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Declining age at menarche in Indonesia: a systematic review and meta-analysis

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Abstract:

Background: There has been much research on the average age at menarche onset. In higher income countries the lowering in average age at menarche is earlier than in middle-income countries and lower income countries. Indonesia as a middle-income country also has some research experience related to the average age at menarche for girls.

Objectives: This study aimed to review the lowering of the average age at menarche in Indonesia and to predict changes in average age at menarche.

Methods: This study provides a systematic review and meta-analysis using references from Google Scholar, PubMed and Popline databases on the trend of age at menarche in Indonesia and other data sources from local and national survey reports. Metaprop command in STATA was used to do the meta-analysis of proportion of early age at menarche and time series with auto-regressive integrated moving average (ARIMA) models were used in analyzing the trend and predicting the age at menarche.

Results: The results show that in Indonesia the timing of age at menarche onset has significantly lowered during the 40 years before 2010. There was meaningful decrease of age at menarche, which changed from 14.43 years [confident interval (CI) 95%: 14.42, 14.44] to 13.63 years (CI95%: 13.63, 13.64). Using the ARIMA model, mean age at menarche onset for the next year predicted that the coefficient regression would be -0.0245 (CI95%: -0.0275 , -0.0215). The predicted average age at menarche shows a decrease of 0.0245 years (8–9 days) each year.

Conclusion: The findings indicate a significant lowering of age at menarche in Indonesian girls that has continued as a predictable trend through time until the present, paralleling recent socioeconomic changes. These predictions provide key indicators of a girl's future healthy transition from childhood into young adulthood.

Keywords: declining, Indonesia, menarche, secular trend

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Introduction

Menarche, the onset of first menstruation, marks the beginning of a girl's reproductive life, and has important implications for adolescent sexual and reproductive health [1]. Potential health effects of age at menarche have received a great deal of attention but age of menarche, is a neglected indicator in public health, especially for non-reproductive and sexual health status [2]. It is a key indicator of a girl's healthy transition from childhood into young adulthood as it is an important determinant of girls' physical, nutritional and reproductive health outcomes [1], [2].

A substantial body of evidence suggests that early menarche – generally defined as menarche before the age of 12 – increases adolescent girls' vulnerability to negative sexual and reproductive health outcomes including early pregnancy and childbearing, sexually transmitted infections, early sexual initiation and sexual violence

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[2]. In addition, earlier menarche has been associated with adverse pregnancy outcomes, such as ectopic pregnancies, miscarriage, low birth weight [3] and preterm birth [4]. Earlier menarche has also been linked to several adverse health consequences in later life, such as breast cancer, cardiovascular diseases [5], [6], [7] and type 2 diabetes mellitus [8].

Adolescence is defined as a period of transition between childhood and adulthood. At that time there is a rapid change in many aspects that include biological, psychological and socio-cultural development [9]. Age at menarche is an important and significant indicator of maturity in a woman's development and reflects the health of the population [10], [11]. Age at menarche is also a basic parameter that signifies biological characteristics for women and is also an indicator to measure quality of life [12] including wealth and good health.

Several studies indicated a trend for a woman to onset menarche earlier in her life as the time progresses. The trend of younger age for onset of menarche has occurred in some countries such as the US [13], [14], South Africa [10], Switzerland [15], Kuwait [16] and India [17] as well as Korea [18]. In the US it was reported that before 1900, on average, women were having menarche onset at 14 years old, then it decreased to 12.43 in studies conducted between 1988 and 1994 [19]. The average changes in age at menarche were influenced by various factors, including both genetic and non-genetic, primarily related to prenatal conditions, lifestyle changes, previous health and nutrition status, community culture and the environment.

Indonesia is a middle-income country with very heterogeneous socio-economic levels and diverse educational, socio-cultural and environmental backgrounds. Lifestyle changes, especially the pattern of consumption of fatty foods and junk food, is a risk factor for earlier menarche. Likewise, global influence through unstoppable communication media development also contributes to accelerating the process of puberty. Sohn has published a paper on "The trend in age at menarche in Indonesia" which illustrated the decreasing of age onset of menarche when societies undergo rapid changes [20]. The data sources used by Sohn are the results of the RAND Indonesian Family Life Survey (IFLS), while there are also some other sources of data on age trends in menarche from various national and local surveys. There are also national data sources for health statistics including the Indonesia Young Adult Reproductive Health Survey (IYARHS), the Indonesian Demographic and Health Survey (IDHS) [21], [22], [23], Basic Health Research (Riskesdas) [24], Community Health and Nutrition Research Laboratory (CHNRL) [25] and the Puberty Survey [26]. This paper addresses the question whether the age of menarche has changed from 1961 to 2010 in Indonesia? The aim of this study was to pool all available data in Indonesia on age at menarche in a comprehensive meta-analysis and review.

Materials and methods

The systematic review and meta-analysis were done in accordance with the Preferred Reporting Items for Systematic-Review and Meta-Analysis guidelines.

Search strategy

Search references using Google Scholar, PubMed and Popline with the keywords "Menarche AND Indonesia" found 25 publications (accessed on 03/09/2017). While for the Indonesian language using the keyword "Umur Menarche" found 227 sources. After being filtered with the term of "trend" or "declining", there are few publications that correspond to the trend of age at menarche (Figure 1), among which were those written by Sohn (2015) with IFLS data sources, Aswin (1982) and Rahmawati (2005). Both Aswin and Rahmawati discuss secular changes in age at menarche onset in the Yogyakarta area. Additionally, to complete the "trend" study of age of menarche there are other survey data used; IYARHS 2003, IDHS 2007 and 2012, Riskesdas 2010 and the baseline survey of CHNRL in the Purworejo District, Central Java Province (Table 1). The similar questions ("How old were you when you had your first menstruation?") and method (interview) were used in all surveys to get the information about the age at menarche.

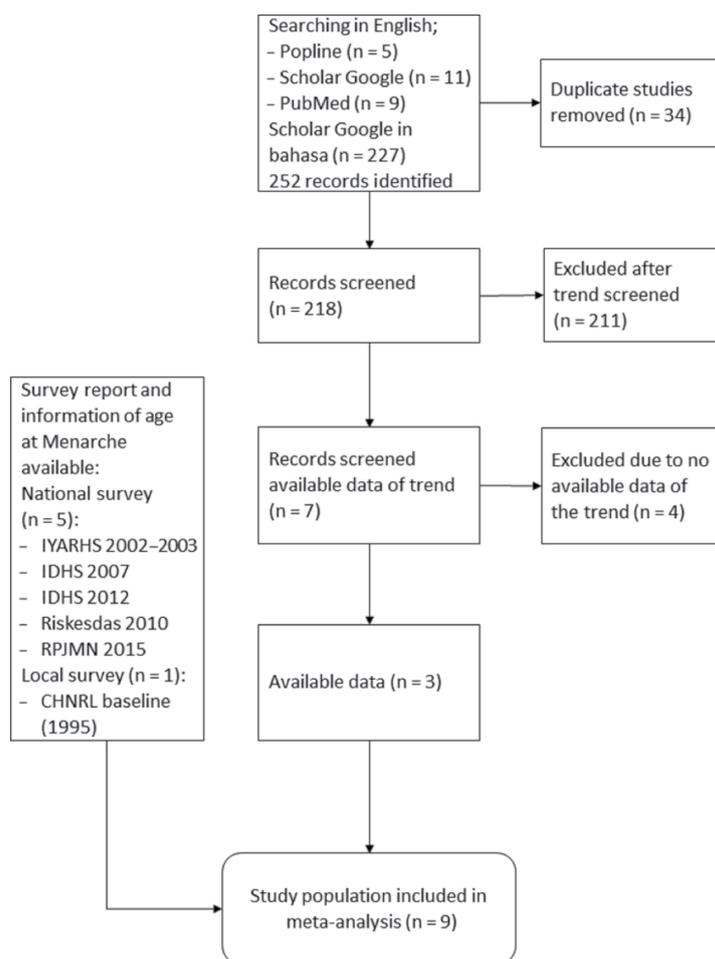


Figure 1: Flow chart detailing of article searching.

Table 1: Description of study meeting inclusion for trend of age at menarche in Indonesia.

No	Year of survey	Author/project	Title/survey project	Design	Study population	Data source for meta-analysis
1.	1982	Aswin et al.	Age at menarche; study in adolescent	Cross-sectional	348 female students of secondary school in Yogyakarta and their mothers	Available from table
2.	1995	Researcher team	Baseline report of CHNRL for the first year	Baseline survey	15,105 women age 15–49 years, Purworejo District Indonesia	Available
3.	2003	CBS of Indonesia	Indonesia Young Adult Reproductive Health Survey (YARHS) 2002–2003	Panel survey	2198 women age 15–49 years, Indonesia	Available
4.	2007	CBS of Indonesia	Indonesia Demography and Health Survey (IDHS) 2007	Panel survey	8324 women age 15–49 years, Indonesia	Available

5.	2012	CBS of Indonesia	Indonesia Demography and Health Survey (IDHS) 2012	Panel survey	8846 women age 15–49 years, Indonesia	Available
6.	2010	MOH	Riset Kesehatan Dasar (The Basic Health Research) 2010 by Health Research Development (Litbangkes) Ministry of Health (MOH)	Cross-sectional	72,665 women age 15–49 years, 33 province	Available by expanding from the table
7.	2013	Ganabaty	Age pattern at menarche as results from a Puberty Survey	Cross-sectional	249 females age 11–70 years old, in Jatinangor, West Java	Available by expanding from the table
8.	2014	Sohn (2015)	The trend in age at menarche/ Indonesia Family Life Survey (IFLS)	Longitudinal survey	8331 ever married women age 15–49 years, 13 provinces in Indonesia	Available
9.	2015	NFPCB	National Medium Term Development Plan (RPJMN)	Panel survey	19,458 females 15–24 years in Indonesia	Available from table

CHNRL (Community Health and Nutrition Research Laboratory) based in Purworejo, Central Java, Indonesia; CBS (Central Bureau of Statistic) called BPS; NFPCB (National Family Planning Coordination Board) called BKKBN.

Selection of studies for analysis

The inclusion criteria used in data sources or literature searching are: observational study design with a quantitative approach, available information of age at menarche and birth year or age at survey and written in English or the Indonesian language. Information of age at menarche, age at survey or year of birth and or the year of menarche onset were partially provided in raw data form and partially in tabulated form. Data which are in the tabulated form were processed by doing “expand” command using software program of STATA 13.1 (StataCorp LP, TX, USA) so that it becomes raw data. The available sources of row data are the IYARHS 2002–2003, IDHS 2007 and 2012, IFLS, also CHNRL. Data of Riskesdas were expanded from tables in the report writing. Thereafter, data were pooled from the six sources and selected by onset year between 1961 and 2010. The total sample of this pooled data is 115,749 cases (Table 2). A descriptive analysis was conducted to determine the average of age at menarche [± 1 standard deviation (SD)] with confident interval (CI) 95% by onset year (timing) with results adjusted based on the number of cases of each study (frequency weight).

Table 2: Weighted and unweighted mean of age at menarche by 5 yearly periods.

Onset year period	Count	Unweighted		Weighted			
		Mean	SD	Mean	SE	[95% Conf. interval]	
						Low	Upper
1961–1965	1614	14.34	0.044	14.43	0.007	14.42	14.44
1966–1970	2365	14.50	0.038	14.58	0.006	14.57	14.60
1971–1975	8460	14.39	0.021	14.43	0.004	14.42	14.44
1976–1980	10,933	14.39	0.018	14.43	0.003	14.42	14.44
1981–1985	12,284	14.25	0.017	14.30	0.003	14.29	14.31
1986–1990	13,291	14.12	0.015	14.16	0.003	14.15	14.16
1991–1995	15,677	13.95	0.014	14.01	0.002	14.01	14.02
1996–2000	16,115	13.82	0.013	13.94	0.003	13.93	13.94
2001–2005	18,746	13.71	0.012	13.79	0.003	13.79	13.80
2006–2010	16,264	13.61	0.012	13.63	0.003	13.63	13.64

Sources pooled data.

Statistical analysis

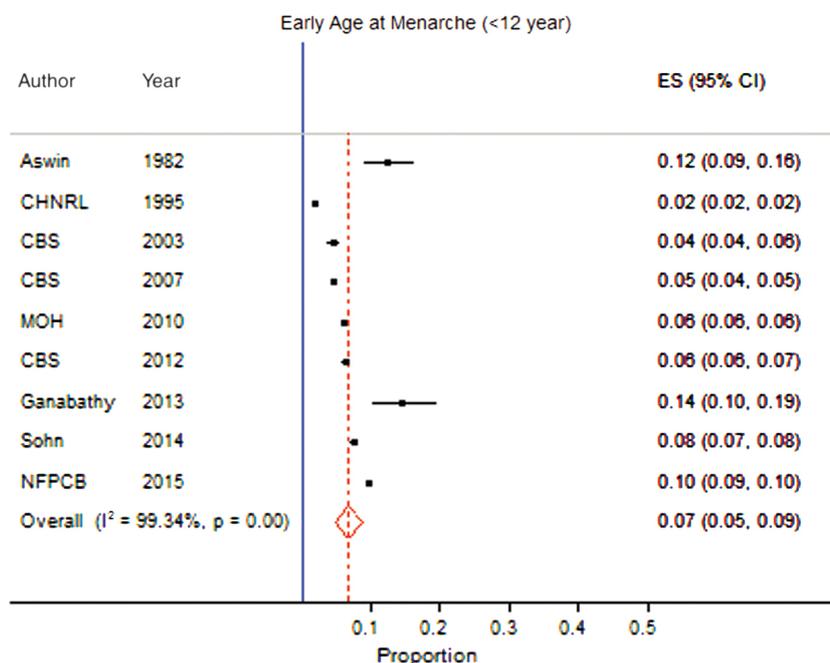
The meta-analysis used Metaprop (meta-analysis for proportion) and auto-regressive integrated moving average (ARIMA). Metaprop syntax in STATA software was used to draw the different proportion of early menarche with a cut-off below 12 years of age [27]. Tabulated data of early menarche proportion were constructed based on information of case numbers divided by number of samples from each source. The ARIMA model in Time Series was used to get the best model to predict age at menarche onset in the oncoming year. ARIMA is one of the most widely used models to predict time series data. In this case, a non-seasonal model was used which classified as an “ARIMA (p,d,q)”, where “p” is the number of autoregressive terms, “d” is the number of non-seasonal differences needed for stationary and “q” is the number of lagged forecast errors in the prediction equation. ARIMA modeling proceeds using well-defined steps. The first step is to identify the models which consist of specifying the appropriate structure and order of the model. The second stage is selecting models with significant coefficients, and then the best model is chosen based on the lowest Akaike information criterion (ACI) value. Finally, based on the pooled data a graph was made using the moving average (MA) technique to get the trend line which can describe the smooth change of secular trend.

Results

There are three sections in the results of this review and meta-analysis: proportion of early menarche onset from sources, mean age at menarche and the secular trend of mean age at menarche.

Proportion of early menarche onset

Figure 2 shows the meta-analysis of proportion (Metaprop) of early age at menarche onset below 12 years of age. There are 10 sources of references which provided data of early menarche onset. The overall proportion of early menarche onset was 0.07 (CI95%: 0.05, 0.10) and p-value < 0.01. There are two sources from Yogyakarta (Aswin) and Jatinangor West Java (Ganabathy) having more than an average 10% with a proportion of 0.12 (CI95%: 0.09, 0.16) and 0.14 (CI95%: 0.10, 0.19), respectively. Then, the lowest proportion occurred in the local survey of the Purworejo District with a proportion of 0.02 (CI95%: 0.017, 0.022). In Figure 2 we could not show the trend of proportion because the time used in this meta-analysis was identified based on the year of the survey. The trend of proportion would be found if calculated based on the timing of menarche onset.



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Figure 2: Meta-analysis; proportion of early menarche in Indonesia.

Mean age at menarche

Based on the pooled data of menarche onset timing indicated that Indonesian girls during the period 1961–1965, on average, got menarche onset at the age of 14.43 years (CI95%: 14.42, 14.44), then in the period 1966–1970 on average they experienced menarche at the age of 14.58 years (CI95%: 14.57, 14.60). However, after 1970 they continuously began to experience a decrease until 2010. In period 2006–2010 the mean ages at menarche were 13.61 and 13.63 years (CI95%: 13.63, 13.64) for unweighted and weighted, respectively (Table 2).

The secular trend of mean age at menarche

Time series analysis with the ARIMA model approach is used to fit the model and fulfill the parsimony requirement. The first step in choosing the best model is to construct some models as a combination of auto-regressive (AR) and MA, there are 16 models constructed. Based on the models that have been prepared, four models were then selected (Table 3) with the criteria having smaller AIC values, i.e. ARIMA (113), (114), (214) and (314) with AIC values are -102.1, -100.3, -107.0 and 105.1, respectively. Among the four models, ARIMA (214) has the lowest AIC value compared to other models, but model (113) satisfies the parsimony requirements compared to models (214) and (314). This model nicely straddles the requirement of goodness-of-fit (due to lower AIC) and parsimony and therefore was chosen as the best model to predict the age at menarche. The ARIMA (113) was constructed by considering autocorrelation degree 1 to predict a 1-year difference by taking into account the previous 3 years. Model (113) shows that the AR [1] coefficient is -0.571 (95%CI: -0.975, -0.166) and the MA [3] coefficient is -0.654 (95%CI: -1.249, -0.0591) and both are significant. This model shows that the coefficient regression is -0.0245 with 95%CI (-0.0275, -0.0215) and p-value < 0.001. This finding means the secular trend of age at menarche onset can be predicted to decline 0.0245 year (or 8–9 days) for every 1 year ahead.

Table 3: Time series analysis using ARIMA(p, d, q) modelling period 1970–2010 to predict declining of mean age at menarche onset.

	ARIMA(113)	ARIMA(114)	ARIMA(214)	ARIMA(314)
Coeff. Reg.	-0.0245 ^a [-0.0275, -0.0215]	-0.0245 ^a [-0.0276, -0.0214]	-0.0243 ^a [-0.0270, -0.0216]	-0.0243 ^a [-0.0275, -0.0212]
ARMA				
L.ar	-0.571 ^b [-0.975, -0.166]	-0.458 [-1.338, 0.422]	-1.659 ^a [-1.872, -1.447]	-1.607 ^a [-2.399, -0.816]
L2.ar			-0.840 ^a [-1.047, -0.633]	-0.729 [-2.091, 0.633]
L3.ar				0.0636 [-0.665, 0.792]
L.ma	-0.142 [-0.142, -0.142]	-5.781 [-40.35, 28.79]	1.122 [1.122, 1.122]	1.090 [1.090, 1.090]
L2.ma	-0.204 [-0.963, 0.555]	0.322 [0.322, 0.322]	-0.237 [-0.237, -0.237]	-0.272 [-0.272, -0.272]
L3.ma	-0.654 [*] [-1.249, -0.0591]	0.375 [-6.395, 7.145]	-1.122 ^a [-1.701, -0.543]	-1.090 ^c [-2.027, -0.153]
L4.ma		4.084 [-16.61, 24.78]	-0.763 ^c [-1.485, -0.0413]	-0.728 [-1.577, 0.121]
Sigma	0.0567 ^a [0.0329, 0.0805]	0.00991 [-0.0474, 0.0672]	0.0498 ^a [0.0321, 0.0675]	0.0498 ^a [0.0314, 0.0682]
AIC	-102.1	-100.3	-107.0	-105.1
N	40	40	40	40

^ap < 0.001, ^bp < 0.01, ^cp < 0.05, AIC, Akaike’s information criterion $[-2 * \ln(\text{likelihood}) + 2 * k]$, 95% confidence intervals in brackets.

Figure 3 shows the declining trend of average age at menarche by a smooth line with MA. In this graph the declining line was made by considering an autocorrelation degree 1 to predict a 1-year difference by taking into account the previous 3 years. This figure also shows that girls having menarche onset in 1960s up to the 1970s showed no decrease in age but instead showed an increasing trend. Furthermore, girls born after 1970–2010 were continuously having declining secular changes of age at menarche onset gradually.

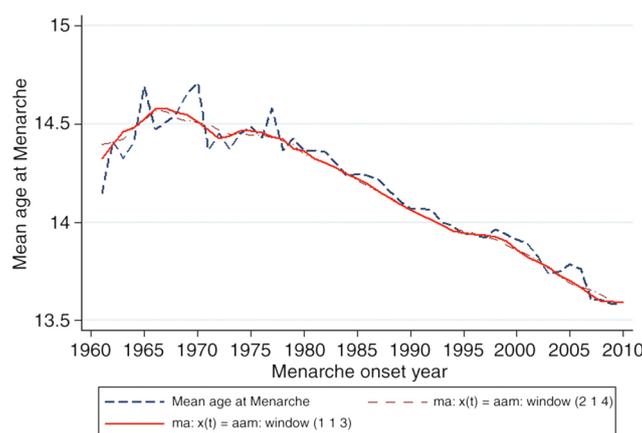


Figure 3: The trend of mean age at menarche in Indonesia.

Discussion

In 2015, Sohn published the trend of the average age at menarche in Indonesia based on a birth year cohort. He indicated that there was a decrease from 14.4 years for those born in 1944 to 13.2 years for those born in 1988. This trend was in line with the history of industrialization progress of an area measured by per capita gross domestic product (GDP) [20]. Industrial areas usually become urban while agricultural areas usually remain as rural. Based on data analysis IFLS 2014 (born between 1940 and 1994) shows that the urban population got menarche earlier than the rural population, i.e. 13.7 years and 13.9 years, respectively. Similarly, judging from the proportion of girls who experienced menarche at age 11 or earlier, the urban population was 6.19% while the rural population was 6.06% (analyzed from IFLS 2014 data).

The results of Riskesdas 2010 indicated that most Indonesian girls experience menarche at between 12 and 14 years old (64.9%) while for those aged 11 years or below (early) it was 6.4%, and for those who got menarche aged 15 years or older (late) it was 28.8% [28]. Amaliah associates age at menarche onset with height status (short and normal). The average age at menarche onset of adolescents with short stature is significantly lower than that of normal high-birth teenagers, i.e. $12.53 + 1.08$ vs. $12.33 + 1.07$ sequentially with p -value < 0.001 on t -test analysis [29].

In this systematic review and meta-analysis, there are two important points to the results based on the pooled data about the mean age at menarche onset in Indonesia. The first is the successive decrease in the average age of Indonesian girls to obtain the first menstruation which began in the 1970s till 2010. The second point is the predicted average age at menarche which shows a decrease of 0.025 years each year. The results of this study complies with our preliminary hypothesis that there has been a significant decline in age at menarche onset in Indonesia in recent years. The overall decrease in age at menarche onset can be demonstrated by data for girls born from 1971 onwards until 2010, although there might be different results for earlier timing onset cohorts.

This decreasing pattern of age at menarche could be correlated to the development of Indonesia after independence especially corresponding to the changing socio-economic situation [20]. After the proclamation of independence, Indonesia experienced a history of the beginning independent (1945–1957) with unstable economic conditions. When rapid economic changes occurred, inflation was cut to 100% in 1967. Inflation could be controlled, and price increases could be suppressed. On April 1st 1969, the First Five Year Development Plan (Repelita I) for the 1969–1974 period began. In the 1980s Indonesia continued to experience rapid economic growth with the GDP growth rate reaching 7.7% [30].

These results are in line with research results in several overseas countries such as the US [13], South Africa [10], Switzerland [15], Italy [31], Israel [32] and India [17] as well as South Korea [18] and China [33]. All of them show a decreasing of mean age at menarche. However, there is a difference in the time period and the number or rate of decline. In China, for example, it was estimated that there was a decline of 0.51 years within a decade (those born between 1973 and 2004) [33], while in India there was a decrease in mean age at menarche by 3 months (0.25 years) within the birth cohort of those born between 1955 and 2005 [17]. In Italy, Rigon concluded that the girls had their menarche one-quarter of a year (median -0.13) earlier than their mothers had had [31].

There are some public health implications correlated to this decrease of age at menarche among Indonesian girls. These implications provide a key indicator of a girl's healthy transition from childhood into young adulthood as it is an important determinant of girls' physical, nutritional and reproductive health outcomes [1], [2]. Early menarche (younger at menarche) was correlated to overweight and obesity [34], adverse pregnancy

outcomes, such as ectopic pregnancies, miscarriage, low birth weight [3] and preterm birth [4]. Early menarche was also identified as a risk factor in later life for breast cancer [35], [36], hypertension [5], cardiovascular diseases [5], [6], [7] and type 2 diabetes [8].

This review and meta-analyses have some limitations. The first limitation is the use of secondary data so that the authors could not control the quality of data collection. The second limitation is the use of data tables to expand into raw data to get the year of events causing the data to not be completely accurate because it is the result of estimation. The third is the use of interview methods to ask the age of menarche that occurred years ago so that the potential for recall bias occurs.

Conclusion

The results of this review and meta-analysis indicate a significant decrease in age of menarche in Indonesia from the 1970s to 2010. The decreasing average age at menarche can be predicted to decrease 0.0245 years (8.9 days) for each increase of 1 year. This decreasing of age at menarche parallels the recent increasing Indonesia socioeconomic history.

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