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Famine, Social Disruption, and Miscarriage: Evidence from Chinese Survey Data

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ABSTRACT

Miscarriage constitutes one of the most important adverse pregnancy outcomes affecting human reproduction, but its risk factors are not well understood. Relying on half million pregnancy histories collected from Chinese women in the late 1980s, we study self-reported miscarriages in China for over a quarter of a century. Our results suggest that miscarriage is not only affected by biological/demographic factors such as age, gravidity, and previous history of miscarriage, but also by individual women's personal social characteristics, and by the larger social environment. In particular, we focus on how two social and economic crises, the Great Leap Famine of 1959-1961 and the Cultural Revolution of 1966-1976, resulted in elevated risks of miscarriage in the Chinese population.

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INTRODUCTION

Miscarriage, or spontaneous abortion, is the most common adverse outcome of pregnancy. Yet, both its prevalence in different populations and its underlying causes are still subject to continuing investigation and understanding. Commonly cited numbers put the prevalence of miscarriages at about 10 to 15 percent of all clinically recognized pregnancies (Simpson and Carson 1993; Simpson and Mills 1986; Zinaman et al. 1996 cf. Garcia-Enguidanos et al. 2002), but empirical estimates of the prevalence vary from as low as 2-3% to as high as 30%. While many studies have attributed miscarriage as an outcome of human biology, largely immune of human social environment,[1] there has also been evidence suggesting the roles of non-biological factors (Carlson and Mourgova 2003; Ellett, Buxton and Luesley 1992; Shapiro and Bross 1980, cf. Wood 1994: 267). In particular, several studies have reported increased level of fetal mortality related to famines and wars (Kang et al. 2001; Rajab et al. 2000; Wynn and Wynn 1993).

In this article, we analyze self-reported incidences of miscarriage among Chinese women for over a quarter century's time, and examine the roles of biological as well as social and environmental factors in affecting this adverse outcome of human reproduction.

[1] One such view is summarized by Bongaarts: “Based on small differences in intrauterine mortality observed between developed and developing countries, some speculated that intrauterine mortality was relatively invariant among populations, therefore largely caused by biological factors that are independent from social, economic and health factors." (Bongaarts and Potter 1983:124)

A special focus of our investigation is on the effects of two large-scale social and economic disruptions on miscarriage. During the period under our examination, 1955-1987, China not only completed its demographic transition from high mortality and high fertility to low mortality and low fertility, but also experienced several large-scale economic and social crises that are unprecedented in human history. One is the Great Leap Famine of 1959-1961. Past studies have already shown the devastating demographic impacts of this famine both in terms of mortality and fertility (e.g. Ashton et al. 1984; Kane 1987, 1988; Peng 1987), but not on an important factor contributing to a sharply declined fertility level during the famine, which is the increase in intrauterine mortality. The Chinese Cultural Revolution of 1966-1976 is another large-scale social and political shock with profound impacts on the daily lives of the population, but its impact on reproduction has hardly been looked on.

Given the varying definitions and estimates of miscarriage and inconclusive findings about the causes, we begin our article with a brief review of the definitions used in measuring miscarriage, of various prevalence rates based on different definitions, and of the risk factors generally recognized in literature. We then turn to our data source and to the examination of the effects of demographic and social/environment factors on miscarriage in the Chinese population.

MISCARRIAGE: MEASUREMENT, PREVALENCE, AND RISK FACTORS

Definitions and Prevalence

Miscarriage is generally defined as a spontaneous or involuntary pregnancy loss at a time before a fetus would be viable outside of a mother's womb. Pregnancy losses after the fetus could have survived, in contrast, are classified as stillbirths. The line separating the two, however, is not a fixed but an evolving one. As health care and medical technology improves, more and more preterm births can be saved. Such improvements therefore change the classification of miscarriage and stillbirth. For example, a recent WHO publication acknowledges the different definitions of miscarriage used by different countries, and concludes that: "At what gestational age a miscarriage becomes a stillbirth for reporting purposes depends on the policy of the country." (WHO 2000:165) Most often, the cutoff point for miscarriage is at the end of the second trimester, usually 20 or 28 weeks. This and other differences in the definition often introduce confusion for international comparisons (Kramer et al. 2002).

What makes defining a miscarriage particularly difficult is not just the ending of a pregnancy, but also the beginning of a pregnancy, which can be very ambiguous. Early stage pregnancies are highly difficult to detect in the absence of more recent technological tools.[2] Physical signs of pregnancy, such as missed menses, breast tenderness, amenorrhea, and morning sickness may be recognizable in the 4-6 weeks of gestation age, but a significant proportion of pregnant women lack such signs. The

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[2] The arrival of two technological tools, hCG (human chorionic gonadotropin) assays and ultrasound machines, have made early pregnancy losses (EPL) detectable. The hCG assays can detect pregnancies within a few days of implantation (Armstrong et al. 1984; Wilcox et al. 1985). Ultrasound technology permits the early diagnosis of pregnancy at about five weeks of gestation age (Nyberg et al. 1983). The clinical and home-use version of hCG assays and ultrasound technology are now widely available in developed countries. In much of the developing world, women continue to rely on traditional methods to count pregnancy and pregnancy loss.

recognition of these signs depends highly on a woman's self-consciousness. A missed period, for instance, might be perceived as a delayed menstruation. Pregnancy losses are often only recognizable in 6-8 weeks of gestation age with signs such as passage of tissue, opening of the cervix, uterine contractions, or bleeding (Simpson and Carson 1993). Moreover, pregnancy (and pregnancy loss) recognition also depends on the social or cultural definition of what is considered a fetus or a life prior to birth. Difficulties in identifying the start of pregnancy imply that a large number of pregnancies and consequently pregnancy losses in the early stages are not recognized. Due to such difficulties, estimated prevalence of miscarriage varies widely by population, time, and, most often, by data sources.

Existing estimates of miscarriage prevalence mostly come from three data sources: prospective clinical studies, hospital records/vital statistics, and surveys. Clinically based prospective studies provide the most accurate estimate of the prevalence of miscarriage, but have limitations for studying socially based miscarriage risk factors, due to the small samples used in such studies. One recent study with a sample of Chinese population reports, for instance, that of 618 pregnancies detected by using the hCG method, 24.6% ended up as early pregnancy losses (EPLs). The majority of these pregnancy losses occur very early in pregnancy. After the sixth and before the 28th week of pregnancy, only 10.5% of pregnancies ended in miscarriage (Wang et al. 2003). Observable miscarriage rate declines quickly further into pregnancy, to about 3-5% of live fetuses beyond the 8th week of pregnancy (Hoesli et al. 2001; Simpson et al. 1987; Sun et al. 2003). In comparison to clinically based studies, studies based on hospital records or vital registrations are large-scale, but they are also subject to underreporting and selection bias.

Studies of this type report miscarriage rates ranging from the high of 13.5% in Denmark (Andersen et al. 2000) to the low of 4.5% in the Czech population (10-28 weeks, Carlson et al. 1999). Retrospective surveys of pregnancy and fertility histories provide a third major source for estimating miscarriage at the population level. These surveys have the desirable features of being large-scale and containing more social background information than vital statistics or clinical studies, but they are subject to recall and underreporting errors and culture biases. Miscarriage rates revealed by the World Fertility Survey data in 40 countries ranged from 2.7 to 13.0, with Asian populations mostly at around the 5% level (Casterline 1989a, Table 3).

Risk Factors

Despite the progress made in the last century on the etiology of miscarriage and related issues, we still do not fully understand the mechanisms of reproduction and miscarriage. While a large number of factors have been suggested as risk factors of miscarriage, only very few are generally accepted. One recent review listed 26 factors and at the same time acknowledged that only two, uterine malformations and chromosomal abnormalities, are being generally accepted (García Enguídanos et al. 2002).

Chromosomal anomaly is the single most important risk factor of miscarriage, accounting for about half of all miscarriages (García-Enguídanos et al. 2002; Simpson and Carson 1993). A number of other health related factors have also been linked to the risk of miscarriage, including uterine anatomic defects, infections, immune diseases, endocrine disorders, trauma, malnutrition, and etc. (García-Enguídanos et al. 2002; Simpson and Carson 1993). Multiple-gestation has also been associated with increased risks of miscarriage, birth defects, and premature birth (Dickey et al. 2002; Glinianaia et al. 2002).

The associations between demographic factors, namely the mother's age, gravidity, length of pregnancy interval, pregnancy history (number of pervious live births and fetal losses), and the risk of miscarriage have long been noticed. Some of them are linked to one or more etiological risk factors listed above. For example, maternal age is positively correlated with the incidence of chromosomal aberrations (Hansen 1986 cf. Garcia-Enguidanos 2002). Others may be due to confounding effects from the selectivity nature of the reproductive process (Andersen et al. 2000 and its critics; Casterline 1989a; El-Saadani 2000; Leridon 1976, Santow and Bracher 1989).[3] Because maternal age,

[3] According to the assumption of heterogeneity (Leridon 1976), women can be divided into two groups: those with a high risk and those with a low risk of miscarriage. In a natural fertility situation, in which couples do not exercise deliberate fertility control (Henry 1961), women with a high risk of miscarriage would have more gestations because of their short pregnancy intervals and thus are overly represented in pregnancy-based samples. In a controlled fertility context, where couples stop childbearing after reaching their desired family size, women who had a history of miscarriage (those biologically more vulnerable to miscarriage) are more likely to continue until reaching desired family size or biological limit. These women are again overrepresented in old age and high gravidity pregnancies. This self-selection effect is more pronounced in a population with controlled fertility than a population under a natural fertility regime, because only a limited proportion of women progress to high gravidities in a population

gravidity, length of pregnancy interval, and pregnancy history are highly correlated, they also pose a challenge to assessing the independent effect of each on the occurrence of miscarriage.

The risk of miscarriage has also been linked to a woman's behavior and to the social and environmental context a woman lives in. Drug use, caffeine, smoking and drinking and exposure to certain environments have been proposed as risk factors, with some linked to etiological sources. The effects of these behaviors on pregnancy outcomes, however, are also believed to confine largely to pregnancies at late stages (Hoyert 1996; Wood 1994). The use of certain contraceptive methods is suspected to increase the risk of miscarriage, but there is no clear evidence. The relationship between previous induced abortion and miscarriage is also inconclusive.

The role of social/environmental factors in miscarriages has been subject to more debate than that of biological or demographic factors (Casterline 1989b). A number of studies have shown that social/environmental factors, such as race, socioeconomic status, and place of residence, affect the risk of miscarriage (Carlson and Mourgova 2003; Ellett, Buxton, and Luesley 1992; Shapiro and Bross 1980 cf. Wood 1994). The conclusions reached in these studies, however, are far from being conclusive. One primary critique of findings of such nature is that differentials by socioeconomic factors may be interpreted more sensibly as a reporting issue (Casterline 1989a, 1989b). For example, people with a higher level of education may be more self-conscious and thus less likely to miss a miscarried pregnancy, especially during the first trimester. Better access to health care

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with fertility control. Most research on this subject has been based on populations practicing birth controls.

services by women of higher socioeconomic status may also facilitate a higher level of early pregnancy recognition among them.

The predominant role of biological factors over that of social factors in determining the risk of miscarriage also suggests that miscarriages are hardly preventable, and that one should not expect to see a drastic change over time in the prevalence of miscarriages. New medical technology and improvement in health care can only result in a gradual decline of miscarriages in the population. Indeed, while considerable variations have been reported across locales, miscarriage rate is also found to be generally stable across time in a specific region (Andersen et al. 2000; Wood 1994).

Nutrition, Stress, Social Crisis and Miscarriage

There is one important exception to the conclusions above regarding the relatively minor roles played by socioeconomic environment in affecting the risk of miscarriage. This is the roles of malnutrition and stress. The roles of these two factors are believed to be particularly important during periods of famine and social disruption.

Nutrition has long been argued as probably the most important environmental factor affecting pregnancy outcomes (King 2003). Since pregnancy is a period of increased nutrition needs – fetus growth is totally dependent on maternal organism, one would expect a direct effect from mother’s nutritional intakes during pregnancy on fetal growth (Rosso 1990). Experimental studies on animals have demonstrated an association between maternal malnutrition during pregnancy and abnormal placental growth (Symonds et al. 2001; Symonds et al. 2003; Vonnahme et al. 2003), and between malnutrition during the periconceptional period and a fetus’ health status (Edwards and McMillen 2002). Some scholars have suggested a number of specific mechanisms through which nutritional factors may affect the risk of pregnancy (Di Cintio 2001; Dillion and Milliez 2000; Lumey 1998). Malnutrition may trigger changes in hormones. Medical evidence indicates that progesterone, a steroid hormone produced in the ovary and prepares and maintains the uterus for pregnancy, can be reduced substantially by restricting food intake (Wynn and Wynn 1993). Also, malnutrition can increase stress hormones in the mother and disrupt the growth of the placenta (Scott and Duncan 2002).

The roles of malnutrition and famine on miscarriage, however, are still a topic subject to debate. Results of the effects of malnutrition and famine on intrauterine mortality in human populations have been inconclusive. Increased levels of fetal wastage were found among poorly nourished Indian women and during the siege of Leningrad in 1942 in the former Soviet Union. A dramatic increase of miscarriage, accompanied by a decline in birth rate and an epidemic of low birth-weight, was also reported in Frankfurt during the period of postwar food shortage (Wynn and Wynn 1993). However, studies of another well-documented war-famine, the Dutch Hunger Winter of 1944-1945, reported no evidence of rising miscarriages (Stein et al. 1975; Stein and Susser 1977).

Stress has been suggested to be abortogenic in mice and human populations through their negative effects on the nervous, endocrine and immune system (Arck 2001). It is suggested that any stressful event, "even a relatively mild one, during pregnancy can cause a marked rise in the level of stress hormones in the mother, with serious repercussions for the fetus and neonate" (Scott and Duncan 2002:137). But again, empirical research has not supplied sufficient support to the link between stress and miscarriage. While some studies are able to identify an association between the two (e.g. Arck et al. 2001; Boyles et al. 2000; Joachim et al. 2001; Neugebauer et al. 1996), others fail to do so (e.g. Milad et al. 1998; Nelson et al. 2003). One important reason contributing to such conflicting results is the relatively small samples used in the laboratory-based studies. Another reason lies in the difficulty in measuring stress accurately. Moreover, unlike in animal-based laboratory research settings, stress in human societies does not exist in isolation, but often confounds with other risk factors, such as the use of tobacco, alcohol, or drugs, which makes separating the role of stress difficult.

One window to understand the role of stress in miscarriage is to study it within non-experimental settings where external factors are known to have resulted in increases in stress level and where other risk factors can also be controlled for. If stress is linked to the level of fetal wastage, large-scale social disruptions such as wars and revolutions should lead to an elevated miscarriage level. In fact, a number of recent studies of the Gulf War of 1991 found that there was an increased level of miscarriage and other adverse pregnancy outcomes in Iraq, Kuwait, Bahrain, and among US veterans (Kang et al. 2001; Rajab et al. 2000). One of the suggested causes of the increase was the stress and anxiety caused by the War. Studies of such nature, however, are still relatively rare in numbers.

To sum up, many factors have been proposed as risk factors for miscarriage. The general consensus so far is that early fetal deaths (miscarriages) are likely to involve factors endogenous to the fetus, such as chromosome anomalies, while late fetal deaths (stillbirths) are more likely to be caused by exogenous factors, from either the uterine or the external environment (Wood 1994). With such an understanding, one would expect that the level of miscarriage in different populations should not vary that much, and social environmental factors should not have much impact on miscarriages. Nutrition and stress, in other words, might not be important factors of miscarriage under normal conditions. Whatever effect they may have, however, they are most likely to be seen when magnified during periods of social crisis such as famines or social disruptions.

DATA AND METHODS

Data

Our examination of miscarriage in this study is based on a large-scale fertility survey conducted in China in 1988, China's National Survey of Fertility and Contraception. The largest fertility survey ever conducted for any population, this survey employed a stratified, systematic, clustered, non-proportional probability sampling design, with an aim to ensure representativeness at the national as well as the Chinese provincial level (Lavely 1991, Wang and Yang 1996).[4] The primary respondents were ever-married women between ages 15 and 57 in 1988.[5] The sample contains about 2.1 million

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[4] The sample is designed to be representative at the provincial level. The sample size (and proportion) varies from province to province according to its population size and fertility level. For detailed information on the survey design and sample scheme, see also Lavely and Gu (1991).

[5] The exclusion of never-married women from the survey does not affect the general finding of this study. Pre-marital sexual relationship was not common in China until relatively recently, and few births took place outside of marriage during the period of our study. Li and Newcomer (1996) discuss in detail the potential problems of excluding never-married women from the survey.

individuals, including nearly half million of ever-married women with 1.5 million pregnancies.

The centerpiece of the survey is the reproductive history of each woman interviewed. The pregnancy history is integrated with contraceptive and birth histories. Such a survey design, with redundant questions in different sections and integrated and successive questions of pregnancy, birth and contraceptive use, help to reduce problems caused by fading memory or recall bias, which represents the most common and serious problem in using retrospective surveys to study miscarriage. The survey also collected information on each household member's socioeconomic characteristics (e.g. education, occupation, marriage status and residence), which enable us to study social risk factors of miscarriage.

Information on reproductive history includes time of menarche (and menopause), age at first marriage, and history of pregnancy and contraceptive use. For each pregnancy, gravidity, time when pregnancy ended, and pregnancy outcome were recorded. The outcome of each pregnancy is coded into one of five mutually exclusive categories: live birth (male or female), miscarriage (before the seventh month), stillbirth, induced abortion, and currently pregnant.[6] With the obvious difficulty in identifying the start of a pregnancy for each woman, no question was asked about the beginning time of

[6] There are three categories on induced abortion in the original questionnaire: first term abortion (1-3 months), midterm abortion (4-6 months), and late-term abortion (7 months and after). These three categories have already been collapsed into one in the released data.

a pregnancy, which prevents us from measuring the exact length of each pregnancy when it ended.

One common source in survey data that complicates the study of miscarriage is the presence of induced abortions and misreporting of induced abortions as miscarriages (Casterline 1989a; Leridon 1976). This is unlikely a problem for the survey data we use here for several reasons. First, the distinction between miscarriage and induced abortion is rather clear in Chinese, and it is unlikely that a respondent might have mixed the two up. Second, while there was a rapid increase in induced abortions in China in the 1970s and 1980s (Wang 1995), there is no parallel increase in miscarriages as shown by our examination later in this paper. Third, while in some populations social pressures may lead respondents to misreport induced abortions as miscarriages, and therefore resulting in higher reported miscarriage rates, this is again not the case in China. Induced abortion is widely used as a birth control method, and there is neither a cultural taboo nor a legal barrier associated with it in the Chinese society.

We restrict our analyses to pregnancies terminated during 1955-1987 by women whose ages were 16-45 when a pregnancy ended, and to pregnancies at the order of six or lower. We do so mainly to avoid small sample size in some subcategories. We exclude pregnancies ended in 1988 because a significant number of pregnancies were reported as “currently-pregnant” at the time of the survey, and some of those pregnancies may end up in miscarriage as well. Ending our study in 1987 avoids the problem of censored cases.

Logistic Regression with Generalized Estimating Equations

There is a rich literature on whether the observed associations between age, gravidity, length of pregnancy interval and the risk of miscarriage are spurious. For instance, Naylor (1974) suggested that there is an increased risk of miscarriage at higher ages. Leridon (1976) designed a classification method to control for heterogeneity and his results suggested that the risk of miscarriage tended to decline with the number of previous live births, as long as the woman had not yet had a miscarriage (El-Saadani 2000; Leridon 1976). Leridon's classification method, albeit illustrative, is less suited for constructing a model that controls for more than two factors simultaneously without losing statistical power. Not only would the model become highly complicated, cell size would also shrink quickly when more variables and categories are added into the model. A regression approach is therefore preferred, as used in the studies of Casterline (1989b) and El-Saadani (2000).

A crucial assumption used in conventional regression analysis is that observations in the study are independent – the outcome of one observation is unrelated to the outcome of the other. The heterogeneity nature of pregnancy data, women with multiple pregnancies and with possibly correlated outcomes, clearly violates the independent assumption. Failure to take such correlations into account can lead to biased estimates of standard errors and test statistics (Allison 1999). In El-Saadani's (2000) study, previous abortion and pregnancy intervals are used as measures of heterogeneity. When pregnancy history is controlled for, pregnancy interval may help to identify "high risk" women for the second pregnancy and after, and to sort out the relationship between age, gravidity and risk of miscarriage. Such a method nevertheless cannot help to identify the "high risk" women during their first pregnancy. Using pregnancy interval to control for heterogeneity is also questionable, because pregnancy interval correlates highly with the practice of breast-feeding.

To remedy the methodological limitations discussed above, we use logistic regression with generalized estimating equations (GEE) in our analysis. The generalized linear model with generalized estimating equations (GEE) is a generalization of regression techniques that relaxes the assumption of independent observations and controls for heterogeneity in the data.[7] Our analytical model is thus written as the following:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_y + \beta_2 X_b + \beta_3 X_s + \beta_4 X_i$$

In this model, the risk of miscarriage (*p*) is expressed in the form of log odds of a pregnancy ended in miscarriage versus that did not.[8] The risk of miscarriage is modeled as a function of biological, demographic, and socioeconomic risk factors. First, we use the woman's age at pregnancy, pregnancy order, and previous history of miscarriage to

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[7] We apply an exchangeable correlation structure to pregnancies from the same mother in our models, following Santow and Bracher's (1989) argument that "the innate risk (of miscarriage) is invariant with age at least until the mid-thirties."

[8] Should we have the beginning date of each pregnancy, a survival analysis model would be more suitable to examine miscarriage risk and to separate cohort and period effects. Unfortunately, only date at the end of pregnancy was recorded in the survey. We did not adjust (synchronize) pregnancy cohort in our model for two reasons: 1) although cohort size changes from time to time, only under extreme circumstances was the change drastic in short term, say in one year; 2) we experimented with some adjustments, such as adjusting all pregnancies to their months of conception, but no drastic change was seen in our model results.

capture the biological and demographic effects (X_b) on miscarriage. To detect the impact of social crises on miscarriage, we include year of the pregnancy (X_y) in the model. Second, we introduce the woman's educational attainment, residence type, and occupation as indicators of her personal socioeconomic status (X_s), as well as access to health care facilities. Finally, we examine the differential impact of these economic and social disruptions on miscarriage for different social groups by introducing interaction terms between the timing of social crises and social groups a woman belongs to (X_i).

RESULTS

Prevalence of Miscarriage

From 1955 to 1987, the 411,696 women in our sample had 1,307,427 pregnancies. Among them, 85.3% were live births, 3.1% ended in miscarriage, 1.3% ended in stillbirth, and 10.3% were terminated by induced abortion.[9] Measured as a lifetime experience, 7.6% of all women aged 15 to 57 in 1988 had at least one miscarriage up to the time of survey. Among those who had completed their reproductive career at the time of the survey (aged 45 and above), 14.6% had experienced at least one miscarriage. In Figure 1, we show the trend in miscarriage prevalence reported in the survey for the time period of 1955-1987.

[Figure 1 about here]

The overall miscarriage rate, 3.1%, is very low if simply compared with rates based on prospective studies that detect all pregnancies. However, such a level is more

[9] All percentages here and results in the regression models are adjusted with sample weight.

consistent with the level of miscarriage in clinical studies for pregnancies after the eighth week, and close to the low end of survey-based estimates found in Asian populations in the World Fertility Surveys, as reviewed earlier. This level of miscarriage prevalence, therefore, should not be interpreted as the true prevalence level of miscarriage in the Chinese population. Rather, it is the reported level of miscarriages by Chinese women in the survey, based on their understanding of what is considered a pregnancy and a miscarriage.

A major reason for such a reported low level of miscarriage prevalence in the Chinese population, we believe, is that most respondents only recognized and remembered pregnancies that ended relatively late into pregnancy. As well explained by Leridon (1976:320), miscarriage is a *"non-objective"* event, since it may: 1) occur without noticing, 2) be hidden from others, 3) be forgotten and 4) be perceived differently in various cultural contexts. In our case, we suspect that the reported low miscarriage rate in our data is most likely due to reasons 1), 3), and 4) above, especially 4). The Chinese perception of what is considered a human life begins rather late in the life course of a pregnancy, and places more emphasis on the social rather than the biological definition. Historically, just as an unborn child was considered a "liquid life" in the Japanese context (LaFleur 1992), a child born in China was not considered a "fully human" until that child was six months or older (Lee and Wang 1999). It is reasonable therefore to entertain the interpretation that for many respondents in the survey, pregnancies that lasted no more than two months were neither recognized as a pregnancy nor its ending interpreted as a miscarriage.[10]

Figure 1 also reveals two prominent features in the overall trend of miscarriage reported by Chinese women. First, with few exceptions, the overall risk of miscarriage is relatively stable across such a long time period, at a level of around 3% of all pregnancies. The absence of an increasing trend, at a first glance, relieves to some extent the concern of a serious recall bias in the survey data, which could result in a higher level of miscarriage among more recent pregnancies as they are less likely to be forgotten. It also affirms us that the reporting of miscarriage is not likely to be contaminated by the rising incidents of induced abortion, since abortion rate increased steadily and drastically after the early 1960s (Wang 1995, Scharping 2003). Second, two spikes show up prominently, with the first during the Great Leap Famine of 1959-1961, when miscarriage rate shot up by more than 50 percent, from 3.4% in 1958 to 4.3% in 1959, 4.4% in 1960, and to 4.9% in 1961. The second spike shows up for 1967, the most turbulent year of the Cultural

[10] To examine the perceived definition of pregnancy and miscarriage, we carried out one experiment, to compare miscarriage rates reported by women themselves and by people familiar with them who answered the survey questions on the women's behalf. There are about 4% of respondents who were not available at the time of interview, and their questionnaires were filled out by people knew them well (presumably family members). The difference in miscarriage rates between these two groups is very small, merely 0.3% (3.1% vs. 2.8%), suggesting that miscarriages reported in the survey were known both to the woman and her family members, and that the pregnancies were well into the term and likely to be recognized and remembered.

Revolution, when miscarriage rate rose from about 2.9% in 1966 to 3.6% in 1967. We shall investigate the impact of these two spikes on miscarriages following an initial examination of the biological and social risk factors below.

Biological and Demographic Patterns

As seen in other populations, miscarriages among the Chinese population follow a clear age pattern, as shown in Figure 2. Besides some irregularities at the beginning and the end of the age distribution, the relationship between maternal age and miscarriage risk resembles almost a prefect U-shape. Miscarriage rate is high at the very young age, at a level of 5% among pregnancies by the late teens. The risk of miscarriage declines with age, to below 3% for women in the late twenties and early thirties, before rising to 4% in the late thirties and to over 5% in the mid-forties. This pattern is consistent with previous research for other populations (Andersen et al. 2000; Casterline 1989a), though showing a higher rate for the youngest group than other studies.

[Figure 2 about here]

Frequencies of miscarriage also vary by other factors. In Table 1, we summarize these patterns of miscarriage by other biological and demographic characteristics of the woman. The relationship between miscarriage and pregnancy order follows a "J" shape, with a reported rate of 3.2% for the first pregnancy, dropping to below 3% for the second and third pregnancies, then rising to 3.9% by the sixth pregnancy. Results in Table 1 also underline a clear pattern of heterogeneity among women with regard to miscarriage. Women who have one previous miscarriage are more than 3.5 times more likely to have another one compared with those who had no such an experience. The rate of miscarriage increases to more than one miscarriage in three pregnancies for those with four previous miscarriages, and to more than one in every two for those who had five previous miscarriages. In contrast to the clear pattern of miscarriage associated with age, pregnancy order, or previous history of non-live birth, there seems to be no strong association between the number of live birth and the risk of miscarriage. Whereas the risk is higher among those with no previous live birth, the risk of miscarriage does not increase with the number of live birth until the high birth order of six. Higher fertility alone, in other words, does not result in higher risks of miscarriage. The relationship between previous stillbirth or abortion and miscarriage is also not apparent.

[Table 1 about here]

The biological and demographic patterns of miscarriages revealed in these Chinese data not only confirm what is generally already known based on other populations, they also lend some confidence in the suitability of using these data for a further examination of the effects of other factors. The low miscarriage rate reported above by itself certainly raises a serious but reasonable doubt about the data quality. But our explanations about the reasons for the low rate – likely accounting of only pregnancies and miscarriages beyond the first two months of pregnancy -- and the biological and demographic patterns we observe here, lead us to conclude that while the survey data are not suitable to provide an estimate of the true level of miscarriage prevalence in the population, they are nevertheless largely suitable for examining the factors affecting the reported miscarriage occurrences.

Differences by Social Status

Reported occurrences of miscarriage also vary by women's social characteristics. Among the social characteristics contained in our data source, we select three to include: the woman's residence type, her educational attainment, and her occupation reported at the time of the survey.[11] For residence type, we use the location of *hukou* (household registration) status reported by the woman, which we classify into cities, towns, and rural areas. Individuals living in cities had the best access among the three groups to health care, which included better early pregnancy diagnosis and prenatal care. We classify women's educational attainment into five categories, from illiterate or semi-illiterate to college educated, and occupational status into six categories. Table 2 presents reported rates of miscarriage by these social characteristics.

[Table 2 about here]

Women in cities reported a level of miscarriage clearly higher than those in towns and in the countryside: 3.7 versus 3.2 and 3 percent. Higher social status as shown by educational attainment and occupational status shows a similar pattern, with those having higher status reporting higher rates of miscarriage. Whereas the difference among the majority of women in the mid-range of the educational distribution is less pronounced, those at the extremes, with college education or no schooling, reported the highest and

[11] The survey did not collect residential or employment history data so residence and occupational status at the time of each pregnancy is not available. Given the relatively low geographic and occupational mobility in China during most of the time period under our study, characteristics at the time of the survey can be trusted as good proxies for social status at the time of pregnancy in most cases.

the lowest rates: 4.7 versus 3.0 percent respectively. Similarly, those with cadre occupational status also reported the highest rate of miscarriage, 4.1%, versus only 3% for peasants. These results seem to suggest a systematic pattern of better recognition and recall of early pregnancy and miscarriage among those with higher social status, rather than a pattern of negative impact of social status on miscarriage. In the later part of this paper, we shall return to the examination of social characteristics in more detail.

Social Crises: Famine and the Cultural Revolution

As shown in Figure 1, the otherwise rather stable trend of self-reported prevalence of miscarriage among Chinese women is marked by two pronounced spikes, once during the Great Leap Famine of 1959-1961, and another in 1967, the most intense year of the Chinese Cultural Revolution.

The Great Leap Famine of China (1959-1961) is the costliest famine ever in human history in terms of human lives lost or postponed. Political blunders during the Great Leap Forward movement that collectivized hundreds of millions of Chinese farmers over a short time period, occasioned by severe weather conditions, resulted in a sharp drop in grain output of about 25% in 1960-61. Between 1958 and 1962, China experienced an estimated 30 million premature deaths and about 33 million lost or postponed births (Ashton et al. 1984; Kane 1988; Yang 1996).

The Cultural Revolution of 1966-1976 is another unprecedented and unsettling historical event in recent Chinese history. Though far less costly in terms of population loss compared with the 1959-1961 famine, the effort led by China's supreme leader Mao Zedong to revitalize the Chinese revolutionary cause resulted in widespread conflict, destruction, and turmoil in China. This unprecedented “revolution from within” resulted in an estimated 750,000 to 1.5 million deaths (Walder and Su 2003), removed at one time at least 60% of officials from their offices, and sent down more than twenty million urban youths, government officials, and intellectuals to live in the countryside or in reform camps. The year 1967 is the most intense year of the decade-long social turmoil, marked by power seizure by the Red Guards and armed battles in Chinese cities.

Unlike the famine, which affected the less privileged population more severely, the Cultural Revolution targeted first and foremost the elite of the Chinese society, those with higher education, higher social status or "bad family backgrounds". Previous studies have shown the demographic marks in terms of mortality and fertility left by the famine (Ashton et al. 1984; Kane 1987, 1988; Peng 1987). No one to our knowledge, however, has examined fluctuations in miscarriage, which represent both an increased level of (intrauterine) mortality, and contributes to the sharply depressed fertility level, and no one has examined in detail the impact of the Cultural Revolution on demographic outcomes.

In order to further examine the impact of these two unusual social crises on the risk of miscarriage in the Chinese population, and to understand the roles of other risk factors as enumerated above, we continue with analyses using multivariate models as specified earlier. Through such analyses, we can differentiate the net effects of social crises from other risk factors and separate the effect of age versus that of gravidity, occupational status versus educational attainment, and other factors that are correlated to each other. In Table 3, we give results of multivariate analyses from three different models.

[Table 3 about here]

The effect of the two social crises under examination, the Great Leap Forward Famine and the Cultural Revolution, is clearly shown in Model 1 of Table 3. Compared with the reference level of miscarriage under study (1980-1987), four years stand out with an excess risk in miscarriage by more than 10%.[12] In 1959, 1960, and 1961, the reported risk of miscarriage was 31.9%, 32.4%, and 51.6% above the reference years. In 1967, the risk was 15.5% higher. At the same time, after controlling for each other in the same analytical model, patterns of miscarriage associated with biological and demographic factors as those shown in the earlier bi-variate analyses largely remain. The adjusted miscarriage risk by maternal age is still in a U-shape, with the highest risk at the ends of the distribution. The risk of miscarriage goes up with pregnancy order in a linear pattern. Compared with women with their first pregnancies, miscarriage risk among second pregnancies, controlling for a woman's age and pregnancy history, is 83.5% (measured in relative odds) higher, and by the fifth pregnancy, 1.9 times higher. Meanwhile, history of live birth decreases the risk of miscarriage about 60%; but additional live birth does not reduce the risk of miscarriage.

Women with a previous miscarriage experience are also under a much-elevated risk of repeating such an experience. Compared with women with no prior miscarriage

[12] A common practice in interpreting results of logistic regression is that when the incidence of an outcome of interest is rare (say, <10%), the adjusted odds ratio could be interpreted as relative risk (risk ratio) without worrying about distortion. The overall risk of reported miscarriage in this analysis is about 3%. We interpret the odds ratios as if they are risk ratios. The same applies to the interaction term – we calculate the odds ratios of interaction terms of interest and interpret them as risk ratios.

history, those with one previous miscarriage is three times as likely to have a miscarriage again, and the risk difference is as large as over six times between a woman with no miscarriage experience and one with three miscarriages. History of stillbirth does not have a significant effect on the risk of miscarriage. History of abortion, contrary to what would be expected, decreases the risk of miscarriage by 23.4%. Risk of miscarriage of multiple-fetus pregnancies is only about 19.2% of that of single-fetus pregnancy, which is just the opposite to clinical observation but makes perfect sense for a survey study: multiple-fetus pregnancies could only be recognized at a late stage of gestation in the absence of medical examination.

In Model 2 of Table 3, we include indicators of a woman's socials status: residence, educational attainment, and type of employment. Overall, after controlling for the time of pregnancy and for biological/demographic risk factors, we observe the same risk pattern as seen in the bi-variate analysis above, namely that women with higher social status reported a higher rate of miscarriage. Compared with women with their household registration in cities at the time of the survey, those in townships on average reported a risk that is 10.4% lower, and in rural areas, 14.4% lower. Compared with illiterate or semi-illiterate women, women with college education reported a risk that is 50.0% higher, and with senior high school education, 25.9% higher. The effects of these two factors are similar to what Casterline (1989b) found in other developing counties. In addition, compared with women in farming, cadres and professionals reported a risk that is 14.8% higher. While the gap between the high and the low educational and occupational groups in miscarriage rate reduces somewhat when all three social factors are taken into consideration, the persistent pattern of high-status/high risk suggests three possibilities: first, such a pattern is an outcome of a systematic recall bias problem, namely that women with higher social status have higher level of awareness and more accurate recall. Second, higher social status may indeed result in a higher risk of miscarriage, with urban and more educated women having a life style and pressure that was more prone to causing miscarriage than for women in the countryside and with less education. Third, the observed pattern could also be the result of a combination of the above two possibilities.

Results in Model 3 of Table 3 provide some partial help to untangle the puzzling results shown in Model 2. In this model, we introduce several interaction terms between social status variables and the peak years of miscarriage rates associated with the social crises under examination, and test two alternative hypotheses. First, if urban and more educated women indeed have higher awareness and better recalling of their miscarriage experiences, or they indeed have higher risks, we would expect to observe the same pattern – that higher status women report higher rate of miscarriage – during these crisis years. Alternatively, if the elevated miscarriage risk in the social disruption years is real, we would expect that the groups who suffered the most, namely peasants in rural area during the famine and social elites during the Cultural Revolution, would report a higher rate of miscarriage.

Results in Model 3 support our alternative hypothesis. Women with higher social status did not always report a higher risk of miscarriage. During the famine years, it was women in rural areas who were hit the hardest, with a much-elevated risk. With interaction terms specifying location and time, we see that the overall impact of famine on miscarriage is no longer statistically significant for 1959 and 1960. Instead, these initial two years of the famine were only devastating for women in rural areas and in townships. Compared with those living in the cities, the risk of miscarriage for the other two groups was over 23% higher in 1959, and over 16% in 1960. By 1961, however, the impact of the famine reached all China, but rural and township areas were still hit harder than cities, with 10% higher risks compared with cities.

Similarly, it was women with the highest educational level who reported an increased level of miscarriage during the peak year of the Cultural Revolution. In 1967, while the overall risk of miscarriage rose by about 15%, women with high level of education and those who worked in service and commerce sectors experienced a much elevated risk above the national average. Compared with those with illiterate or semi-illiterate educational level, women with college education reported an additional 126.5% excess in the risk of miscarriage. Though this additional effect has a lower statistical significance level due the small number of college educated women at that time in our sample, it is nevertheless more than suggestive to indicate that the Cultural Revolution, just as the famine, affected segments of the population differently. Another piece of evidence is the 45.0% higher risk among women with occupation reported at the time of the survey in 1988 as working in service and commerce compared with peasants. Though we lack information on occupational status at the time of the Cultural Revolution for these respondents, we can assume a high degree of consistence in social status among these women given the low occupational mobility in China during the time period under our study. As carriers or accused agents of “feudal” and “bourgeois” culture, intellectuals and commerce worker were among the primary targets of the Cultural Revolution. These results in Model 3 of Table 3 therefore not only portray a more detailed picture of the impact of the famine and the Cultural Revolution on fetal wastage, they also suggest that at least to certain extent, the higher miscarriage rate reported by higher social status women cannot be attributed totally to their better recall or higher awareness.

DISCUSSION AND CONCLUSIONS

Large-scale social and economic crises leave heavy demographic footprints. In this article, we find that miscarriage, a common adverse reproductive outcome that has been largely associated with biological factors, does not escape from the impact of famine and other social disruptions. Relying on data from a survey that encompasses a large number of pregnancy histories and covers a long time period, including two unusual social disruptions, we are able to examine in detail the influencing factors of miscarriage in China for over a quarter century's time. The results of our study confirm the biological and demographic patterns of miscarriage shown for other populations, but they fail to lend indisputable support to findings in some earlier studies that miscarriage is associated with the social background of the pregnant women. Our results, that more educated urban women reported a higher prevalence rate of miscarriage than their rural counterparts with less schooling, may well be a function of urban women's better awareness and recall of pregnancy and fetal loss than of a higher rate of miscarriage. What emerges more indisputably from our analyses, however, is the role of famine and social turmoil in resulting a higher level of miscarriage.

The Great Leap Famine of 1959-1961 in China not only led to a massive number of premature deaths, but also a large number of deaths that could not be observed directly from existing population records: prenatal deaths. Whereas earlier studies revealed a sudden dearth in the number of births during the famine years, the precise mechanisms leading to the drastic fertility reduction were not well analyzed. Our study shows that, among other factors, the sharp increase in miscarriages caused by the famine was a direct and important contributing factor to the drastic reduction in fertility during this time period. The impact of the famine on miscarriage was particularly evident among the less privileged segment of the population, those residing in rural and township areas who could not enjoy the same degree of food supply protection as did the urban population from the government.

Our study also provides clues to another demographic puzzle in China's recent history that has so far largely escaped from careful scholarly scrutiny. This is the temporary but pronounced fertility reduction in Chinese cities during the peak years of the Chinese Cultural Revolution. For Chinese urban population as a whole, fertility level, measured by the total fertility rate, dropped by almost 25% during the first two years of the Cultural Revolution, from 3.8 in 1965 to 3.1 in 1966 and to 2.9 in 1967, before bouncing back to 3.8 in 1968. In the capital city of Beijing, fertility dropped from 2.6 in 1965 to 2.4 and 2.2 in 1966 and 1967 respectively, before rising to 2.9 in 1968. In Shanghai, another epicenter of the Cultural Revolution, fertility went down even further, diving below replacement level to as low as 1.36 in 1966 and 1.4 in 1967, before rising back to 2.1 in 1968 (Coale and Chen 1987). The Cultural Revolution interrupted reproduction through multiple ways, by postponing marriage, reducing coitus and therefore conception within marriage, and by increasing the incidences of induced abortion. What this study further reveals is that the drop in fertility was also a result of a rise in involuntary abortion among urban women. The risk of miscarriage rose by more than 15% in 1967 compared with the reference time period. The rise appears to be particularly pronounced if not totally concentrated among urban and highly educated or high social status women who were affected the most by the social movement. Reckoning that there were an even larger proportion of pregnancies loss ended in miscarriage without recognition, this social disruption's contribution to fertility decline is considerable.

Could the two miscarriage spikes revealed in this study be artifacts of selective memory of large historic events? We have several reasons to believe that this is not the case. First, Chinese census and fertility surveys in the 1980s are known for their accuracy of age and date of vital events because people "almost universally know their date of birth" (Coale 1984:18). Second, by integrating pregnancy and birth history in a consecutive order, the survey we rely on in this study to some extend reduced the likelihood of selective memory. Third, if memory is selective, we should see parallel spikes of live birth during these crises years, which is not the case. Fourth, there were other major social and political events in the years between 1955 and 1987, but we do not observe similar miscarriage spikes as those shown here. Fifth and lastly, based on medical research that suggests male fetuses are more venerable to miscarriage than female fetuses, one would expect a decline in sex ratio at birth in the miscarriage epidemic years. The sex ratio at birth for birth cohorts of 1959 (102.8) and 1968 (103.2) was indeed substantially lower than the 23-year mean between 1955 and 1987 (107.0), revealing a disproportional share of male fetus loss, as would be expected from a miscarriage epidemic.

How do famines and revolutions result in a higher rate of miscarriage? Our study points to stress as a highly plausible candidate. Whereas in the case of a severe famine, a sudden decrease in nutritional intake for the population may explain the elevated level of miscarriage, this is clearly not the case for the rise in miscarriage during the Cultural Revolution among urban Chinese women, who were certainly well nourished at the time. For both social events, the common factor underlying the increased risk of miscarriage is a much-increased level of social stress, caused either by a severe food shortage, loss of means of livelihood, dislocation, or a massive political turmoil. Our findings based on this large-scale and non-experimental study lend some support to the inconclusive findings derived from small-scale laboratory research that stress plays an important role in the occurrences of miscarriage (e.g. Scott and Duncan 2002).

Famines, revolutions, wars, ethnic clinching, and social disruptions of other forms are a recurring theme in human history, present time included. The extent to which these events affect human society not only manifests in the demographic losses they incur, but also in the ways they produce such losses. The present example, based on China's recent history, illustrates that such losses can occur even before a birth takes place, and therefore hidden from observed records of birth and deaths. It also suggests that what affect people's reproductive outcomes are not only physical factors, such as a reduction in food intake, but also psychological, in the form of social stress generated by social upheavals.

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Table 1: Miscarriage Rates by Pregnancy Order and Pregnancy History, China, 1955-87

		Pregnancy History				
Order/No.	Gravidity	Non-live Birth	Live Birth	Stillbirth	Miscarriage	Abortion
0		2.7	3.8	3.1	2.7	3.1
1	3.2	5.4	2.6	4.1	9.3	2.5
2	2.8	6.6	2.8	4.2	14.1	2.9
3	2.9	8.6	3.0	6.0	20.5	3.0
4	3.1	13.3	3.1	2.2	37.7	2.2
5	3.5	34.5	2.8		55.2	
6	3.9		4.4			

Table 2: Miscarriage Rates by Mother's Socioeconomic Status, China, 1955-87

Variable	Rate	Number of Cases (Pregnancies)*
Residence (hukou)		
City	3.7	173,075
Town	3.2	295,686
Rural	3.0	838,016
Education		
College and Above	4.7	12,939
Senior Middle School	3.7	85,707
Junior Middle School	3.2	198,675
Primary School	3.1	351,093
Illiterate & Semi-illiterate	3.0	659,013
Occupation		
Peasant	3.0	915,563
Peasant-Worker	3.3	50,439
Worker	3.6	91,779
Service/Commerce	3.5	48,083
Cadre	4.1	56,896
Other	3.0	144,667

Note: The number of cases (pregnancies) listed here are un-weighted.

Table 3: Effects of Demographic and Social Factors on Miscarriage (Results from Logistic Regression Models)

Independent Variables	Model 1		Model 2		Model 3	
	Odds Ratio	*p* value	Odds Ratio	*p* value	Odds Ratio	*p* value
*Year (1980-1987 as Reference)***						
1959	1.319	0.000	1.370	0.000	0.986	0.896
1960	1.324	0.000	1.369	0.000	1.031	0.758
1961	1.516	0.000	1.572	0.000	1.251	0.028
1967	1.155	0.000	1.189	0.000	1.166	0.000
Mother's Age (21-25 as Reference)						
16-20	1.216	0.000	1.276	0.000	1.276	0.000
26-30	0.793	0.000	0.754	0.000	0.753	0.000
31-35	0.672	0.000	0.635	0.000	0.633	0.000
36-40	0.739	0.000	0.700	0.000	0.698	0.000
41-45	1.061	0.441	1.017	0.826	1.014	0.854
Pregnancy Order (Order=1 as Reference)						
Order=2	1.835	0.000	1.852	0.000	1.852	0.000
Order=3	2.250	0.000	2.323	0.000	2.324	0.000
Order=4	2.560	0.000	2.694	0.000	2.696	0.000
Order=5	2.926	0.000	3.142	0.000	3.144	0.000
Order=6	3.168	0.000	3.471	0.000	3.475	0.000
Number of Previous Live Births (No Previous Live Birth as Reference)						
1	0.427	0.000	0.439	0.000	0.439	0.000
2	0.388	0.000	0.406	0.000	0.407	0.000
3	0.394	0.000	0.418	0.000	0.419	0.000
4	0.390	0.000	0.414	0.000	0.415	0.000
5	0.384	0.000	0.405	0.000	0.406	0.000
Number of Previous Miscarriage (No Miscarriage History as Reference)						
1	3.068	0.000	3.000	0.000	3.000	0.000
2	4.312	0.000	4.174	0.000	4.171	0.000
3	5.582	0.000	5.401	0.000	5.401	0.000
4	10.316	0.000	9.857	0.000	9.847	0.000
5	14.111	0.000	13.257	0.000	13.281	0.000
Abortion History (Yes vs. No)	0.776	0.000	0.708	0.000	0.706	0.000
Stillbirth History (Yes vs. No)	1.067	0.235	1.090	0.117	1.090	0.117
Multi-gravidity	0.192	0.000	0.193	0.000	0.193	0.000
Residence (Urban as Reference)						
Town			0.896	0.000	0.872	0.000
Rural			0.856	0.000	0.832	0.000
Education (Illiterate or Semi-illiterate as Reference)						
College and Above			1.500	0.000	1.469	0.000
Senior High School			1.259	0.000	1.258	0.000
Jonior High School			1.127	0.000	1.127	0.000
Primary School			1.067	0.000	1.069	0.000
Mother's Occupation (Peasant as Reference)						
Peasant-Worker			1.071	0.019	1.072	0.018
Worker			1.078	0.007	1.066	0.023
Service/Commerce			1.037	0.276	1.020	0.560
Cadre/Professional			1.148	0.000	1.143	0.000
Other			0.930	0.001	0.936	0.002
Interactions						
Rural 1959					1.479	0.001
Rural 1960					1.396	0.004
Rural 1961					1.325	0.015
Town 1959					1.470	0.005
Town 1960					1.434	0.008
Town 1961					1.268	0.078
College 1967					1.542	0.107
Service/Commerce 1967					1.422	0.047
-2 Log Likelihood	348878.0		348307.0		348267.8	
Number of Cases	1307427		1307427		1307427	

***All other years are included in the models but omitted in this table to save space. None of them has significantly (.05 level) higher miscarriage risk than the reference years.*

Figure 1. Prevalence of Miscarriage, China 1955-1987

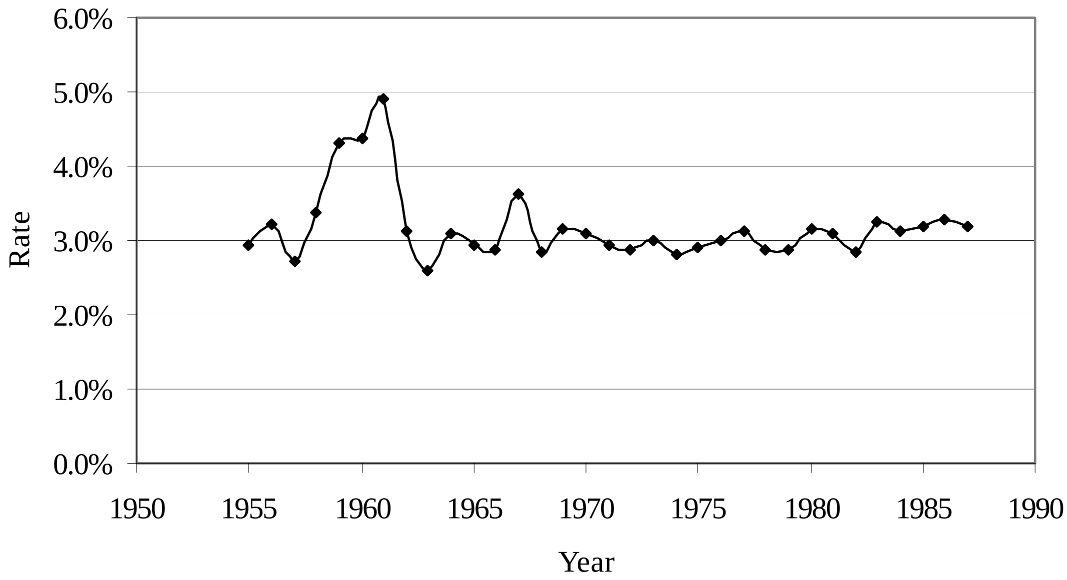

Figure 2. Prevalence of Miscarriage by Maternal Age, China 1955-1987