

Introduction

Pregnancy termination (PT) refers to the termination of pregnancy before live birth, including spontaneous termination (ST, including miscarriage and stillbirth) and induced abortion (IA).

Whether it is ST or IA, PT is related to the reproductive health and fertility level of the country and region, as it represents the portion of human fecundity lost. A comparative study of over 20 countries found that a significant proportion of pregnancies end with termination, ranging from 4.9% to 52.0% (1). High-level PT usually occurs in low - and middle-income countries (LMICs). In 2015, the number of late pregnancy stillbirths in LMICs accounted for 98% of the world, with 75% occurring in sub-Saharan Africa and South Asia (2). From 2010 to 2014, IA in LMICs contributed to approximately 88% of the total number worldwide (3). From 2015 to 2019, the incidence of induced abortion in sub-Saharan Africa was 33‰, North Africa and the Middle East was 53‰, Central and South Africa was 46‰, and East and Southeast Africa was 43‰, all of which were generally higher than the global level of 39‰ (4).

Therefore, it is necessary to analyze the trend of PT in LMICs over the past decades, which will be beneficial for the subsequent development of maternal and child health care in key areas and key female populations. Studies have shown that the global level of stillbirths has been decreasing at a rate of -2.0% year by year, including in sub-Saharan Africa, from 24.7 ‰ in 2000 (2). Although the abortion rate in developed countries gradually decreased from 1990 to 2014, that in developing countries is rising with an average annual change rate of 4%, and that of African countries is 3% (5). However, previous research mostly analyzes the temporal changes of specific categories of PT, that is, SA or IA, while few take into account PT as a whole. In addition, the analysis of temporal trends usually confuses the effects of age, period, and cohort.

This study aimed to use the Age-Period-Cohort-Interaction (APC-I) model to analyze the temporal trend of PT in LMICs, encompassing age, period, and cohort dimensions, and to investigate the generational patterns of PT incidence. It will provide a quantitative understanding of the development of PT in the developing world and provide a reference for future global maternal and child health and reproductive health work.

Method

Data

The Demographic and Health Surveys (DHS) are nationally representative cross-sectional household health surveys conducted every five years in over 90 LMICs worldwide, with a focus on problems including maternal and child health, childbirth, health insurance, and so on. The survey sampling method is two-stage cluster sampling to ensure representativeness.

This study retained a sample of women aged 15-49 years, as well as PT data between 2005 and 2020, and removed samples with missing key variables. The final sample consisted of 10 countries and four regions, including the Middle East, West Africa, East Africa, and South Africa, with a total sample size of 54826.

Outcomes

In this study, the outcomes were assessed as whether a participant had any pregnancies that did not result in a live birth in the past 5 years (1=yes, 0=no).

Measures

Age is grouped in 5-year intervals, ranging from 15 to 49 years: 15-19, 20-24, 25-29, 30-34, 35-39,

40-44, and 45-49.

Since the period should be also coded into 5-year groups, we ranged it from 2005 to 2019: 2005-2009, 2010-2014, and 2015-2019.

Resulted from 7 age groups and 3 period groups, we have 9 birth cohort groups also at 5-year intervals, born in the following years: 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, and 2000.

Covariates

The covariates include residence (urban, or rural), education level (uneducated, primary education, middle/high school education, and higher education), number of children (set as continuous), family wealth level (poorest, relatively poor, moderate, relatively wealthy, and wealthiest), and region (the Middle East, West Africa, East Africa, and South Africa).

Statistical analysis

This study used the APC-I model to analyze the age, period, and cohort effects of pregnancy termination levels in low - and middle-income countries. The APC-I model can be expressed as a generalized linear model as follows:

$$g(E(Y_{ij})) = \mu + \alpha_i + \beta_j + \gamma_k \quad (1)$$

Here, $g(E(Y_{ij}))$ is a function of the expected PT rate Y for the i^{th} age group within the j^{th} time period; μ represents the global mean of observed PT; α_i represents the average difference in the mean of the i^{th} age group, namely the age effect; β_j represents the average difference in the mean of the j^{th} period, namely the period effect; γ_k represents the average difference in the mean of the k^{th} cohort, which can also be written as $\alpha_i\beta_j(k)$, namely the cohort effect. The cohort effect includes two types: inter-cohort deviation, which compares the differences among cohorts, and intra-cohort slope, which displays the life course trend within the cohort.

Expected findings

Age and period main effects on PT incidence

Table 1 presents the estimated age main effects of PT incidence, which were significant in group 15-19, 20-24, 35-39, 40-44, and 45-49. The global mean incidence of PT per 1000 people was 143 ($e^{-1.943} \times 1000$). Compared with it, the PT incidence was 33.97% ($1 - e^{-0.415}$) and 19.02% ($1 - e^{-0.211}$) lower in the 15-19 and 20-24 age groups, but 17.47% ($e^{0.161} - 1$), 31.92% ($e^{0.277} - 1$), and 19.72% ($e^{0.180} - 1$) higher in the groups aged 35-39, 40-44 and 45-49, respectively. Overall, the PT incidence increased with age (See Figure 1).

The estimated period main effects can be referred to Table 1. The PT incidence decreased over time (See Figure 1). The incidence in 2005-2009 and 2010-2014 were 90.41% ($e^{0.644} - 1$) and 43.05% ($e^{0.358} - 1$) higher but in 2015-2020, it was 63.29% ($1 - e^{-1.002}$) lower than the mean value.

Cohort effect on PT incidence

Inter-cohort deviations

Table 2 reports the results of inter-cohort deviations, which indicate to what extent a cohort is different from the effect predicted by age and period main effects. Except for the cohorts 1990 and 1995, the inter-cohort deviations of PT were all significant, presenting a W-shape pattern (See

Figure 1). The PT incidence in cohort 1960 and 1965 was significantly higher, while that in cohort 1970, 1975, 1980, and 1985 was significantly lower than predicted. In cohort 2000, the PT incidence showed a rising trend, which was significantly higher than predicted.

Intra-cohort slopes

Intra-cohort slopes mean the life course dynamics within a certain cohort, which are shown in Table 2 and Figure 1. Cohort 1970 and 1975 had significant negative slopes, indicating that the incidence of PT decreased continuously across the life course, and the risk of PT was higher in women of early childbearing age compared to women of late childbearing age. The slopes in cohort 1985, 1990, and 1995 were significantly positive, and the PT incidence increased with the aging of the cohorts. It can be concluded that the PT risk tends to concentrate in late reproductive age women across generations.

Generational patterns

Based on inter-cohort deviations and intra-cohort slopes, we found that cohort 1965 and 1980 had a pattern of “Constant”, with their higher or lower inter-cohort deviation persistent across the life course. Cohort 1970 and 1975 had a “Cumulative Advantage”, as its lower-than-predicted incidence was even lower with cohort aging. Cohort 1985, 1990 and 1995 had a “Age-as-level” pattern. For cohort 1985, its cohort incidence was lower than expected but had a rising trend within the cohort. Although the incidence of cohort 1990 and 1995 was not significant, it increased with the cohort aging. Therefore, it was found that the PT was shifting to the older reproductive ages within the cohorts although the overall cohort incidence was declining from generation to generation.

Reference

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Table 1 Estimated age and period main effects of PT

	Coef.	IRR	SE
Intercept	-1.943***	0.143	0.065
Age main effects			
15-19	-0.415***	0.660	0.079
20-24	-0.211***	0.810	0.047
25-29	-0.039	0.962	0.038
30-34	0.046	1.047	0.039
35-39	0.161***	1.175	0.043
40-44	0.277***	1.319	0.049

45-49	0.180**	1.197	0.067
Period main effects			
2005-2009	0.644***	1.904	0.028
2010-2014	0.358***	1.430	0.028
2015-2020	-1.002***	0.367	0.032

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; IRR=Incidence Rate Ratio; the same below.

Table 2 generational patterns concluded from inter-cohort deviation and intra-cohort slopes

Cohort	Inter-cohort Deviation			Intra-cohort slopes			Generational Patterns
	Coef.	IRR	SE	Coef.	IRR	SE	
1960	0.340***	1.405	0.086	NA	NA	NA	NA
1965	0.203***	1.225	0.057	0.071	1.074	0.073	Constant
1970	-0.161***	0.851	0.045	-0.466***	0.628	0.073	Cumulative Advantage
1975	-0.075*	0.928	0.035	-0.131*	0.877	0.06	Cumulative Advantage
1980	-0.071*	0.931	0.032	0.097	1.102	0.056	Constant
1985	-0.097**	0.908	0.033	0.126*	1.134	0.058	Age-as-level
1990	-0.010	0.990	0.046	0.301***	1.351	0.074	Age-as-level
1995	0.115	1.122	0.063	0.308***	1.361	0.077	Age-as-level
2000	0.262*	1.300	0.115	NA	NA	NA	NA

Note: “NA” means “not available”, because the oldest and youngest cohorts only contain one interaction of age and period main effects and are unable to estimate intra-cohort slopes.

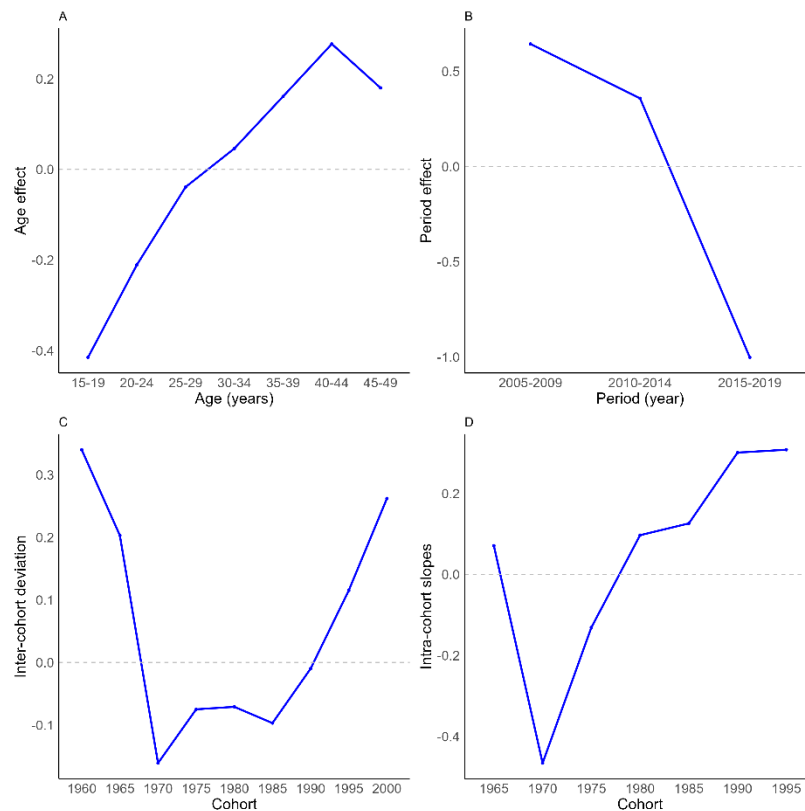


Figure 1 Age, period and cohort effects of pregnancy termination (PT) incidence

Note: (A) Estimated age main effects on PT incidence (B) Estimated period main effects on PT incidence (C) Estimated inter-cohort deviation on PT incidence (D) Estimated intra-cohort life-course slopes on PT incidence.