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Investigation on the Status of Spontaneous Abortion among Reproductive-Age Women in Shaanxi Province

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Abstract: *The incidence of spontaneous abortion among reproductive women in Shaanxi province was 4.94%. The ratio of spontaneous abortion to pregnancies was 3.58%, with a spontaneous abortion rate of 3.92%. The risk of spontaneous abortion increased with maternal age, number of pregnancies, lower education levels, and poorer economic conditions. The southern region had the lowest risk of spontaneous abortion, while rural areas had higher risks than urban areas. Xianyang and Yan'an had significantly higher risks compared to other districts.*

Keywords: *Spontaneous abortion; Reproductive women; Reproductive history*

1. Introduction

Natural miscarriage refers to the process in which pregnancy, less than 28 weeks, spontaneously ends due to certain pathological factors without the use of any artificial methods to expel the embryo or fetus from the mother's body. According to reports, the incidence of natural miscarriage among clinically diagnosed women of childbearing age is approximately 10% to 25% [1,2]. In reality, observing natural miscarriage is challenging because many women do not exhibit any symptoms and it is often overlooked as a one-time excessive or delayed menstruation. It is only detected during ultrasound examinations when anomalies in embryo development and cardiac activity are observed, presenting as "empty gestational sac" or "embryo ceased development". Therefore, the distribution of natural miscarriage in the population is difficult to accurately understand and typically requires estimation through reproductive history data. In this study, data from the "Survey on Risk Factors for Birth Defects in Shaanxi Province" conducted from August to November 2013 in Shaanxi Province were utilized to investigate the occurrence and distribution characteristics of natural miscarriage.

2. Data and Methods

2.1 Data Source

The data used in this study were from the "Survey on Risk Factors for Birth Defects in Shaanxi Province" conducted from August to November 2013 in Shaanxi Province.

2.2 Study Population

Childbearing women in Shaanxi Province who had been pregnant between 2010 and 2013 and had a clear pregnancy outcome. In this study, childbearing women with incomplete reproductive histories or unclear outcomes of their last pregnancies were excluded, and only those with complete and clear reproductive histories and outcomes of their last births were included.

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2.3 Study Design

A cross-sectional survey design was employed. With an estimated sample size based on a birth defect rate of 140 per 10,000 live births and considering a loss to follow-up rate of 10% to 20%, approximately 30,000 childbearing women needed to be surveyed. The study subjects were obtained using a stratified multistage random sampling method. Specifically, urban and rural areas were stratified, followed by random sampling of counties. Ten urban districts and twenty counties were randomly selected based on the urban-rural ratio in Shaanxi Province, considering population density and fertility levels. In each selected urban district, three street offices were randomly chosen, and in each street office, six communities were randomly selected. Sixty childbearing women who had been pregnant and had clear pregnancy outcomes were randomly surveyed in each community. In each sampled county, six townships were randomly selected, and in each township, six villages were randomly chosen. Thirty eligible women were randomly surveyed in each village.

This study utilized three indicators to reflect the status of natural miscarriage. First is the proportion of childbearing women who experienced natural miscarriage, which is the proportion of women who had experienced one or more natural miscarriages among all surveyed childbearing women, as shown in Formula 1. Second is the miscarriage-to-pregnancy ratio, which is the proportion of pregnancies resulting in natural miscarriage among the total number of pregnancies of all surveyed childbearing women, as shown in Formula 2. Third is the miscarriage rate, which is the ratio of the number of natural miscarriages among all pregnancies (excluding induced abortions) of all surveyed childbearing women, as shown in Formula 3.

$$\text{The proportion of childbearing women who experienced natural miscarriage} = \frac{The\ number\ of\ women\ who\ experienced\ one\ or\ more\ spontaneous\ abortions}{The\ total\ number\ of\ women} \quad (1)$$

$$\text{Spontaneous abortion rate} = \frac{number\ of\ spontaneous\ abortions}{total\ number\ of\ pregnancies} \quad (2)$$

$$\text{Spontaneous abortion rate} = \frac{number\ of\ spontaneous\ abortions}{total\ number\ of\ pregnancies - number\ of\ induced\ abortions} \quad (3)$$

2.4 Survey Method and Quality Control

The survey employed a self-designed questionnaire titled "Risk Factors for Birth Defects in Shaanxi Province," administered through face-to-face interviews by trained investigators. All investigators were recruited from the Medical School of Xi'an Jiaotong University and underwent unified training before being qualified to conduct interviews. After the survey, the completed questionnaires underwent three rounds of review, including self-review, peer review, and team leader review. The data obtained were entered into a database and checked for logic errors using Epidata 3.0, with double data entry.

During the collection of pregnancy outcomes, investigators explained the concepts and clinical manifestations of "spontaneous abortion" and other pregnancy outcomes to the surveyed women, helping them to recall their reproductive history as completely and accurately as possible. If the surveyed women could not accurately recall relevant information, their spouses or other informed individuals were consulted, or relevant documents such as identity cards and household registers were consulted to ensure the accuracy of the information.

2.5 Data Quality Analysis

The data for this study are derived from the Key Project of the National Natural Science Foundation of China, titled "Primary Prevention Effect of Periconceptional Micronutrient Intervention on the Incidence of Congenital Heart Disease" (Project No.: 81230016), sub-project "Investigation of the Status and Risk Factors of Birth Defects in Shaanxi Province." This project has been approved by the Medical Research Ethics Committee of Xi'an Jiaotong University School of Medicine (Ethics Approval No.: 2012001). The survey content includes basic family information, reproductive history, adverse lifestyle factors during the last pregnancy, covering the necessary content for this study. The definitions of various pregnancy outcomes in the reproductive history are consistent with this study. A stratified multistage random sampling method was used to randomly select 30,027 women of childbearing age from 10 urban districts and 20 counties in Shaanxi Province, meeting the requirements of the sampling method and sample size for this study. Quality control was implemented throughout the entire research process. Therefore, the research data from this sub-project can be used in this study.

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2.6 Statistical Methods

Three indicators reflecting the status of spontaneous abortion were described statistically using rates or proportions. The Pearson χ^2 test was used to compare differences between groups for count data, while the Cochran-Armitage trend test was used for ordinal data. All statistical tests were two-sided, and a P-value < 0.05 was considered statistically significant. The statistical analysis was performed using SAS 9.4 software.

3. Results

3.1 Basic Characteristics of the Study Population

A total of 30,027 women were surveyed, with 459 of childbearing age women excluded due to incomplete reproductive history or last pregnancy outcomes, resulting in 29,568 women of childbearing age being included as subjects for this study. Of these, 5,986 were from southern Shaanxi, accounting for 20.24%; 15,912 were from central Shaanxi, accounting for 53.82%; and 7,670 were from northern Shaanxi, accounting for 25.94%. There were 19,951 women from rural areas, accounting for 67.47%, and 9,617 women from urban areas, accounting for 32.53%. The mean age of women was 27.06 years, and the mean age of husbands was 29.17 years. Both women and husbands mainly had an educational level of junior high school, accounting for 49.73% and 50.64%, respectively. See Table 1 for details.

Table 1: Basic Characteristics of Women of Childbearing Age in Shaanxi Province

Basic Characteristics	Number	Composition(%)
Region Southern Shaanxi	5986	20.24
Central Shaanxi	15912	53.82
Northern Shaanxi	7670	25.94
Urban-Rural Rural	19951	67.47
Urban	9617	32.53
Women's Education Level Primary School and Below	3608	12.20
Junior High School	14704	49.73
High School/Vocational School	5880	19.89
College and Above	5376	18.18
Husband's Education Level Primary School and Below	2708	9.16
Junior High School	14972	50.64
High School/Vocational School	6104	20.64
College and Above	5784	19.56

3.2 Overall Occurrence of Spontaneous Abortion

Among the included women in the study, a total of 29,568 women experienced 48,957 pregnancies, with an average of 1.66 pregnancies per woman. There were 6,055 total miscarriages, averaging 0.21 miscarriages per woman, and 1,752 cases of spontaneous abortion, averaging 0.06 occurrences per woman. The proportion of reproductive-age women in Shaanxi Province experiencing spontaneous abortion was 4.94%, with a spontaneous abortion rate of 3.92%. The ratio of spontaneous abortions to pregnancies was 3.58%. Of these, 1,272 cases occurred in early pregnancy (<12 weeks gestation), accounting for 77.42% of all spontaneous abortions, while 371 cases occurred in late pregnancy (≥12 weeks but <28 weeks gestation), accounting for 22.58% of all spontaneous abortions. See Table 2 for details.

Table 2: Composition of Early and Late Spontaneous Abortions in Shaanxi Province

	Spontaneous Abortion Cases	Composition Ratio(%)
Early Spontaneous Abortion (<12 weeks gestation)	1272	77.42
Late Spontaneous Abortion (12 weeks ≤ gestation < 28 weeks)	371	22.58
Total	1643[a]	100.00

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3.2.1 Relationship between Age and Spontaneous Abortion

The proportion of reproductive-age women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate were all highest in the age group >30 years, at 7.70%, 4.47%, and 4.93%, respectively. With increasing age of women, there was a rising trend in the proportion of reproductive-age women experiencing spontaneous abortion, and this trend was statistically significant according to the chi-square trend test(χ^2 =165.724, P<0.001);Additionally, the spontaneous abortion-to-pregnancy ratio and the spontaneous abortion rate also exhibited a similar increasing trend.(χ^2 =59.697, P<0.001; χ^2 =64.767, P<0.001).

The occurrence of spontaneous abortion among women across different age groups of husbands is generally similar to that among women across different age groups. The proportion of women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate are all highest in the group where husbands are older than 30 years, with values of 6.88%, 4.18%, and 4.62%, respectively. As the age of husbands increases, there is also a rising trend in the proportion of women experiencing spontaneous abortion, and this trend is statistically significant according to the chi-square trend test(χ^2 =142.435, P<0.001);Furthermore, the spontaneous abortion-to-pregnancy ratio and the spontaneous abortion rate also show a similar increasing trend(χ^2 =48.480, P<0.001; χ^2 =53.689, P<0.001).

3.2.2 Relationship between Education Level and Spontaneous Abortion

The proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate were highest among women with primary school education or below, at 6.26%, 4.16%, and 4.48%, respectively. As women's educational level increased, there was a decreasing trend in the proportion of reproductive-aged women experiencing spontaneous abortion, and this trend was statistically significant according to the chi-square trend test (χ^2 =64.464,P<0.001);Additionally, the spontaneous abortion-to-pregnancy ratio and the spontaneous abortion rate also exhibited a similar decreasing trend (χ^2 =31.046,P<0.001; χ^2 =26.002,P<0.001).

The situation of reproductive-aged women experiencing spontaneous abortion across different educational levels of their husbands was generally similar to that of women across different educational levels. The proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate were highest among women whose husbands had primary school education or below, at 6.17%, 4.37%, and 4.73%, respectively. As the educational level of husbands increased, there was a decreasing trend in the proportion of reproductive-aged women experiencing spontaneous abortion, and this trend was statistically significant according to the chi-square trend test(χ^2 =60.595,P<0.001);Additionally, the spontaneous abortion-to-pregnancy ratio and the spontaneous abortion rate also exhibited a similar decreasing trend (χ^2 =35.996,P<0.001; χ^2 =30.563,P<0.001).

3.2.3 Relationship between Household Economic Conditions and Spontaneous Abortion

The proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate were highest among households classified as poor according to the household wealth index, at 5.66%, 4.00%, and 4.32%, respectively. There were statistically significant differences in the proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate among different household economic conditions(χ^2 =15.108,P<0.001; χ^2 =12.713,P=0.002; χ^2 =9.900,P=0.007).

3.2.4 Relationship between Parity and Spontaneous Abortion

Among women with parity of 4 or more, the proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate

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were highest, at 36.57%, 14.56%, and 20.90%, respectively. With increasing parity, there was an upward trend in the proportion of reproductive-aged women experiencing spontaneous abortion(χ^2 =3723.184,P<0.001);Additionally, the spontaneous abortion-to-pregnancy ratio and the spontaneous abortion rate also exhibited a similar increasing trend (χ^2 =2249.759,P<0.001; χ^2 =2933.528,P<0.001).

3.2.5 Relationship between Residential Area and Spontaneous Abortion

The proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate were highest in the northern region of Shaanxi Province, at 5.35%, 4.02%, and 4.32%, respectively. According to the chi-square test, there were statistically significant differences in the distribution of the proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate among the three regions (χ^2 =36.758,P<0.001; χ^2 =49.688,P<0.001; χ^2 =51.473,P<0.001).

The proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate were significantly higher in rural areas than in urban areas, with statistically significant differences (χ^2 =25.518,P<0.001; χ^2 =16.490,P<0.001; χ^2 =10.130,P=0.002).

The proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate were highest in Xianyang, at 8.04%, 5.36%, and 5.89%, respectively. According to the chi-square test, there were statistically significant differences in the distribution of the proportion of reproductive-aged women experiencing spontaneous abortion, the spontaneous abortion-to-pregnancy ratio, and the spontaneous abortion rate among the nine regions(χ^2 =223.170,P<0.001; χ^2 =226.231,P<0.001; χ^2 =232.619,P<0.001).Please refer to Table 3 for details.

Table 3: Proportion of Childbearing Women, Pregnancy Loss Rate, and Miscarriage Rate of Childbearing Women in Shaanxi Province under Different Characteristics Conditions

Indicator	Number of Childbearing Women	Total Pregnancy Times	Number of Spontaneous Abortions	Number of Induced Abortions	Number of Women with Spontaneous Abortions	Proportion of Childbearing Women Experiencing Spontaneous Abortions (%)	Spontaneous Abortion Pregnancy Rate (%)	Spontaneous Abortion Rate (%)
Age (years) Women <20	735	835	18	41	18	2.45	2.16	2.27
20~	10363	13862	394	1087	349	3.37	2.84	3.08
25~	11676	19548	683	1799	571	4.89	3.49	3.85
>30	6794	14712	657	1376	523	7.70	4.47	4.93
Husband <25	6283	7905	207	556	187	2.98	2.62	2.82
25~	12580	19168	630	1677	538	4.28	3.29	3.60
>30	10705	21884	915	2070	736	6.88	4.18	4.62
Education Level Women Primary school and below	3608	7507	312	539	226	6.26	4.16	4.48
Junior high school	14704	25749	979	2155	813	5.53	3.80	4.15
High school/vocational school	5880	8838	276	893	251	4.27	3.12	3.47
College and above	5376	6863	185	716	171	3.18	2.70	3.01
Husband Primary school and below	2708	5519	241	421	167	6.17	4.37	4.73
Junior high school	14972	26430	1005	2136	834	5.57	3.80	4.14
High school/vocational school	6104	9483	307	937	277	4.54	3.24	3.59
College and above	5784	7525	199	809	183	3.16	2.64	2.96
Family Wealth Index Poor	9219	16455	658	1224	522	5.66	4.00	4.32
Middle	10449	16788	562	1448	474	4.54	3.35	3.66
Rich	9900	15714	532	1631	465	4.70	3.39	3.78
Parity 1	14941	14941	5	5	5	0.03	0.03	0.03

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2	11037	22074	543	1504	542	4.91	2.46	2.64
3	2715	8145	651	1643	594	21.88	7.99	10.01
≥4	875	3797	553	1151	320	36.57	14.56	20.90
Residence Region Shaannan	5986	9562	229	746	205	3.42	2.39	2.60
Guanzhong	15912	26096	988	2646	846	5.32	3.79	4.21
Shaanbei	7670	13299	535	911	410	5.35	4.02	4.32
Urban/Rural Rural	19951	34215	1301	2568	1074	5.38	3.80	4.11
Urban	9617	14742	451	1735	387	4.02	3.06	3.47
Region Xian	5905	9207	276	1301	256	4.34	3.00	3.49
Baoji	2063	2972	70	139	64	3.1	2.36	2.47
Xianyang	5967	10999	589	1000	480	8.04	5.36	5.89
Weinan	1977	2918	53	206	46	2.33	1.82	1.95
Ankang	831	1283	23	59	22	2.65	1.79	1.88
Shangluo	2044	3382	57	164	53	2.59	1.69	1.77
Hanzhong	3111	4897	149	523	130	4.18	3.04	3.41
Yan'an	3855	7151	334	560	240	6.23	4.67	5.07
Yulin	5905	9207	276	1301	256	4.34	3.00	3.49
Total	29568	48957	1752	4303	1461	4.94	3.58	3.92

4. Discussion

4.1 Current Status of Spontaneous Abortion among Reproductive-Aged Women in Shaanxi Province

The occurrence of spontaneous abortion is generally estimated through a history of childbirth. In this study, the outcomes of pregnancy included both the most recent pregnancy and past childbirth history, providing a true reflection of the status of spontaneous abortion among reproductive-aged women in Shaanxi Province. The occurrence of spontaneous abortion reflects the reproductive function and reproductive health level of reproductive-aged women and is also a sensitive indicator reflecting the socio-economic and health conditions as well as maternal and child health care. Therefore, understanding and analyzing the occurrence of spontaneous abortion in the population and exploring its influencing factors are of great significance for studying preventive measures for spontaneous abortion and improving the health quality of the national population. The study found that among all cases of spontaneous abortion, early spontaneous abortion accounted for 77.42%, while late spontaneous abortion accounted for 22.58%, consistent with related reports [3]. The occurrence rate of spontaneous abortion among reproductive-aged women in Shaanxi Province was 3.92%, with a proportion of reproductive-aged women experiencing spontaneous abortion of 4.94% and a spontaneous abortion-to-pregnancy ratio of 3.58%.

4.2 Influence of Social Demographic Factors on Spontaneous Abortion

Impact of Age: This study shows that the proportion of spontaneous abortion increases with the age of women and their husbands. The possible reason is that older women are more likely to produce eggs with chromosomal abnormalities during the process of meiosis or mitosis, leading to spontaneous abortion in the early stages of pregnancy [4]. Additionally, as male age increases, the rate of chromosomal abnormalities in sperm also increases, leading to an increased occurrence of spontaneous abortion. Many studies have also confirmed conclusions similar to those of this study [5,6]. Impact of Education Level and Household Economic Conditions: The study also found that poorer household economic conditions increase the risk of spontaneous abortion. The risk of spontaneous abortion is also higher among women or husbands with lower educational levels. This may be because women or husbands with higher educational levels have a better understanding of reproductive health and eugenics knowledge, leading to a reduction in the occurrence of spontaneous abortion.

4.3 Impact of Parity on Spontaneous Abortion

Many studies have shown that higher parity increases the risk of spontaneous abortion [7-9]. This study indicates that the proportion of spontaneous abortion increases with parity, and women with parity ≥4 have the highest proportion, spontaneous abortion-to-pregnancy ratio, and spontaneous abortion rate. In Shaanxi Province, there are still some reproductive-aged women with a high number of pregnancies (up to 10). Therefore, reducing pregnancies and implementing effective contraception measures can help reduce the occurrence of spontaneous abortion to some extent.

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4.4 Influence of Residential Area on Spontaneous Abortion

This study also found that the incidence of spontaneous abortion in the central and northern regions of Shaanxi Province is higher than in the southern region. This may be due to the harsh geographical and climatic conditions in the central and northern regions, including higher altitude and latitude, strong winds and sandstorms, dry climate, and lower temperatures, which can affect the healthy growth and development of fetuses. A study based on Swedish birth cohort data also indicated that with decreasing environmental temperatures during pregnancy, the risk of stillbirth increases (HR=1.08, 95%CI: 1.00-1.17) Additionally, rural reproductive-aged women have a significantly higher proportion of spontaneous abortion than urban women, with Xianyang and Yan'an regions showing significantly higher rates than other areas. This suggests that rural areas, as well as Xianyang and Yan'an regions, require special attention and corresponding measures to reduce and prevent the occurrence of spontaneous abortion.

4.5 Potential Biases

According to existing literature, the incidence of spontaneous abortion among reproductive-aged women who can be clinically diagnosed is approximately 10%, whereas the rate obtained through retrospective reports from reproductive-aged women in our study was 3.92%. Reported spontaneous abortions may underestimate the actual incidence, considering that some early spontaneous abortions (within 12 weeks) may not be perceived by women, and there may be recall biases among older women. Additionally, the implementation of family planning may not completely rule out cases of concealing true pregnancies or abortion numbers. Recall bias is an important factor affecting the reporting of spontaneous abortion in retrospective studies. Some studies have shown that even women with higher levels of education may forget 1/4 of their reproductive history. Based on this proportion, the estimated incidence of spontaneous abortion in our study population is approximately 5.23%. However, considering that our study subjects were mainly rural women with primary education levels, the rate of forgetting should be higher than 1/4. Assuming that half of the spontaneous abortions were not reported, the estimated incidence would be approximately 7.84%. If two-thirds of spontaneous abortions were not reported, the estimated incidence would be approximately 11.76%. Therefore, we estimate that the incidence of spontaneous abortion among reproductive-aged women in Shaanxi Province is also around 10%, consistent with related reports.

5. Conclusion

This study found that the incidence of spontaneous abortion among reproductive-aged women in Shaanxi Province is 3.92%, with higher rates in the central and northern regions compared to the southern region. Rural areas have a higher incidence than urban areas, with Xianyang and Yan'an regions showing significantly higher rates than other areas. The risk of spontaneous abortion increases with age and parity, as well as among women and husbands with shorter educational durations and lower household economic conditions. Therefore, encouraging higher education, conducting reproductive health education, providing antenatal care and contraception services, reducing the number of pregnancies, and preventing advanced maternal age pregnancies can help reduce the occurrence of spontaneous abortion.

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