views, ideas and experiences. This may lead the behaviour of individuals living in the same community to be more homogenous than the behaviour of individuals from different communities. In Bangladesh, family planning services are provided in the community by FWAs (Family Welfare Assistants), government family planning outreach workers. This means that women in the same community will have access to similar services and range of family planning methods. As a result, women living in the areas served by the same FWA may behave similarly and demonstrate similar patterns of dynamics of contraceptive use and fertility behaviour.

The hierarchical structure of the data may also arise as a result of the design of the sampling. For example, if the data are collected using multistage sampling procedures, hierarchical data structures arise. In such situations, the assumption of standard regression techniques that the individuals are distributed independently is often violated since the responses within the community tend to be correlated. Therefore survey data, which are complex in terms of sampling techniques, need to be analysed using appropriate methodology which takes care of the intra-community correlation, even if the analysis of hierarchical structure is not of primary interest.

Hierarchical data structures also may arise when longitudinal data are used. In a longitudinal study, observations made on the same individual over time may be correlated. As a result, repeated observations over time lead a two-level hierarchical data structure in which observations for an individual at successive points of time (level 1) are nested within the individual (level 2). In this research, longitudinal data are used and hence, an individual is observed over time until the occurrence of the event of interest or the end of the study period. A discrete-time event history approach is used in this research. In a discrete-time approach, event history data are expanded so that each individual's duration to the occurrence of the event generates a series of responses one for each discrete-time point. In the discrete-time approach, the response variable may be binary or may be more than two categories depending on the nature and the number of outcomes of interest. Therefore, the reconstructed data set for the discrete-time approach has a two-level (successive time points are nested within individuals) data structure.

In this research, multilevel modelling techniques are used to analyse contraceptive use dynamics in rural Bangladesh. In Chapter 6, a multilevel logistic regression model is used to study the association between FWAs contact and contraceptive use prevalence and the variations in contraceptive use prevalence between *union* (FWAs supervisors' work area), and within *union* between *unit* (FWAs work area). In the second analysis, in Chapter 6, a multilevel discrete-time hazards model is used to study the association between FWAs contact and contraceptive adoption and the *unit*-level and the women-level variation in contraceptive adoption. The third analysis, in Chapter 6, a multilevel discrete-time competing risk hazards model is used to study the association between FWAs contact and contraceptive choice and the *unit*-level and the women-level variation of contraceptive choice. In addition, an OLS and a logistic regression are used to analyse the determinants of perceived quality of family planning services and the desire for additional children, respectively.

In Chapter 7, a multilevel discrete-time competing risk hazards model is employed to study the association between FWAs contact and the reasons for contraceptive discontinuation and the *unit*-level and the women-level variations in reasons for contraceptive discontinuation. In the final analytical Chapter 8, two two-level discrete-time competing risks hazards models are used to study the association between FWAs contact and the type of transitions of contraceptive use and the extent of unobserved heterogeneity at the women-level in contraceptive switching behaviour between contraceptive methods.

The main results from these above mentioned empirical studies are summarized in this chapter. This is followed by a discussion of the limitations of using longitudinal data and limitations of this research. Both on the substantive and methodological side, some of the ideas for further work are finally suggested.

9.2 Summary of findings

In Chapter 6, a multilevel logistic regression model is used to analyse the association between FWAs contact and current use of any method of contraception in four rural areas of Bangladesh. The study has shown that contraceptive use differs considerably by individual socio-demographic characteristics as well as programmatic characteristics and the characteristics of the community. It is well demonstrated that a woman's age, her level of education, her desire for more children, number of living sons, number of living daughters and her religion are positively associated with the current use of any method of contraception. Additionally, a multilevel discrete-time hazards regression model and a multilevel discrete-time competing risk hazards model are used respectively for subsequent contraceptive adoption and for contraceptive choice analysis in four rural areas of Bangladesh. An index of perceived quality of service of the family planning worker is created using latent class analysis. In addition to the variables used in the current contraceptive use model, an index of perceived quality and a dummy for the prior use experience of any method of contraception is included in the adoption and choice models.

Most of the findings in the adoption and the choice analysis are similar to the current use analysis. However, the number of living daughters is found not to be significantly associated with subsequent contraceptive adoption and choice. Perceived quality of family planning worker and prior use status is found to be significantly associated with adoption and contraceptive choice. The results reveal that, even after controlling for the effect of women's socio-demographic background characteristics, FWAs contact with women have a significant association with the current use, subsequent contraceptive adoption of any method of contraception and contraceptive choice. The chance of adopting a method of contraception increased significantly when there is contact from the FWAs. The chance of choosing pill, condom, injectables and IUDs is also increased significantly with FWAs contact. The results also reveal that there are substantial variations in the levels of current use of any method of contraception both between *unions* and within *union* between *units*, even after controlling for a range of socio-demographic and programmatic characteristics at the individual-level. Since the *union*-level random effect was found not to be associated with the contraceptive adoption and choice, only the *unit*-level and the women-level analysis is conducted for the adoption and choice analysis. The *unit*-level random effects appear to be significantly associated in all these models. The significance of the *unit*-level random effect may explain omission of some unobserved variables, such as the socio-demographic characteristics of the FWAs assigned in the *unit*.

In Chapter 7, a multilevel discrete-time competing risk hazards model is used to estimate the cumulative probabilities of contraceptive discontinuation by different reasons in four rural areas of Bangladesh. A competing risk framework was used to distinguish between five major reasons for discontinuation: due to side effects, women wanted to get pregnant, due to method failure, due to other method-related reasons and due to other reasons. The index of the perceived quality of service of the family planning worker is dropped from the model of contraceptive discontinuation and from the models of contraceptive switching.

The education of the husband and the size of the dwelling unit is found to be significantly associated with the discontinuation and hence kept in the model. It is demonstrated that woman's age, her level of education, her desires for additional children, number of living sons, number of living daughters, level of education of husband, size of the dwelling unit, her religion, and her prior use status are positively associated with contraceptive discontinuation. The results reveal that even after controlling for the effect of women's socio-demographic and economic characteristics, FWAs contact with women is significantly associated with the reduction of contraceptive discontinuation due to other-method related reasons. Interestingly, the FWAs contact with women is found not to be related with discontinuation due to side effects and method failure. The results also reveal that even after controlling for a wide range of individual level characteristics, a substantial variation in the rates of contraceptive discontinuation between *unit*-level, and within *unit* between women remains. Unobserved heterogeneity in women's discontinuation risks is incorporated by adding a woman-specific random effect for each type of discontinuation reason in the discrete-time competing risk model of discontinuation. The random parameter at the women level shows significant extra variation between women for the contrast between other method-related discontinuations and continuation. These unobserved random parameters have a significant association with other method-related discontinuations. Lack of inclusion of some attitudinal factors especially for husbands, may be the cause for the unexplained variation at the women-level. A woman's switches to another method or her desires to switch to another method are the major two causes in the other method-related reasons for discontinuation. Lack of the inclusion of the ability of a FWA to motivate a woman to switch to another method in the model may explain the unexplained variation at the *unit*-level.

In the final analytical chapter (Chapter 8), the analysis of contraceptive switching in four rural areas of Bangladesh is presented. Switching from the use of pills and switching from the use of modern methods other than pill is considered in

Chapter 8. Initially multiple decrement life-tables are used for estimating the cumulative probabilities of switching from the use of pills, condoms, IUDs, injectables and traditional methods. Among the pill users, a multilevel discrete-time competing risk model is used to estimate the probability that a woman transits to non-use but not at risk, non-use but at risk of an unintended pregnancy, other modern method or to a traditional method. Among the other modern method users, another multilevel discrete-time competing risk model is used for estimating the probability that a woman transits to non-use but not at risk, non-use but at the risk of an unintended pregnancy or to another modern method. Because of the small number of cases the transiting from other modern method to a traditional method is omitted from the switching analysis of other modern methods. For comparative purposes, all the covariates used in the discontinuation analysis were also used in the switching analysis. The number of living children is used instead of number of living sons and the number of living daughters. Education of women is the only variable found not to be significantly associated with switching from the use of pills at 5 percent level. In transiting from a modern method other than pill use model, the size of the dwelling unit is found not to be significantly associated at 5 percent level. Results show that FWAs contact with rural women is associated with a decrease in the risks of transiting from the use of pill to non-use but at risk of an unintended pregnancy and also with a decrease in the chance of transitions from other modern method to non-use but at risk of unintended pregnancy. Results also show that the FWAs contact is also associated with a decrease in the risk of switching to a traditional method from the use of pills. The results also show that FWAs contact with rural women is associated with an increase in the chance of switching to another modern method. To control for the unobserved heterogeneity between women in their risk of switching method use, the two-level competing risk models are used. Initially, three level (inclusion of *unit*-level) models were tried but no evidence of extra variation between *units* has found. The lack of variation at the *unit*-level suggests that the decision to discontinue or switch a method of family planning is largely depending on individuals and is relatively unaffected by the behaviour of others in the community. Among the pill users, the women-level random parameter is significantly associated with the transition to non-use but at risk of an unintended pregnancy. Among the other modern method users, the women-level random parameter is also significantly associated with the transition to non-use but at risk of an unintended pregnancy and also with the switching to the other modern method. These may perhaps be the fact that some unobserved individual factors other than those evaluated in the analyses might have vital influence on these transitions.

In all three analyses (conducted in Chapter 6 through 8), the use of multilevel techniques has revealed a considerable amount of extra-variation at various levels of nesting. These analyses for estimating the impact of family planning workers' contact on the contraceptive use dynamics in four rural areas of Bangladesh provides the evidence of impact of family planning programme in the ongoing process of demographic transition in Bangladesh.

The results of all the regressions conducted in this research are summarized in Table 9.1. A few socio-demographic and programmatic variables are found significantly associated with the outcome in all the models of contraceptive use dynamics– desire for additional children, the age of women, religion, family planning outreach workers' contact and some measure of the number of living children. However, perceived quality of outreach services and prior contraceptive use status were not used in all the models, but they were found significantly associated with all the outcomes in all models when used.

Table 9.1 Summary of the effects of the covariates used in the analyses of contraceptive use dynamics according to different outcomes: four rural areas of Bangladesh, 1986-1992

Variables	Contraceptive use and choice				Method switching	
	Current use	Adoption	Choice	Reasons for disconti-nuation	Switching from pill	Switching from other modern
Number of living sons	•	•	•	•	nu	nu
Number of living daughters	•	o	o	•	nu	nu
Number of living children	nu	nu	nu	nu	•	•
Desire for additional children	•	•	•	•	•	•
Age of women	•	•	•	•	•	•
Education of women	•	•	•	•	o	•
Education of husband	in	in	in	•	•	•
Size of dwelling unit	in	in	in	•	•	o
Religion	•	•	•	•	•	•
quality of care	na	•	•	na	na	na
Prior use of contraception	na	•	•	•	•	•
Family planning workers' contact	•	•	•	•	•	•

• Significant at 5 percent
o Not significant
na Not available
nu Not used
in Insignificant and excluded from final model

Considering research interest and the hypotheses, a conceptual framework is developed and presented in Chapter 1 (Figure 1.1). However, no significant association between programmatic characteristics (prior contraceptive use status and outreach family planning workers' contact) and women's desire for additional children is observed from this data. A dotted line is drawn to show the insignificant association between programmatic characteristics and women's desire for additional children.

9.3 Policy implications

A number of policy implications can be derived from the findings of the research conducted in this thesis. Among others, the women's education and FWAs contact appear to be the most important socio-demographic and programmatic determinants of contraceptive use dynamics in rural Bangladesh. The level of female education in Bangladesh is still very low. FWAs contact with women is not good either. Almost one-third of married women are being contacted by an outreach worker in six months (Mitra et al., 1997). This research clearly points out that if the level of female education is improved and the family planning outreach services are maintained one may expect that contraceptive use and continuity of use in Bangladesh will be increased and will have an increasing impact on fertility transitions in the country.

Side effects and other method related reasons are observed to be the two main reasons for contraceptive discontinuation in four rural areas of Bangladesh. FWAs contact with women is associated with a reduced risk of contraceptive discontinuation due to other method-related reasons. FWAs contact is found not to be associated with discontinuation due to side effects. One plausible explanation is that, at present, side effects due to contraceptive use are treated at the clinics by female paramedics at the *union*-level. There is only one female paramedic in such clinics with one for each 25,000 population. When a rural woman has experienced any side effect due to method use, it is very unlikely that the woman will travel to a clinic, which may not be near to her residence. When problems arise, the FWAs role is limited to persuading women to switch to a more suitable method. This has been observed in the contraceptive switching analysis. FWAs contact with women is associated with the increased risk of a woman switching from one modern method to another modern method and of discontinuing use any modern method and becoming at risk of an unintended pregnancy. Therefore, if these outreach family planning workers are trained in managing and treating side effects and ensured the regularity of visitations, the contraceptive use and the continuity of use may increase and may eventually have an impact on the ongoing fertility transition in the country.

One must not be confused with the findings from this research and the present population policy of the Government of Bangladesh. In this research, the data were used for a period 1986-1992, which is well before the recent changes in the population policy in the country. Policy makers have recently indicated that the existing doorstep service delivery system cannot be sustained for the following reasons: (1) doorstep service is quite resource intensive; (2) the family planning programme costs will require an incremental increase of US$10 million per annum on the existing annual total of US$140 million (Cunnane, 1995); (3) increasing demand for services caused by population momentum and (4) the high dependency of the programme on donor funding. As a consequence a Five-Year (1998-2003) Health and Population Sector Strategy was developed by the Government which started testing the alternative service delivery strategies to move from the door-step to fixed sites (Khuda and Routh, 2000).

Hossain and Phillips (1996) state that the effects of outreach worker visits grow with time, which suggest that the effect of outreach is undiminished as the demographic transition proceeds. They also state that recruiting of workers to follow up clients has been a central strategy of programmes in Bangladesh for four decades. The research presented in this thesis shows the importance and the justification of outreach activities. If decisions to terminate use are volitional, driven solely by personal choice, then client characteristics alone would explain variability in the attrition process. In the absence of active household outreach, many women will stop using contraceptives, not because they plan to do so, but because they depend upon the programme for outreach support. Although sustained, demand-driven contraception may eventually become the norm, this research suggests that contraception increases as prevalence increases, and that outreach is, therefore, more important to users now than it was in the past.

Policy deliberations on the merits of scaling back household service delivery should be pursued with great caution, because scaling back in the interest of nurturing sustainability of the programme may counteract the sustainability of contraceptive practice instead.

9.4 Limitation of the Study

The chance to include explanatory variables that may alter their values during the observation period is one of the great advantages of longitudinal event history models. It is also one of the most difficult aspects of event history modelling since various mistakes can be made in the causal interpretation of the effects of time-varying coefficients (Yamaguchi, 1991:130-134). With respect to the causal interpretation of the effects of time-varying covariates, a possible pitfall may be the problem of reverse causation. Time-dependent covariates may be subject to reverse causation, that is, the process under study may influence the covariate process. The covariate process may either be influenced by the state occupied at the different points in time or by the size of the hazard rate. The former is called state dependence, and the latter is called rate dependence (Yamaguchi, 1991: 137-139). Both forms of reverse causation may severely bias the results obtained from an event history analysis. The problem of selection bias and reverse causation that are associated with the use of time-dependent covariates can be clarified using the distinction between exogenous and endogenous covariates. Endogenous covariates may be subject to spuriousness and reverse causation, while the exogenous variables do not have these problems.

9.4.1 Problems of Endogeneity and Causality

By endogeneity we mean the correlation of the right-hand side regressors and the disturbances. This may be due to the exclusion of relevant variables, selectivity of samples, measurement errors, or other reasons. Endogeneity causes inconsistency of the ordinary least squares (OLS) estimates (Greene, 2000). To obtain consistent estimates of parameters, one can use instrumental variable methods like two-stage least squares (2SLS). Endogeneity is often a problem in econometrics. Behavioural relationships like consumption, production, investment import and export are a few examples in econometrics where endogeneity is suspected. In economics, many relationships are a part of a larger system of equations (or model). If we are estimating a supply curve, either price or quantity needs to be taken as exogenous. Usually, however, economists would consider both variables to be endogenous, the system being completed with a demand curve. Suppose that we are only interested in one of the equations in a system. For example, the estimation of agricultural supply schedules is an important issue in the design of macroeconomic policy in developing countries: structural adjustment policies rely on a reasonable degree of price elasticity of supply from this sector. Can we then just ignore the demand side and estimate the supply equation? The answer might be no. Single-equation estimation of a relationship that is in fact part of a larger system can lead to simultaneity bias. This bias arises since the endogeneity of the regressors in the system as a whole means that these regressors are related to the error term, thus violating one of the assumptions underlying OLS.

Many demographic researchers use data sets to examine the impact of background explanatory variables on binary outcomes. The determinants of contraceptive use, for example, may include women's age, years of education, number of living children, number of additional children desired and as well as some programmatic characteristics as explanatory variables. Since the explanatory variables are exogenous to the decision regarding contraceptive use, estimation of statistical models for the determinants of contraceptive use with these types of variables is straightforward. However, the problem may arise when the analysis includes an explanatory variable that are also choices made by the women.

There are some other methodological limitations of the study. Statistical associations are by themselves not conclusive of cause-effect relationships unless a strong conceptual case can be made. There is a potential bias that could account for some of these findings that should be acknowledged. Determining the effects of FWAs contact on contraceptive use dynamics in a longitudinal study is problematic, because contraceptive use may influence FWAs contact. Contraceptive use, choice, discontinuation and switching are the outcome variables of this research. These FWAs are supposed to visit each and every woman once in two months. FWAs may contact women who are the prospective users or the past users to maintain supply of methods. However, the contact rate is much higher than the current use rate. Workers' also contacting women irrespective of use status. It is also possible for some women to get condoms and pills from other sources (dispensaries, kiosks, etc.). However, the inclusions of FWAs contact variable as explanatory variables and use a single equation method may result in biased estimates.

Since, this research used event history data on contraceptive use and FWAs contact collected over time and the research interest was to see the impact of family planning workers contact on contraceptive use dynamics, simultaneous structural equation models should have been used to overcome the problem of endogeneity (Bollen et al., 1995). Two/three-stage ordinary least square (OLS) regressions are also used to overcome such problem of endogeneity. It is not appropriate to use two/three stage OLS regressions with this longitudinal data. It was also intended to apply hierarchical regression modelling using MLwiN software (Goldstein et al., 1998) to explain the variation due to workers' work area level. Again, the MLwiN software does not support any simultaneous equation modelling. Considering the nature of the data and at the same time the lack of appropriate statistical software which can handle such situations, it is decided to use multilevel discrete-time modelling for estimating single equation models for assessing the impact of FWAs contact with women on contraceptive use dynamics in rural Bangladesh. For the contraceptive discontinuation and the switching analysis, the problem of endogeneity may not arise since only the users of contraceptive methods are analysed.

However, I believe if we had used a model which controlled for the effect of endogeneity similar conclusions would have been made.

9.5 Future work

Depending on the tangible question of concern and interest, each of the three analyses presented in this thesis may be augmented in a number of manners. One obvious area is to do an elaborate study to know the types of side effects that a woman faces while using any method of family planning. For this purpose, a qualitative and a quantitative study may be conducted and analysed with a view to making policy recommendations. If the nature of the side effects is known, family planning programme managers may then be able to decide which methods and which brand of method is causing the perceived or actual side effects. Future study may also be able to recommend programme managers how to and on what the FWAs need to give training for improving side effects management and for enhancing the continuity of use.

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APPENDIX

Appendix A1: Quality of care questions:

Q1. Is the field-worker responsive to your questions?

Q2. Is she appreciative of your need for privacy?

Q3. Is she someone you can depend upon to help with your problems?

Q4. Is she sympathetic to your problems and needs?

Q5. When she explains something to you, does she provide enough information?

Responses to these questions were coded in the following manner: Always and usually=2 (positive); sometimes and never=1 (negative).

Appendix A2: Latent class analysis probabilities for the indices of quality of care

Combinations of responses for each quality of care questions (1='negative', 2='positive')					Probability of response pattern
Q1	Q2	Q3	Q4	Q5	
1	1	1	1	1	0.0000
2	1	1	1	1	0.0023
1	2	1	1	1	0.0181
2	2	1	1	1	0.3128
1	1	2	1	1	0.0207
2	1	2	1	1	0.3426
1	2	2	1	1	0.8061
2	2	2	1	1	0.9904
1	1	1	2	1	0.0148
2	1	1	2	1	0.2708
1	2	1	2	1	0.7477
2	2	1	2	1	0.9865
1	1	2	2	1	0.7724
2	1	2	2	1	0.9882
1	2	2	2	1	0.9985
2	2	2	2	1	0.9999
1	1	1	1	2	0.0033
2	1	1	1	2	0.0747
1	2	1	1	2	0.3919
2	2	1	1	2	0.9409
1	1	2	1	2	0.4246
2	1	2	1	2	0.9480
1	2	2	1	2	0.9932
2	2	2	1	2	0.9997
1	1	1	2	2	0.3446
2	1	1	2	2	0.9285
1	2	1	2	2	0.9904
2	2	1	2	2	0.9996
1	1	2	2	2	0.9916
2	1	2	2	2	0.9997
1	2	2	2	2	0.9999
2	2	2	2	2	0.9999

Appendix A3: Percentage of currently married women of reproductive age currently using a method of contraception by selected individual and programmatic characteristics: four rural areas of Bangladesh, 1986

Variables	Percentage of total women using contraceptives	Number of women using contraceptives	Total women
Number of living sons:			
0	9.3	137	1478
1-2	30.4	879	2888
3+	32.7	419	1275
Number of living daughters:			
0	14.9	238	1593
1-2	29.5	829	2814
3+	29.8	368	1234
Desire for any additional child:			
Want more children	12.4	319	2579
Don't want any more children	36.5	1116	3062
Woman's age:			
Less than 20	7.4	57	774
20-29	25.3	637	2519
30+	31.6	741	2348
Women's education:			
No education	22.1	873	3943
Primary and below	30.3	400	1321
Above primary	43.0	162	377
Religion:			
Muslim	23.0	1105	4811
Hindu and others	39.8	330	830
Worker's contact in last 90 days:			
No	22.3	757	3401
Yes	30.3	678	2239
Mean literacy of women:			
Less than 21 percent	18.0	423	2347
21-30	26.8	463	1731
31+	35.1	549	1563
Contraceptive methods:			
Condom	1.6	91	
Pill	4.7	264	
Injectables	1.9	105	
IUD	2.9	163	
Sterilization	9.1	518	
Traditional methods	5.2	294	
Any method user	25.4	1435	
Total women			5641

Appendix B1: Parameter estimates of the desire for no additional children using logistic regression among currently married women of reproductive age: four *rural areas of Bangladesh, 1986*

Variables	Parameter estimates	Standard errors
Intercept	-5.813***	0.376
Background characteristics		
Number of living sons: (Base: 0)		
1-2	1.841***	0.220
3+	2.944***	0.234
Number of living daughters: (Base: 0)		
1-2	1.157***	0.165
3+	1.506***	0.183
Woman's age: (Base: Less than 20)		
20-29	2.384***	0.281
30+	3.914***	0.291
Woman's education: (Base: No education)		
Primary and below	0.169	0.123
Above primary	0.519*	0.205
Religion: (Base: Muslim)		
Hindu and others	0.226	0.171
Programmatic characteristics		
Prior use of contraceptives: (Base: No)		
Yes	0.020	0.025
Workers' contact in last 90 days: (Base: No)		
Yes	-0.117	0.115
Unit level random effect	0.113*	0.052

* p<0.05; ** p<0.01; *** p<0.001

Appendix B2: Parameter estimates of the perceived quality of care using OLS: four rural areas of Bangladesh, 1986

Variables	Parameter estimates	Standard errors
Intercept	0.448***	0.087
<u>Background characteristics</u>		
Number of living sons: (Base: 0)		
1-2	0.036	0.026
3+	0.011	0.028
Number of living daughters: (Base: 0)		
1-2	0.010	0.023
3+	-0.011	0.026
Woman's age: (Base: Less than 20)		
20-29	0.039	0.025
30+	-0.048	0.027
Woman's education: (Base: No education)		
Primary and below	0.036*	0.018
Above primary	0.085**	0.031
Religion: (Base: Muslim)		
Hindu and others	-0.037	0.026
<u>Programmatic characteristics</u>		
Prior use of contraceptives: (Base: No)		
Yes	0.095***	0.018
Workers' contact in last 90 days: (Base: No)		
Yes	0.057**	0.018
Union level random effect	0.074***	0.032
Unit level random effect	0.014*	0.004

* $p<0.05$; ** $p<0.01$; *** $p<0.001$