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Father's social and economic position has strongest impact on age at menarche in girls from Central India

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ABSTRACT: We assessed the impact of socio-economic factors on age at menarche among the adolescent female population from the state of Madhya Pradesh, Central India. Records such as date of birth, chronological age, caste affiliation, size of place of residence, parents' level of education and occupation, number of siblings, body height and weight, and age at menarche were collected for 330 students of A Central University, Sagar. The impact of socio-economic factors on age at menarche was analysed using analysis of variance. To establish the probability of menarche occurrence at a given age, time-to-event analysis was carried out using Kaplan-Meier curves and the log-rank test for curve comparison. The association between probability of attaining menarche and the independent variables was investigated using Cox proportional-hazard model. ANOVA and the Kaplan-Meier curves showed statistically significant differences in age at menarche according to size of the place of residence, number of siblings, parental level of education, father's occupation and females' BMI. The Cox proportional hazard model revealed that father's occupation was the strongest factor affecting age at menarche among all SES characteristics under study. Irrespective of rapid economic progress over the past few decades, Indian society is still patriarchal with societal male dominance. This translates into participation of fewer women in the paid workforce and labour market, their lower wage rates and smaller contribution to the household budget compared to their male counterparts.

KEY WORDS: nutrition, BMI, caste system, economy, social status, Indian society

Introduction

A large number of biological and environmental factors influence the age at which menarche occurs. These include genotype, health status at birth, diet and nutritional status, family socio-economic standing as expressed by parental in-

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come and education, area of residence, number of children in the family, environmental stress, and sport and physical activity (e.g. Łaska-Mierzejewska 1983; Bielicki et al 1986; Malina et al.1997, 2004; Ibáñez and Zegher 2006; Ellis and Essex 2007; Braithwaite et al. 2009; Day et al. 2015; Krzyżanowska et al. 2016; Liczbińska at al. 2018, 2019a).

Results of previous research on the impact of SES factors on age at menarche have been inconsistent. Numerous studies have linked better socio-economic background with earlier timing of the menarche, and vice versa (e.g. Bielicki et al. 1986; Orden et al. 2011; Krzyżanowska et al. 2016; Nieczuja-Dwojacka et al. 2019). Earlier age at menarche is also linked with improvement in standard of living and diet, resulting in increased fat accumulation, body weight and BMI in youth (Merzenich et al. 1993; Berkey et al. 2000; Whincup et al. 2001; Pierce and Leon 2005; Kaplowitz 2008; Bralić et al. 2012; Mohamad et al. 2013). Other research, however, has revealed that higher BMI does not necessarily reflect an improvement in social status. Studies of American girls have shown that those growing up in poorer socio-economic environments have poorer access to healthy foods as well as lower physical activity than those with higher SES, translating into a higher risk of obesity and earlier menarche (Gordon-Larsen et al. 2006; Singh et al. 2010). Some studies have shown no association between SES and age at menarche or have yielded mixed results, depending on the SES indicators used in the studies (Windham et a. 2004; Buttke et al. 2012 after: Deardoff et al. 2014). Deardorff and colleagues (2014) claimed for example that the reason for such discrepancy in the results is due the variety of SES indicators taken into account in the studies and the fact that they can collectively affect the timing of maturation.

In developing countries, where social gradients are more visible among inhabitants than in economically developed ones, the relationship between SES–dietary habits–BMI–age at menarche seems to be clearer and the results more definitive.

The main aim of the presented studies was to determine age at menarche of women from Central India and to explore its variation across socio-economic factors that could be potential determinants of menarcheal age.

Material and methods

The sample consisted of 330 women aged 19–21, recruited from the area of Sagar, a city located in the north-central region of the state of Madhya Pradesh, Central India. All participants were students attending A Central University in Sagar, MP. The data were collected between November 2017–January 2018 by anthropologists from the Department of Anthropology, A Central University in Sagar, Madhya Pradesh, India and the Institute of Anthropology, Faculty of Biology, Adam Mickiewicz University, Poznań, Poland.

Age at menarche was calculated by the retrospective method and reported in years as the age at last birthday. Height was measured with an anthropometer to the nearest 0.1 cm following the protocol of Martin and Saller (1957). Weigh was measured to the nearest 0.1 kg. To assess the nutritional status of the women surveyed, BMI was calculated (kg/m^2).

Socio-economic environment was described on the basis of variables covering the respondents' living conditions and variables affecting menarcheal age.

The selection of variables was based on the rich literature on the subject (see: Introduction). Data were collected on the following: caste affiliation, degree of urbanisation of residence place, father's and mother's level of education, father's and mother's occupation and number of siblings.

Studied variables were categorised into subgroups in accordance with the specifics of the research area and the availability of the collected material:

Caste system was categorized in four main groups:
1. general castes,
2. other backward castes,
3. scheduled castes,
4. scheduled tribes (see more in Gautam and Thakur 2009).

For the purpose of this research scheduled castes and scheduled tribes were combined into a single group.

Urbanisation of residence places were categorised as:
1. rural,
2. urban areas.

Number of siblings in the family was divided into 3 groups:
1. 0–2,
2. 3,
3. 4–x.

Level of parental education (mother's and father's) was divided into three categories:
1. illiterate, literate, primary,
2. middle and high school,
3. secondary and above.

Level of the father's occupation was summarized in three categories:
1. unemployed, agriculture labourers, unskilled workers, daily workers,
2. medium-qualified workers,
3. employed in government positions (holders of a regular job and holders of a contract job).

Occupational level of the mother was also summarized in three groups:
1. housewives,
2. agriculture labourers, unskilled workers, daily workers,
3. employed in government positions (holders of a regular job and holders of a contract job).

BMI was classified using WHO standards (1995):
1. undernourishment (<16.99),
2. thin (17.00–18.49 kg/m^2),
3. normal weight (18.5–24.99 kg/m^2),
4. overweight (25.0–29.99 kg/m^2),
5. obese (≥30.0 kg/m^2).

Basic descriptive statistics were carried out for exploratory data analysis. Differences in age at menarche according to SES and BMI were compared with ANOVA and unplanned multiple comparison tests of the differences between particular pairs of groups (e.g. HSD – Honestly Significant Difference with unequal sample sizes test). Time-to-event analysis was applied to establish the fraction of females attaining menarche in a certain amount of time after birth. Estimated the Kaplan-Meier curves were used to indicate the proportion of each cohort of women attaining menarche at a certain time, and to specify the time from birth to puberty. To investigate the association between the time of menarche occurrence and one or more predictor variables (BMI and SES factors) a regression Cox Proportional-Hazards model was used (Cox 1972). For the presented research, in which the occurrence of an event was regarded as a positive situation, hazard was understood as a chance. The Kaplan-Meier curves and log-rank tests, which describe event occurrence according to a single factor – the occurrence of menarche depending on explanatory variables SES and BMI –

were considered as significant by the Cox Proportional-Hazards model.

Statistical analyses were carried out using R v. 3.5.2 (R Development Core Team 2019). Significance was set at $p<0.05$.

The authors confirm that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised (2008).

Results

The analyses (Table 1) revealed a significant relationship between the cur-

Table 1. Relationship between SES and BMI and age at menarche in female students from Central India

Variables	n	Mean	SD	Values of ANOVA
BMI (kg/m²)				$F_{4.325} = 2.553$, $p<0.04$
>16.99	20	15.20	1.47	
17.00–18.49	21	14.19	1.25	
18.50–24.99	68	14.58	1.55	
25.00–29.99	202	14.18	1.71	
≥30.00	19	13.89	1.94	
Caste system				$F_{2.330} = 2.632$, $p>0.05$
Scheduled castes & tribes	108	14.17	1.71	
Other backward caste	151	14.54	1.72	
General caste	71	14.06	1.43	
Place of residence				$F_{1.328} = 7.741$, $p<0.006$
Rural	161	14.57	1.55	
Urban	169	14.06	1.74	
Number of siblings				$F_{2.327} = 4.408$, $p<0.02$
0–2	105	13.92	1.69	
3	97	14.42	1.75	
4–x	128	14.55	1.54	
Father's education				$F_{2.327} = 6.824$, $p<0.002$
without education/primary	42	14.71	1.66	
middle and high school	95	14.69	1.62	
secondary and higher	193	14.03	1.64	
Mother's education				$F_{2.327} = 5.738$, $p<0.004$
without education/primary	89	14.58	1.72	
middle and high school	133	14.44	1.58	
secondary and higher	108	13.88	1.66	
Father's occupation				$F_{2.327} = 10.050$, $p<0.001$
unemployed/low-paid job	176	14.65	1.63	
medium-qualified workers	55	14.44	1.45	
government posts	99	13.71	1.70	
Mother's occupation				$F_{2.327} = 2.864$, $p>0.05$
house wife	292	14.34	1.67	
medium-qualified workers	18	14.67	1.45	
government posts	20	13.50	1.73	

rent nutritional status of the studied women (BMI) and age of menarche ($F_{4.325}$=2.553, p<0.04). Higher BMI was related to lower menarcheal age and vice versa: menarche occurred the earliest at 13.9 years among females with BMI ≥ 30 and at the latest in those aged 15.2 with BMI <17. The effect of nutritional status determined by the ratio of body weight to body height is confirmed by statistically significant value of the correlation between menarche age and BMI (r=–0.116, p<0.04) and the lack of this significance between menarche age and body height (r = 0.086, p>0.05) and menarche age and body weight (r=–0.076, p>0.05).

A significant influence on age at menarche was also revealed in the case of socio-economic variables, with the exception of caste affiliation and mother's profession (Table 1). Despite the lack of statistical significance, the analysis of the influence of caste affiliation, shows a reduction in the maximum value of age at menarche in the general caste (higher caste position). The highest age of menarche (14.5 years) was found in females from other backward classes. This corresponds to a difference of 4 months compared to scheduled castes and scheduled tribes, and 5 months compared to general castes (14.2 years). Age at menarche differed significantly according to size of place of residence. Females from rural areas matured a few months later than those from urban centres (14.6 years and 14.1 years, respectively). Women having none or a maximum of 2 siblings matured a few months earlier (13.9 years) than those with 4+ siblings (14.6 years). Age at menarche was positively associated with the level of father's and mother's education. The earliest occurrence of menarche was recorded in the group of females for whom both parents had high level of education. The multiple comparisons show that daughters of fathers having secondary and higher level of education matured significantly earlier (14.0 years) than those whose fathers were without education or had graduated from primary school only (14.7 years). The same was true for maternal level of education – girls whose mothers had secondary and higher education matured significantly earlier (13.9 years) than those whose mothers had graduated from primary schools or were illiterate (14.6 years). A further socio-economic factor associated with age at menarche was father's occupation. Girls whose fathers were unemployed or had a low-paid job (agriculture labourers, unskilled workers, daily workers) or were medium-qualified workers attained maturation later (14.7 years and 14.4 years; respectively), compared to those whose fathers had a government position (13.7 years). Differences between unemployed/ low-paid workers – employed on government posts and unemployed/ low-paid workers – medium-qualified workers were confirmed by the HSD test (respectively p<0.0003 and p<0.05). Mothers' occupation, on the other hand, did not have a significant impact on age at menarche.

The results of the Kaplan-Meier analysis confirmed the significant impact of size of place of residence, number of siblings, parental education, father's occupation and BMI on the probability of attaining menarche. Differences in the course of the above variables over time according to SES factors were revealed by comparison of the curves. The course of the curve for females with higher SES (urban areas, better educated parents, higher occupational position of fathers,

fewer siblings) and higher BMI was above the one generated for the groups with lower SES and lower BMI. These results show, therefore, that the groups of women with higher SES have a greater probability of attaining menarche earlier than females with lower SES and lower BMI (Figs 1–6).

The Cox proportional hazard models indicate father's occupation as the variable which most greatly affected the probability of attaining menarche in the females from Central India (Table 2). The positive sign of the regression coefficients for this variable indicates that the hazard (chance of menarche occurrence) is higher for girls whose fathers have higher values for this variable, with the highest being for those whose fathers are employed in a government position (holders of regular job and holders of contract job). The exponentiated coefficients, which give the effect size of covariates, revealed that fathers' occupation strengthens the chance of menarche by 1.76.

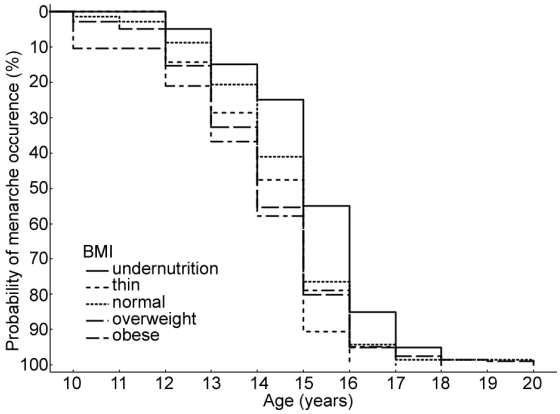

Fig. 1. Probability of menarche occurrence according to nutritional status $\chi^2=11.197$, df=4, $p<0.0025$.

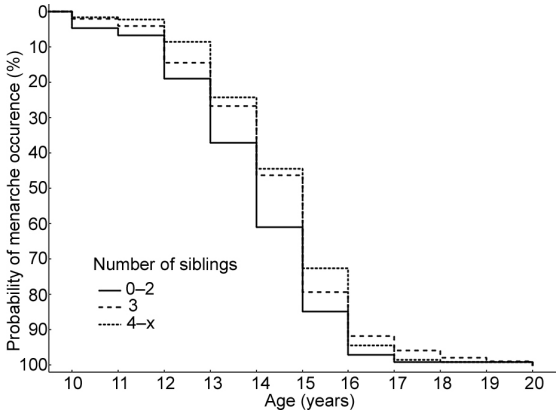

Fig. 2. Probability of menarche occurrence according to the number of siblings $\chi^2=19.005$, df=2, $p<0.012$.

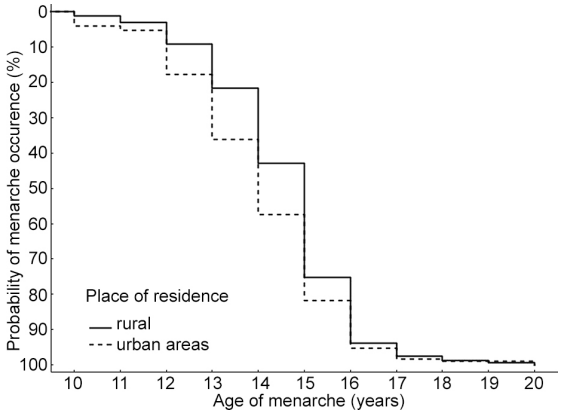

Fig. 3. Probability of menarche occurrence according to size of the place of residence $\chi^2=2.900$, df=4, $p<0.004$.

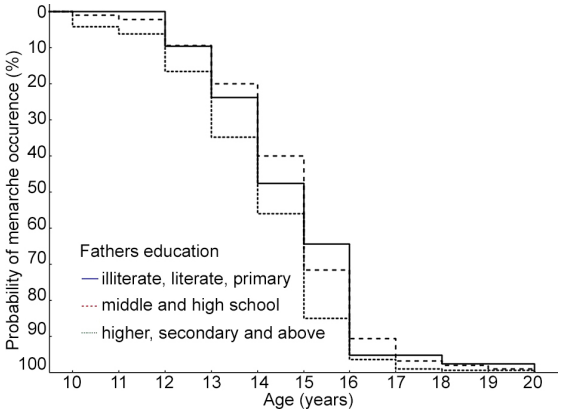

Fig. 4. Probability of menarche occurrence according to father's education $\chi^2=12.184$, df=2, $p<0.003$.

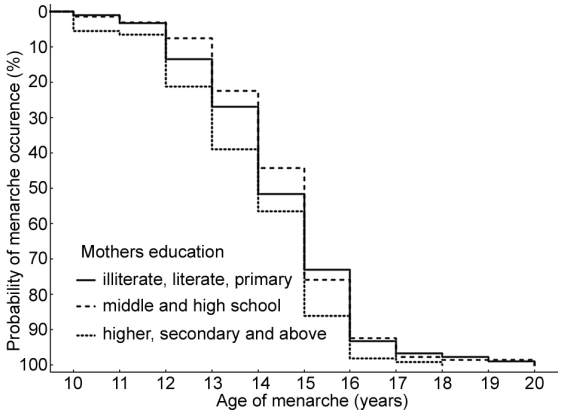

Fig. 5. Probability of menarche occurrence according to mother's education $\chi^2=9.051$, df=2, $p<0.011$.

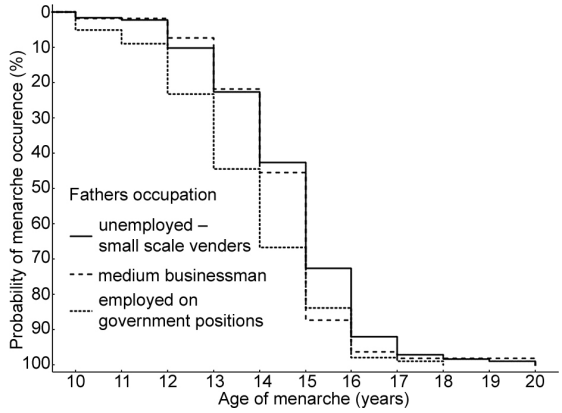

Fig. 6. Probability of menarche occurrence according to father's occupation
χ^2=18.095, df=2, p<0.001.

Table 2. Cox proportional hazards models explaining the effects of independent variables on age at menarche

Variable	Estimate β	SE	Wald statistic	p	HR	95% CI of the HR
BMI	0.084	0.059	1.436	0.151	1.088	0.97–1.22
Caste system	0.075	0.084	0.898	0.369	1.077	0.92–1.27
Place of residence	0.065	0.121	0.549	0.583	1.068	0.85–1.35
Number of siblings	−0.100	0.073	−1.383	0.167	0.905	0.79–1.04
Father's education	0.144	0.095	1.560	0.119	1.155	0.96–1.38
Mother's education	0.015	0.093	0.163	0.871	1.015	0.85–1.21
Father's occupation	0.175	0.071	2.305	0.022	1.175	1.02–1.35*
Mother's occupation	1.048	0.118	0.400	0.689	1.048	0.83–1.32

LR test = 23.46, df = 8, p = 0.003; Wald test = 23.23, df = 8, p = 0.003; Score (log-rank) test = 23.5, df = 8, p = 0.003; *0.05 – significance code.
Abbreviations: SE – standard error; LR-test – likelihood ratio test; HR – hazard ratio.

Discussion

Menarche, the onset of menstrual period, is considered the main event in the maturation of the female reproductive system – a milestone in a girl's life. Mean ages at menarche have varied substantially between women across different countries or across different ethnic or even social groups (Danker-Hopfe 1986; Thomas et al. 2001; Whincup et al. 2001). To understand the causes of menarcheal age variation the influence of genetic and numerous environmental factors are considered. Among environmental factors nutritional status and socioeconomic status are the most frequently cited (e.g. Berkey et al. 2000; Junqueira et al. 2003; Ellis 2004; Malina et al. 2004; Ellis and Essex 2007; Bralić et al. 2012; Krzyżanowska et al. 2016; Bharthi et al. 2017; Ganguly et al. 2018). Results of earlier research on girls from Central India have shown that they attain menarche at the mean age of 14 years, with wide variations: 10–20 years, only 13% of studied females attained menarche up to 12 years, while almost 50% of the group between 14–15 years

(see: Liczbińska et al. 2019b). The mean age of menarche in different parts of the world, including India, ranged 12–13.4 years (Khadgawat et al. 2016). Such a late age at menarche and its wide variation is explained by socio-economic factors of students from Central University in Sagar.

The district of Sagar is situated in the north-central part of Madhya Pradesh, Central India. It is inhabited by people of diverse ethnic, religious and linguistic backgrounds. Central India, including Madhya Pradesh, is still considered one of the poorest parts of the country demographically, economically and healthwise (Adak et al. 2006; Gautam and Thakur 2009). Statistics produced by the National Sample Survey Organization (2009) reveal that the State of Madhya Pradesh is 3rd lowest in the country in terms of monthly average food consumption per person. An average inhabitant of rural and urban areas spends monthly 234.4 and 336 Indian Rupees (INR), respectively on food (after: *Madhya Pradesh Development Report* 2011).

According to the authors' calculations this value is equal 4–5 USD (calculations on the basis on currency rate using the web page: https://www.xe.com/currencyconverter/conver, where 1USD was equal to around 70 INR). In 2005–2006 an average person from the rural areas of Madhya Pradesh consumed 11.5 kgs of food and spent only 86.5 INR on food per month. The Madhya Pradesh people spend 7.44 INR per month on egg, fish and meat, while an individual in Kerala spends almost 84 INR per month on these items. An individual from Madhya Pradesh spends only 44.7 INR on food grain, milk and milk products, while an individual from Punjab spends 511.25 INR per month on these items (after: *National Sample Survey Organization* 2009).

The results obtained confirmed the significant impact of nutritional status on menarchal age. Although nutritional status was not observed at the time of the survey, the results could to some extent reflect conditions in the prepubertal phase: it was assumed that current state of nutrition, in the absence of radical changes in socio-economic status, is closely related to the one from earlier phases of ontogenesis. The conducted analyses confirm the relationship between BMI and time of menarche, i.e. earlier onset of puberty in girls with higher BMI. As revealed in the literature (e.g. Merzenich et al. 1993; Berkey et al. 2000; Pierce and Leon 2005; Kaplowitz 2008; Kshatriya et al. 2009; Bralić et al. 2012; Mohamad et al. 2013; Kumar and Gautam 2016), women with higher BMI started puberty at younger age than those with lower BMI. Despite the poverty and malnutrition observed in Central India, more and more reproductive and child health programs (RCH) are being launched all across the country. Their aim is to improve the nutritional status of families, family welfare, maternal and child health status (Gautam and Thakur 2009). The group of women under study included both malnourished and lean women: 12% of these had BMI below the norm. According to Indian statistics 42% of adult women suffer from malnutrition and only 51% of them are at a healthy weight for their height. Undernutrition is a very serious problem among the population aged 15–19, especially for those belonging to the purest caste groups, i.e. scheduled tribes and scheduled castes. The statistics show that 74% of tribal children in Madhya Pradesh are underweight while 73% are stunted (after: *Madhya Pradesh Development Report* 2011), conceivably giving rise to an increased

average age of menarche. Earlier research on Indian girls from the states of Uttar Pradesh and Himachal Pradesh showed that undernourished girls had menarche more than 2 years after girls with normal BMI (Kshatriya et al. 2009; Kumar and Gautam 2016).

Socio-economic factors affect many components of the standard of living, including quality and quantity of nutrition or the distribution of goods per person (e.g. Bharthi et al. 2017; Ganguly et al. 2018). Our ANOVA results confirmed the impact of socio-economic factors in causing the diverse average age of menarche. The exceptions were different caste membership and mother's profession.

Indian society is characterized by division of castes, which generally practice different occupations, traditionally passed on from generation to generation (Gautam 2007). Hence, the lack of significance influence of caste membership on age of menarche seems hard to understand. The Indian caste system is categorized in four main hierarchically ranked groups. The Brahmins and Rajputs are considered as general castes and occupy a high position in the social hierarchy. Currently they practice agriculture and horticulture, domesticate cows and buffalo. This group is socially, economically and politically affluent, and dominates in Indian society, being members of the Indian government and holding prestigious jobs and positions (Adak et al. 2006; Gautam and Thakur 2009). The representatives of other backward castes also belong also to economically and politically affluent part of society and they dominate the scheduled castes and scheduled tribes. Cultivation is their primary occupation: they are traditional farmers and labourers. Some of them are also pastoralists or blacksmiths (Adak et al. 2006). The existence of scheduled tribes is based on cultivation, food gathering, hunting and fishing. In Madhya Pradesh scheduled tribes make up 23% of the total state population (Adak et al. 2006). Agriculture is the main livelihood of scheduled castes. Many people also work as agricultural and daily labourers. Scheduled castes also practice their traditional professions: Chamars – shoe making and repairing, Kumbhars – pottery, Koris – weaving. According to the 1991 census in the state of Madhya Pradesh they accounted for approximately15% of the population (Adak et al. 2006).

In the light of the caste hierarchy presented above the explanation of the lack of significance influence of caste membership can be found in the economic reforms introduced since the 1990s. The resulting employment opportunities in the non-agricultural sector reduced poverty and increased per capita income in all segments of Indian society (Hanstad 2005; Cassan 2011; Aiyar 2011). Relationships between castes have become more relaxed. There is food sharing between castes and eating at restaurants. New career opportunities have opened up for men (and later among women). They now practice occupations previously unrelated to their caste, such as government jobs, teaching, retail and services, and machine repair. Wealth and power in the village is less associated with caste than before, and landownership more diversified. Education for women is becoming widely spread (Deshpande 2010). Moreover, lactating, pregnant women and small children have been given special attention and receive supplementary nutrition in so-called *aganwadi* centres (Gautam and Thakur 2009).

In turn, the lack of significance for the influence of mothers' occupation is a

consequence of status of women in India. The women under study were born at the end of the 1990s. Although this period was characterized by economic reform, women have not substantively benefited from India's economic progress; they still experience barriers to entering the workforce. Indian society is stratified not only on the basis of caste but also of sex. The Indian family is still patriarchal and males dominate in society. Women are at the very bottom of the stratified society, particularly where this is more prominent, i.e. in rural India (Gautam and Thakur 2009; Raj 2014). Societal attitudes still prioritize early marriages over work and education for women. There is also widespread disapproval of working women and a lack of suitable employment opportunities. Women are employed mainly in low-paid, low-value jobs (Mondal et al. 2018).

Men's and women's roles and responsibilities in the family have not changed appreciably for years (Roopnarine et al. 2013). The women's role is constrained by gender and family relations while their activities are often confined to unpaid work (de Mattos and Dasgupta 2017). According to the 2011 census the female literacy rate is 65.6% compared to the male literacy rate of 82.1% (Raj 2014). The rate of women's participation in the labor market is small. Almost 48% women drop out of workforce before they reach the middle of their careers. This indicator is that of the Asian region as a whole, where it is 29% on average (Raj 2014). Women in India still have limited opportunities for participation in paid employment outside the home (Bourmpoula et al. 2016; Mehrotra et al. 2016). In Madhya Pradesh only about 20% of women work professionally (*National Sample Survey Organization* 2009). In our research 80% of respondents declared their mother's occupation as "housewife". In practice, this means that even if they devote themselves to raising children and running a household, formally they do not contribute anything to the household budget.

The impact of other socioeconomic variables is consistent with reports from other authors, including those relating to economically developed countries (e.g. Łaska-Mierzejewska 1970, 1983; Bielicki et al. 1986; Danker-Hopfe 1986; Kirchengast and Hartman 1994; Malina et al., 1997, 2004; Ellis 2004; Ibáñez and de Zegher 2006; Ellis and Essex 2007; Day et al. 2015). The Cox Proportional-Hazards Model, which also evaluates the effect of considered socio-economic factors on studied event at a given point in time, showed that the rate of menarche occurrence was mainly influenced by the father's social and economic position measured by his occupation status. Comparison of the course of the Kaplan-Meier curves (see: Figure 6) showed that up to the age of 16, there was a clearly higher probability of menarche occurring in girls whose fathers have higher professional status. Their course confirms the positive impact of the father's higher professional position, which doubtlessly translates into a higher socio-economic status (e.g. Oduntan et al. 1976; Łaska-Mierzejewska et al. 1982; Bielicki et al. 1986; Adadevoh et al. 1989; Junqueira et al. 2003; Chavarro et al. 2004; Ersoy et al. 2004; Gomuła and Kozieł 2018).

Summing up, deep social gradients in India, especially in the poorest states, inform the differences in age at menarche. Indian society is still patriarchal with societal male dominance. This translates into participation of fewer women in the paid workforce and labour market, their

lower wage rates and smaller contribution to the household budget compared to their male counterparts.This in turn means that the father is the main breadwinner in the vast majority of Indian families.

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Note

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Authors' contributions

MK contributed to analysis and interpretation of the data, drafting and critical revision of the manuscript, study conception and design.

GL contributed to establishing the database, analysis and interpretation of the data, drafting and critical revision of the manuscript, study conception and design.

RG, PD, AKA and ACh contributed to acquisition of the data, establishing the database, interpretation of the data, and critical revision of the manuscript.

All authors read and approved the final manuscript.

Ethical Issues

The project was realized with permissions of the Bioethics Committee (Statement of the Institutional Review Board at Poznań University of Medical Sciences, no. 2431/00 and 538/14).

Conflict of interest

The authors declare that they have no competing interest.

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