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Timing and determinants of age at menarche in low-income and middle-income countries

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ABSTRACT

Introduction Understanding the timing and determinants of age at menarche is key to determining potential linkages between onset of puberty and health outcomes from a life-course perspective. Yet, we have little information in low-income and middle-income countries (LMICs) mainly due to lack of data. The aim of this study was to analyse trends in the timing and the determinants of menarche in LMICs.

Methods Using 16 World Fertility Survey and 28 Demographic and Health Surveys (DHS) from 27 countries, we analysed cohort trends and used fixed-effects models for DHS surveys to investigate sociodemographic and regional effects in the timing of age at menarche.

Results Trends of the mean age at menarche across time within and between countries show a declining or stalling path. Results of the determinant modelling show the relationship with wealth changes over time although not consistently across countries. We see a shift from poorer women having earlier menarche in earlier surveys to richer women having earlier menarche in later surveys in Indonesia, the Philippines and Yemen, while in Egypt, the reverse pattern is evident.

Conclusions There is a considerable gap in both literature and data on menarche. We see a trend which is declining rapidly (from 14.66 to 12.86 years for the 1932 and 2002 cohorts, respectively), possibly at a faster pace than high-income countries and with a strong link to socioeconomic status. This study calls for menarche questions to be included in more nationally representative surveys and greater use of existing data because of its impact on life-course health in fast-ageing settings. Further studies will need to investigate further the use of the age at menarche as an indicator of global health.

Key questions

What is already known?

- We have scarce information on menarche, a key vital topic in understanding adolescent health and also health later on in life.
- Key literature focuses mainly on high-income countries.
- We need to establish trends and patterns in low-income and middle-income countries (LMICs) to understand causes and possible implications.

What are the new findings?

- No other study has looked at trends in timings of menarche in so many LMICs using the valuable and underused Demographic and Health Surveys data.
- This paper demonstrates a gradual decline in the timing of menarche in LMICs and reflects on the implications for fast-ageing settings.
- It shows a changing link to socioeconomic status with further repercussions on the future health status of women.

What do the new findings imply?

- This study highlights that the real issue is data availability over quality, with many countries either not including or discontinuing collecting the information.
- There is a need to do more research on menarche and to make menarche a common variable in future health surveys.

INTRODUCTION

Menarche (first menstrual bleeding) serves as a critical marker of puberty, and the associated physiological, behavioural and social changes which collectively symbolise sexual maturation, adulthood and fertility. From the adoption of adult behaviours and the beginning of sexual life to the shame and stigma which could lead to dropping out of school, the process and timing of puberty can have dramatic consequences in girls' lives.[1–4] Timing and determinants of the age at menarche are key to understanding the potential linkages with health outcomes later on in life and also important because of the repercussions on sexual initiation and age at marriage and consequently fertility. Age at menarche is such a fundamental determinant of women's physiological development that it has been suggested in the literature that it should be used as a key global health indicator.[5]

Research in high-income countries (HICs) shows that early menarche (before the age of 12 or 13) has been linked to an increased risk of a number of adverse reproductive health outcomes, including breast cancer,[6] endometrial cancer[7] and spontaneous abortion[8]

among others. Early puberty has also been associated with mental health problems in middle adolescence, with the longer-term impact unknown.[9] Eating disorders and lack of self-esteem are often associated with an early age at menarche. On the other end of the spectrum, late menarche has consequences for osteoporosis, anxiety and depression later in life.[6 10 11] All of these factors have implications for health at older ages. However, to date, the evidence of physical health impacts derives almost exclusively from HICs. With the exception of breast cancer, it is unclear whether or not these patterns hold true elsewhere. The psychological issues are even less studied with the stigma and distress linked to periods and their onset being poorly understood.[1] Finally, in settings with high fertility, low contraceptive use and early age at first sexual intercourse, earlier menarche could potentially have implications for early childbearing. For example, a recent study in the Philippines has shown that age at menarche played an important role in anticipating sexual debut.[12]

The downward trend in age at menarche in HICs is well established and has been attributed mostly to better nutrition and changes in body mass index, as well as improvements in public health, increased wealth, fattier diets and also genetics to a lesser extent.[13 14] While the trends and mechanisms are pretty much stable in HICs, our understanding of the declines and determinants of menarche in low-income and middle-income countries (LMICs) is comparatively poor, mainly due to a lack of data.

Evidence in some European countries and the USA suggests a downward trend from >16 years in the mid-1800s to <13 years by the 1980s.[15] This trend has been observed irrespective of socioeconomic status, race or ethnicity.[8 14 16 17] So far, in LMICs, there are signs that the age at menarche is following these historical data,[18] but fast improvements in nutrition and public health could lead to a decline at a greater speed with possible health implications. We also lack evidence on the differential trends within countries as different socioeconomic groups could move at different paces. A study describing the mean age at menarche (MAM) using World Fertility Survey (WFS) data from 1950 to 1980 in sub-Saharan African countries showed that age at menarche was undergoing a transition similar to that of European countries in the 19th century and was generally linked to an improvement in nutrition and health of young women.[18] It is not clear though whether this is a generalisable result and whether it replicates some of the results found in HICs. Another study by Šaffa *et al* collated the age at menarche for 82 countries to understand its relationship with fertility and mortality levels. However, a closer look at the data showed the vast gap in evidence in LMICs and the reliance on small-area studies as well as very old information.[4] Overall, despite the analyses offered by recent studies in LMICs, the evidence comes mainly from ad hoc, small-scale samples, and the majority of studies focus on nutritional and biological determinants of menarche, neglecting a social science perspective. There is a dearth in the literature on comparable nationwide studies across time in LMICs.

From a deterministic point of view, several studies point to a trend in increased socioeconomic status, predicting declining age at menarche.[19–22] Adair showed evidence from the Philippines which suggests that earlier menarche could be characteristic of girls who live in urban, higher socioeconomic status households, as indicated by higher maternal education, better housing quality and household asset ownership.[19] Separate studies in Colombia, Mexico, Egypt, India, Peru and Vietnam confirmed that urban girls had younger ages at menarche.[20–23] In addition, in Colombia, maternal education and family wealth negatively predicted menarcheal age.[20] The same applies to a study in Turkey where the number of siblings is also positively associated with age at menarche,[24] possibly due to competing needs within the household food resources. Yet, none of these studies have looked systematically across time and across countries to see if there is a consistent pattern, and important social factors are often relegated to mere control variables. From a macroperspective, a recent study on sub-Saharan countries using Demographic and Health Surveys (DHS) data showed that food intake and living in urban areas are linked to lower age at menarche.[18 25]

The aim of this study was to investigate the timing and individual-level socioeconomic determinants affecting age at menarche in LMICs. This study's ultimate objectives are to map the extent of the evidence and gaps in knowledge with data and literature to investigate patterns of menarche timing across time and countries. In addition, this study's objective was to give a greater focus to socioeconomic backgrounds—wealth, education, residence—and broader socioeconomic and ecological drivers, not just individual-level diet and genetics as in most of the literature. Given the increasing attention on adolescent health and the life-course approach to health later in life, there is a need to gather more evidence from LMICs for future researchers to explore.

Evidence so far: systematic mapping of the evidence

We mapped the literature that has looked at the timing of menarche in LMICs since 1990. We first searched in August 2018 and again in April/May 2020. The aim of this exercise was to highlight the gaps in the data and research in the field.

We used Popline (seven hits), Medline Ovid (45 hits), Embase (60 hits), Scopus (298 hits), LILACS (196 hits), CINAHL Plus (13 hits), ADOLEC (121 hits), WHO Reproductive Health Library (10 hits) and Google Scholar (1137 hits). Search strategies were database-specific but included the following key terms and their synonyms: "Menarche" AND "Low income population" OR "Middle income population" OR Demographic and Health Surveys" (specific search terms are included in the search strategy presented in the online appendix). We included all eligible items published from 1990 to

2020. We searched in English, French, Spanish and Portuguese. We also reviewed 14 systematic review papers that came up in our search for potentially relevant references that were not already included on our list, with 11 of these yielding a further 65 new studies. The results of the mapping reported in online supplemental appendix figure A1 show that from an initial selection of 1952 studies, only 577 included information on LMICs, and of these, only 10 had used DHS data despite the wealth of information available in these surveys.

Overall, this mapping excercise reveals a picture of scarce information on a key vital topic in understanding adolescent health and also health later on in life. The review showed that menarche was most often explored in cross-sectional studies (n=404) (see online supplemental figure A2). Most studies reported menarcheal timing in their sample(s) (most often as a mean, and sometimes as a median or the percentage who had experienced menarche in different age groups), but the vast majority of all studies were analytical in their approach, rather than just descriptive; that is, they explored determinants and/or impacts of menarche rather than just estimating the age at menarche in a sample. In addition to the quantitative study types shown in online supplemental figure A2, there were also 14 qualitative studies that looked at menarche in LMICs. Overall, most studies focused on nutrition and anthropometrics, socioeconomic status, family structure and secular trends as determinants. Nutrition and anthropometrics were also commonly studied impacts, as were health and fertility outcomes. Given the broad scope of the mapping exercise and the wide time interval analysed, the review highlighted a rather limited range of research in the field.

Data availability and data quality

We mapped the data in LMICs that contain age at menarche using academic papers, websites such as the DHS, Integrated Public Use Microdata Series (https://ipums.org/) and other major collections of datasets, as well as personal communications with academics and practitioners in the field of health. We wanted to establish both the availability and a general sense of data quality.

The mapping of the data showed vast gaps. The majority of large household surveys that cover demographic, health, fertility and reproduction topics have not asked about age at menarche, for example, Multiple Indicators Cluster Survey, Performance Monitoring and Accountability 2020 (plans have informally been communicated to include this question in future data) and Survey on Ageing are among a long list neglecting to include this information. Looking at longitudinal data, we found that the information is even scarcer with studies from demographic surveillance sites also not including age at menarche.

For the DHS, of the more than 300 surveys carried out in over 90 countries since 1984, only 29 surveys in 16 countries have asked about age at menarche. The WFS fare only slightly better, with only 16 of the 43 surveys conducted having included the question. Furthermore, many of the countries who included it in the DHS only did so once in older surveys (1980s and 90s; for example, Botswana, Ghana, Kyrgyz Republic). Only two countries, the Philippines and Indonesia, have repeatedly included this question up until the last round with Egypt stopping after three rounds (1998). After a long break (22 years) India included the question in their latest National Family Health Survey (NFHS) (2015–16).

The quality of national household survey data has been questioned in the past as it relies on recall and most samples do not survey below age 15 which leads to the inability to collect data in real time.[1] Data quality has usually been measured in HICs leaving doubts on the accuracy of a measure which could be hampered by longer time to recall[26] and by different cultural understandings in LMIC contexts. Studies in LMICs suggest that asking adolescents close to the event may reduce the probability of memory bias as recall of menstruation could be biassed if it has occurred more than 3 years prior.[27] However, previous studies in both HICs and LMICs have showed moderate-to-high correlation (r=0.66–0.83) when comparing self-reported age earlier and later on in life.[28]

One study based in Uganda triangulated the information obtained from the DHS and concluded that the DHS were very close to other studies on settings similar to the one being studied. The author went as far as saying that the quality of these data in LMICs might even be better than in HICs as the event is often of great cultural significance and therefore more likely to be remembered.[29]

The way in which menarche information is collected may also affect estimates. The readiness to report age at menarche may be culturally-dependent, with some girls being reluctant to discuss this information in a face-to-face interview. The words “menstruation” and “menarche” may not be familiar and their meaning not known for some girls and as such it is recommended that questions aiming to measure age at menarche are worded in such a way so as to ensure participants understand.[27] The DHS, however, does this with its simple survey wording - “How old were you when you had your first menstrual period?” - although there is some variation across surveys.

METHODS

Following the mapping of the available menarche data, we identified 16 WFS and 29 DHS datasets from 27 countries (DHS: Botswana, Cameroon, Colombia, Egypt, Gabon, Ghana, India, Indonesia, Kyrgyz Republic, Morocco, Philippines, Senegal, Turkey, Uganda, Uzbekistan and Yemen; WFS: Bénin, Cameroon, Colombia, Cote d’Ivoire, Ghana, Haiti, Kenya, Lesotho, Mauritania, Nigeria, Philippines, Rwanda, Sudan, Syria, Tunisia and Yemen), spanning from 1976 to 2017, which included the question on age at first period. This included a total of 1 222 338 women between the ages of 15 and 49 years (The Indonesia surveys were special surveys that

collected data for women aged 15–24; Colombia 2015 and India 2015–2016 collected data for women aged 13–49 years. WFS age ranges were more variable: Cameroon 1978 collected data for women aged 15–54 years; Cote d'Ivoire 1980–1981, Kenya 1977–1978 and Rwanda 1983 from women aged 15–50 years; Mauritiania 1981 from women aged 12–50 years; Sudan 1978–1979 and Yemen Arab Republic 1979 from women under 51 years; and Syria 1978 from women under 50 years). All women within these age ranges were eligible for inclusion for most of the surveys (DHS n=21, WFS n=9), but six DHS and seven WFS surveys included only ever-married women (DHS: Egypt 1988, 1992 and 1995; India 1992–1993; Indonesia 2002–2003 (special); Yemen 1991–1992; WFS: Lesotho 1977, Mauritiana 1981, Philippines 1978, Sudan 1978–1979, Syria 1978, Tunisia 1978, Yemen Arab Republic 1979), and two included only never-married women (Indonesia 2007 (special) and 2012 (special)). To account for a greater number of cohorts, we included all women in reproductive ages. This could have potentially included women who had not had their period yet. However, an analysis of the cut-off point at the age of 20 years showed that there was no significant difference as most women would have had their period by the age 16 years.

Our data analysis followed three steps. First, we looked at time trends within and between countries. Second, we reconstructed the cohort trends with a pseudo-panel approach,[30] in particular, to make up for the lack of trend data for countries where only one survey year is available. This approach considers age groups as cohorts within a cross-sectional dataset rather than looking at individuals over time. It allows us to look at stable groups over time, giving us a greater indication of the trends. We also included fitted values calculated as a regression line (on a log scale) of the menarche values, which includes the 95% CIs as well.

Third, to understand the determinants of menarche, we conducted cross-sectional multivariate statistical analysis for the DHS data only to allow for comparative sampling and variables. We used logistic models with fixed-effects accounting for survey design and weights to explore the socioeconomic determinants (wealth, education and place of residence) of early menarche (with effect sizes relating to the risk of early menarche at age 13 or less). To test the behaviour of the variable, we also ran linear regression models with menarche as a continuous outcome. It did not substantively change the conclusions, but we deemed it unsuitable as the residuals not being normally distributed pointed to not treating menarche as continuous. We approached the quantitative modelling parsimoniously and looked at the key variables only. We chose the cut-off point of age 13 years, looking at the distributions of mean age at menarche (MAM) in the data across countries (table 1) and also the evidence in the literature, which usually points at a global average of 13 years.[4] The analysis included all women aged aged 15–49 years.

Table 1 MAM and SD by country and year of survey

Country	Year	Cohorts	MAM	SD
Botswana	1988	1943–1973	15.67	1.62
Bénin	1981	1936–1966	14.70	1.60
Cameroon	1991	1946–1976	13.93	1.63
Cameroon	1978	1933–1963	14.23	1.47
Colombia	2015	1970–2000	12.81	1.58
Colombia	1976	1931–1961	13.53	1.44
Cote d'Ivoire	1980	1935–1965	14.12	1.39
Egypt	1988	1943–1973	13.13	1.39
Egypt	1992	1947–1977	13.17	1.38
Egypt	1995	1950–1980	12.97	1.44
Gabon	2000	1955–1985	13.78	1.56
Ghana	1998	1953–1983	15.00	1.63
Ghana	1979	1934–1979	14.94	1.19
Haiti	1977	1934–1964	14.72	1.67
India	1992	1947–1977	13.70	1.35
India	2015	1970–2000	13.48	1.20
Indonesia	2002	1957–1987	13.48	1.33
Indonesia	2007	1963–1993	13.40	1.33
Indonesia	2012	1967–1997	13.24	1.34
Indonesia	2017	1972–2002	13.08	1.32
Kenya	1977	1934–1964	14.36	1.64
Kyrgyz Republic	1997	1954–1984	14.52	1.45
Lesotho	1977	1934–1964	14.58	1.41
Mauritania	1981	1936–1966	13.68	1.68
Morocco	2003	1958–1988	13.72	1.65
Nigeria	1981	1936–1966	14.07	1.70
Philippines	1993	1948–1978	13.63	1.68
Philippines	1998	1953–1983	13.66	1.71
Philippines	2003	1958–1988	13.29	1.66
Philippines	2008	1963–1993	13.21	1.58
Philippines	2013	1968–1998	13.13	1.69
Philippines	2017	1972–2002	13.11	1.86
Philippines	1978	1933–1963	13.89	1.70
Rwanda	1983	1938–1968	15.28	1.60
Senegal	1986	1941–1971	14.52	1.43
Sudan (North)	1978	1933–1963	13.16	1.43
Syria	1978	1933–1963	13.41	1.26
Tunisia	1978	1933–1963	13.60	1.60
Turkey	2013	1968–1998	13.20	1.36
Uganda	2000	1955–1985	14.41	1.52
Uzbekistan	1996	1951–1981	14.12	1.29
Yemen	1979	1934–1964	14.44	1.53
Yemen	1991	1946–1976	13.98	1.44
Yemen	2013	1968–1998	13.80	1.36

MAM, mean age at menarche.

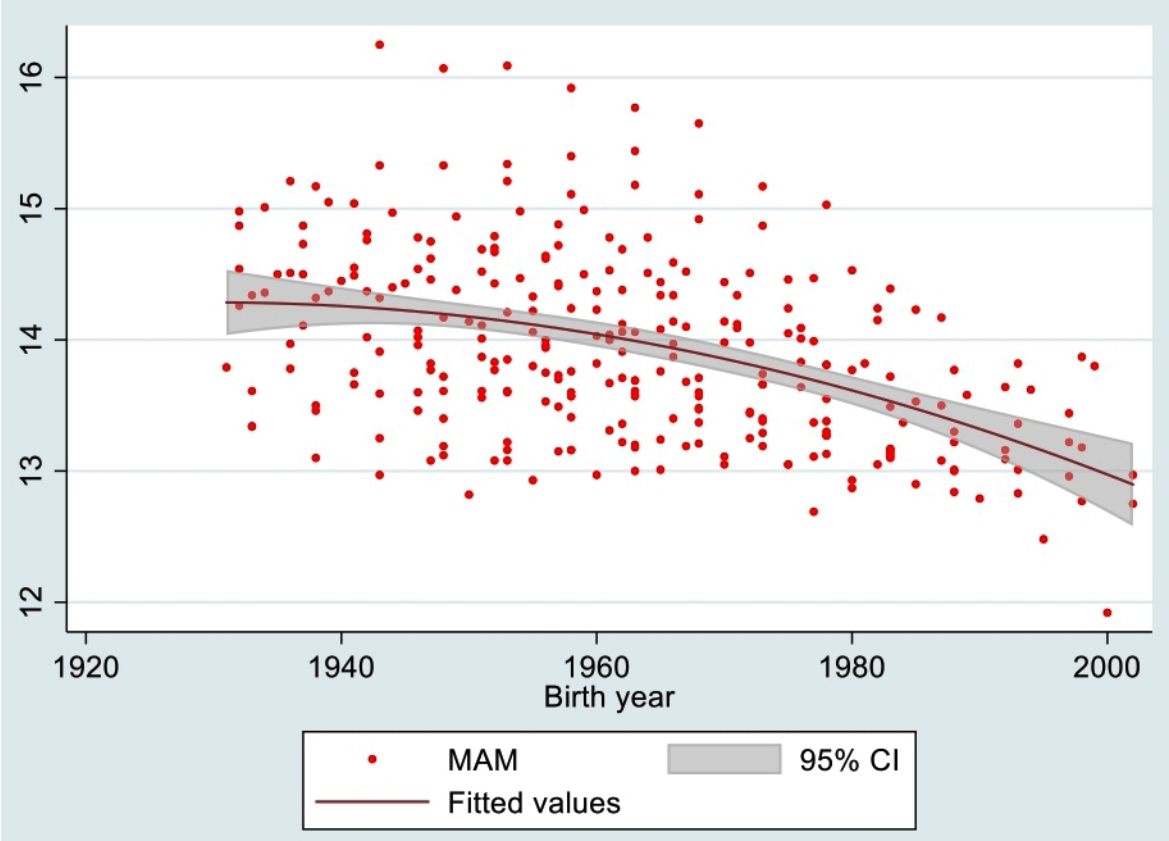

Figure 1 Trends in MAM WFS and DHS datasets, 1976–2017. Birth cohorts 1932–2002. DHS, Demographic and Health Surveys; MAM, mean age at menarche; WFS, World Fertility Survey.

We included residence, education and wealth calculated as quintiles derived from an urban/rural specific principle component analysis of the asset variables (eg, toilet facilities, water, electricity and wall material). Wealth and urban/rural residence are considered good proxies that capture socio-economic variation in nutrition, while education can be thought of as both cause and consequence of menarche.[2] Ideally, we would have liked to use parental education as respondents' final educational achievement would have most likely occurred after menarche. However, educational achievement could also be influenced by age at menarche in LMIC settings. As mentioned in the introduction, early menarche is linked to early sexual initiation, but it is also linked to stigma due to the challenge of menstrual hygiene management and can be a reason for school dropouts.[2] At the same time, we would have liked to control for place of residence at birth. However, most of the datasets considered do not include this variable.

No patients were involved in this study.

RESULTS

The distribution of the MAM shows a significant decrease over time (figure 1 and table 1) both in absolute terms but also in the variance highlighting a convergence of the MAM across countries. The average goes from 14.66 years for the 1932 cohorts (CI 95%: 14.34–14.98) to 12.86 years (CI 95%:12.64–13.07) for the 2002 cohorts. Between countries the gap is greater from 16.25 years for the 1943 cohort in Botswana to 11.92 years (CI 95%: 15.96–16.53) for the 2000 cohort in Colombia (CI 95%: 11.88–11.96). The decline is in line with what we were expecting given improved nutritional and health standards. This is possibly at a faster pace than that recorded in HICs.[15] However, within countries (figure 2) the speed of decline is somehow less dramatic even though we would have probably expected a faster decline than in HICs. Overall, aside from India and Morocco, all countries show a downward trend across cohort years.

The distributions of ages at menarche across countries looked feasible with little heaping and generally very little under-reporting (figure 3). We recoded data which were infeasible (eg, menarche lower than eight or greater than 25 years) into missing cases. This amounted to a handful of cases for each country where present at all. Figure 3 shows an overall bell shape of the distributions with a median and mode generally around 15 for Sub-Saharan African countries and with a median around 13 for most of the other countries in particular in Asia and Latin America. For the Philipines, there is a gradual shift of the distribution towards younger ages as time goes by.

In the analysis of the determinants of menarche (figure 4), we see a shift from poorer women having earlier menarche in earlier surveys to richer women

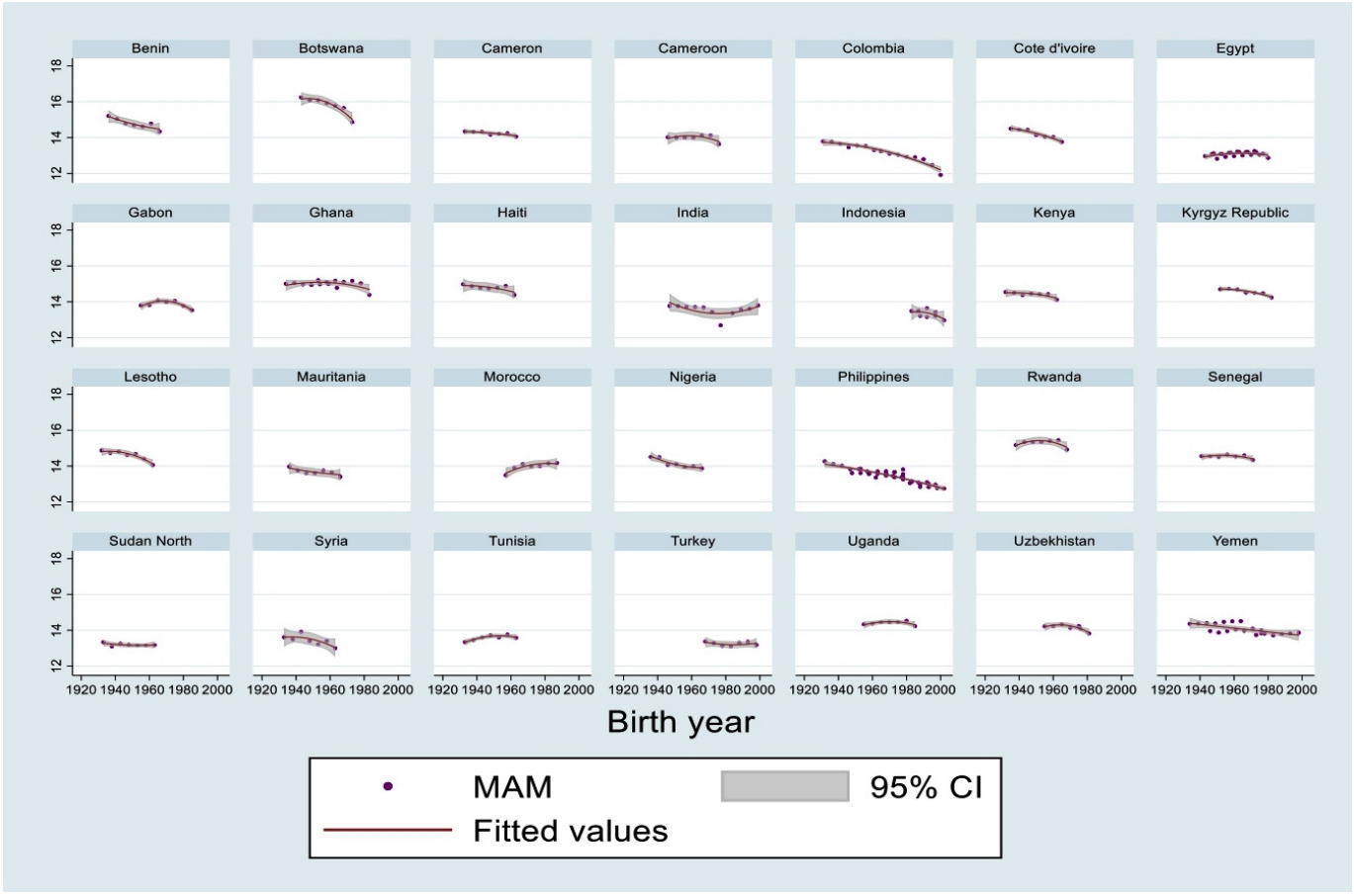

Figure 2 Fitted MAM and 95% CIs by birth cohort, WFS and DHS data 1976–2017. MAM, mean age at menarche.

having earlier menarche in later surveys in Indonesia, the Philippines and Yemen, while in Egypt the reverse pattern is evident; in India, the poorest women had the greatest chances of earlier menarche in both the 1992–1993 and 2015–2016 surveys (figure 4). Previous studies in Egypt showed a lack of correlation between wealth and age at menarche but an earlier menarche for overweight girls, which could be associated with less-advantaged socioeconomic backgrounds.[21] The same could be true for India. A more in-depth analysis of the reasons behind these deviations, including information on weight and height, would be required. Controlling for wealth and residence, education was not significantly associated with early menarche in seven surveys (Botswana 1998, Cameroon 1991, Indonesia 2007, Kyrgyz Republic 1997, Senegal 1986, Uzbekistan 1996 and Yemen 1991–1992). In 13 surveys, women with higher levels of education were less likely to report early menarche (Egypt 1988, 1992 and 1995; Ghana 1998; India 1992–1993; Indonesia 2002–2003, 2012 and 2017; Morocco 2003–2004; Philippines 1993 and 1998; Uganda 2000–2001; Yemen 2013). However, in seven surveys, women with higher levels of education were *more* likely to report early menarche (Colombia 2015; Gabon 2000; India 2015-16; Philippines 2003, 2008, 2013 and 2017).

Although the directions of association between education and menarche varies between and within countries, most surveys show a dose–response pattern whereby the risk of early menarche increases/decreases across education categories. However, for Turkey, in 2013, both women with no education and those with secondary and higher education were significantly less likely to report early menarche than those with primary education. In 2017, Indonesia showed a similar pattern with both women with primary education and those with academy or university education being significantly less likely to report early menarche than those for whom senior high school was their highest education level. This is possibly caused by school dropouts due to early menarche, resulting in a lack of connection between the education and wealth results.

Across variables, we would expect public health, nutrition and physical development to follow similar patterns across the same groups, for example, better nutrition in urban areas and among wealthier groups. One could expect the relationship between nutrition and menarche to change over time, such as that which has happened in HICs (the shift from earlier menarche in richer, better nourished women to earlier menarche in poorer women).[31] This is possibly what the results for Yemen, Indonesia and the Philippines show (figure 4), where the relationship between wealth and menarche reverses from 2003, possibly reflecting a change in nutrition habits and more sedentary lifestyles among wealthier groups.

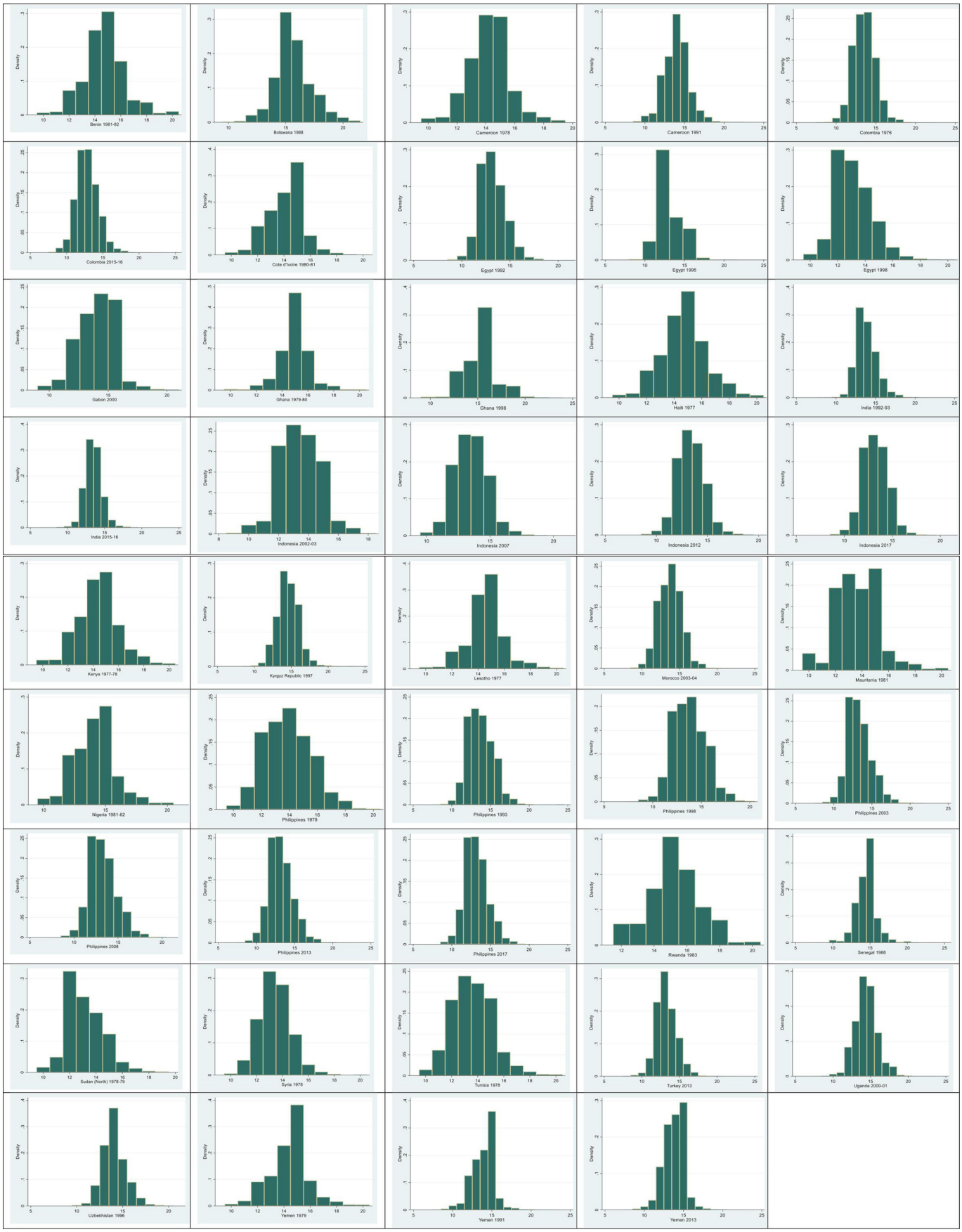

Figure 3 Histogram distribution mean age at menache by country, 1976–2017

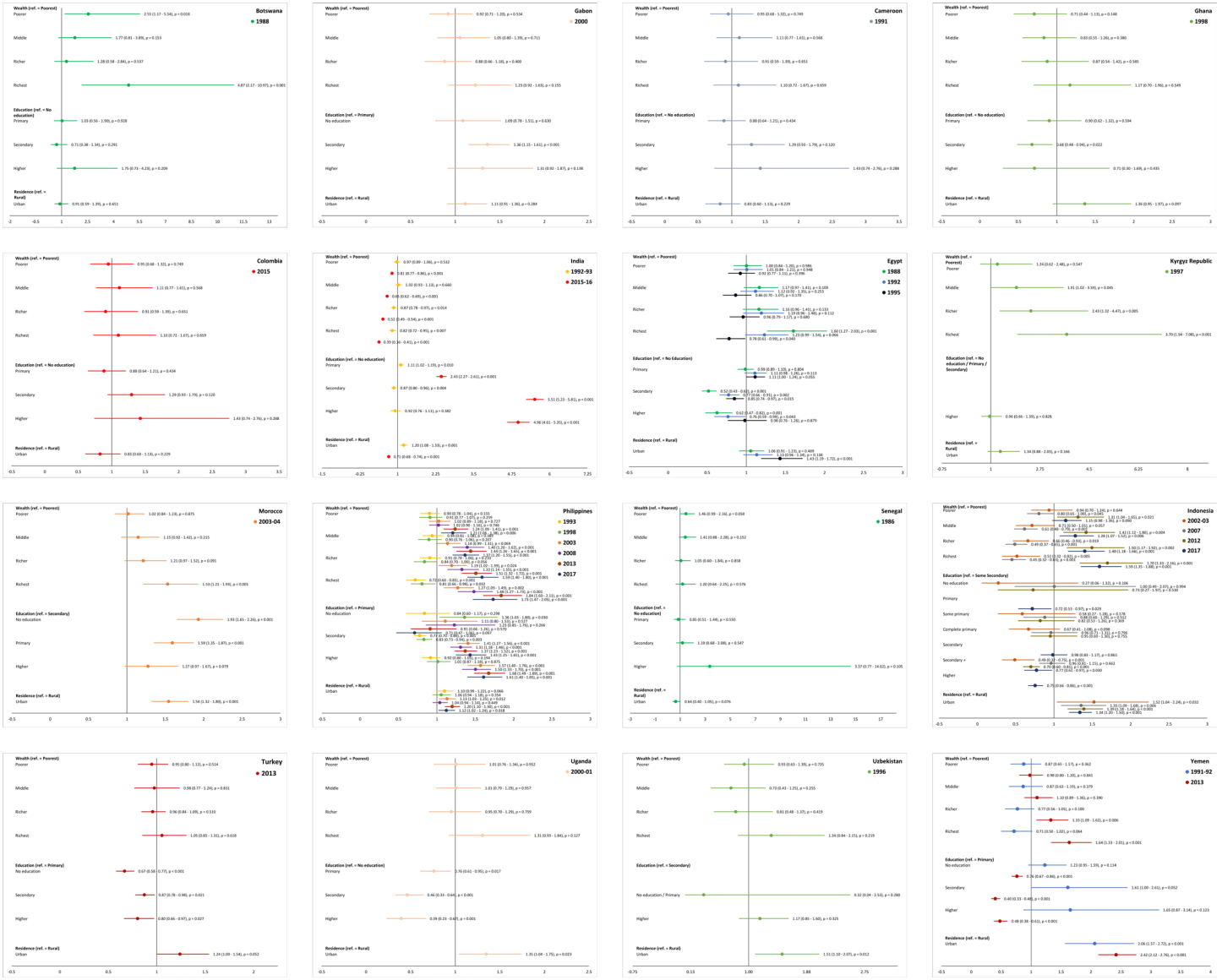

Figure 4 Logistic regression likelihood of having menarche before age 13, DHS data for countries with surveys asking about menarche (arranged alphabetically). Kyrgyz Republic: collapsed no education/primary/secondary due to small numbers in lowest two categories that gave spurious estimates (very small but significant effect sizes). Uzbekistan: collapsed no education/primary due to small numbers that gave spurious estimates (very small but significant effect sizes). Two 2017 Indonesia surveys available, standard and special, special used for these estimates (Nb: education categories slightly different in this survey: primary, junior high school, senior high school, academy/di/dii/diii, div/university). DHS, Demographic and Health Surveys.

DISCUSSION

This is the first study to systematically map cohort trends across all the WFS and DHS in LMICs. The results of this paper show a general decline in the age at menarche across time and across countries with a few exceptions (eg, India and Morocco). In addition, they show a significant decline in the age at menarche within a rather short time period with the speed of decline across countries varying, with some showing stalling (eg, Egypt and Tunisia) and others presenting a dramatic decline (eg, Botswana). This is a fundamental result which highlights the disparities across regions and the need to investigate further the differences across cohorts, which could be due to data quality issues, but more importantly to different transitions in nutrition and health. Above all, data availability has come out as a key issue over the quality of the information, in the extent to which countries have continued to ask the question.

The modelling results show a clear change in the relationship between wealth and age at menarche in the Philippines, Indonesia and Yemen, where it is possible to analyse patterns across time. Assuming that these socioeconomic indicators proxy nutritional status, these findings suggest that socioeconomic disparities in nutrition vary across different stages of socioeconomic development. These results need to be further investigated in light of possible increases in obesity and changes in nutrition.[31]

The Philippines, with the longest time series among the countries analysed, shows a shift from the poorest being most at risk of early menarche (in 1993 and 1998) to the wealthiest being most at risk (2003, 2008, 2013 and 2017). This is in contrast to India, which shows a reversal of the trend, but in general, more countries show a positive relationship between wealth and likelihood of early menarche. Future studies will need to look more in detail at how menarche can therefore be taken as a proxy for socioeconomic development.[5]

Beyond the results obtained in the statistical analysis, this study has highlighted the dearth of information around timing of menarche in LMICs. The lack of studies around the DHS signifies the lack of interest or lack of knowledge that such data exist. Our informal discussions showed an overall surprise, firstly, that menarche has not been included more systematically and, second, that where it has been included, there is low interest in analysing it. We can only speculate that this might be derived from a lack of trust in the data and also a lack of forward thinking when approaching health in a life-course perspective.

Overall, the data mapping exercise showed an absence of forward planning when designing longitudinal surveys. The issues around ageing processes in LMICs are still poorly understood, and we should rely on a wider range of reproductive health experiences when setting out the health issues that might develop in the future. Given the importance of studying the life-course consequences of age at menarche, longitudinal studies would benefit from including menarche as a survey question. In addition, as we put much more emphasis on menstrual hygiene and school dropouts and the interaction with adolescent mental health, we need to better understand how early interventions need to start and which groups need to be targeted in particular.[1 5] We would urge any future longitudinal data collection to consider its inclusion.

Our study also reinforces that there is lack of data for the youngest age groups (10–14 years), which is key in obtaining high-quality information on puberty as shown in previous research.[1] We have, however, managed to overcome this, at least partially, by looking at cohort information which differentiates the trends by age groups.

This paper calls for a deeper understanding into the reasoning behind the decline in inclusion of menarche questions. We need to better recognise the reasons behind the inclusion/exclusion of this question in nationally representative surveys. We also need to investigate further the high level of under-reporting in response to the MAM questions in many longitudinal studies. If a question about menarche is to be included in future surveys, we need to make more and better use of those data once they are available. Menarche is just one marker of a complex process which occurs over several years, and it occurs quite late on in the puberty process; we really need a lot more data on the whole process of puberty in LMICs. Researchers should also be encouraged to make greater use of the currently available (and forthcoming) DHS data to ensure that menarche continues to be included in future survey rounds. Despite their cross-sectional nature, the DHS surveys allow a pseudo-longitudinal/cohort approach which could identify key life-course linkages.

Finally, a key contribution of this paper is having brought together a wealth of datasets which need to be further exploited in the future. This review of the existing data should encourage new researchers to further analyse menarche within wider health analysis and data producers to expand the number of datasets that include this variable. Possible analyses on menarche could include linkages between age at menarche, sexual intercourse onset and mean age at marriage. Furthermore, from a life-course perspective, the increasing inclusion of anthropometric measures in the DHS and other nationally representative surveys will facilitate analysis of a wide range of issues when looking at the determinants of health later in life.

No other study has looked at trends in timings of menarche in so many LMICs using underused data. This paper demonstrates a gradual decline in the timing of menarche in LMICs and reflects on the implications for fast-ageing settings. It shows a changing link to socioeconomic status with further repercussions on the future health status of women. It highlights that the real issue is data availability over quality, with many countries either not including or discontinuing collecting the information. There is a clear need to do more research on menarche in particular from the social science

perspective and to make menarche a common variable in future health surveys.

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