Short Report

THE TREND IN AGE AT MENARCHE IN INDONESIA: BIRTH COHORTS 1944–1988

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Summary. Employing the Indonesian Family Life Survey, this paper depicts the trend in age at menarche in Indonesia for women born in 1944–1988. Mean age at menarche decreased from 14.39 years for birth year 1944 to 13.18 years for birth year 1988. Subsequently, this trend is related to the improvement in material conditions, measured by GDP *per capita* in childhood. The OLS results indicate that this decrease is largely explained by the improvement in material conditions. If age at menarche is considered an indicator of biological standard of living, these results suggest that the improvement in material conditions during the period converted to an improvement in biological standard of living.

Age at menarche is known to be influenced by environmental factors such as early-life events, current body weight and height, health, nutritional intake, physical activity, family size and structure, level of educational achievement and altitude (Prentice *et al.*, 2010, and references therein). In general, an improvement in material conditions reduces age at menarche. In this light, Indonesia provides an interesting case for understanding how improvement in material conditions influences age at menarche. Industrialization in Indonesia began in earnest in the late 1960s, and its material condition, measured by GDP *per capita*, improved by 123% during the period 1944–1988 (van der Eng, 2010). If age at menarche is considered an indicator of biological standard of living, this exercise can indicate the degree to which the improvement in material conditions during the period converted to an improvement in biological standard of living. This question is important because evidence shows that such conversion did not happen in some countries (e.g. the UK and the US) during early industrialization (Komlos & Baten, 2004).

There have been several attempts to examine Indonesian menarcheal data at a point in time, as P. van der Eng's (personal communication) data going back to sample years 1872–1878 have indicated. In addition, Sohn (2014a) investigated the relationship

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between age at menarche and height in Indonesia. However, little research has been performed to relate a long trend in age at menarche in Indonesia to the improvement in material conditions. This paper attempts to fill the void in the literature.

Age at menarche was obtained from the Indonesian Family Life Survey (IFLS). In 1993, the IFLS selected thirteen provinces to maximize representation of the population and then randomly selected enumeration areas (EAs) within each of these provinces. Then, within the selected 321 EAs, the IFLS randomly selected 7730 households and obtained partial or complete interviews for 7224 households. In total, 22,327 individuals aged 0–80+ were interviewed. After this, follow-ups were conducted in 1997 (IFLS-2), 2000 (IFLS-3) and 2007 (IFLS-4), adding new members (another *ad hoc* follow-up was conducted in 1998, but this concerned a 25% subsample, and the data are not publically available) (see Sohn, 2014a, b, c, d and e for details of human biology variables).

Ever-married women aged 15–49 recalled their ages at menarche in whole years, answering the following question: 'How old were you on your first menstruation?' Because this is a recalled measure, measurement error and bias could be a concern. However, there is ample evidence that this concern is minor (e.g. Clavel-Chapelon & The E3N-EPIC Group, 2002; Must *et al.*, 2002). All women aged 15–49 with valid information in IFLS-1 were first selected. Then, new members with valid information in IFLS-2, IFLS-3 and IFLS-4 were added to this IFLS-1 sample. In this manner, the same woman was not counted multiple times. In addition, age at menarche was restricted to 10–18 years; numbers found beyond this range are probably due to recording error. GDP *per capita* was provided by van der Eng (2010), and are the best available to date for a long GDP *per capita* series. The IFLS sample was merged with the GDP *per capita* in childhood (defined later) for each birth year, and birth years for which at least 50 observations existed were kept. The final sample covered birth years 1944–1988 with a sample size of 8331.

The mean age at menarche over the period was 14.15 years with a standard deviation (SD) of 1.64, which is late in international comparisons: the mean age at menarche in 67 developed and developing countries is 13.53 years (Thomas *et al.*, 2001). More importantly, Fig. 1 depicts a downward trend in age at menarche for all birth years. Specifically, mean age at menarche decreased from 14.39 years for birth year 1944 to 13.18 years for birth year 1988, or 0.275 years per decade. It is notable that the decrease accelerated for women born in the late 1960s and later; interestingly, this point coincides with the beginning of industrialization. This visual inspection anticipates the OLS results below.

Despite the acceleration, the decrease is slow given the initial old age at menarche and fast economic growth over the period. For example, the corresponding speed for German women born in 1925–1964 is 0.32 per decade, although their initial age at menarche was already lower than the Indonesian one at about 13.5 years (Onland-Moret *et al.*, 2005). This fast reduction occurred despite the Great Depression, hyperinflation and the Second World War. The reduction in Indonesia is slow even compared with two rural (meaning poor) counties in Anhui Province, China: the mean age at menarche decreased from 15.8 years for women born in 1949–1953 to 13.7 years for women born in 1947–1978, or a reduction of 0.72 years per decade (Graham *et al.*,
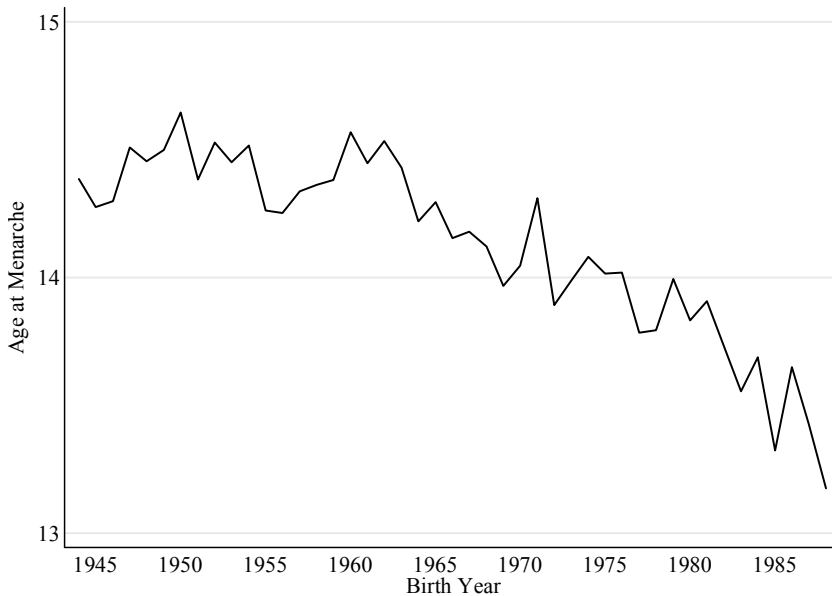
Fig. 1. Trend in age at menarche, women born in Indonesia in 1944–1988, Indonesian Family Life Survey. Each birth year is weighted by the number of women born in the year.

1999). Furthermore, this fast reduction occurred despite the severe retrogression in material conditions caused by the Great Leap Forward (1958–1961) and the Cultural Revolution (1966–1976).

The slow speed notwithstanding, age at menarche did decrease over the period. Because it is influenced by material conditions in childhood, the downward trend is consistent with the improvement in material conditions in Indonesia during that period. Age at menarche can be formally related to improvement in material conditions, measured by GDP *per capita* in childhood. Specifically, the following specification was estimated.

$$y_t = \beta_1 \, ln \, (GDP \, per \, Capita_t) + trend_t \, \beta_2 + \mu_t,$$

where *GDP per Capita* refers to GDP *per capita* in childhood, calculated by taking the mean GDP *per capita* from birth to the following 10 years (i.e. a total of 11 years); *trend* is a time trend measured by either a series of dummy variables for birth cohorts 1944–1953, 1964–1973, 1974–1983 and 1984–1988 or a linear year; μ is an error term; and β_1 and β_2 are the coefficients to be estimated. Each birth year is weighted by the number of women born in the year. Birth cohort 1984–1988 does not cover a decade. However, because it distinctively exhibits a rather fast decrease in age at menarche, it constitutes its own cohort. In addition, estimation is performed at the year, instead of individual, level to avoid the famous Moulton (1990) bias. That is, correlation of errors within groups (i.e. year) results in spurious regression in estimating the effect of an aggregate variable (i.e. GDP *per capita* in childhood) on micro units (i.e. age at menarche); as

Table 1. Relationship between GDP *per capita* in childhood and age at menarche, women born in Indonesia in 1944–1988, Indonesian Family Life Survey

	1	2	3	4	5
ln(GDP *per capita* in childhood)	−0.826	−0.678		−1.296	
	(0.054)*	(0.208)*		(0.238)*	
Born in 1944–1953		Reference	Reference		
Born in 1954–1963		−0.032	−0.036		
		(0.063)	(0.066)		
Born in 1964–1973		−0.037	−0.337		
		(0.109)	(0.065)*		
Born in 1974–1983		−0.052	−0.570		
		(0.170)	(0.067)*		
Born in 1984–1988		−0.232	−0.953		
		(0.238)	(0.098)*		
Linear year				0.015	−0.024
				(0.007)	(0.002)*
Constant	20.72	19.57	14.45	−4.652	61.45
	(0.43)*	(1.57)	(0.05)*	(12.552)	(4.05)*
N	45	45	45	45	45
Adjusted R^2	0.842	0.841	0.803	0.853	0.755

Each birth year is weighted by the number of women born in the year.
*$p < 0.01$.

a consequence, the coefficient on the aggregate variable suffers from the serious downward bias of the standard errors and the resulting inflation of test statistics.

First, only GDP *per capita* in childhood was considered to estimate its full relationship with age at menarche. Column 1 of Table 1 displays a negative relationship between GDP *per capita* in childhood and age at menarche. The R^2 statistic indicates that the independent variable alone explains 84% of the variation in age at menarche. It is possible that β_1 captures only some trends that are correlated with the improvement in material conditions but not strictly material conditions, such as good weather. In this case, β_1 is spurious. To check this possibility, the decadal dummies were added to the specification. Column 2 shows that β_1 decreased by only 18% and remained statistically significant; β_1 suggests that an additional 10% increase in GDP *per capita* in childhood is related to a 0.068 year decrease in age at menarche. Moreover, no element of β_2 is statistically significant. However, the decadal dummies are not unrelated to age at menarche. As shown in Column 3, when GDP *per capita* in childhood was excluded from the specification, all (except one) elements of β_2 were statistically significant. The comparison between Columns 2 and 3 suggests that GDP *per capita* in childhood, not trends, plays a considerable role in the reduction in age at menarche. The substance of the results remains the same when a linear year, instead of the decadal dummies, was considered (Columns 4 and 5): β_1 in Column 4 is much greater than that in Column 2 because the linear trend term is positive ($p < 0.05$). Of course, the inclusion of *trend*

does not completely eliminate omitted variable bias in β_1. However, it is important to note that its inclusion does not reduce β_1 much although *trend* captures broad effects of omitted variables. Thus, after the inclusion of *trend*, the bias is probably small.

Incidentally, Column 3 shows that compared with the previous birth cohort (1974–1983), birth cohort 1984–1988 experienced a reduction of 0.38 years in age at menarche, which is 1.6 times as great as that exhibited by birth cohort 1974–1983 over the previous cohort (1964–1973). This suggests that the decrease in age at menarche had not slowed. Considering the fast improvement in material conditions in Indonesia in recent years and early ages at menarche in developed countries at present, a further decrease in age at menarche in Indonesia is expected.

In summary, although relatively slow, age at menarche has decreased by about 1 year for women born in 1944–1988. Moreover, the decrease is largely explained by improvement in material conditions, measured by GDP *per capita* in childhood. Hence, these results imply that the improvement in material conditions during the period converted to an improvement in biological standard of living. In addition, considering that early menarche is an established risk factor in the development of breast cancer (Collaborative Group on Hormonal Factors in Breast Cancer, 2012), and the possible further reduction in age at menarche in Indonesia, this paper recommends a close monitoring of the prevalence of breast cancer in Indonesia.

Acknowledgments

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