Intergenerational health impact of adverse environment in utero under civil conflict: evidence from Cambodia

Midori Matsushima
Faculty of Humanities and Social Sciences, University of Tsukuba, Tsukuba, Japan

Abstract

Purpose – This study aims to empirically examine how the Khmer Rouge regime (1975–1979) in Cambodia continues to affect the health of the second generation.

Design/methodology/approach – The 2000 and 2005 Cambodia Demographic and Health Surveys were used in the analysis. The study sample were women with a child/children in 2000/2005. The sample population was identified according to whether the person was in utero "91 months or earlier before the Khmer Rouge regime," "46–90 months before the Khmer Rouge regime" and "1–45 months before the Khmer Rouge regime" and during the Khmer Rouge regime. The authors then regressed the size of babies of the targeted population on the timing of the mothers being in utero.

Findings – Mothers who were in utero during the regime had a higher likelihood of giving birth to smaller-than-average babies. Additionally, mothers born in the areas that had a higher probability of death of children aged five or under during the regime were at risk of giving birth to smaller-than-average babies if they were in utero during that time.

Social implications – The findings have significant implications for today's society in practice, which still has a considerable number of people suffering from civil conflict and malnutrition. Civil conflicts not only severely affect current, but also future generations.

Originality/value – This is the first paper to assess the impact of the Khmer Rouge regime on the health of the second generation.

Keywords – Adverse environment in utero, Fetal origin, Intergenerational health transfer, Khmer Rouge, Civil conflict

Paper type – Research paper

Introduction

The world still suffers from civil conflicts, and 815 million people are chronically undernourished mostly due to problems of food distribution caused by human, notably civil, conflicts [1]. The fetal origins hypothesis known as Barker's hypothesis [2], later evolved as the Developmental Origins of Health and Disease (DOHaD) hypothesis, proposes that when a fetus is exposed to an adverse environment in utero, the negative impact remains for the entire lifespan due to scheduled prenatal brain and body development deficiencies [3, 4]. It further speculates that the reproductive system also suffers, leading to an adverse environment for a fetus [5]. Therefore, the negative impact is not just on those affected, but also their offspring. This is compounded when food problems occur due to conflicts, as it

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wipes out the educational system, leading to low socio-economic status (SES) and lower educational attainment that may cause the ill health of second generations during parenthood.

This study focuses on mothers who were born in Cambodia from 1960 to 1979 and their children. This was the period when the country’s environment changed from relatively peaceful times to the devastating experience of the infamous Khmer Rouge (KR) regime. We use the mother’s birth year cohort and the provincial variation in the percentage of deaths of children aged five or under during the KR regime as a proximate variable of the severity of food shortage, assuming that the death of children under five years of age was likely due to malnutrition. The study aims to increase an understanding of how an adverse environment in utero affects the health of succeeding generations.

Some studies investigated the consequences of the KR regime, indicating a negative impact. For example, women who spent their early teenage years under the KR regime (born between 1961 and 1965), on reaching adulthood, were, on average, shorter than women aged between 0 and 24 years in 1975 [6]. Another study that uses the data of individuals born between 1950 and 1965 revealed that exposure to civil conflict during primary school age lowered educational attainment, causing reduced wages as adults [7]. Moreover, conflict-exposed children experienced higher fertility (a 1% increase in female fertility) [8]. However, no studies have been conducted to investigate the effects of those conflict-affected parents on children.

**A brief overview of Cambodia and food insecurity: 1950s to 1980s**

After independence from France in 1953, Cambodia remained relatively peaceful, enjoying significant investment from foreign donors until 1970 [9, 10]. The country’s economy deteriorated from 1970 to 1975, experiencing a large drop in food production, including staples due to a civil war between Prince Sihanouk and the National Salvation Army represented by Lon Nol (LN) and Sisowath Sirik Matak [11]. The economy and food shortage further became critical under the KR regime, which came into power on April 17, 1975. The country was heavily influenced by the Maoist ideology and closed its economy, aiming to achieve a communist society with a completely collectivized agriculture and nationalization of all sectors, leading the country into a famine (KR Famine). Conservative estimates show that 14.8% of the children born between 1975 and 1979 had died within their first year of life, a figure higher than other birth cohorts around the KR regime [9]. This period is also known as the KR genocide, having caused a massive destruction of intellectual infrastructure by targeting urban educated males, recording a death toll of about 1.2–3.4 million people [7]. The KR fell on January 1979, and the People’s Republic of Kampuchea (PRK) was established in September of the same year. The food shortages were gradually eased through the food relief provided by international humanitarian aid organizations, as well as Vietnam and the Soviet Bloc countries [9].

**Methods**

**Data collection**

The study uses the data from the Cambodia Demographic Health Surveys (CDHS) of 2000 and 2005. The CDHS is the largest demographic and health survey in the country, focusing on women aged 15–49 and includes information regarding their children. A total of 15,351 and 16,823, women were surveyed in the 2000 and 2005 CDHS, respectively [12, 13]. With these 32,174 women, there were 36,361 children aged five or under with birth size records. This study limited the sample to respondents who had not changed their place of residence since giving birth. This allowed us to identify their place of birth, resulting in 10,163 observations
for children and 10,140 for mothers. After excluding the respondents who left some questions unanswered, we obtained a final sample of 2,464 observations for children and 2,347 for mothers.

Cohort selection
The study sample is divided into four cohorts based on the period in utero. Since the KR ruled the country from the beginning of April 1975 to the beginning of January 1979, we designate the cohort of “in utero under the KR regime” to include individuals who were born between January 1976 and September 1979, i.e. from ten months into the KR regime until the establishment of the PRK regime. For comparison, we created cohorts of “in utero before 91 months or earlier before the KR regime,” “in utero 46–90 months prior to the KR regime” and “in utero 1–45 months prior to the KR regime,” comprising of in utero earlier than 91 months before the KR regime, in utero 46–90 months before the KR regime and in utero 1–45 months before the KR regime.

The cohort “in utero 46–90 months prior to the KR regime” consisted of respondents who were in utero from 1969 to 1972, the beginning of the civil war. The fetuses in the cohort “in utero 46–90 months prior to the KR regime” spent their time in utero during the most peaceful period among the cohorts, consisting of women born before 1969. This was the period when Cambodia gained independence, and Prince Sihanouk established a neutral foreign policy to receive large investments and support from both sides of the Cold War alliances.

Health of the succeeding generations
We use “Smaller-than-average” as an outcome variable to include babies who were born smaller-than-average and very small. This variable is created based on the answer to the question “When (NAME) was born, was he/she very large, larger than average, average, smaller-than-average or very small?” Although CDHS data contain actual birth weight for sub-samples, this study uses the mothers’ evaluation of the size of their babies because birth weight was only available for a small portion of the sample (e.g. 17% for 2000 CDHS), which would further shrink the number of observations [12]. According to the summary statistics, approximately 15.7% of the babies were born smaller-than-average (Table 1). This figure is about the same as the percentage calculated from the whole sample data [12, 13]. We use size at birth as a sign of the health of the succeeding generation because the demographic and health surveys (DHS) suggests that birth weight is a major determinant of infant and child health and mortality, and in the case of DHS, when a mother reports their baby’s size at birth as “very small” or “smaller than average,” they are considered to have a higher-than-average risk of early childhood death [12, 13].

Demographic characteristics and reproductive-related variables
Our analytical observations include children born between 1995 and 2000, with some variations in the number of children born each year. The sex ratio is approximately 50%, about the same as in the entire sample [12, 13]. Reproductive-related variables are important to control for proximate determinants of the babies’ sizes. The summary statistics in Table 1 show that there are large variations among all indicators, including the order of birth, child-to-child birth intervals, age of mothers at giving birth and the number of antenatal care visits.

Regarding the characteristics of mothers and households, we looked at the wealth index and the educational levels of mothers and fathers to control for the SES of parents. Wealth was evaluated using a wealth index calculated and provided by the DHS, which is a composite measure of the cumulative living standard of the household in relative terms, calculated using a principal components analysis [12, 13]. Because this is the wealth index at the time of the survey, it can vary from the wealth status at the time of childbirth. However, as
they are the only possible data available, we assume that this wealth index is proximate to that at childbirth. We use education in single years to control for the mothers’ and fathers’ educational achievements, and our data show that fathers have higher education than mothers on average.

Analytical model

To reveal the association between birth cohort and a baby’s size, we set our empirical specification as follows:

$$\text{Small}_{im} = \beta_0 + \beta_1 \text{Timing being in Utero}_m + \beta_2 \text{Child Demographic}_i + \beta_3 \text{Reproductive}_{im} + \beta_4 \text{Socioeconomics}_{im} + \epsilon_{im}$$ (1)

Table 1.  
Descriptive statistics
The outcome variable $\text{small}_{im}$ is a binary variable used to capture the size of baby $i$ of mother $m$ at birth. When a baby is considered smaller-than-average at birth, $\text{small}_{im}$ takes 1, and 0 otherwise. For regression analysis, a probit model was used. Probit and logit models yield similar results. The differences between them are the assumption about the distribution of the errors; the former uses normal distribution, and the latter uses logistic distribution [14]. Because there is no assertive reason to assume logistic distribution in errors, we selected the probit model. The Wald test was used to test the hypothesis ($H_0: \beta_1 = 0$, $H_1: \beta_1 \neq 0$). The results are reported as marginal effects of the predicted probability of giving birth to a smaller-than-average baby.

$\text{Timing being in Utero}_m$ is the set of birth cohort dummies of mother $m$. For instance, the dummy variable “in utero under the KR regime” takes the value of 1 if a mother was in utero under the KR regime. Child Demographic, and Reproductive$_{im}$ are the sets of variables that control child demographic information and reproductive-related information, respectively. The variable Socioeconomics$_{im}$ represents a mother’s and her husband’s socioeconomic status, including mother’s age at giving birth, wealth index, mother’s natal place and mother’s and father’s (mother’s husband) educational achievements, Table 1. Our focused variable was the birth cohort dummies of a mother of a child. If $\beta_1$ was positive and significant for the birth cohort of the KR regime (“in utero under the KR regime”), it implied that the KR regime had a negative effect on second generations.

We create a variable of the average percentage of deaths of children aged five or below in the residential province during the period of birth cohort “in utero under the KR regime for further exploration.” Since the major cause of death of young children is either malnutrition or diseases, which can be prevented if children are sufficiently nourished, this variable captures the prevalence of malnutrition in the province during the time that the mothers were in utero. The percentage is calculated using the data of the siblings of all the respondents of CDHS in 2000 and 2005, providing us with a large number of observations from the sample about the year and month of death of the sibling and the age at death. The number of siblings aged five or under who died during the period of the birth cohort “in utero under the KR regime” was counted and divided by the total number of siblings who were aged five or under at that time (NOTE 3 of Table 2). An interaction term of birth cohort and the provincial average percentage of death of children aged five or under for the period of the birth cohort “in utero under the KR regime” was created by using this variable. We can capture the differential effects of the food shortages under the KR famine on different age groups by considering the interaction of this continuous variable with the timing of being in utero. We also use an ordinal indicator in the analysis, with five categories by dividing the mortality rate into quintiles, where one is the least severe and five is the most severe. Figure 1, we can at least observe a significant increase in the mortality rate of children aged five or under during, before and after the beginning of the KR regime, suggesting that the variable measures the relative severity of the KR famine (Footnote 1).

**Ethics approval**
Not applicable, because this study uses the publicly available data of the Cambodian Demographic Survey.

**Results**
The probability of giving birth to a smaller-than-average sized baby is significantly higher for mothers in the birth cohort after 1969 (“in utero 46–90 months prior to the KR regime,” “in utero 1–45 months prior to the KR regime” and “in utero under the KR regime”), as compared to those before 1968 (“in utero 91 months or earlier before the KR regime”), when a mother’s
Marginal effects of provincial mortality rate of children aged five or under at each birth cohort (%) Quintile (5: highest – 1: lowest)

| In utero before 91 months or earlier | 0.000 (0.003) | −0.003 (0.008) |
| In utero 46–90 months prior to the KR regime | 0.007 (0.005) | 0.015 (0.013) |
| In utero 1–45 months prior to the KR regime | −0.003 (0.006) | 0.010 (0.014) |
| In utero under the KR regime | 0.011* (0.007) | 0.034** (0.014) |

Note(s): 1. Standard errors reflect clustering at the level of mothers because some mothers had more than one child. The motivation for the clustering adjustments in standard errors here is to adjust unobserved components in outcomes for units within clusters that are correlated.
2. For a robustness check, we have conducted an additional analysis. It is the same as Table 2 with clustered standard errors at a provincial level to adjust unobserved components in outcomes for units within clusters that are correlated. It has yielded nearly identical results, which are provided upon request.
3. Marginal effects of covariates are not shown in this table for brevity. Covariates include a childbirth year dummy, sex of a child, birth intervals preceding a childbirth, times visited for antenatal care, age of mother at giving birth to a child, wealth index, mother’s educational attainment in single years, father’s educational attainment in single years and survey year dummy. Their marginal effects are consistent with the model without interaction terms.
4. Number of observations used for calculations for each province, those who have (had) at least one sibling aged five or under for the period of birth cohort “in utero under the KR regime” are shown in parenthesis.

Table 2. Differential effects of provincial mortality rate of children aged five or under on a mother’s birth cohort

<table>
<thead>
<tr>
<th>Province</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banteay Meanchey (11,205)</td>
<td></td>
</tr>
<tr>
<td>Baat Dambarg (13,383)</td>
<td></td>
</tr>
<tr>
<td>Kampong Chaam (12,384)</td>
<td></td>
</tr>
<tr>
<td>Kampong Chhnang (13,023)</td>
<td></td>
</tr>
<tr>
<td>Kampong Speu (13,293)</td>
<td></td>
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<tr>
<td>Kampong Thom (13,122)</td>
<td></td>
</tr>
<tr>
<td>Kampot (13,293)</td>
<td></td>
</tr>
<tr>
<td>Kandaal (10,368)</td>
<td></td>
</tr>
<tr>
<td>Koh Kong (12,843)</td>
<td></td>
</tr>
<tr>
<td>Kratie (normal spelled as Krachh) (10,368)</td>
<td></td>
</tr>
<tr>
<td>Mondol Kiri (11,043)</td>
<td></td>
</tr>
<tr>
<td>Phnom Penh (12,537)</td>
<td></td>
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<tr>
<td>Preah Viheur (10,071)</td>
<td></td>
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<tr>
<td>Prey Veng (12,168)</td>
<td></td>
</tr>
<tr>
<td>Pousat (12,015)</td>
<td></td>
</tr>
<tr>
<td>Rotanak Kiri (11,637)</td>
<td></td>
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<tr>
<td>Siem Reab (normal spelled as Siem Reap) (12,069)</td>
<td></td>
</tr>
<tr>
<td>Krong Preah Sihanouk (12,339)</td>
<td></td>
</tr>
<tr>
<td>Stung Traeng (10,530)</td>
<td></td>
</tr>
<tr>
<td>Svay Rieng (3,276)</td>
<td></td>
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<tr>
<td>Taakaev (normal spelled as Takeo) (3,339)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Provincial mortality rate of children aged five or under

Note(s): Otad Meanchey, Krong Pailn and Krong Kaeh are not included due to lack of observations for analysis followed by this section.
reproductive behavior and SES are controlled. Marginal effects for all birth cohorts are statistically significant at the 10% significance level and increase for more recent birth cohorts at 4.6, 7.0 and 8.6%, for the birth cohorts “in utero 46-90 months prior to the KR regime,” “in utero 1-45 months prior to the KR regime” and “in utero under the KR regime,” respectively. This implies that mothers who were in utero during the KR regime had an 8.6% higher propensity to give birth to smaller-than-average babies in comparison to mothers who were in utero 91 months or earlier before the KR regime, Table 3.

While they are not our focused variables, other factors are worth noting. Later-born children tended to be smaller, and more antenatal care visits reduced the risk of giving birth to a smaller baby. The sex of the child does not influence the risk of being a smaller baby in Cambodia. Education is often regarded as an important factor in reducing child mortality or underweight babies. Our regression findings show a statistically significant negative association between the educational level of a father and the birth of smaller-than-average babies. The wealth index had no significant relationship with the probability of birth of a smaller-than-average baby, even though the coefficient suggests a negative relationship.

The results of an additional regression analysis (Table 3) include interaction terms between a mother’s birth cohort and the mortality rate of children aged five or under during the period of the birth cohort “in utero under the KR regime.” The equation used here is the same as that for Table 3, but with the addition of these interaction terms. The left column shows the marginal effects of a 1% increase in the mortality rate on the propensity of giving

<table>
<thead>
<tr>
<th>Mother’s birth cohort and place of birth</th>
<th>Marginal effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Ref: in utero before 91 months or earlier before the KR era)</td>
<td></td>
</tr>
<tr>
<td>In utero 46-90 months prior to the KR regime</td>
<td>0.046* (0.258)</td>
</tr>
<tr>
<td>In utero 1-45 months prior to the KR regime</td>
<td>0.070* (0.036)</td>
</tr>
<tr>
<td>In utero under the KR regime</td>
<td>0.086* (0.051)</td>
</tr>
<tr>
<td>Type of place of residence at birth (1: rural 0: urban)</td>
<td>0.005 (0.024)</td>
</tr>
</tbody>
</table>

| Child demographic information | Sex of a child (0: male 1: female) | 0.017 (0.014) |

| Reproductive-related information | Birth order of a child | 0.012* (0.005) |
|                                | Birth intervals preceding a childbirth | 0.000 (0.000) |
|                                | Times visited for antenatal care | −0.012* (0.005) |
|                                | Age of mother at giving birth to a child | 0.003 (0.004) |

| Mother’s (household’s) SES | Wealth index (1: poorest – 5: richest) | −0.007 (0.007) |
|                           | Mother’s educational attainment in single years | −0.003 (0.004) |
|                           | Father’s educational attainment in single years | −0.006** (0.020) |
|                           | Wald χ² | 1213.74 |
|                           | Prob > χ² | 0.0000 |
|                           | Log pseudolikelihood | −986.31697 |
|                           | McKelvey and Zavoina pseudo-R² | 0.304 |
|                           | Number of observations | 2,464 |

**Note(s):** 1. Provincial dummies, birth year dummies and survey year dummies are included in a regression model. They are not shown in this table for brevity. 2. Standard errors reflect clustering at the level of mothers because some mothers had more than one child. The motivation for the clustering adjustments in standard errors here is to adjust unobserved components in outcomes for units within clusters that are correlated.
Birth to a smaller-than-average baby. The right column presents the marginal effects of a one-category increase in the severity of food insecurity on the same outcome variable.

Information from both columns indicates that the severity of food insecurity during the KR regime was relevant to those who were in utero during that period. It is difficult to assess the magnitude of the marginal effects based on the mortality rate. This result can be interpreted to suggest that a 1% increase in the mortality rate of children aged five or under during the time in utero increases the probability of giving birth to a smaller-than-average baby by 1.1% when the baby becomes a mother. As the highest mortality rate is 17.58%, it implies that a mother is nearly 20% more likely to give birth to a smaller-than-average baby if she was in utero during that region of the KR regime where the famine was most severe. The interaction term with the ordinal variable also suggests that when the severity of famine is divided into quintiles, there is a 3.4% increase in the probability of giving birth to a smaller-than-average baby as each severity indicator increases. Further, if a mother were in utero in the most severe famine-affected area, she is 13.6% more likely to give birth to a smaller-than-average baby, as compared to mothers who were in utero in the least affected area.

Another interesting finding here is that those born before the KR regime were not affected by famine in terms of transmitting health problems to the next generation, even though they were exposed to the KR regime, hence the food shortage, over a longer time. On limiting our sample to mothers who were born before the KR regime and including the months of a mother’s exposure to the KR regime instead of birth cohort dummies, the association between giving birth to smaller-than-average babies and the duration of a mother’s exposure is insignificant (the marginal effect is 0.0016, and the mother’s clustered standard error is 0.0011768). These findings imply that exposure to an adverse environment in utero is a critical issue for the transmission of poor health between generations. However, it should be noted that this result is obtained after controlling for current SES. Those born before the regime (between 1950 and 1965) have lower earnings and educational attainment [7]. Therefore, the second generation may have been impacted through different means, and this result does not refute such means and impacts.

Discussion
This study demonstrated that the negative impact of an adverse environment in utero, particularly food shortages, can be transferred to the next generation. The results reveal that those who were in utero during the KR regime were more likely to give birth to smaller-than-average-sized babies. Women who were in utero with severe food shortages under the KR regime were the most likely to give birth to smaller-than-average babies, which is a proxy of having poor health at birth.

In the mid-1980s, David Barker discovered the correlation between the starvation of pregnant women during the Dutch famine of 1944–1945 and cardiovascular and metabolic diseases in their offspring in adulthood [17]. Currently, the DOHaD hypothesis provides more insight into how fetal over- or under-nutrition can also lead to diseases related to the immune system, reproduction and mental health [18–20]. Based on the experimental and clinical findings, the DOHaD hypothesis suggests that supplementation or restriction of the maternal diet can alter epigenetic patterns in offspring. Further, epigenetics is a strong plausible molecular mechanism that links genes, environment and susceptibility to disease [21, 22]. The results suggested that intergenerational transmission can occur when a mother is affected by nutrition deficiencies when they were in utero.

Despite the important contribution of this study, it has some limitations. The data set could not include data on agricultural products during the KR regime, which could measure food shortages directly. Moreover, the analysis includes non-movers only; thus, many were living in rural areas. Considering the past 30 years of rural–urban migration, this may bias
the estimates. Another important issue worth considering is the validity of the measurement of babies’ size because this study uses the mothers’ evaluation of their babies’ size. According to the DHS report, such evaluation can be a useful proxy for birth weight, although it is a subjective evaluation.

To check whether the measurement issue does not bias our results, we conducted an additional analysis by using a small number of sub-samples in which both birth weight and child size were reported. When checking the measurement error, we found no systematic differences between the correct and incorrect evaluation of mothers in the socio-economic characteristics, and more importantly, in the birth year of mothers (cohort groups). Therefore, we assumed these measurement errors occur randomly throughout the cohort (Footnote 2). In other words, there is less likely to be a large estimation bias for the results of differences in the offspring outcomes by each cohort. However, imprecision may have occurred. It will be a benefit to future research if the weight data of babies are made widely available.

Conclusion
The findings of this study have significant practical implications for today’s society. A considerable number of people still suffer from civil conflicts and malnutrition. We have to be aware of the fact that civil conflicts severely affect not only the current but also future generations through the intergenerational transfer of adverse health impacts.

Notes
1. The author did not reflect survey weights to take the complex survey design into account in this paper. The author has followed a generally agreed convention within economics that there is a consensus on using sampling weight to ensure population representation, especially for descriptive statistics. However, whether weights should be routinely used in multivariate models is debatable because weights introduce a substantial design effect into data. It increases the standard errors of statistics, making findings less precise and more variable. In addition, when the variability in the weights is larger, the results are affected more by design effects [15, 16].

2. A total of 7.0 and 0% of mothers responded that their baby was smaller than average, yet the measured weight was more than the average in 2000 and 2005, respectively (average weight was 3,185 g for births in 2000, and 3,183 g for births in 2005). Among those who did not consider their baby to be small, 19.5 and 14.1% were actually lighter than the average weight, respectively. Thus, when a mother considers their baby was small, it is likely to be correct. On the other hand, when a mother thinks their baby was not small, it could in fact weigh less than average. Nevertheless, when we check this further, most of these babies (mothers consider them as not small) weighed more than 2,500 g, which is the threshold for being underweight or not. Therefore, this subjective measurement may not precisely capture smaller than average, but it indicates small babies are likely to weigh less than 2,500 g.

References


**Corresponding author**
Midori Matsushima can be contacted at: matsushima.midori.gb@u.tsukuba.ac.jp

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