Center for Economic Institutions
Working Paper Series

No. 2018-12

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November, 2018

Center for Economic Institutions
Working Paper Series

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The Biological Standard of Living in Indonesia during the 20th Century: Evidence from the Age at Menarche

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Abstract*

This paper analyses long-term changes in the mean age at menarche (MAM) as a biological indicator of changes in the standard of living in Indonesia. It finds that MAM was about 15.5 for birth cohorts in the late-19th century, decreasing to 14.5 by the 1930s, at which level it stagnated until the gradual decrease resumed since the early 1960s to around 12.5 in the mid-2000s. The paper considers that long-term improvements in nutrition, educational attainment and health care explain these trends. An international comparison of long-term changes finds that MAM in Indonesia was much lower than in Korea and China until respectively 1970 and 1990, but comparable to Japan until 1950 and to Malaysia until 1930. The paper presents reasons why these differences are unlikely to be related to dissimilarities in climate and ethnicity, and concludes that they are indicative of relative standards of living.

Keywords: living standards, human growth, menarche, Indonesia, Asia
JEL codes: I12, I31, N15, O15
This version: 5 October 2018

* Research for this paper benefited from support of the DP140103603 project of the Australian Research Council. Van der Eng also acknowledges support from the Institute of Economic Research at Hitotsubashi University and thanks participants in research seminars at Hitotsubashi University and at the Lembaga Demografi at the University of Indonesia in March and May 2018 for their comments, and Christopher Reinhart (University of Indonesia) for research support.

The Biological Standard of Living in Indonesia during the 20th Century: Evidence from the Age at Menarche

1. Introduction

The age at menarche is an important marker of the physical development of girls and an indicator of their living conditions during infancy, childhood and adolescence. The mean age at menarche (MAM) of representative groups of women is an indicator of the standard of living in societies in which they were raised. It is one of the biological indicators of the standard of living and secular trends in MAM reflect changes in the standard of living as a result of economic development. Studies have observed downward trends in MAM and have associated it with improved living standards in several countries, particularly improvements in nutrition and diminished exposure to diseases during infancy and childhood due to improved hygiene and medical care (Danker-Hopfe 1986).

The purpose of this paper is to analyse long-term trends of MAM in the context of Indonesia's social and economic history. A further purpose is comparison of these outcomes with historical MAM in other Asian countries in order to establish intra-Asian differences in standards of living, and to reflect on an old, but unresolved debate about the impact of climate and ethnicity (or 'race') on international variations in human growth. The paper finds that living standards in Indonesia gradually improved since the late-19th century, stagnated during the 1940s-1960s, before improving significantly. It also finds that living standards in Indonesia were until the 1950s comparable to those in Japan and better than in China and Korea, and that climate and ethnicity are not crucial to explaining these differences.

The findings are in line with historical trends in GDP per capita (Van der Eng 2010), a concept that is often used as a proxy for living standards. However, GDP has its shortcomings for that purpose, as the more appropriate indicators would be GNP and national income.[1] Booth (1998: 89-134) probed various indications of long-term changes in living standards in Indonesia. She focused on their shortcomings and ultimately remained inconclusive due to the absence of concise and consistent indicators of change across the 20th century. A similar exercise for Southeast Asia led Booth (2012: 1174-1178) to conclude that the standard of living in Indonesia was low by the early 1940s, but that a composite indicator is needed.

Composite indicators for intertemporal and international comparisons of stages of economic development have been developed during the 1930s-1960s as substitutes for national accounts data that were not yet available for several Asian countries (Van der Eng 2011). UNDP designed the basic Human Development Index (HDI) to compare living standards since 1990, comprising just three unweighted variables: GDP/capita, longevity and educational attainment. Prados (2015) applied this concept to analyse

[1] GNP is GDP less net factor payments overseas, essentially net payments related to inward foreign investment and the employment of foreign workers. National income is by definition the same as NNP, or GNP less depreciation of productive capital stock.

international changes in human wellbeing during 1870-2015. An indicator that takes account of an even larger number of variables is the international Composite Measure of Wellbeing (CMW) index, created by Van Zanden *et al.* (2014) for 1820-2010. Relevant for this paper is that CMW includes anthropometric data, particularly average heights. However, no composite index has yet considered MAM as an anthropometric indicator of wellbeing.

Van Zanden and Marks (2012: 119) analysed long-term changes in living standards in Indonesia, based on studies of real wages, average heights, inequality and numeracy. They concluded: 'There is little evidence that colonial rule in the long run brought about a real improvement in the standard of living of the Indonesian population' and 'peasants had […] not profited from agricultural modernization; their living standards had remained the same at best, and the gains of growth had gone to the Chinese merchants and the Dutch capitalists'. By contrast, they identified improvements in Indonesia's living standards after the 1940s. Average heights confirm that living standards increased, as Indonesian adults were in the 2000s on average 3% taller than in the 1940s (Baten *et al.* 2013: 111-112). However, Indonesian adults also became on average 2% taller between the 1870s and 1940s which contradicts Van Zanden and Marks (2012).[2]

The key questions this paper addresses are: What is the evidence for changes in the biological standard of living based on the long-term trend in MAM in Indonesia, how can these trends be explained, and how does it compare to trends in MAM in other Asian countries? Sohn (2015) already found a decrease in MAM in Indonesia during 1944-1988. Sohn (2017a) compared this change in MAM with GDP per capita and average height to conclude that MAM is a better indicator of living standards than average height. However, this assumes that the available estimates of GDP per capita are a good indicator of the living standard, which is not necessarily the case, as noted. In addition, Sohn did not analyse the reasons for the decrease in MAM in Indonesia.

This paper extends the findings of Sohn (2015, 2017a) by covering a longer time span, placing the outcomes in the context of Indonesia's economic and social history, and comparing long-term trends in MAM across Asian countries. The paper also offers historical grounding for the growing number of studies on aspects of menarche in Indonesia. These are generally occasional, regional, and unable to put findings in a long-term Indonesia-specific context. This paper draws on such occasional studies in order to augment the analysis based on outcomes from three large surveys.

The next section discusses the available data on MAM and established broad trends during the 20th century. Section 3 analyses and explains these trends with due reference to other literature on economic change in Indonesia during the 20th century. Section 4 discusses the implications of decreasing MAM trend, especially for population growth,

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2 For analysis of changes in average height, Van Zanden and Marks (2012) rely on Foldvari *et al.* (2013). Like Baten *et al.* (2013), this bases its findings for post-war years on IFLS. Unlike Baten *et al.* (2013) the analysis is not based on standardised samples to minimise consequences of sample bias. In addition, for pre-war years Foldvari *et al.* (2013) rely on the truncated height data for military recruits in 1945-1947. Most observations are for 1920-1928 birth cohorts, with very few observations before birth year 1914. Using birth cohorts of the late-1920s is concerning. For example, 1928-born recruits were just 16 or 17 in 1945 and not yet fully grown.

which was an initial reason for academic interest in the age at menarche in Asia. Section 5 offers a comparison of long-term trends in MAM with other Asian countries.

2. Data and trends

Van der Burg (1879), a medical practitioner in colonial Jakarta, was the first to conduct empirical research into MAM in Indonesia to contribute to an international debate about whether MAM in countries closer to the equator was lower than in countries with a temperate climate (Bojlén and Bentzon 1968). An additional motivation was the question whether lower MAM increased fecundity and therefore population growth in such countries. Glogner (1905) added further observations, arguing that Van der Burg had failed to distinguish between European and Indo-European girls in his data collection. There was an uptick in published research since the 1930s, when medical practitioners renewed interest.

The number of studies only increased quickly since the 1990s (Table A.1). A reason was that the study of aspects of menarche and to a lesser extent menopause on the basis of small-scale occasional surveys lent themselves to research projects conducted by undergraduate and graduate students at Faculties of Medical Science, Nursing and Public Health at universities across Indonesia. Initially these studies served the purpose of simply establishing MAM, but increasingly they also sought to test theory. Some theoretical themes have been the relationships between obesity and MAM (*e.g.* Widyaningtyas 2012) and exposure to pornography and MAM (*e.g.* Rahma 2016). Although occasional, covering a small area and small samples, and using different methodologies, the outcomes of many of these studies are used in this paper, although with due care of their limitations in terms of sampling, surveying and analysis.

Results of occasional studies based on small samples or on observations from only primary schools were included in Table A1, but not in further analysis. Included are the outcomes of occasional analyses of correlations between the ages at menarche of young women and their mothers, as well as studies into the age at menopause. These asked regional samples of older or elderly women to recall their age at menarche.

Despite their shortcomings, there are two reasons to analyse the results from about 200 occasional studies in this paper. Firstly, women in the older age brackets in the larger national surveys may not have been able to recall their age at menarche instantaneously, being recorded as non-replies. For example, the responses to the large Riskesdas (2010: 180) survey revealed a 26% non-reply for women aged 55-59, compared to 8% aged 35-39 and 1.6% aged 15-19. By contrast, enumerators of the small-scale surveys may have given older women time to consider their replies, as non-responses were low or zero.

Secondly, there is a potential survivor bias in all MAM estimates based on surveys involving older women. Generations of older women may have experienced more hardship during childhood that reduced their life expectation and increased their age at menarche. Consequently, the older women in the surveys are survivors who experienced better conditions growing up than peers who were in poorer health, experienced late menarche, and already passed away before the survey. As a consequence, MAM may be biased downward in the higher age groups. A comparison of the outcomes of the larger and smaller datasets may allow further consideration of this effect. A third auxiliary reason is that the outcomes of the smaller surveys allow extrapolation of the time span, although with due care.

Three large datasets containing retrospective data at the level of individual women are available. They are the Indonesia Family Life Survey (IFLS), the Demographic and Health Survey (DHS), and the *Riset Kesehatan Dasar* (Basic Health Research, Riskesdas) survey of the Ministry of Health. In principle these much richer data sets allow more substantive testing of MAM-related theory than the occasional studies. Nevertheless, only Sohn (2015, 2017a) analysed time trends based on IFLS.

Table 1 lists MAM calculated from the IFLS and DHS data bases as five-year averages. The Riskesdas (2010: 177 and 180) data are based on 91,711 observations for birth years 1951-2000. Figure 1 shows MAM by birth year from the occasional surveys as individual observations, and from the IFLS, DHS and Riskesdas datasets as lines.[3] The latter reveal a clear and consistent trend: MAM decreased from a level of around 14.5 in the 1940s and 1950s to less than 13.0 in the mid-1990s. The IFLS also reveals an increase in MAM for both the late-1940s and the early-1960s, which may be related to food shortages that these cohorts suffered during infancy (Van der Eng 1994, 2012). Results from both IFLS and Riskesdas indicate that the sustained decrease in MAM started after the early-1960s. This trend is less profound for Riskesdas, because the line in Figure 1 is based on the published five-year averages, not the survey's microdata.

[Figure 1 about here]

The results of the occasional surveys are more difficult to interpret. Only a small survey in the Jatinangor rural town in West Java quizzed several generations of women in the same rural township. It revealed a time trend that is consistent with the larger surveys, but difficult to extrapolate. Out of about 230 observations, the occasional surveys in Figure 1 reveal just nine upward outliers, and five downward outliers. To confirm that these are truly outliers and not indicative of bias in the whole population of occasional survey results, we briefly discuss the upward outliers. After doing so, we will draw on some of the occasional studies for the purpose of further analysis of the likely causes of MAM decrease.

The four upward urban outliers are: 1961 - 14.8 Medan (North Sulawesi), 1962 - 14.9 in Yogyakarta, 1972 Pariaman (West Sumatra), and 1996 - 13.9 in Kupang (Nusatenggara). The studies do not offer clues as to why these are outliers, possibly because there is no standard for the age at menarche in Indonesia to alert researchers to extraordinary observations. The first two may be related to the significant food shortages and disintegration of national markets for staple foods that plagued Indonesia during the late-1950s and the 1960s (Van der Eng 2012). Food shortages, malnutrition and occasional famines affected especially Central Java, including Yogyakarta city.

[3] Sohn (2015: 408) explains how data from the IFLS dataset were converted into time series.

Medan and the whole of North Sumatra have always been heavily dependent on rice imported from overseas or other parts of Indonesia, and may have been affected by the disintegration of national rice markets and by the decrease of rice imports as the result of a combination of foreign exchange shortages and a misguided rice self-sufficiency campaign.

Kupang is the capital city of East Nusatenggara province, which is one of the poorest in Indonesian. Table A.1 shows that it also had a 13.9 MAM for birth year 1980 in a 1992-95 survey. In 2010 MAM of women aged 10-59 in East Nusatenggara was 14.4 (calculated from Riskesdas 2010: 179). Pariaman is a small city in West Sumatra province and is located in a relatively deprived part of Indonesia.

The seven upward rural outliers are 1945 and 1955 - 15.0 in Cirebon (West Java), 1956 - 14.8 in Lampung (South Sumatra), 1958 - 15.3 Kayu Agung (South Sumatra, not shown in Figure 1), 1968 – 15.2 Sarumsokar village (West Java, not shown in Figure 1), 1996 - 13.6 in Pesawaran (South Sumatra), and 2000 - 13.7 Sumbul (North Sumatra). The high 1945 MAM in rural Cirebon is based on a cohort of women born during 1940-1949, and may be a related to food shortages, malnutrition and famine during the 1940s (Van der Eng 1994). At normal times, Cirebon and Lampung were not deprived areas, but the 1955 Cirebon MAM is an average for a 1950-1959 birth cohort, and the 1956 Lampung MAM is based on a sample from a single remote village from a 1950-1965 birth cohort. As mentioned above, these high MAMs may be related to the food shortages and disintegration of national food markets during these birth years.

The Kayu Agung people are an ethnic tribe in South Sumatra who maintain their own culture and cohesiveness, but who are relatively deprived. The same thing applies for two other ethnic tribes represented with very small samples in Table A.1 but not shown in Figure 1; the Alfur (Maluku) and Baduy (West Java), both living in remote upland areas. Lastly, Sarumsokar, Pesawaran and Sumbul are located in relatively poor rural areas, where a higher than overall MAM is not unexpected.

Very few of the high occasional studies observations has MAM exceeding 15 years of age. This indicates that even in some of the most deprived parts of Indonesia MAM was well-below the levels of 15.5 to 17.1 for 1920s-1950s birth cohorts in the poor Shandong and Anhui provinces in China (Van der Eng and Sohn 2018), or 18.0 to 18.6 for 1960s-1980s birth cohorts in rural highlands of Papua New Guinea and high altitude Nepal in the (Wood 1994: 419).

Figure 1 indicates that most occasional surveys were conducted in urban areas, particularly in greater Jakarta, or the Jakarta-Bogor-Depok-Tangerang-Bekasi (Jabodetabek) area. These were generally conducted by university students and academic researchers with limited funds for fieldwork in distant places, except when incidentally visiting their region of origin.

Figure 1 shows two polynomial curves, fitted onto respectively all rural and urban observations. Both confirm the trends from the large datasets, with the key difference that estimated MAM in urban areas is lower than MAM in rural areas; the difference increasing from 0.75 in the 1920s to 1.0 year by the 2000s. Extrapolation predicts that MAM will be 11.5 in urban areas and 12.5 in rural areas for the 2005 birth years.

The fitted rural polynomial is close to the national averages from the larger datasets in Figure 1. The key reason is that until very recently most people in Indonesia lived in rural, rather than urban areas. Available estimates suggest that the percentage of people living in rural areas decreased as follows: 1920 94%, 1930 93%, 1950 88%, 1970 83%, 1990 69%, 2010 50% (Hugo *et al.* 1987: 89; UN 2014). This explains why the results of most of the occasional surveys conducted in urban areas are well below the outcomes based on the nationally representative large datasets.

The results in Figure 1 suggest that the general MAM may have been 14.5 for generations born during 1940s-1950s, before decreasing for generations born in the 1960s and after, who came of age during 1970s until mid-1990s. But what about MAM before the 1940s? Assuming that the difference of one year between rural and urban areas holds, and that rural MAM is indicative of the national average due to the low level of urbanisation before the 1930s, it is possible to estimate total MAM on the basis of the limited data in Table A.1. The table indicates for rural Mojowarno (East Java) and rural Sincincin (West Sumatra) that MAM was about 14.5 for late-1910s birth cohorts. Based on MAM for urban Semarang for birth years 1881-82, the overall MAM may then also have been 14.5. Based on MAM in urban Jakarta around birth year 1860, the overall MAM may have been 15.5. Informed conjecture is therefore that MAM in Indonesia decreased gradually from 15.5 around 1860 to 14.5 by the 1930s, at which level it stagnated until the gradual decrease resumed after the early 1960s.

This trend in MAM is broadly in line with trends in GDP per capita, although the correlation is of course negative (Van der Eng 2010). The only difference is that the average rate growth of GDP per capita is significantly higher than the rates of decrease in MAM. Consequently, the GDP per capita elasticity of MAM was on average -0.07 for the 1870s to 1940s and -0.04 for the 1960s to 2000s, so that a 1% annual per capita GDP growth is associated with a -0.07%, respectively -0.04% decrease in MAM.

3. Explanations of trends

What is the evidence on how economic growth lowered MAM in Indonesia? One way to analyse the relevant determinants is through observations at the level of individuals of their living conditions early in life. The large datasets for Indonesia capture current situations, they do not contain responses to survey questions that enquire about childhood conditions. We can therefore only discuss general trends of potentially explanatory factors based on the assumption that they reflect changes early in the lives of survey participants.

An alternative approach to identify determinants is based on the assumption that they are the same as those that explain decreases in the mortality rates of infant (up to 1 year of age) and children (up to 5 years of age). Figure 2 shows trends in the infant mortality rate (IMR) and child mortality rate (CMR), as far as data are available. There reason to suggest that there were gender differences in IMR and CMR, as there is no evidence for son-preference in the age-sex structure of data from Indonesia's population censuses.

[Figure 2 about here]

It is well-known that IMR and CMR decreased consistently in Indonesia (*e.g.* Hugo *et al.* 1987: 120-130). However, consistent IMR and CMR estimates are only available for the decades since Indonesia's 1961 population census; the World Bank's data for 1951-1960 are based on a retropolation of trend. There are no consistent and nationally representative estimates of IMR and CMR for 1910-1961. Figure 2 shows IMR estimates from small-scale, regional studies that were generally conducted for single years. These surveys may have been skewed towards deprived and overcrowded urban areas where medical researchers tended to locate their studies, and deprived and distant rural areas where physical anthropologists conducted their research. The outcomes are based on different methodologies and are not necessarily comparable. Nevertheless, the fitted regression line reveals that IMR (and by implication CMR) decreased consistently from the 1910s to the 1960s. It offers support for the secular decrease in MAM identified in Figure 1.

Generally, studies assume that secular decreases in IMR, CMR and MAM, and also the increase in average height are correlated with improvements in the quantity and quality of nutrition (mitigated by demands on food intake related diseases and physical work during childhood), improvements in hygiene and other ways in which childhood diseases were prevented, and also improvements in health and medical care to treat diseases and other ailments during infancy, childhood and adolescence. None of the surveys underlying Figure 1 contain questions about such variables in relation to the early lives of surveyed women.

A further possibility is to extrapolate from research into the factors explaining decreasing IMR and CMR. The relationship between improved nutrition during infancy and lower IMR is well-researched. For example, Kardjati *et al.* (1978) substantiated this with a nutrition survey in East Java in 1975-1976, identifying better maternal nutritional status, sustained breastfeeding and increased supplementary infant nutrition as factors that reduced IMR.

Regarding health care, an older strand of research into IMR does not offer conclusive evidence of what factors are important. It points to the beneficial impact of infant immunisations, which were stepped up in Indonesia through mass campaigns since the early 1980s. This led to the systematic integration of immunisations into primary health care services provided through local health centres and health posts, including maternal and child health services (Hugo *et al.* 1987: 113 and 133-134).

Other strands of research used quantitative methods to explain decreasing IMR. The downside of such studies is that their outcomes are driven by the variables for which the large surveys contain data. For example, such surveys did not ask mothers about their own food intake and nutrition during their childhood. Nevertheless, using 1985 DHS data, Frankenberg (1995) identified better access to health care facilities and higher maternal education levels are associated with lower IMR in Indonesia. This was confirmed by Mellington and Cameron (1999), who used 1994 DHS data to establish that higher maternal education levels had a particularly significant impact on lower CMR, especially in urban areas.

Knowing that nutritional intake, educational attainment and access to health care were important factors in explaining lower IMR, CMR and – by implication – MAM in Indonesia, what has been the historical development of those explanatory variables during the 20th century? Van der Eng (2000: 597-599) identified a significant improvement in total calorie supply per capita per day from an average of 1,600 to 1,700 kcal per capita per day during 1880-1905 to 2,000-2,100 kcal during 1914-1943, a decrease to 1,800-2,000 kcal during 1947-1975, and a sustained increase since then. Using per capita protein supply as an indicator of the quality of nutritional intake during the 20th century, suggests similar changes. Such estimates take no account of changes in the distribution of available food, but they are broadly consistent with the trends observed in Figure 2.

Average educational attainment increased slowly during the colonial era to a level almost one year of education per person by 1940 (Van der Eng 2010: 299). After 1950 average education attainment in Indonesia increased to about 2.5 in 1970, about 4.5 in 1990 and 6.5 by 2010. In other words, the susceptibility to advice on personal hygiene and nutrition that was disseminated during public information campaigns may have gradually increased in Indonesia. As better-educated mothers, young women may also have imbued their children with their improved understanding of hygiene and nutrition.

There are no concise and consistent indicators of long-term trends in the expansion of public and private health care facilities, campaigns to improve public awareness about private hygiene and trends, and medical education. In essence, improvements were gradual during 1900-1940, although they may have accelerated somewhat during the 1920s and 1930s (Hugo *et al.* 1987: 108-109; Gooszen 1999: 186-191). By 1940 Indonesia had over 500 public and private hospitals and health clinics (Murakami 2015: 32-33). There was a public agency that focused on hygiene and rural health care, and educational institutions offered high-quality education in medicine and midwifery, but for a limited number of students. Hugo *et al.* (1987: 109) concluded that colonial Indonesia 'had developed an elaborate public health infrastructure which was the envy of much of the rest of Asia, and had gone a long way toward eradicating plague, cholera and malaria, and controlling smallpox, tuberculosis, and nutritional deficiencies'.

A lack of public funding made a further expansion of this system difficult during the 1950s and 1960s (Murakami 2015: 46-54). Alternative forms of health care were tried, such as extending experiences from the colonial era to building a national network of maternal and child health centres (*Balai Kesehatan Ibu dan Anak*) (Swastika 2014; Neelakantan 2017: 83-91). These became the basis for the Community Health Centres (*Balai Kesehatan Masyarakat*) that gradually emerged across the country during the 1970s. They experienced an exponential expansion during the 1980s, when Indonesia's oil boom bolstered public spending. Increased public spending since the 1970s also facilitated improvements in the number of hospitals and clinics, the number of medical personnel employed, and facilities available at health centres, clinics and hospitals (Hugo *et al.* 1987: 110-114). These broad trends are also conversely related with the change in MAM in Figure 1.

To conclude, the available evidence supports the proposition that improvements in food consumption and nutrition, in educational attainment, and in hygiene awareness and health care all contributed to a gradual decrease in MAM before World War II, a stagnation in MAM 1940s-1960s, and an accelerating decrease in MAM since the 1960s.

4. Implications of trends

The relevance of establishing a decrease in MAM during the 20th century goes beyond its indication of change in livings standards. As mentioned, academic interest in the age at menarche in Indonesia was sparked in the 19th century by the question whether MAM was lower in countries around the equator compared to countries with a temperate climate. The implications of lower MAM were believed to be higher fecundity, fertility and population growth, but there was no evidence for at the time. Even when Komlos (1989) analysed this issue, the relationship between lower age at menarche and higher population growth was still controversial. Using historical data from Vienna in 1907, Komlos (1989) established a positive correlation between age at menarche and first childbirth in unmarried women of diminutive stature in Vienna, and that a gap of 7 to 10 years separated both. This suggests that abstinence or birth control moderate the relationship between lower MAM and higher population growth.

Anthropologists and medical practitioners in colonial Indonesia debated similar questions, particularly whether a relatively low MAM in Indonesia meant that girls married and started to conceive at an early age. For example, writing in 1891 about rape within child marriage, cultural anthropologist Wilkens (1912: 616-618) observed that in Indonesia girls tended to marry just after menarche, and sometimes even before, as there were no Islamic and customary rules preventing this. However, he noted that in the case of pre-menarche girls consummation of the marriage was generally postponed.

Researching menarche, gynaecologist and obstetrician Meuleman (1937: 2414-2415) drew on publications by Dutch scholars about the Koran and its interpretation in Indonesia to confirm Wilkens observation. She noted that Indonesian girls with early menarche continued to be regarded as underage until turning 16, and that in the experience of colleague obstetricians and paediatricians women generally gave first birth at the age of 18. This placed colonial government attempts to eliminate under-15 child marriage and underage motherhood in a different light, as common practice in Indonesian society did not condone underage intercourse and pregnancy, although it accepted child marriage. Using data from 123 patients attending maternity clinics in Jakarta, Meuleman established that MAM had been 14.2, the average age at marriage 17.1 and age at first birth 18.4 (calculated from Meuleman 1937: 2421-2423). This confirmed existing impressions and for the first time identified a gap between menarche and first birth of 4 years; less than the case of Vienna.

Hugo *et al.* (1987: 160-161) stated that 'women traditionally married during the years around menarche', and that the 'pattern of early arranged marriage, however, was sometimes associated with a delay in the actual consummation of the union and husband-wife cohabitation'. They did not offer numerical confirmation. It seems that this statement refers largely to the decades before World War II (see also Gooszen 1999: 144-148), because by the 1950s and 1960s the average age of marriage and first childbirth had increased, even though MAM stagnated and then decreased (Figure 1). In 1964 the average age of marriage across Indonesia was 18.1, and it increased further to 18.7 in 1971, 19.5 in 1980 and 21.1 in 1990 (Hugo *et al.* 1987: 162; Niehof 1998: 244). There were significant regional variations and it took longer for child marriages to diminish in some regions, despite the 1974 Marriage Law decreeing that the minimum age at first marriage was 16 for females (Jones 2001). However, in general terms, it is difficult to argue that lower MAM necessarily reduced the age of first childbirth and contributed to an increase in the fertility rate in Indonesia.

By the 1970s it was unlikely that trends in fertility drove changes in MAM, because the Indonesian government had implemented a national family planning program in 1969, which it up-scaled nationwide during the 1970s. In combination with falling IMR and CMR, which reflected increased child survival rates, the family planning program caused Indonesia's nation-wide fertility rate to decrease from 5.6 in 1967-70 and to 3.2 in 1985 (Hull and Dasvarma 1988: 119).

The second way in which a lower MAM could have impacted on a change in population growth is the fact that lower MAM is generally associated with an increasing mean age at menopause (MAMP), thus extending the average number of reproductive years of women. This effect was first noted by Backman (1948: 456-457) and later confirmed by others, such as Boulet *et al.* (1994: 170, 174-175) and Thomas *et al.* (2001). Research has not yet linked early menarche and later menopause directly, but both effects share some common explanations, particularly better socio-economic conditions during infancy and childhood (Mishra *et al.* 2009: 180, 182-183). There is hardly any research on the relationship between MAM and MAMP in Indonesia, except for some small-scale regional studies (*e.g.* Aulia 2014; Sulistiany 2013). In principle, the IFLS, DHS and Riskesdas datasets can be used to analyse trends in MAMP and their relation with trends in MAM, but there are no studies of this issue yet.[4]

Figure 3 shows the results from small-scale regional studies. The results may be difficult to compare. Like the results in Figure 1, the samples may be biased in several ways. Nevertheless, they clearly indicate the negative correlation between MAM and MAMP in Indonesia. If the relationship between MAM and MAMP shown in Figure 3 was stable over time, MAMP may have increased from 48.5 when MAM was 15, to 49.5 when MAM was 12.5.

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[4] Snopkowski *et al.* (2012) used IFLS to analyse MAMP for women aged 40-62, but lumped all birth years together. Their SQ estimate of MAMP is 53 years, which seems high. MAMP has to be estimated from survey responses to questions whether women still menstruated and what their age at the last menstrual cycle (at least 1 year prior to survey) was, in the context of a question why women no longer use prophylactics or other birth control methods.

[Figure 3 about here]

In principle, therefore, fecundity in terms of the number of fertile years per adult woman increased in Indonesia as a consequence of lower MAM and higher MAMP. Nevertheless, it is difficult to specify the contribution of this combined effect to the acceleration of population growth, because of the increasing use of birth control methods during the span of fertile years since the 1970s, as mentioned. However, before birth control policies kicked in during the 1970s, the increasing period of fertility may have contributed to an increase in the average number of children women gave birth to. But it is difficult to distinguish the impact of the longer fecundity on the birth rate from other factors that explain the increased birth rate. In addition, net population growth is the balance between birth and mortality rates. For the same reasons that MAM decreased, IMR and mortality of children up to 5 years old (CMR) decreased, as Figure 2 showed. The more significant and immediate reason for the increase in the net birth rate was this decrease in mortality.

Figure 4 shows that net population growth had been around 1% during the 1930s and early 1940s. It was significantly negative during the famine of 1944-45. But since the 1940s the overall mortality rate decreased gradually as a consequence of decreasing IMR and CMR until it stabilised in the late-1990s. By contrast, the birth rate accelerated from the late 1940s to the mid-1960s, when it started to decrease until the late-1990s as well. Consequently, net population growth accelerated from around 1% during the 1930s to more than 2.5% during the 1960s. On average it was 2.5% during 1955-1985, before decreasing to about 1.4% by 2010. The more significant and immediate reason for the increase in net population growth was the decrease in mortality, rather than lower MAM, which defies 19th century concerns about the negative correlation between low MAM and population growth.

[Figure 4 about here]

The economic consequences of this demographic transition to which decreasing MAM and increasing MAMP contributed were quite significant. The high natural increase of the population during 1955-1985 increased the dependency rate, as the number of children per adult increased. It limited per capita GDP growth and also the increase in the per capita availability of public services that improved hygiene and health care. This continued until decreasing population growth started to reduce the dependency rate, which created the basis for Indonesia's 'demographic dividend' since about 2010 that may last until aging increases the dependency rate again (McDonald 2014).

5. International comparison

Section 2 indicated that levels of MAM in colonial Indonesia seemed to have been low relative to the Netherlands. What about Indonesia relative to other Asian countries? Sohn (2016) analysed the differences in secular changes in MAM of Indonesia, Malaya and Korea. Figure 5 extends these data for Indonesia, and adds MAM in China and Japan for comparative purposes. It shows that MAM in Korea and China exceeded that in Indonesia by far; in the case of Korea until 1970, and in the case of China until 1987. It also shows that MAM in Indonesia was at a level comparable to Japan until 1950, and slightly higher than in Malaya in the 1920s

[Figure 5 about here]

On the basis of the Indonesia-Malaya-Korea comparison, and after controlling for levels of GDP per capita in 1990 PPP dollars and life expectancy as proxies for living standards, Sohn (2016: 332 and 335-336) revived the long-standing discussion in the fields of physiology and human biology about the role of climate in determining MAM. Sohn hypothesised that 'climate exerts a significant influence on age at menarche because the relatively easy availability of food in the tropics increases energy intake while the absence of cold weather decreases energy expenditure on maintenance and activity', the remainder benefiting human development.

It is now possible to consider a few implications of this hypothesis. Annual average per capita supply of calories from the main grains, pulses and tubers was during 1911-1940 almost exactly the same in Korea as in Indonesia and Japan: around 1,750 Kcal per capita per day (Kim *et al.* 2012: Table II-58; Van der Eng 2000; Mosk and Pak 1977). It is therefore unlikely that differences in nutrition account for differences in MAM between these three countries, at least during the 1920s-1930s. Sohn (2016) assumed that Indonesia was less-affected by pre-harvest food shortages, as food crops could be harvested year-round. In actual fact, pre-harvest food shortages were long a significant problem in Indonesia, especially in land-scarce, densely populated Java, where population and food production growth remained finely balanced until the Green Revolution in rice agriculture in the 1970s (Van der Eng 2000). Malaysia was different in this respect. It was land-abundant and had an economy that depended to a greater degree on commodity exports facilitating imports of rice and other food products from mainland Southeast Asia to bridge the period until the main harvest.

While per capita calorie supply was at a comparable level in Korea and Indonesia before World War II, Korea's lower average ambient temperature during winter may have required Koreans to consume food in first instance to retain body heat, before nutrition would benefit human growth. If that were the case, the impact would not only reveal itself in a higher MAM, but also in lower average height. In fact, from the 1870s until the 1980s, Korean adult males were taller than Indonesian and Japanese males, not shorter (Blum and Baten 2012).

In addition, much of Japan has a climate comparable to Korea. Figure 5 also shows that MAM was almost as high in China as it was in Korea until the mid-1950s.[5] While the climate in Northern China may be comparable to Korea, China's MAM is based on nationally representative surveys, including Southern China where the ambient temperature in winter is higher than in Korea. If climate is a key issue in explaining different levels of MAM, we would expect MAM in China to have been lower than Korea until Korea's prosperity increased in the 1960s. This was not the case. Korea's cold climate in winter can therefore not explain differences in MAM between Korea and other Asian countries in Figure 5.

It is more likely that relative levels of GDP per capita are not fully reflective of relative living standards across the Asian countries in Figure 5. This is possible, because the historical estimates of GDP per capita in 1990 PPP dollars are based on retropolations of a single 1990 benchmark year, which takes insufficient account of historical changes in relative prices and the actual purchasing power of national currencies in Asia. Using historical PPP-based converters of GDP per capita indicates that levels of GDP per capita in most of Asia – with the exception of Korea and China – were closer to those of Japan before World War II, and in some cases comparable to Japan just before World War I, than the retropolations of 1990 suggest (Bassino and Van der Eng 2016). For example, by these estimates, GDP per capita in Malaysia was well ahead of Japan until the late-1950s, which is consistent with the relative MAM levels in Figure 5.

Consequently, it is likely that the levels of MAM across countries in Figure 5 are more appropriate indicators of relative living standards across Asia than the existing estimates of GDP per capita in 1990 PPP dollars. If so, lower levels of MAM reflect a better socio-economic environment during infancy, childhood and adolescence that on average allowed households to purchase better hygiene and health care and nutrition. This helps to understand why large numbers of migrants left China and also Korea before World War II, and why most Chinese migrant workers departed for Southeast Asia, including Malaya and Indonesia, until those countries closed their borders to inward migration in the 1950s.

Figure 5 also shows that the rate of decrease in MAM was much faster in Japan, Korea and China, and that Japan moved ahead of Indonesia after 1950, Korea after 1970, and China after 1990. All three comparator countries had much lower population growth when Indonesia's population growth accelerated to high levels in the 1950s-1970s. Higher population growth limited the rate of increase in per capita availability of, for example, health care services or nutrition.

To return to the case of Indonesia, Table A.1 indicates that there are few studies of age at menarche with which to gauge trends in MAM before the 1940s. In addition several of these studies included European and Indo-European women in their surveys,

[5] Theoretically, son-preference in China and Korea suggests that women may have been disadvantaged in the intra-household allocation of food and amenities, compared to women in parts of Asia without son-preference. However, studies comparing longitudinal changes in the average heights of boys and girls suggest that this impact of son-preference may be limited. Height gains were comparable for boys and girls in China since 1979 (Morgan 2014: 1040).

which allows consideration of the possibility that ethnicity is a factor in explaining the different levels of MAM in Figure 3.

The mere fact that levels of MAM in some parts of Asia before World War II (*i.e.* China and Korea) can be just as high as in the less-developed parts of Europe in the early-19th century (Backman 1948; Danker Hopfe 1986), and the fact that levels of MAM in Asia in the 1990s can be just as low as in the developed parts of Europe, suggests that ethnicity by itself is unlikely to be relevant as a predictor of relative levels of MAM. But the issue of ethnicity needs further consideration in historical context.[6]

As mentioned, Glogner (1905) found no difference in MAM for European (generally Dutch) and Indo-European women born in Indonesia around 1881: 13.6, respectively 13.4. He noted – without reference to sources – that these averages were lower than in Northern Europe. He may have been right, as Evers (1873) found MAM in the Netherlands for birth cohorts around 1857 to be 16.6, and Bolk (1926: 372) estimated MAM to be 15.2 for women born in The Netherlands before 1880. A reason for the lower MAM in Indonesia is that the same income would have afforded (Indo) European households a higher standard of living than in The Netherlands due to differences in the purchasing power of the currencies in both countries.

Rodenwaldt (1932: 178) also found a marginal difference in MAM between groups of European and Indo-European women born in Indonesia: 12.8 respectively 12.5. But he noted that the MAM of women born and raised in Europe – possibly 30 years earlier – was higher: 13.4. In line with common belief at the time, he concluded: 'the tropical climate gives cause to a lower age at menarche'. However, he omitted to mention that Bolk (1926: 366 and 372) had estimated MAM for women born and living in The Netherlands during 1880-1913 to be 13.3. This is the same as MAM of their peers in Indonesia, and therefore discredits Rodenwaldt's conclusion.

Lastly, Meuleman (1937) found a higher MAM for midwifery students and hospital patients of Indonesian ethnicity in Jakarta (14.1, respectively 14.2), which was higher than for (Indo) European women. Her findings confirmed the higher level of MAM found by Müller (1932) for Indonesian women in rural Mojowarno (14.6). Meuleman therefore re-stated the conclusion of Müller (1932: 61): 'This clearly shows that the general perception that women native in warmer climes experience menarche earlier is not valid'.[7] Neither mentioned that their findings pointed to the possibility that socio-economic differences were the key reason for the different levels of MAM between European and Indonesian women rather than climate.

Bree-Meuleman (1940) was the first in Indonesia to confirm that implication, finding a relatively low MAM of 13.1 for Indonesian students at élite schools with a medium to high level socio-economic background. This was lower than MAM of the

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[6] There is no modern study that strikes an unambiguous balance between ethnic and environmental factors in explaining variance in the age at menarche. There are some indications that ethnicity may be relevant. However, the problem with research into this issue is the unavailability of a dataset that allows controlling for all relevant environmental factors (Karapanou and Papadimitriou 2010: 4). There is no study that informs intra-Asia comparisons of MAM on this issue.

[7] Based on his research among Indonesian women in Jepara-Pati, Bervoets (1931) was an earlier proponent of this view (Van Loon 1928: 1068).

groups of midwifery students and hospital patients in 1937, and comparable to that of (Indo) European women.

The and Soepatmi (1962: 339-340) corroborated the irrelevance of ethnicity with a comparison of MAM for ethnic Chinese and ethnic Indonesian students at schools in Surabaya, finding no significant difference in MAM between the two ethnic groups. They did find a lower MAM for well-off students of both ethnicities, compared to students from poorer households.[8]

Siandhika (1994: 21-22) also found no difference in MAM between two groups of ethnic Chinese and ethnic Indonesian students in Yogyakarta city, but a one year higher MAM in a group of ethnic Indonesian students in rural Yogyakarta. Other studies confirmed that in Indonesia – like elsewhere in the world – higher household affluence reduces MAM of female offspring (*e.g.* Artaria and Henneberg 2000: 564; Ginarhayu 2002; Hendrawati and Glinka 2003: 19-20). Consequently, despite the long-standing interest in ethnicity and climate, different levels of MAM across groups in Indonesia and also across Asian countries were foremost biological indicators of different living standards.

6. Conclusion

This paper investigated long-term trends in MAM in Indonesia in order to contribute to the discussion about living standards in the country during the 20th century. Section 2 presented the available evidence from two main sources of data. The analysis of data from three large datasets established consistent time trends: stagnation in MAM for females born during the 1940s to early-1960s, and a decrease for birth cohorts from the late-1960s to the late-1990s. The second source of data augmented these findings. The outcomes of about 200 relatively small-scale studies were broadly consistent with the first category of results.

The occasional studies indicated that the decrease of MAM since the early-1960s was consistent in urban and rural areas, albeit that MAM was consistently lower in the first by 0.75 to 1.0 years. They also indicated that the decrease in MAM continued to the mid-2000s. The available results for birth cohorts before the 1940s had to be interpreted with caution, as there are fewer, and several relate to groups of women who are not necessarily representative of the population of women in Indonesia. Nevertheless, none of the outcomes pointed to levels of MAM exceeding 15.0 during the 20th century. Instead, it is likely that MAM in Indonesia in the late-19th century was around 15.5, decreasing gradually to a level of 14.5 where it stagnated until the early 1960s.

To explain these trends, the paper referred to studies that examined changes in IMR and that identified improvements in nutrition, educational attainment and health care as key factors explaining decreased in IMR and by implication MAM. An analysis of the evidence for improvements in all three confirmed that they are likely to explain in broad terms trends in MAM.

[8] Although only the results from the SQ method provided confirmation, not the Rec-based results.

A discussion of the potential implications of decreasing MAM discarded the possibility that it contributed to an increase in population growth through higher fecundity and fertility. Lower MAM coincided with an increasing average age at marriage, but the decrease in MAM was not high enough to add much to fecundity. This development coincided with decreasing birth and fertility rates due to Indonesia's birth control campaign since the late-1960s, which dominated trends in population growth, rather than increased fertility due to decreasing MAM.

The paper compared changes in MAM in Indonesia with the experience in 4 other Asian countries. International differences in MAM have given rise to suggestions that the warmer climate in Indonesia and ethnicity were causal factors. But discussion of the implications of either suggestion led to the conclusion that differences in MAM are more likely a consequence of socio-economic differences between populations, confirming that differences in MAM across populations reflect differences in living standards. Consequently, the results suggest that living standards in Indonesia were comparable to Japan until 1950, well ahead of Korea until 1970 and of China until 1990. The rate of decrease was so much faster in China, Korea and Japan, as all three had much lower population growth than Indonesia, which limited the rate of increase in per capita availability of, for example, health care services.

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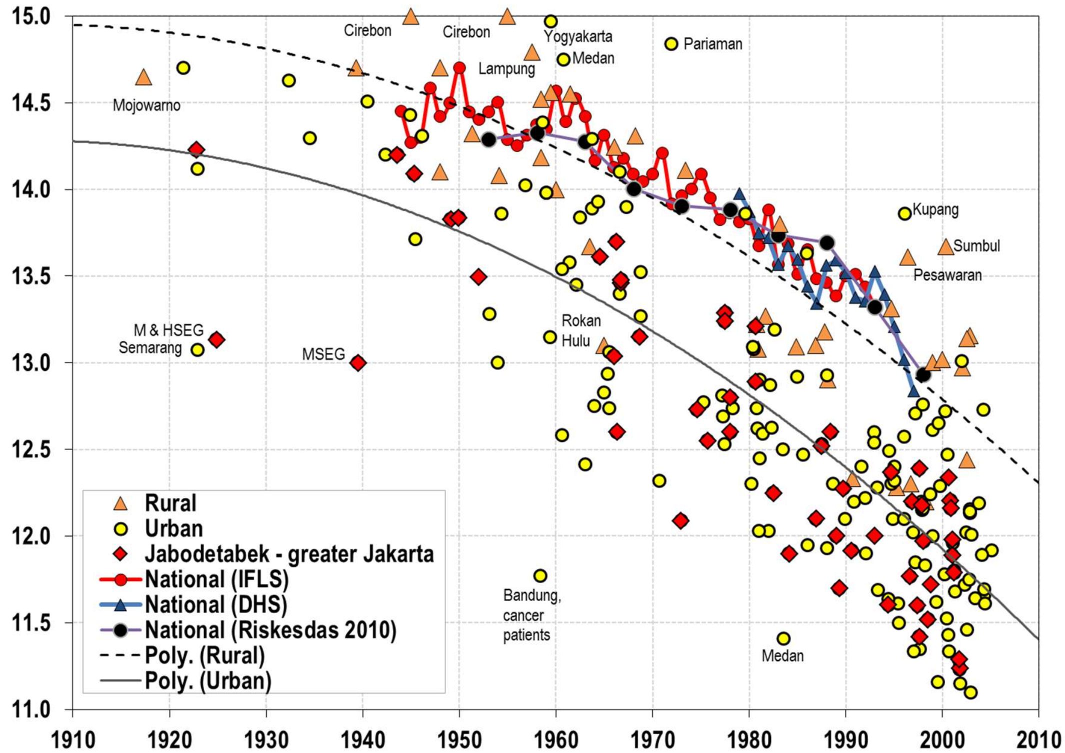
Table 1: Mean Age at Menarche in Indonesia, IFLS and DHS Data Sets, 1925-2003

Birth year cohorts	Total				Urban				Rural			
	MAM	95% CI lower	95% CI upper	N	MAM	95% CI lower	95% CI upper	N	MAM	95% CI lower	95% CI upper	N
A. IFLS results												
1945-1949	14.4	14.6	14.3	418	14.4	14.7	14.2	222	14.4	14.7	14.2	196
1950-1954	14.5	14.7	14.4	741	14.3	14.5	14.2	383	14.7	14.9	14.6	358
1955-1959	14.4	14.5	14.2	910	14.3	14.4	14.1	513	14.4	14.6	14.3	397
1960-1964	14.5	14.6	14.4	1,102	14.4	14.6	14.3	547	14.5	14.7	14.4	555
1965-1969	14.1	14.2	14.1	1,196	14.1	14.2	14.0	613	14.2	14.4	14.1	583
1970-1974	14.0	14.1	13.9	1,141	13.8	14.0	13.7	572	14.2	14.4	14.1	569
1975-1979	13.9	14.0	13.8	1,153	13.8	13.9	13.7	576	14.0	14.2	13.9	577
1980-1984	13.7	13.8	13.6	1,181	13.6	13.8	13.5	665	13.9	14.0	13.7	516
1985-1989	13.5	13.6	13.4	949	13.4	13.6	13.3	526	13.6	13.7	13.4	423
1990-1994	13.5	13.6	13.4	540	13.4	13.6	13.2	259	13.6	13.8	13.4	281
All				9,331				4,878				4,455
B. DHS results												
1980-1984	13.7	13.7	13.6	2,077	13.6	13.6	13.5	1,322	13.9	14.0	13.7	755
1985-1989	13.5	13.5	13.5	7,149	13.3	13.4	13.3	4,073	13.7	13.8	13.7	3,076
1990-1994	13.4	13.5	13.4	7,632	13.3	13.4	13.3	4,263	13.6	13.6	13.5	3,369
1995-1997	13.0	13.1	13.0	3,515	12.9	13.0	12.9	1,778	13.2	13.2	13.1	1,737
All				20,373				11,436				8,937

Notes: MAM = mean age at menarche, CI = confidence interval. DHS surveyed never married women aged 15-24. The sample taken is restricted to women who had experienced menarche between ages 8-19 and excludes a small number of outliers. The table excludes small numbers of observations for birth years 1978-1979 from DHS and for birth years 1937, 1943 and 1995-1998 from IFLS.

Sources: Calculated from data of the Indonesia Family Life Survey (IFLS, rounds 1993, 1997, 2000, 2007 and 2014) https://www.rand.org/labor/FLS/IFLS.html and the Demographic and Health Survey (DHS, rounds 2002-03, 2007 and 2012) https://www.dhsprogram.com/.

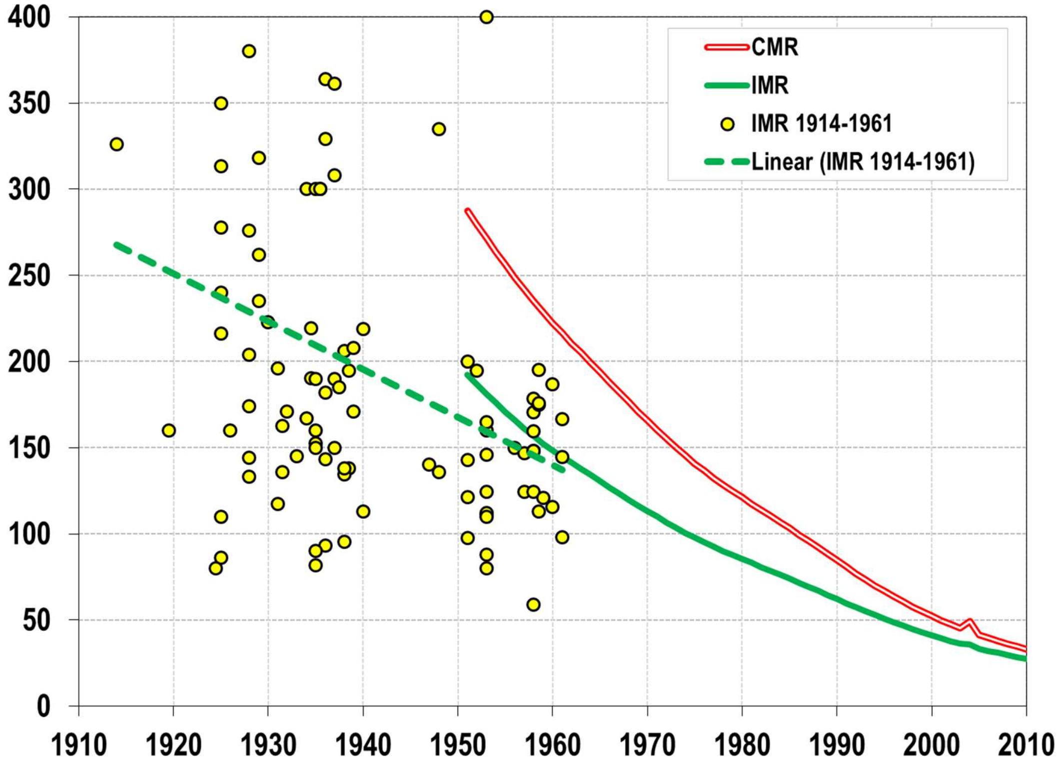
Figure 1: Mean Age at Menarche in Indonesia by Birth Years, 1917-2005



Notes: MSEG = Medium-level socio-economic group, HSEG = High-level socio-economic group. Excludes results from occasional surveys in primary school only because the age distribution tends to be truncated. Also excludes averages from samples with less than 35 observations. DHS results for 1996 and 1997 cohorts are corrected for shares of all girls over 16, respectively 15 who had not reached menarche yet, assuming the average of these groups to be 17.5, respectively 16.5. Riskesdas ages are estimated by centred 5-year birth cohorts for girls and women aged 10-59. Greater Jakarta comprises Jakarta, Bogor, Depok, Tangerang and Bekasi (Jabodetabek). It is included in the estimated urban polynomial.

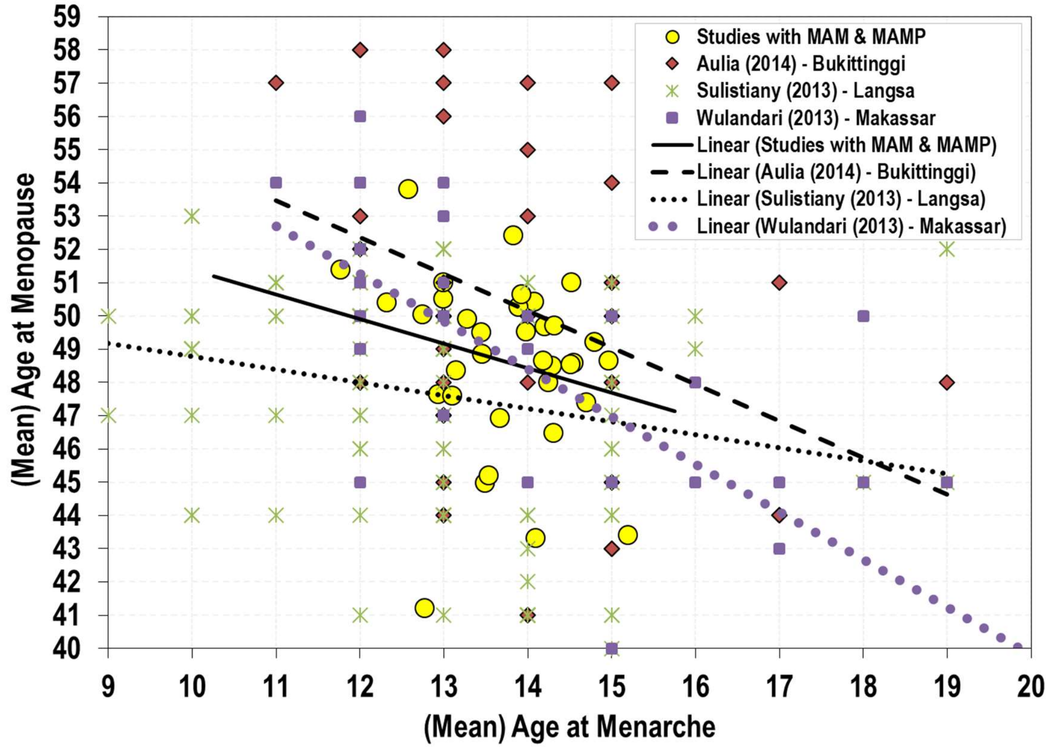
Sources: Calculated from IFLS and DHS (see main text and Table 1) and from Riskesdas (2010: 180); Table A1.

Figure 2: Infant and Child Mortality Trends in Indonesia, 1914-2010



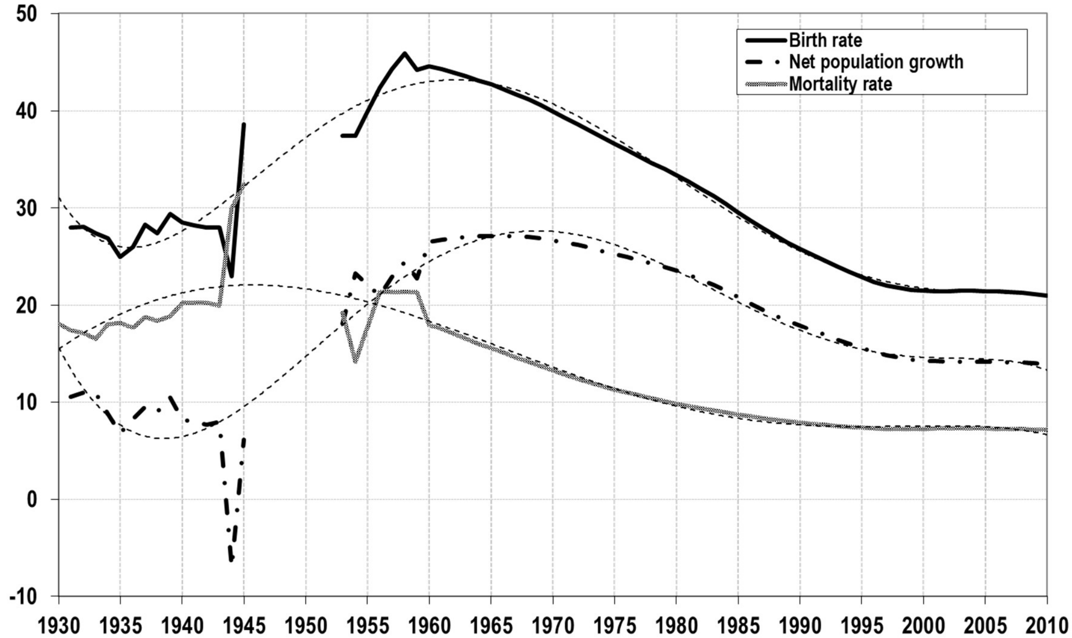
Note: 1914-1961 estimates are for a range of areas and years.
Sources: 1914-1961 occasional study results Appendix A.2; 1951-2010 series UN Inter-agency Group for Child Mortality Estimation (IGME) (9 September 2015), http://www.childmortality.org [accessed 9 June 2018].

Figure 3: Relationship between Mean Age at Menarche (MAM) and Mean Age at Menopause (MAMP) in Indonesia



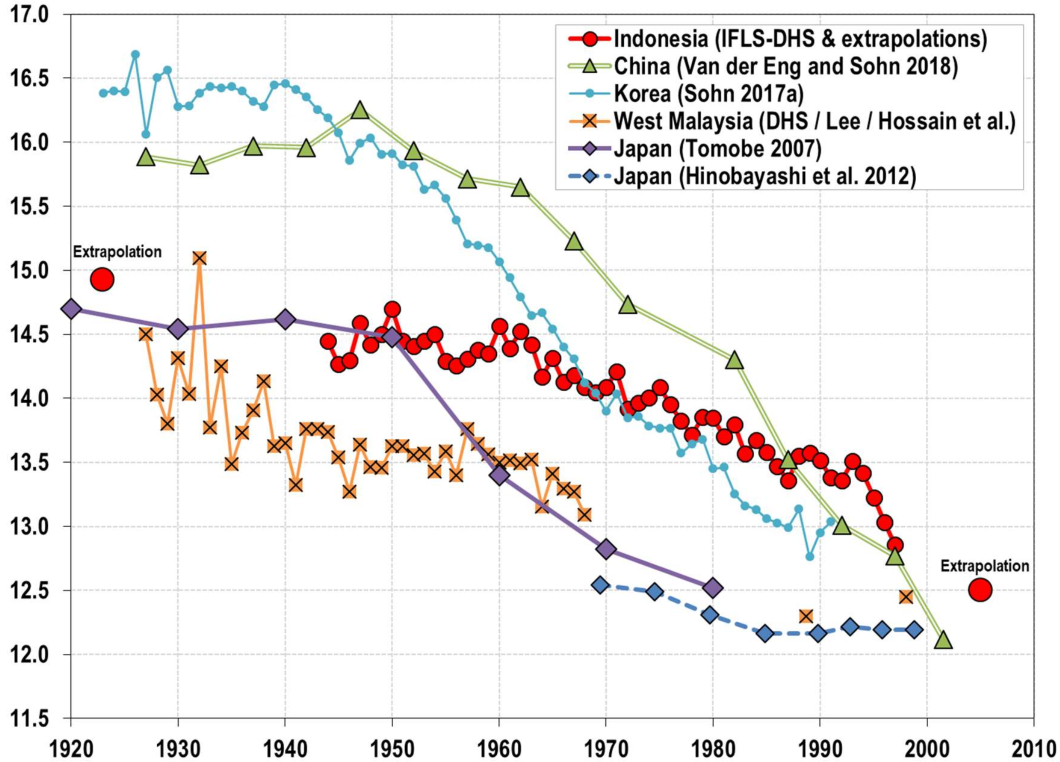
Sources: Table A.2; Aulia (2014: Appendix 5); Sulistiany (2013: Appendix 2); Wulandari (2013: Appendix 4).

Figure 4: Demographic Transition in Indonesia, 1930-2010 (‰)



Notes: 1930-1945 and 1953-1959 refers to Java only.
Sources: 1930-1944 Van der Eng (2002: 493); 1945 and 1953-1959 BPS (1968: 2-3) and *UN Demographic Yearbook* (1948-1962); 1960-2010 World Bank, http://databank.worldbank.org/

Figure 5: Mean Age at Menarche in Five Asian Countries by Birth Years, 1920-2005



Notes: For Indonesia, the IFLS and DHS data are combined for the overlapping birth years, and 1923 and 2005 are extrapolated on the basis of the rural polynomial in Figure 1 (see the main text). Malaysia 1989 and 1998, and Japan 1969-1999 average birth years approximated as survey years less MAM.

Sources: Indonesia calculated from IFLS and DHS (see main text); West Malaysia calculated from the Malaysian Family Life Survey; Malaysia 1989 from Lee *et al.* (2006) and 1998 from Hossain *et al.* (2013); China from Van der Eng and Sohn (2019); Korea from Sohn (2017b); Japan from Tomobe (2007) and Hinobayashi *et al.* (2012).

The Biological Standard of Living in Indonesia during the 20th Century: Evidence from the Age at Menarche

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Appendix tables and sources

Appendix 1: Sources for Figure 1

Table A.1: Mean Age at Menarche by Approximated Birth Year from Occasional Studies in Indonesia, 1860-2005

Age at menarche in Indonesia	Sam-pling years	Sample size	Method	(Av.) age, ages or birth year range	Approxi-mated average birth year*	Mean or median age at menarche	SD/SE	Source (original and = used source)
Jakarta (West Java), Indonesia-born (Indo-)European	1872-78	168	Rec		1860	14.65		Van der Burg (1879) p.122
Java (general)	< 1883	-	Guess		1870	12 - 13		Van der Burg (1883) p.70 ('13th or 14th year of life')
Indonesia (general)	< 1891	-	Guess		1880	10 - 12		Wilken (1912) p.623, footnote 19
Nias (West Sumatra)	< 1891	-	Guess		1880	15 - 16		Wilken (1912) p.623, footnote 19
Semarang (Central Java), Indonesia-born Indo-European	1890-1900	50	Rec		1881	13.61		Glogner (1905) pp.339-340
Semarang (Central Java), Indonesia-born European		22	Rec		1882	13.43		Glogner (1905) p.339
Java (general), European and Indonesian	< 1924	-	Guess		1911	12 - 13		Stratz (1924) p.509 in Müller (1932) p.60
Indonesia, Europe-born European, HSEG	1929-30	193	Rec		1916	13.45		Rodenwaldt (1931) p.149; Rodenwaldt (1932) p.177
Indonesia, Indonesia-born European, HSEG	1929-30	33	Rec		1916	12.85		Rodenwaldt (1931) p.150; Rodenwaldt (1932) p.177
Indonesia, Indonesia-born Indo-European women, HSEG	1929-30	43	Rec		1916	12.53		Rodenwaldt (1931) p.150; Rodenwaldt (1932) p.177
Jepara-Pati (Central Java)	1930	25	SQ		1917	13.50		Estimated from Bervoets (1931) p.236
Mojowarno (East Java), rural	1932	54	SQ		1917	14.65		Estimated from Müller (1932) p.60
Flores (Nusatenggara), rural	< 1932	-	Guess		1918	12 - 13		Vatter (1932) in Höltker (1949) p.20 ('13th or 14th year of life')
Sicinsin (West Sumatra), rural	1992	9	Rec	60-80+	1919	14.30	±1.82	Oenzil (1995) p.725
Surabaya (East Java)	1968	391	Rec	46.6	1921	14.70		Toda *et al.* (1970) abstract
Jakarta (West Java), midwives (from across Indonesia)	1937	42	Rec		1923	14.12		Calculated from Meuleman (1937) p.2420
Jakarta (West Java), hospital patients	1937	35	Rec		1923	14.23		Calculated from Meuleman (1937) p.2421
Semarang (Central Java), Kartini high school, HSEG	1936	82	Rec		1923	13.07		Calculated from Meuleman (1937) p.2419
Bali	< 1937				1924	12 - 13		Weck (1937) in Höltker (1949) p.20
Jakarta (West Java), Kemajuan Istri high school, MSEG	1938	185	SQ		1925	13.50		Estimated from Bree-Meuleman (1940) p.167
Jakarta (West Java), Kartini high school, HSEG	1938	92	SQ		1926	12.40		Estimated from Bree-Meuleman (1940) p.167
Jakarta (West Java), high schools, average	1938	277	SQ		1925	13.13		Estimated from Bree-Meuleman (1940) p.167
Klaten (Central Java)	1947	103	Rec	11-17	1932	14.63	±0.54	Radiopoetro and Soemartin (1948) in Doerjadibroto (1962) p.361

Alfur people, Seram (Maluku)	< 1949				< 1934	15 <		Höltker (1949) p.20
Bandung (West Java)	1982	1,025	Rec	1927-42	1935	14.30		Calculated from Agoestina and Van Keep (1984) p.329
South Kalimantan, Dayak, rural	1954	133	Rec		1939	14.70		Hoogenkamp (1956) p.58
Jakarta (West Java), MSEG (79% high school graduates)	1989	345	Rec	1930-49	1940	13.00		Samil and Wishnuwardhani (1994) p.193
Yogyakarta (Central Java), students	1952-58	1,468	Rec	10-19	1940	14.50	±1.19	Doerjadibroto (1962) p.374
Yogyajarta (Central Java), labourers	1952-58	353	Rec	10-18	1940	14.54	±1.38	Doerjadibroto (1962) p.373
Yogyakarta (Central Java), total	1952-58	1,821	Rec	10-19	1940	14.51	±1.23	Doerjadibroto (1962) p.374
Makassar (South Sulawesi)	2003	270	Rec	60.7	1942	14.20	±1.82	Tumedia and Harun (2010) abstract
Jakarta (West Java)	1989-92	900	Rec	46.9	1944	14.20	±1.50	Budiningsih *et al.* (1999) p.130
Jakarta (West Java)	1989-92	110	Rec	45.2	1945	14.09		Calculated from Tjindarbumi *et al.* (1999) p.112
Cirebon (West Java)	2010	56	Rec	1940-49	1945	15.00		Wati'ah (2011) p.22
Yogyakarta (Central Java), mothers of students	1980-81		Rec		1945	14.43	±0.95	Aswin *et al.* (1982) in Damayanti (2001) p.25 (assuming mothers' av. age 23)
Surabaya (East Java), ethnic Indonesian, LSEG	1959	1,237	Rec	8-18	1945	13.67	±1.11	The and Soepatmi (1962) p.344
Surabaya (East Java), ethnic Indonesian, MSEG	1959	269	Rec	8-18	1946	13.34	±1.07	The and Soepatmi (1962) p.344
Surabaya (East Java), ethnic Indonesian, HSEG	1959	195	Rec	10-19	1946	13.04	±1.17	The and Soepatmi (1962) p.344
Surabaya (East Java), ethnic Indonesian, HSEG, high school	1959	1,316	Rec	9-21+	1945	13.96	±1.16	The and Soepatmi (1962) p.344
Surabaya (East Java), ethnic Indonesian, total	1959	3,017	Rec	8-21+	1945	13.67	±1.17	The and Soepatmi (1962) p.344
Surabaya (East Java), ethnic Indonesian, LSEG	1959	6,092	SQ	8-18	1945	13.82	±0.06	The and Soepatmi (1962) p.345
Surabaya (East Java), ethnic Indonesian, MSEG	1959	1,521	SQ	8-18	1945	13.72	±0.12	The and Soepatmi (1962) p.345
Surabaya (East Java), ethnic Indonesian, HSEG	1959	1,428	SQ	8-19	1945	13.72	±0.12	The and Soepatmi (1962) p.345
Surabaya (East Java), ethnic Indonesian, HSEG, high school	1959	2,532	SQ	11-21+	1945	13.54	±0.12	The and Soepatmi (1962) p.345
Surabaya (East Java), ethnic Indonesian, total	1959	11,573	SQ	11-21+	1945	13.75	±0.04	The and Soepatmi (1962) p.345
Surabaya (East Java), ethnic Chinese, MSEG	1959	80	Rec	10-17	1946	13.17	±1.16	The and Soepatmi (1962) p.346
Surabaya (East Java), ethnic Chinese, HSEG	1959	144	Rec	10-17	1946	12.58	±1.09	The and Soepatmi (1962) p.346
Surabaya (East Java), ethnic Chinese, HSEG, high school	1959	435	Rec	9-21+	1946	13.07	±1.17	The and Soepatmi (1962) p.346
Surabaya (East Java), ethnic Chinese, total	1959	659	Rec	9-21+	1946	12.82	±1.19	The and Soepatmi (1962) p.346
Surabaya (East Java), ethnic Chinese, MSEG	1959	587	SQ	8-17	1945	13.75	±0.20	The and Soepatmi (1962) p.347
Surabaya (East Java), ethnic Chinese, HSEG	1959	1,278	SQ	8-17	1945	13.80	±0.15	The and Soepatmi (1962) p.347
Surabaya (East Java), ethnic Chinese, HSEG, high school	1959	842	SQ	12-21+	1946	12.90	±0.20	The and Soepatmi (1962) p.347
Surabaya (East Java), ethnic Chinese, total	1959	2,707	SQ	8-21+	1945	13.55	±0.10	The and Soepatmi (1962) p.347
Semarang (Central Java)	1998	71	Rec	51.9, 42-62+	1946	14.31		Tan (1999) p.27
Lombok (Nusatenggara)	1964	195	Rec	19-35	1948	14.10	±1.77	Toda and Mori (1967) p.146

Ciamis (West Java)	2003	40	Rec	45-65	1948	14.70		Setiasih (2003) abstract
Jakarta (West Java)	1997-06	56	Rec	52.4, 30-72	1949	13.83		Hasanuddin *et al.* (2010) pp.139-140
Jakarta (West Java), mothers of students	< 1986	203	Rec	ca.1950	1950	13.84	±2.74	Busmar (1986) p.44 (assuming mothers' av. age 23)
Kertasura (West Java), rural	2001	60	Rec		1951	14.32	±0.07	Anggraini (2008) p.207
Bogor (West Java)	2013	420	Rec	31-91	1952	13.49		Wulandari (2013) pp.3-4
Soppeng (South Sulawesi)	2013	67	Rec	59.9	1953	13.28		Ratna *et al.* (2014) pp.3-5
Surabaya (East Java)	2014	107	Rec	60+	1954	13.00	±2.00	Anggrainy and Indriani (2015) pp.112-113
Bali	< 2013	52	Rec	57.9	1954	14.08		Yulianto *et al.* (2013) p.122
Malang and Surabaya (East Java), mothers of students	1990			ca.1955	1954	13.86	±0.05	Artaria (1991) abstract (assuming mothers' av. age 23)
Cirebon (West Java)	2010	73	Rec	1950-59	1955	15.00		Wati'ah (2011) p.22
Makassar (South Sulawesi)	2013	40	Rec	56.2	1957	14.03	±2.23	Calculated from Wulandari (2013) appendix 4
Lampung (South Sumatra), rural	2010	97	Rec	45-60	1958	14.79	±1.64	Ifayanti (2012) pp.50-51
Kampung Naga (West Java), rural	< 2009				1958	14.52		Vidiawati (2009) in Maretta (2011) p.16
Banyumas (Central Java), rural	2012	76	Rec	53.6	1958	14.18		Rohmatika *et al.* (2012) pp.94-96
Kayu Agung people (South Sumatra)	1973	100	SQ	12-17	1958	15.32	±0.22	Noer (1975) p.173
Bandung (West Java), breast cancer patients	2003-08	164	Rec	47.1, 25-80	1958	11.77	±1.87	Sander (2011) pp.6-7
Palembang (South Sumatra)	1973	1,681	SQ	10-19	1959	14.39	±0.19	Noer (1975) p.173
Bandung (West Java)	2008	668	Rec/SQ	39-63	1959	13.98		Sukmaningrasa (2009) p.27 (graph 3)
Palembang (South Sumatra)	2010-11	40	Rec	45-55	1959	13.15	±1.30	Amran *et al.* (2012) pp.131-132
Rokan Hulu (Riau)	2012	100	Rec	52.5	1960	14.56	±2.05	Herawati (2012) p.5
Palangka Raya (Central Kalimantan)	2012	100	Rec	52.5	1960	15.20	±1.73	Nansia (2012) p.24
Cirebon (West Java)	2010	18	Rec	av.1960	1960	14.00		Wati'ah (2011) p.22
Jakarta (West Java) mothers of university students	2000-01	57	Rec	ca.1960	1960	14.61	±2.02	Damayanti (2001) pp.67-68 (assuming mothers' av. age 23)
Medan (North Sumatra)	1975-76	266	Rec	12-18	1961	14.75	±1.25	Siregar *et al.* (1981) p.144
Klaten (Central Java)	2014	124	Rec	53.4, 45-60+	1961	12.58		Calculated from Wahyuni and Safitri (2017) pp. 4 and 7-8
Medan (North Sumatra)	2009	125	Rec	47.9	1961	13.54	±1.92	Safitri (2009) pp.49-50 and 105
Lampung (South Sumatra), rural	2010	114	Rec	40-60	1961	14.55		Maretta (2011) pp.14-16
Baduy people (West Java), rural	2010	34	SQ	40-94	1961	14.97		Rohmatullayaly (2010) pp.10-13
Cirebon (West Java)	2010	359	Rec	35-70	1961	14.51		Wati'ah (2011) p.22
Surabaya (East Java)	< 1976	351		12-15	1961	13.58	±1.11	Ferdinandus (1976) in Ginarhayu (2002) p.13
Sleman, Yogyakarta (Central Java)	2013-14	88	Rec	51.4, 45-60	1962	13.45	±1.50	Trisetiyaningsih et al. (2016) p.194
Tondano (North Sulawesi)	2013	71	Rec	45-55	1963	12.42		Makahanap *et al.* (2014) p.4

Yogyakarta (Central Java)	1981	70	Rec	18.5-21.5	1960	14.97	±1.79	Afiati (1984) pp.46-47
Yogyakarta (Central Java)	1981	191	Rec	15.5-18.5	1963	13.84	±1.40	Afiati (1984) pp.46-47
Yogyakarta (Central Java)	1981	74	Rec	12.5-15.5	1966	13.06	±1.05	Afiati (1984) pp.46-47
Yogyakarta (Central Java), total	1981	335	Rec	12.5-21.5	1963	13.97	±1.47	Afiati (1984) pp.46-47
Kuranji, Padang (West Sumatra)	2014-15	40	Rec	45-55	1964	12.75	±1.25	Resti (2015) abstract
Bukittingi (West Sumatra)	2014	37	Rec		1964	13.89	±1.68	Aulia (2014) appendix 5
Makassar (South Sulawesi)	< 1979				1964	14.29		Luhulima (1979) in Hendrawati and Glinka (2003) p.19
Pekalongan (Central Java)	2015	98	Rec	46-55	1964	13.93		Calculated from Ta'adi *et al.* (2016) p.102
Minahasa (Central Sulawesi)	2014	225	Rec	44-57	1964	13.67		Kalengkongan *et al.* (2015) pp.59-60
Langsa Barat (Aceh)	2013	112	Rec	40-55	1965	12.94	±1.95	Calculated from Sulistiany (21013) appendix 2
Banjarmasin (Kalimantan)	2017	47	Rec	45-59	1965	12.83		Widodo *et al.* (2017) pp.568-569
Rokan Hulu (Riau)	2015	120	Rec	45-55	1965	13.10	±1.50	Sepduwiana (2016) p.147
Jakarta (West Java), mothers of students	2009	100	Rec	ca.1962-67	1965	13.61	±1.55	Oktavianto (2009) p.38 (assuming mothers' av. age 23)
Jakarta (West Java), mothers of students	2001	267	Rec	ca.1966	1966	12.60	±1.30	Simamora (2001) p.63 (assuming mothers' av. age 23)
Jakarta (West Java), mothers of students	2002	323	Rec	ca.1967	1967	13.48		Ginarhayu (2002) pp.61 (assuming mothers' av. age 23)
Jakarta (West Java)	2004-06	7,480	Rec	20-70, 38.8	1966	13.70	±1.70	Vet *et al.* (2012) p.775
Bandung (West Java), rural suburbs	2013	171	Rec	47.0	1966	14.25		Calculated from Madjid *et al.* (2015) pp.3-9
South Jakarta (West Java), mothers of students	2001	138	Rec		1966	13.04	±1.56	Yuliana (2001) abstract (assuming mothers' av. age 23)
Tasikmalaya (West Java), urban and rural	2004-06	8,007	Rec	20-70, 38.4	1967	14.10	±1.50	Vet *et al.* (2012) p.775
Bali, urban and rural	2004-06	6,553	Rec	20-70, 37.7	1967	13.90	±1.30	Vet *et al.* (2012) p.775
Jakarta (West Java)	2016	100	Rec	45-55, 49.3	1967	13.46		Calculated from Muharam *et al.* (2017) p.169
Yogyakarta (Central Java)	2010-14	115	Rec	46.5	1966	12.74		Supartoto *et al.* (2016) p.3
Yogyakarta (Central Java)	1980	378		12-15	1967	13.40	±0.23	Aswin *et al.* (1985) in Ginarhayu (2002) p.13
Yogyakarta (Central Java)	1980-81	389	SQ		1968	13.07	±0.95	Aswin *et al.* (1982) in Damayanti (2001) p.25
Sarumsokar, Priangan (West Java), rural	1983	63	SQ	10-19	1968	15.20	±0.36	Estimated from Igarashi (1988) pp.599-600
Kakas (North Sulawesi), rural	2014	55	Rec	45.8	1968	14.31		Senolinggi et al. (2015) p.139-140
Malang (East Java)	< 1983				1969	13.27		Sjamsuar (1983) in Hendrawati and Glinka (2003) p.19
Bekasi (greater Jakarta, West Java), mothers of students	2002	228	Rec	ca.1969	1969	13.15		Aryati (2002) p.49 (assuming mothers' av. age 23)
Bandar Lampung (Lampung), cancer patients	2017	40	Rec	17-65	1969	13.53		Calculated from Simanora *et al.* (2018) pp.9-10
Medan (North Sumatra)	2011-15	70	Rec	42.3	1971	12.32		Sitompul *et al.* (2017) pp.2009-2010
Pariaman (West Sumatra), mothers of students	2007	254	Rec	ca.1970	1972	14.84	±0.94	Lindayati (2007) p.67 (assuming mother's av age 23)
Jakarta (West Java), junior high school	< 1986	300	Rec	13.5, 9-15	1973	12.09	±1.09	Busmar (1986) pp.38-43

Jakarta (West Java), mothers of students	2009	173	Rec	ca.1975	1975	12.73	±1.26	Kartika Putri (2009) abstract (assuming mothers' av. age 23)
Surakarta (Central Java)	2016-17	70	Rec	41.2	1975	12.77		Calcutated from Rahmah (2017) pp.37-39
Jakarta (West Java)	< 1990	1,444	SQ		1976	13.00	±1.10	Samsudin (1990) abstract
Jakarta (West Java), university students	1993-94	274	Rec	18.3, 17-20	1976	12.55	±0.90	Zulmely (1997) pp.35-36
Surabaya (East Java)	1990				1977	12.53	±0.04	Artaria (1991) abstract
Malang (East Java)	1990	1,169		9-15	1977	12.69	±0.04	Artaria (1991) abstract and in Agustin (2011) p.
Malang and Surabaya (East Java)	1990				1977	12.62	±0.04	Artaria (1991) abstract
Surabaya (East Java)	< 1990				1977	12.81		Yoeliana (1990) in Hendrawati and Glinka (2003) p.19
Depok (West Java), mothers of students	2011	113	Rec		1977	13.24	±1.38	Mutia (2011) pp.31-32 (assuming mothers' av age 23)
Bogor (West Java), mothers of students	2012	156	Rec		1978	13.29	±1.04	Siswianti (2012) p.30 (assuming mothers' av. age 23)
Jakarta, West (West Java), mothers of students	2014	121	Rec		1978	12.60	±1.29	Fadhilah (2014) p.39 (assuming mothers' av.age 23)
Jakarta, East (West Java), mothers of students	2013	324	Rec	ca.1978	1978	12.80	±1.14	Harmiyani (2013) p.34 (assuming mothers' av. age 23)
Medan (North Sumatra)	1991	469			1978	12.74		Rousyidi (1991) in Nurdiani *et al.* (1999) p.77, Pulungan (2009) p.15
Pamekasan (Madura, East Java)	< 1993				1979	12.62		Hendrawati (1993) in Hendrawati and Glinka (2003) p.19
Medan (North Sumatra)	2008-09	61	Rec	28.3	1980	12.30	±1.13	Siregar *et al.* (2011) p.76
Palembang (South Sumatra)	1992-95	570	Rec	8-18	1980	13.08		Batubara *et al.* (2010) p.79-80
Makassar (South Sulawesi)	1992-95	587	Rec	8-18	1980	13.09		Batubara *et al.* (2010) p.79-80
Kupang (Nusatenggara)	1992-95	382	Rec	8-18	1980	13.86		Batubara *et al.* (2010) p.79-80
Yogyakarta (Central Java)	1992-95	689	Rec	8-18	1981	12.45		Batubara *et al.* (2010) p.79-80
Balikpapan (East Kalimantan)	1992-95	646	Rec	8-18	1981	12.62		Batubara *et al.* (2010) p.79-80
Jakarta (West Java)	1992-95	539	Rec	8-18	1981	12.89		Batubara *et al.* (2010) p.79-80
Bandung (West Java)	1992-95	733	Rec	8-18	1981	12.74		Batubara *et al.* (2010) p.79-80
Indonesia (total, 7 cities)	1992-95	4,145	Rec	8-18	1981	12.96		Batubara *et al.* (2010) p.79-80
Surabaya (East Java)	< 1994				1981	12.03		Kurniasari (1994) in Hendrawati and Glinka (2003) p.19
Pekanbaru (Riau), mothers of students	2016	110	Rec		1981	12.90	±1.40	Zalni et al. (2017) p.156 (assuming mothers' av.age at birth 23)
Flores (Nusatenggara)	< 1995				1981	13.22		Sukadana (1995) in Hendrawati and Glinka (2003) p.19
Padang (West Sumatra)	< 1995				1981	12.59	±1.07	Masrizal (1995) in Yuda Putra *et al.* (2016) p.555
Depok (West Java), mothers ofstudents	2014	115	Rec		1981	13.21		Aprilia (2014) p.39 (assuming mothers' av.age at birth 23)
Bantul (Yogyakarta), rural, junior high school	1994	26	Rec		1981	13.08	±0.90	Siandhika (1994) p.14 (26 of 54 had experienced menarche)
Surabaya, Madura (East Java), junior high schools	1996-97	2,461	SQ	14.2, 13-15	1982	12.63		Soekarjo (2003) pp.27-29
Tengger (East Java), rural	< 1996				1982	13.27		Putri (1996) in Hendrawati and Glinka (2003) p.19
Yogyakarta, urban, pribumi, junior high school	1994	138	Rec		1982	12.03	±0.69	Siandhika (1994) p.14 and 22 (138 of 168 had experienced menarche)

Yogyakarta, urban, non-pribumi, junior high school	1994	7	Rec		1982	12.07	±0.53	Siandhika (1994) p.21 and 22 (7 of 9 had experienced menarche)
Yogyakarta, junior high schools	< 1995				1982	12.87		Paristiawati (1995) in Sudarman (2017) p.82
Medan (North Sumatra)	2016	59	Rec	33.4	1983	13.19	±1.87	Lubis (2017) pp.1 and 38
Teminabuan (West Papua)	< 1998	975	Rec		1983	13.80		Lautenbach (1998) p.120
Jakarta (West Java) university students	2000-01	401	Rec	16-20	1983	12.25	±1.21	Damayanti (2001) p.42
Jakarta (West Java)	1996	363	Rec	14-18	1984	11.90		Angeles-Agdeppa (1997) p.58
Medan (North Sumatra)	1995	227	SQ	8-15	1984	11.41	±0.95	Nurdiani *et al.* (1999) p.77
Padang (West Sumatra)	< 1996	151		8-15	1984	12.50		Ulfa Syukur (1996) in Agustin (2011) p.20
Sidoarjo (East Java)	2006	100	Rec	21.0, 15-30	1985	12.92		Calculated from Novia and Puspitasari (2008) p.98
Malang (East Java) - LSEG	< 2000	524	SQ	12-19	1985	13.99	±1.33	Artaria and Henneberg (2000) p.565
Malang (East Java) - MSEG	< 2000	315	SQ	12-19	1986	13.06	±1.38	Artaria and Henneberg (2000) p.565
Malang (East Java) - HSEG	< 2000	7	Rec	12-19	1986	12.74	±1.41	Artaria and Henneberg (2000) p.564
Semarang (Central Java), rural	1998	111	Rec	13.5	1985	13.09	±0.90	Harjono (1998) p.33
Semarang (Central Java), urban	1998	131	Rec	13.3	1986	11.95	±0.90	Harjono (1998) p.33
Indonesia, national 2010 Riskesdas survey	2010	13,550	Rec/SQ	10-59	1986	12.39	±1.08	Amaliah *et al.* (2012) p.150
Denpasar (Bali), urban, junior high schools	1998	228	SQ	11-17	1986	12.47	±0.81	Soetjiningsih (1999) p.158
Tambun (Bekasi, West Java)	< 2000				1987	12.10	±0.80	Sayogyo et al. (2000) in Simamora (2001) p.32
Demak (Central Java)	< 2001	70		14.3	1987	12.53		Yulianto (2001) abstract
Jakarta (West Java), primary school	1999	109	Rec	10-12	1987	10.60	±1.47	Muthmainnah (1999) pp.50-52 (100 of 109 had experienced menarche)
Pekalongan (Central Java), rural	< 2001	160		21.0, 15-30	1987	13.10	±1.00	Viyantimala (2001) in Munda *et al.* (2013) p.2
Pekalongan (Central Java), urban	< 2001	161			1988	11.93	±0.85	Viyantimala (2001) in Munda *et al.* (2013) p.2
Bugis (South Sulawesi), rural	2001	200			1988	13.18	±1.03	Burhanuddin (2003) p.56
Bugis (South Sulawesi), urban	2001	200			1988	12.93	±0.92	Burhanuddin (2003) p.56
Bugis (South Sulawesi), total	2001	400			1988	13.05	±0.98	Burhanuddin (2003) p.55
Depok (West Java)	2001	238	SQ	8-14	1988	12.60		Calculated from Abdurrahman (2001) p.55
Bantul (Central Java), junior high school	< 2002	70			1988	12.90		Widada (2002) abstract
Jakarta (West Java), university students	2009	100	Rec	ca.1985-90	1988	12.52	±1.24	Oktavianto (2009) p.36
Jakarta (West Java), primary and junior high school	2001	90	SQ	9-13	1989	11.70	±0.80	Simamora (2001) pp.60-61, 74 (90 of 267 had experienced menarche)
Yogyakarta (Central Java)	< 2002				1989	12.30		Hernawati (2002) in Kawulur *et al.* (2012) p.128
South Jakarta (West Java)	2001	138	SQ	10-15	1989	12.00		Calculated from Yuliana (2001) pp.54-55
Jakarta (West Java), HSEG, primary and junior high schools	2002	75		9-15	1990	11.75	±0.30	Ginarhayu (2002) abstract
Jakarta (West Java), LSEG, primary and junior high schools	2002	105		9-15	1989	12.59	±0.95	Ginarhayu (2002) abstract

Jakarta (West Java), total, primary and junior high schools	2002	180		9-15	1990	12.28	±1.12	Ginarhayu (2002) pp.48-50 (180 of 344 had experienced menarche)
Siak (Riau)	< 2003				1990	12.10		Desmeri (2003) in Maulina (2015) p.10
Depok (West Java), junior high school	2002-03	86	Rec		1991	11.92	±0.25	Harpini (2003) p.53-54 (41 of 86 had experienced menarche)
Pati (Central Java)	< 2004	91			1991	12.20	±0.61	Aribowo (2004) abstract
Hulu Sungai Tengah (South Kalimantan), junior high schools	< 2009	1,093	Rec		1991	12.33		Wibisono (2009) abstract
Jakarta (West Java), primary school	2003	76	Rec	9-12	1992	10.83		Matondang (2003) p.37 (76 of 330 had experienced menarche)
Bekasi (greater Jakarta, West Java), primary school	2002	64	Rec	9-12	1992	10.39	±0.72	Aryati (2002) p.48 (64 of 228 had experienced menarche)
Sleman, Yogyakarta (Central Java), senior high school	2009	55	Rec	17+	1992	12.22		Calculated from Astuti (2009) pp.3-4
Surabaya (East Java)	< 2005				1992	11.90		Wahdi (2005) in Kusuma Dewi *et al.* (2010) p.53
Surabaya (East Java)	< 2005	40	Rec	12-18	1992	12.40		Qomaruddin (2005) p.32
Medan (North Sumatra), primary and junior high schools	2005-06	900	SQ	9-17	1993	12.28		Fachri *et al.* (2007) Table 3
Berastagi (North Sumatra), primary and junior high schools	2005-06	786	SQ	10-17	1993	12.60		Fachri *et al.* (2007) Table 3
Pantai Cermin (North Sumatra), primary and junior high schools	2005-06	511	SQ	10-17	1993	12.54		Fachri *et al.* (2007) Table 3
Jakarta (West Java) hospital patients	2013	106	Rec	15-24	1993	12.00		Padesma (2013) p.9
Depok (West Java), primary and junior high school	2006	89	Rec	9-14	1994	11.60	±0.86	Menur (2006) p.69
Yogyakarta (Central Java), junior and senior high school	2005	109	Rec	11-18	1993	11.69	±0.84	Rahmawati and Hastuti (2005) p.174
Jember (East Java), primary school	< 2007				1994	11.64		Setyowati (2007) p.vii
Padang (West Sumatra), junior high school	< 2008	100			1995	12.49		Ramadanus (2008) in Yulia (2011) p.4
Kapuas Hulu (West Kalimantan)	2007	57			1995	12.30		Dahliansyah (2008) abstract
Pariaman (West Sumatra), primary and junior high schools	2007	158	Rec	9-15	1995	12.10	±0.91	Lindayati (2007) p.58 (158 of 255 had experienced menarche)
Bogor (West Java)	2007	399	Rec	11-17	1995	12.37	±1.00	Suhartini (2007) p.4
Pekalongan (Central Java), rural	2008	497	SQ	8-17	1995	13.31		Ulinnuha (2008) pp.2-3
Surabaya (East Java), congenital genitalia anamolies	2013-16	80	Rec	10-29	1995	14.28	±2.02	Azinar *et al.* (2017) p.158
Bandung (West Java)	2008	160	Rec		1995	12.71		Sukmaningrasa (2009) p.27
Bandung (West Java), primary and junior high school	2007	198	Rec	9-15	1995	11.61	±0.83	Aryati (2008) pp.245 and 247
Bandung (West Java), junior high school	2008	83	Rec	12-15	1995	12.32		Susanti and Sofiyah (2008) pp.46 and 50
Makassar (South Sulawesi) university students	2016	146	Rec		1995	12.40	±1.19	Sumara (2016) abstract
Baduy people (West Java), rural	2010	18	SQ	10-20	1996	14.16		Rohmatullayaly (2010) pp.10-13
Deli Serdang (North Sumatra), junior high school	2008	58	Rec	12.7	1996	11.50		Toanubin (2009) abstract
Bogor (West Java), primary school	2007	120	Rec	;9-11	1996	11.23		Lusiana and Dwiriani (2007) p.28 (60 of 120 had experienced menarche)
Kupang (Nusatenggara)	< 2011				1996	13.86		Saputra (2011) in Fitriyah (2015) p.3

Pesawaran (South Sumatra), rural	2010	208	SQ	7-18	1996	13.61		Maretta (2011) pp.20-21
Yogyakarta, junior high schools	< 2007	82	SQ	12-13	1996	11.22		Sudarman (2017) p.81 (51 of 82 had experienced menarche)
Semarang (Central Java), high school	2012	76	Rec	15-17	1996	12.10	±1.30	Widyaningtyas (2012) pp.5 and 7
Depok (Jakarta, West Java), primary school	< 2007	113			1996	10.68	±0.58	Barus (1997) in Fadhilah (2014) p.11
Surakarta (Central Java), university students	2015	92	Rec		1996	12.58		Calculated from Elvira Aditiara (2018) p.4.
Langkat (North Sumatra)	< 2010	73			1997	12.30	±0.95	Shaliha (2010) in Sipayung (2014) p.21
Surabaya (East Java)	2016	102	Rec	18.8	1997	12.71		Calculated from Handayani *et al.* (2017) p.23
Jakarta (West Java)	2009	57	Rec	15-19	1997	12.20	±0.90	Sianipar *et al.* (2009) p.310
Medan (Sumatra), Vitamin E deficient	2009	58	Rec		1997	12.08	±1.15	Wagito *et al.* (2011) p.43
Medan (Sumatra), control group	2009	58	Rec		1997	11.96	±1.13	Wagito *et al.* (2011) p.43
Denpasar (Bali), excl. non-menarche	2008	15	Rec		1997	11.00		Kusuma Dewi *et al.* (2010) p.51
Medan (North Sumatra) with dysmenorrhea	2010	58	Rec		1997	13.17	±3.46	Alam *et al.* (2011) p.214
Medan (North Sumatra) without dysmenorrhea	2010	58	Rec		1997	13.37	±3.89	Alam *et al.* (2011) p.214
Jakarta (West Java), junior high school, years 7-9	2008-09	371	Rec	9-15	1997	11.77	±0.99	Basalim (2009) p.39
Jakarta (West Java), primary and junior high school	2009	211	Rec	10-13	1997	11.60		Fadhilah (2009 abstract
Semarang (Central Java), junior high schools, suburbs	2009	90	Rec	11-16	1997	12.10	±1.00	Astuti and Handarsari (2010) p.182
Semarang (Central Java), junior high schools, city	2009	90	Rec	11-16	1997	11.60	±0.80	Astuti and Handarsari (2010) p.182
Yogyakarta (Central Java), junior high school, year 7	2010	102	Rec	13.0, 12-15	1997	11.33		Sukriani and Sobri (2010) pp.5-6
Jakarta (West Java), junior high schools, year 7	2010	96	Rec		1998	11.52	±0.75	Ristriyani *et al.* (2010) pp.28-29
Jakarta, Tangerang, Bekasi (West Java), primary & junior high	< 2011	128		9-14	1998	12.18	±0.91	Arifianto (2011) abstract
Malang (East Java)	< 2010	1,091	SQ/probit		1998	12.15	±1.01	Artaria (2010) p.162
Medan (North Sumatra), junior high schools	2009	235	Rec	10-17	1998	11.35		Calculated from Pulungan (2009) pp.40-44
Padang (West Sumatra), junior high school	2010	150	Rec		1998	12.20		Yulia (2011) p.10
Manokwari (West Papua), rural	2010-11	231	SQ	6-19	1998	12.20		Kawulur *et al.* (2012) pp.125-126
Watansoppeng (South Sulawesi), senior high school	2014	102	Rec	15-17	1998	12.76	±1.22	Jayanti (2014) abstract
Jakarta (West Java) vegetarians, junior high schools	2010	164	Rec	11-16	1998	11.97	±1.01	Rachmawati (2010) pp. 54 and 76
Jakarta (West Java), year 7 and 8, junior high school	2009	161	Rec	12-14	1998	11.42	±0.93	Kartika Putri (2009) pp.44-45 (161 of 173 had experienced menarche)
Jakarta (West Java)	2010				1998	12.39		Alchoiriah (2010) in Maretta (2011) p.21
Bekasi (West Java), junior high school	2010	116	Rec	11-15	1998	11.59	±0.29	Agustin (2011) p.62 (116 of 159 had experienced menarche)
Semarang (Central Java), junior high school	2010	72	Rec		1998	11.83		Rahmawati (2010) abstract
Bulukumba (South Sulawesi), rural, junior high school	2013	113	Rec	12-16	1999	13.00	±0.80	Emilia et al. (2013) pp.13-15
Makassar (South Sulawesi), junior high school	2012	209	Rec	11-15	1999	12.00	±0.70	Emilia et al. (2013) pp.13-15

Yogyakarta (low birth weight)	2016	39	Rec		1999	12.80		Febrina (2016) abstract
Yogyakarta (normal birth weight)	2016	35	Rec		1999	12.40		Febrina (2016) abstract
Yogyakarta (total sample)	2016	74	Rec		1999	12.61		Febrina (2016) abstract
Bandung (West Java), university students	2017	38	Rec	18-20	1998	12.16		Fauziah *et al.* (2016-17) p.306
Tegal (Central Java)	2011	116	Rec	11-15	1999	12.24	±0.95	Prabasiwi (2011) p.26; Prabasiwi (2016) pp.107-108
Medan (North Sumatra)	2011	20			1999	11.62	±0.73	Noor (2012) abstract
Jakarta (West Java), high school	2010-11	155	Rec	10-14	1999	11.72	±0.79	Derina (2011) p.34
Medan (North Sumatra)	2012	85	Rec	10-15	2000	11.16		Olivia *et al.* (2012) p.310
Tangerang (West Java), primary school	2011	256	SQ		2000	10.97		Suryansyah (2013) p.349
Klaten (Central Java), junior high school	2012	60		8-14	2000	11.53		Ayuningtyas (2013) abstract
Bogor (West Java), junior high schools, year 8, rural	2013	50	Rec	13-15	2000	13.02		Calculated from Handayani *et al.* (2013) p.183
Sumedang (West Java), primary and junior high school	2013	67	Rec	9-15	2000	12.72		Primandina Putri *et al.* (2015) p.522
Sumbul (North Sumatra), rural, junior high school, years 7, 8	2014	126	Rec		2000	13.67		Sipayung (2014) abstract; Sipayung *et al.* (2014) p.3
Padang (West Sumatra), junior high school	2012-13	72	Rec	10-14	2000	12.29	±0.49	Mutasha (2013) and Mutasha *et al.* (2016) p.234
Depok (West Java), junior high school, years 7, 8	2012	124	Rec		2000	11.78	±0.67	Prasetyarini (2012) p.45
Depok (West Java), junior high schools	2014	119	Rec	12-17, 14.4	2000	12.65	±1.01	Maretta (2014) pp.44-46
Depok (West Java), primary school	2011	26	Rec	9-12	2000	10.55	±0.88	Mutia (2011) pp.30-31 (26 of 113 had experienced menarche)
Jakarta (West Java), junior high schools, year 8	2013	50	Rec	13-15	2001	12.34		Calculated from Handayani *et al.* (2013) p.183
Semarang (Central Java), junior high school	2012	70	Rec	10-13	2001	11.43		Susanti and Sunarto (2012) p.118
Surakarta (Central Java), primary school	2012	179	Rec		2001	10.72		Moelyo and Fitriana (2013) p.94
Tangerang (West Java) urban/rural, primary school	2012	220	Rec		2001	11.46	±0.99	Darmawati *et al.* (2012) p.1
Jakarta, East (West Java), primary and junior high school	2013	87	Rec	10-14	2001	12.21	±1.13	Wulandari and Ungsianik (2013) p.56
Jakarta, East (West Java), primary and junior high school	2013	229	Rec	9-15	2001	11.98	±0.98	Harmiyani (2013) pp.30-31 (229 of 324 had experienced menarche)
Medan (North Sumatra), primary and junior high school	2013	35	Rec	10-14	2001	12.03		Siregar (2013) appendix 7
Bogor (West Java), primary school	2012	49	Rec	10-13	2001	10.82		Siswianti (2012) pp.29-30 (49 of 156 had experienced menarche)
Manado (North Sulawesi), primary school	2012	234	Rec	8-12	2001	10.63	±0.72	Munda et al. (2013) p.4 (30 of 234 had experienced menarche)
Manado (North Sulawesi), junior high school	2012	220	Rec	12-15	2001	11.34	±1.35	Munda *et al.* (2013) p.4 (166 of 220 had experienced menarche)
Tangerang (West Java), junior high school	2013	121	Rec	13.0, 12-15	2001	11.68	±0.71	Wahyuni (2013) pp.26 and 30.
Kebumen (Central Java), junior high school	2013	214	Rec	11-16	2001	11.80		Indriyastuti (2013) p.54 (125 of 214 had experienced menarche)
Purwokerto (Central Java), primary and junior high school	2013	99	SQ	8-14	2001	12.40		Oktaviani (2014) p.3
Bandung (West Java), dentistry patients	<2014	84	Rec	8-17	2001	12.47	±0.73	Mardiati et al. (2014) p.69
Jakarta, East (West Java), junior highschool	2013	100	Rec	12-16	2001	12.16		Rahmadullah (2013) p.33 (87 of 100 had experienced menarfche)

Jakarta, South (West Java), junior high school	2013	107	Rec	13-15	2001	11.79	±0.77	Purnamasari (2013) p.44
Jakarta, West (West Java), Buddhist primary and junior high	2014	121	Rec	11-14	2001	11.89	±1.09	Fadhilah (2014) p.39
Makassar (South Sulawesi), junior high school	2013				2001	11.96	±0.87	Kasmaliana (2014) abstract
Gorontalo (North Sulawesi), junior high school	2013	146	Rec	12-15	2002	11.15	±1.07	Laadjim (2013) p.29
Makassar (South Sulawesi), junior high school	2014	96			2002	11.72	±0.79	Afany (2014) abstract
Sidoarjo (East Java), junior high school	2013	71			2002	11.23	±0.67	Rusdyanti (2013) abstract
Malang (East Java), 11 and 12 year olds only	2014	47	Rec	11-12	2002	11.75	±0.57	Handayani (2014) p.3
Jakarta (West Java), primary and junior high school	2013	90	Rec	9-14	2002	11.29	±1.00	Rosanti (2013) p.7
Bogor (West Java), primary and junior high school	2012	35	Rec	9-12	2002	10.34		Christianti and Khomsan (2016) p.140
Bekasi (West Java), primary and junior high school	2013	105	SQ	9-14	2002	11.24	±0.85	Hardiningsih and Kusharisupeni (2013) online
Tidore (Maluku), junior high school	2015	97	Rec	11-15	2002	13.01		Calculated from Lasandang *et al.* (2016) p.3
Bogor (West Java), junior high school	2014-15	41	Rec	12-15	2002	12.02	±0.81	Sofya (2015) p.10
Padang (West Sumatra), junior high school	2015	234	Rec		2003	12.14		Calculated from Maulina (2015) p.10
Marioriwawo (South Sulawesi), rural, junior high school	2015	54			2003	12.44	±1.29	Mulia (2015) abstract
Surakarta (Central Java), primary school	2014	53	Rec		2003	11.19		Astuti (2014) p.4
Bandung (West Java), primary and junior high school	2014	123	Rec	9-15	2003	11.46		Khotimah *et al.* (2017) p.205
Gresik (East Java), junior high school	2015	91	Rec	10-15	2003	12.13	±0.91	Aisya (2016) p.45; Aisya and Wibowo (2016) p.37
Boyolali (Central Java), primary school	2015	15	Rec		2003	11.75		Noviyanti *et al.* (2016) p.59
Padang (West Sumatra), primary and junior high school	2014-15	77	Rec		2003	11.75	±1.17	Yuda Putra *et al.* (2016) pp.553-554
Takalar (South Sulawesi), rural	2016			13-14	2003	13.14	±0.68	Jumria (2017) abstract
Cirebon (West Java), junior high school	< 2015	65	Rec	11-13	2003	11.10	±0.74	Pangestika *et al.* (2015) p.257
Wuluhan, Jember (East Java), junior high school	2016	38	Rec		2003	13.16		Calculated from Budiana (2016) p.2
Medan (North Sumatra), junior high schools	2015	216	Rec	10-16	2003	11.64	±1.13	Wulandari *et al.* (2017) p.325
Surakarta (Central Java), junior high school	2015	148	Rec	14-17	2003	12.16		Calculated from Gustina (2015) p.5
Yogyakarta (Central Java), junior high schools, urban	2015	175	Rec	13-15	2003	12.01	±0.89	Rahmawati *et al.* (2017) p.354
Bantul (Yogyakarta, Central Java), junior high schools, rural	2015	226	Rec	13-15	2002	12.97	±0.91	Rahmawati *et al.* (2017) p.354
Medan (North Sumatra), junior high school	2016	68	Rec	12-14	2004	11.66		Oktaviani and Novziransyah (2018) pp.26-27
Yogyakarta (Central Java), junior high schools	2016	364	Rec	13-15	2004	12.19	±0.86	Khoris (2016) p.47
Yogyakarta (Central Java), junior high school, year 8	2016	78	Rec	13-14	2004	11.69		Noranita (2016) p.53
Serdang Bedagai (North Sumatra), junior high school	2016	114	Rec	10-13	2004	11.89	±0.08	Fadillah (2016) pp.88-89
Denpasar (Bali), primary school	2015	70	Rec		2004	11.37	±1.51	Edi Putra *et al.* (2016) p.34
Jakarta, East (West Java), junior high school, year 7 and 8	2016	100	Rec	12-14	2004	11.61	±0.85	Imansari (2016) p.39-41

Depok (West Java), primary school, years 4-6	2014	115	Rec	9-13	2004	10.37	±0.37	Aprilia (2014) pp.35-36 (35 of 115 had experienced menarche)
Surakarta (Central Java), junior high school	2016	247			2004	11.60		Widyasmoro (2016) abstract
Makassar (South Sulawesi), junior high schools	2017	90	Rec		2004	12.73		Calculated from Pratiwi (2017) p.45
Pekanbaru (Riau) primary schools	2016	110	Rec	9-14	2004	11.90	±0.80	Zalni et al. (2017) p.155-156
Medan (North Sumatra), junior high school	2017	74	Rec	13.5, 12-15	2005	11.92	±0.99	Calculated from Harahap (2017) appendix J.
Depok (West Java), primary schools	2016	106	Rec	10-13	2005	11.21		Rahmah (2016) pp.65-69
Yogyakarta (Central Java), primary school	2017	81	Rec	9-15	2005	11.73		Ratnaningsih (2017) p.9
Surabaya (East Java), primary school	2016	55	Rec	10.7, 9-11	2005	10.65		Lutfiya (2016) p.138
Gresik (East Java), primary school	2017	49	Rec	9-12	2007	10.26		Makarinah (2017) pp.8 and 40 (49 of 140 had experienced menarche)
Jatinangor (West Java)	2013	4	Rec	<1964	1930	15.75		Calculated from Ganabathy *et al.* (2016) pp.641-642
Jatinangor (West Java)	2013	4	Rec	1964-73	1954	13.75		Calculated from Ganabathy *et al.* (2016) pp.641-642
Jatinangor (West Java)	2013	10	Rec	1974-83	1963	14.40		Calculated from Ganabathy *et al.* (2016) pp.641-642
Jatinangor (West Java)	2013	45	Rec	1984-93	1973	14.11		Calculated from Ganabathy *et al.* (2016) pp.641-642
Jatinangor (West Java)	2013	12	Rec	1994-03	1984	13.42		Calculated from Ganabathy *et al.* (2016) pp.641-642
Jatinangor (West Java)	2013	174	Rec	2004<	1995	12.28		Calculated from Ganabathy *et al.* (2016) pp.641-642

* If (average) birth years were not given, approximated as year of survey less mean or median age at menarche.
Notes: HSEG = Higher Socio-Economic Group; MSEG = Middle Socio-Economic Group; LSEG = Lower Socio-Economic Group; Methods: SQ = status quo and probit or logit; Rec = recollection; All ages in terms of last birthday, e.g. 13.1 is the 14th year of life; generally, mean in the case of the Rec method. In the case of the SQ method, generally with logit.

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Appendix 2: Sources for Figure 2

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Appendix 3: Sources for Figure 3

Table A.2: Mean Age at Menopause by Approximated Birth Year from Occasional Studies in Indonesia, 1921-1975

Age at menarche in Indonesia	Sampling years	Sample size	Approximated average birth year*	Mean or median menarche	Mean menopause	SD/SE	Source (original and used)
Surabaya (East Java)	1968	391	1921	14.70	46.60		Toda *et al.* (1970) abstract
Lombok (Nusatenggara)	1964	52	1923	14.10	43.30	±8.35	Toda and Mori (1967) p.146
Bandung (West Java)	1982	1,025	1935	14.30	48.50		Agoestina and Van Keep (1984) p.332
Jakarta (West Java)	1989	345	1940	13.00	50.50		Samil and Wishnuwardhani (1994) p.193
Makassar (South Sulawesi)	2003	270	1942	14.20	49.68	±4.20	Tumedia and Harun (2010) abstract
Semarang (Central Java)	1998	32	1946	14.31	46.47	±4.24	Tan (1999) p.26
Ciamis (West Java)	2003	40	1948	14.70	47.40		Setiasih (2003) abstract
Jakarta (West Java)	1997-06	56	1949	13.83	52.41		Hasanuddin *et al.* (2010) pp.139-140
Kertasura (West Java), rural	2001	60	1951	14.32	49.70	±0.87	Anggraini (2008) p.207
Bogor (West Java)	2013	420	1952	13.49	44.96		Wulandari (2013) pp.3-4
Soppeng (South Sulawesi)	2013	67	1953	13.28	49.91		Ratna *et al.* (2014) pp.3-5
Surabaya (East Java)	2014	107	1954	13.00	51.00	±4.00	Anggrainy and Indriani (2015) pp.112-113
Bali	< 2013	52	1954	14.08	50.42		Yulianto *et al.* (2013) p.122
Bandung (West Java)	2003-08	66	1954	11.77	51.39	±2.47	Sander (2011) pp.6-7
Makassar (South Sulawesi)	2013	40	1957	14.03	48.36	±4.67	Calculated from Wulandari (2013) appendix 4
Lampung (South Sumatra), rural	2010	97	1958	14.79	49.20		Ifayanti (2012) pp.50-51
Kampung Naga (West Java), rural	< 2009		1958	14.52	50.99		Vidiawati (2009) in Maretta (2011) p.16
Banyumas (Central Java), rural	2012	76	1958	14.18	48.64		Rohmatika *et al.* (2012) pp.94-96
Bandung (West Java)	2008	668	1959	13.98	49.53		Sukmaningrasa (2009) p.27 (graph 3)
Palangka Raya (Central Kalimantan)	2012	100	1960	15.20	43.40	±1.43	Nansia (2012) p.24
Klaten (Central Java)	2014	124	1961	12.58	53.81		Calculated from Wahyuni & Safitri (2017) pp.4, 7-8
Medan (North Sumatra)	2009	125	1961	13.54	45.20	±3.99	Safitri (2009) pp.49-50 and 105
Lampung (South Sumatra), rural	2010	114	1961	14.55	48.59		Maretta (2011) pp.14-16
Baduy people (West Java), rural	2010	34	1961	14.97	48.64		Rohmatullayaly (2010) pp.10-13
Cirebon (West Java)	2010	359	1961	14.51	48.53		Wati'ah (2011) p.22
Sleman, Yogyakarta (Central Java)	2013-14	88	1962	13.45	49.50	±3.60	Trisetiyaningsih et al. (2016) p.194
Medan (North Sumatra)	2011-15	70	1963	12.32	50.40		Sitompul *et al.* (2017) pp.2009-2010
Kuranji, Padang (West Sumatra)	2014-15	40	1964	12.75	50.03	±1.85	Resti (2015) abstract
Bukittingi (West Sumatra)	2014	37	1964	13.89	50.27	±4.90	Calculated from Aulia (2014) appendix 5
Pekalongan (Central Java)	2015	98	1964	13.93	50.65		Calculated from Ta'adi *et al.* (2016) p.102
Minahasa (Central Sulawesi)	2014	225	1964	13.67	46.92		Kalengkongan *et al.* (2015) pp.59-60
Langsa Barat (Aceh)	2013	112	1965	12.94	47.63	±3.41	Calculated from Sulistiany (2013) appendix 2
Rokan Hulu (Riau)	2015	120	1965	13.10	47.60	±2.80	Sepduwiana (2016) p.147
Bandung (West Java), rural suburbs	2013	171	1966	14.25	48.00		Calculated from Madjid *et al.* (2015) pp.3-9
Jakarta (West Java)	2,016	100	1967	13.46	48.85		Calculated from Muharam *et al.* (2017) p.169
Surakarta (Central Java)	2016-17	70	1975	12.77	41.21		Calcutated from Rahmah (2017) pp.37-39

* If (average) birth years were not given, approximated as year of survey less mean or median age at menopause.

References to Table A.2

See references to Table A.1