Original Research Article

Role of biological, social and psychological factors in determining the menarche age: a multi-centered cross-sectional study in Karachi, Pakistan

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ABSTRACT

Background: Menarche marks the beginning of the menstrual cycle, reflecting a complex interplay of biological, environmental, nutritional and socio-economic factors that contribute to variations in age at menarche. To determine the impact of physical and psychosocial factors on the age of menarche in girls from different socioeconomic backgrounds in Karachi, Pakistan.

Methods: A cross-sectional descriptive study was conducted among 305 female students aged 9 to 15 years from four different schools in urban and rural areas of Karachi district, Pakistan in 2022. Subjects who had not yet menstruated were excluded. Bilingual questionnaires were used in the study to record the responses. Height and weight were measured using calibrated instruments. The psychological stress levels were measured using APA LEVEL 2-anxiety-child aged 11-17 (Promis emotional distress -Pediatric Item bank). SPSS version 25 was used to find a correlation between the age of menarche with different biological, social and psychological factors.

Results: The mean age of menarche was 11.9±1.09 years. The study showed a significant correlation between body mass index and the father's occupation was found (p<0.05). Presence, education, occupation, the combined income of both parents, number of siblings and female siblings, physical activity, diet, abuse, home environment, psychological and physical effect of COVID-19 lockdown and anxiety levels did not show any significant correlation with age of menarche.

Conclusions: This study supports the significant influence of body mass index and the father's occupation on the age of menarche.

Keywords: Biological, Menarche, Psychological, Social, Women's health

INTRODUCTION

The first menstrual cycle or menarche, occurs when a female reaches sexual maturity and signifies her passage from infancy to adulthood. Menarche is affected by genetic factors, race, environmental conditions, nutrition, physical activity, geographic location, urban or rural residence, health status, psychological factors, blindness, body mass index (BMI), family size, socioeconomic status, parental educational level, occupation of parents, loss of parents, child sexual abuse, physical stress, tea consumption and passive smoking.[1] Menstruation is the monthly shedding of the functional layer of the uterine endometrial lining that occurs when ovulation is not followed by fertilization. It comprises 4 phases menstrual, follicular, ovulatory and luteal. Several hormones play

crucial roles in regulating the menstrual cycle GnRH, FSH, LH, Estrogen and Progesterone. These hormones work in a coordinated manner to regulate the menstrual cycle. Any disruptions or imbalances in these hormones can lead to irregular menstrual cycles or other reproductive health issues.

Menarche occurs 2-3 years after thelarche and six months after peak height velocity (PHV) is achieved. PHV is defined as the highest velocity observed during the pubertal growth spurt. Menarche typically occurs between the ages of 10 and 16, with the average age of onset being 12.4 years. Menstruation occurs approximately every 28 days, ranging from every 21 to 45 days, with a mean cycle interval of 32.2 days in the first gynecologic year. Most menstrual periods last between three and seven days, with menses lasting more than ten days considered abnormal.[2]

In a previously published extensive review of ages at menarche across the world of 67 countries, a huge variability was observed while some sources suggest a decline in the age of menarche others report an advanced trend over the years.[4,5] However, Pakistan lacks data about the topic as people are reluctant to talk about menarche due to cultural and religious norms. It is however noted that a study was conducted in Punjab, province of Pakistan, between 2015 and 2017, to determine the age of menarche and its association with the growth status of eight 16-years-old schoolgirls of the province of Punjab province of Pakistan.[6]

It was known that Black females experienced menarche three months earlier than White females. This finding may reflect genetic factors, as Black females presented with higher insulin responses to glucose challenges and increased free IGF-1, which are associated with skeletal and sexual maturation.[3]

Environmental factors such as nutrition, SES, urbanization, chemical exposure, stress and family structure and dynamics can interact in complex ways and influence the timing of menarche observed worldwide. Earlier onset of menarche was seen in those surrounded by stressful family environments, those in foster care and those living with a stepparent.[7] Adolescents from families of high socioeconomic status (SES) experience menarche at an earlier age when compared to those from families of a lower SES.[8]

Studies have shown that those who consumed more animal protein and less vegetable protein between the ages of three to five experienced earlier menarche.[9] Another study found a positive correlation between the consumption of sugar-sweetened beverages and the onset of menarche. Menstrual irregularities among females in Pakistan pose a significant burden, impacting their health, economic well-being and their standard of living. Adolescent girls face significant psychosocial problems during menstruation in terms of access to clean materials, lack of privacy for changing pads, disposal facilities for sanitary napkins, socio-cultural restrictions, less psychological and social support, poor knowledge about managing pain during menses, non-availability of counselling services and inadequate information on menstruation and its management, no preparation before menarche, menstrual distress, burden and stigma.[11]

Cultural and societal taboos around menstruation limit access to hygiene products and healthcare, negatively affecting women's health and empowerment. Many girls, especially in developing countries like Pakistan, face poor menstrual hygiene due to inadequate WASH facilities, lack of awareness and cultural barriers.

Initiatives like India's subsidized napkin scheme and banana fiber pads during COVID-19 show promise in reducing these issues. Premenstrual psychological problems, including depression and suicidal thoughts, are prevalent. Research on menarche often suffers from recall bias and limited geographic scope. This study addresses gaps by analyzing data from Karachi, highlighting maternal age and family size as influencing factors.

Teachers, nurses and female health workers could play a central role in providing up-to-date and reliable information through outreach programs regarding menarche and decrease the stigma related to this topic. This could contribute to improving the sexual and reproductive health of adolescents and young girls, as well as the whole community. For coming-of-age girls, a time slot can be specified in schools where in groups, these girls are provided knowledge and awareness about menarche, duration of menstrual cycle, premenstrual syndrome, changing of pads, safe disposal of sanitary napkins, onset of secondary sexual characteristics and dispelling myths and misconceptions about menstruation.

This study determines the present age of menarche for Pakistani girls under the influence of various physiological variables and psychosocial factors. Thus, this study aims to correlate age at menarche with factors like body mass index, nutrition, physical activity, parents' qualifications and occupation, socioeconomic status, COVID-19 lockdown, abuse, home environment and psychological factors.

METHODS

Study design

This is a cross-sectional descriptive study evaluating factors affecting age at menarche among young adolescents.

Study place

This study was conducted on schoolgirls studying in public and private schools in Karachi.

Study population

386 girls were chosen at random of which 43 had not started menstruating and 38 questionnaires were incomplete and hence discarded. 305 were left which were then evaluated. The participants were aged 9 to 15 years.

Inclusion criteria

Inclusion criteria included all those who consented to the study and completed the questionnaire and all female students who had started menstruating at the time of data collection.

Exclusion criteria

Exclusion criteria included female students who did not consent to the study, had not attained menarche and did not complete the questionnaire.

Sample size determination

The sample size was calculated using a sample calculator (https://www.calculator.net/sample-size-calculator.html). The calculated sample size was 402 with a 95% confidence interval.

Sample technique

A cluster sampling method was used in which 4 schools Mama Parsi School, NJV school, Sindh Government Secondary Girls College and Karachi Public School, located in 4 different areas of Karachi, were selected and random classes were chosen from those schools for data collection. 2 of our authors took the questionnaire to the schools, where the schoolteachers supervised the filling of the questionnaire by the students. The data was collected between 10th June 2021 to 25th October 2021.

Study tools

A predesigned and pre-tested survey questionnaire and SPSS software were used.

Data collection

Data collection was done from 10th June 2021 to 25th October 2021.

Pre-testing/validation of questionnaire

The questionnaire was validated by 40 of the 386 participants. To ensure data quality, prefield activities such as proper question sequencing, coherency of questions, training and field invigilation and pretesting were performed before data collection. The pre-tested questionnaire was disseminated amongst the participants. To improve convenience and enable a better understanding of the questions, the questionnaire provided an option to answer in one of two languages (English or Urdu).

Data analysis

SPSS version 25 was used for data analysis. Pearson Chi-square tests were used to find the correlation between biological, social and psychological factors and their influence on the age of menarche. The mean and standard deviation were calculated for continuous variables and frequencies and percentages for categorical variables.

Data management

The time of menarche was asked for the subject by the "recall method".[10] Height and weight measurements were done on the spot using a weighing balance and a measuring tape. Body mass index (BMI) was calculated using these two measurements recorded. The psychological stress levels were measured using APA LEVEL 2-Anxiety-Child Aged 11-17 (Promis emotional distress -Pediatric Item bank).[9] the raw score was used to calculate the T-score for each individual. They were then classified into four groups based on severity level. Data variables, Continuous variables were participant's height, weight and age. Categorical variables included number of siblings, presence of parents or guardians, SES and physical activity.

Ethical consideration

For ethical considerations, ethical clearance was obtained from the Institute ethics committee. Written informed consent for the girls' participation was obtained from the school institution head. The participants were briefed about the study before collecting data.

RESULTS

This study included a total of 305 participants between ages 9 to 15 in the 4 schools from which data was collected. The mean age of menarche was 11.93 years and Standard Deviation (S.D) of ±1.086.

Among the socioeconomic and biological factors, age of menarche, presence, education, occupation, the combined income of both parents, number of siblings and female siblings, physical activity, diet and BMI were taken into account as shown in table 1. Age of menarches were seen to be 9, 10, 11, 12, 13, 14 and 15 years with percentage frequencies being 1.2, 8.6, 19, 37.4, 22.4, 3.7 and 0.9 per cent respectively. Girls who had menarche before and after COVID-19 showed a 50.6% and 42.6% frequency.

Mother's information showed that the presence of biological mother and stepmother among the participants was 88.3% and 4.9% respectively. Mothers' occupations showed housewives, working women and others (including religious workers) with frequencies of 75.8%, 15% and 2.8% respectively. Mothers' education was

categorized into postgraduate, graduate, high school, school and never been to school with frequencies of 21.5%, 29.1%, 11.3%, 16.3% and 15.3% respectively.

The presence of a father was seen as a biological father in 87.7% of cases and only 5.8% had a stepfather or a guardian. Fathers' occupations included businessman, doctor, laborer, private job, public job, scientist and others with frequencies 20.2, 2.5, 10.4, 34.7, 14.1, 4.6 and 6.4% respectively with the highest number of people doing private jobs. Father's education was categorized as postgraduate, graduate, school, never been too school and other (technical education) with frequencies 36.2, 23.3, 21.5, 8.0 and 4.6% respectively. Socioeconomic status as categorized based on the combined income of both parents was high, middle, low and very low income with approximates of greater than 300,000 pkr per month, 300,000 to 100,000 per month, 100,000-50,000 per month and less than 50,000 per month respectively. 10.1% reported having high income, 22.4% with middle income, 55.5% with low income and 5.5% with very low income.

Physical activity was categorized as active (3-5 hours per week), moderately active (1-2 hours per week) and inactive (less than 30 minutes per week) and percentage frequencies were seen as 20.2, 42 and 31.3% respectively.

Questions related to diet included more meat or more vegetables with frequencies recorded as 42.9% and 49.7% respectively. BMI showed underweight, healthy weight, overweight and obese with percentages of 48.8, 37.4, 6.1

and 0.9% respectively. Several siblings, female siblings and co-education did not show any significance.

Table 2 shows the effects of the COVID-19 lockdown with responses showing that psychological effects were low, moderate and severe with percentages of 26.1, 35.6, 31.9% respectively. Whereas the physical health effects of COVID-19 were low, moderate and severe with frequencies of 20.2, 32.5 and 40.8% respectively.

Table 3 shows frequencies and percentages of anxiety levels as categorized by T-scores from the APA scale. Anxiety levels were classified as none, mild, moderate and severe with percentages of 30.7, 14.4, 30.1 and 18.1% respectively.

Table 4 shows the association of age of menarche concerning biological factors with a p-value for BMI, physical activity, diet and physical effects of COVID-19 lockdown of 0.024, 0.072, 0.153 and 0.291 respectively. Only BMI showed a significant correlation with age of menarche (p<0.05).

Amongst social factors, only the father's occupation showed a significant correlation (p<0.05) as shown in Table 5.

Amongst the psychological factors, kinds of abuse, home environment, the psychological effect of lockdown and anxiety levels did not show any significant relationship with the age of menarche as shown in Table 6.

Table 1: Frequencies and percentages of socioeconomic factors.

	Frequency	%
Menarcheal age (years)		
9	4	1.2
10	28	8.6
11	62	19
12	122	37.4
13	73	22.4
14	12	3.7
15	3	0.9
Menarche before or after menarche		
After February 2020	165	50.6
Before February 2020	139	42.6
Presence of mother		
Biological mother	288	88.3
Stepmother	16	4.9
Mother's occupation		
Housewife	247	75.8
Other	9	2.8
Working woman	49	15
Mother's education		
Graduate	95	29.1
Highschool	37	11.3
Never been to school	50	15.3
Postgraduate	70	21.5

Continued.

	Frequency	%
School	53	16.3
Presence of father		
Biological father	286	87.7
Step father	19	5.8
Father's occupation		
Businessman	66	20.2
Doctor	8	2.5
Labourer	34	10.4
Other	21	6.4
Private job	113	34.7
Public job	46	14.1
Scientist	15	4.6
Father's education		
Graduate	76	23.3
Never been to school	26	8
Other	15	4.6
Postgraduate	118	36.2
School	70	21.5
The combined income of the parents		
High	33	10.1
Low	181	55.5
Middle	73	22.4
Very low	18	5.5
Physical activity		
Active	66	20.2
Inactive	102	31.3
Moderately active	137	42
Diet		
More meat	143	43.9
More veg	162	49.7
BMI		
Healthy weight	122	37.4
Obese	3	0.9
Overweight	20	6.1
Underweight	159	48.8

Table 2: Frequencies and percentages of effects of COVID-19.

Psychological effect of COVID-19		
Low	85	26.1
Moderate	116	35.6
Severe	104	31.9
Physical health effects of COVID-19		
Low	66	20.2
Moderate	106	32.5
Severe	133	40.8

Table 3: Frequencies and percentages of psychological factors.

Anxiety based on T-scores		
Mild	47	14.4
Moderate	98	30.1
None	100	30.7
Severe	59	18.1

Table 4: Frequencies and association of menarcheal age with biological factors. Chi-square values (p<0.05 is significant).

Association of menarcheal age with biological factors										
	Menarcheal age	9	10	11	12	13	14	15	Frequencies	P value
Body mass index	Underweight	0	14	30	71	39	4	1	159	0.024*
	Healthy weight	3	8	26	47	29	6	2	122	
	Overweight	1	3	6	4	5	1	0	20	
	Obese	0	2	0	0	0	1	0	3	
The physical effect of lockdown	Low	1	5	9	37	13	1	0	66	0.153
	Moderate	3	10	26	33	29	3	1	106	
	Severe	0	13	27	52	31	8	2	133	
Physical activity	Active (more than an hour)	2	6	17	32	9	0	0	66	0.072
	Moderately Active (about an hour)	1	15	31	45	34	7	3	137	
	Inactive (half hour/day)	1	7	14	45	30	5	0	102	
Diet	more meat	3	12	27	60	37	3	0	143	0.291
	more veg	1	16	35	62	36	9	3	162	

*Significant

Table 5: Frequencies and association of menarcheal age with social factors. Chi-square values (p<0.05 is significant).

Association of menarcheal age with social factors										
Mother	Biological mother	4	28	57	117	68	11	3	289	0.790
	Stepmother	0	0	5	5	5	1	0	16	
Mother's Occupation	Housewife	2	22	48	99	60	12	3	247	0.586
	Other	0	0	1	4	4	0	0	9	
	Working woman	2	6	13	19	9	0	0	49	
Mother's qualification	Graduate	0	8	23	40	21	2	0	95	0.056
	Highschool	1	0	11	13	11	0	1	37	
	Never been to school	0	7	9	19	11	3	1	50	
	Postgraduate	3	10	13	30	13	1	0	70	
	School	0	3	6	20	17	6	1	53	
Father	Biological father	4	28	58	114	66	12	3	286	0.705
	Step father	0	0	4	8	7	0	0	19	
Father's Occupation	Businessman	0	5	11	34	13	2	0	66	0.003*
	Doctor	1	1	0	3	3	0	0	8	
	Labourer	0	5	2	10	9	5	3	34	
	Other	0	2	6	9	6	0	0	23	
	Private job	3	10	32	40	24	4	0	113	
	Public job	0	4	10	18	13	1	0	46	
	Scientist	0	1	1	8	5	0	0	15	
Literacy (Father)	Graduate	1	6	14	33	19	3	0	76	0.533
	Never been to school	0	3	4	12	4	3	0	26	
	Other	0	0	5	5	5	0	0	15	
	Postgraduate	3	14	30	43	24	2	1	118	
	School	0	5	9	29	21	4	2	70	
Extended Family	No	2	17	46	87	58	9	1	221	0.366
	Yes	2	11	16	35	15	3	2	84	
Monthly Income Of both parents	High	0	3	3	17	9	0	1	33	0.599
	Low	3	16	32	74	44	9	2	181	

Association of menarcheal age with social factors										
combined	Middle	1	9	20	26	15	2	0	73	
	Very low	0	0	7	5	5	1	0	18	
Number of Siblings	0	0	0	1	2	1	0	0	4	0.477
	1 to 3	3	14	38	74	33	4	1	168	
	4 to 6	1	9	16	33	28	4	0	91	
	>7	0	5	7	13	11	4	2	42	
Female Siblings	0	0	4	18	26	7	5	0	61	0.104
	1 to 3	4	23	43	89	61	6	3	229	
	4 to 6	0	1	1	7	5	1	0	15	
Co-education	No	4	18	33	86	46	9	2	199	0.269
	Yes	0	10	29	36	27	3	1	106	

*Significant

Table 6: Frequencies and association of menarcheal age with psychological factors. Chi-square values (p<0.05 is significant).

Association of menarche age with psychological factors										
Kinds of abuse	All	1	4	1	5	3	0	0	14	0.102
	Emotional	0	8	18	24	7	0	0	57	
	No	3	10	21	54	39	7	3	138	
	Physical	0	1	8	12	13	1	0	35	
	Sexually	0	2	1	2	1	1	0	7	
	Verbally	0	3	13	25	10	3	0	54	
Home environment	Disturbed	0	3	4	11	0	0	0	18	0.506
	Neutral	0	6	16	25	14	2	0	63	
	Secure	4	19	42	86	59	10	3	224	
Psychological effect of lockdown	Low	2	6	7	42	23	4	1	85	0.061
	Moderate	0	14	31	44	24	2	0	116	
	Severe	2	8	24	36	26	6	2	104	
Anxiety t-scores	Mild	1	5	10	16	14	1	0	47	0.626
	Moderate	0	8	19	43	23	4	1	98	
	None	3	7	16	43	25	4	1	100	
	Severe	0	7	17	20	11	3	1	59	

DISCUSSION

In the present study, the mean age at menarche was noted as 11.93 years and the majority of girls attained menarche at 12 years. It was found that girls who reached menarche early had higher BMIs and a positive correlation was found with the father's occupation and physical activity of less than 30 minutes or>3-5 hours. No significant correlation was found in this study with menarche about high protein intake, SES, family stressors and dynamics and psychological factors.

Trends in age at menarche have been decreasing in Pakistan as seen by a study conducted at Ziauddin University, Karachi where the mean age was 11.73+1.2 years, 12.4 years in a study conducted in Punjab.[6,11] This variability invites a thorough exploration of the causes as the decrease in AAM is more significant in Asian women. Recent studies reported the mean AAM in Asians to be from 13 to 11.67 years.[12] A recent study in the USA showed a significantly lower age of menarche by about 4.3 and 3.2 months, respectively, of non-Hispanic (NH) black and Hispanic girls relative to NH white girls when lifestyle and physiological factors were taken into account.[13] The mean age at menarche in France has also decreased from 12.78 years in 1979 to 12.6 years in 1994, although it has recently stabilized at 12.5±0.08 years.[28] Meanwhile, the mean age of menarche among Indo-Pakistani girls was found to be 13.06 years according to a study.[14]

In this study, BMI showed a strong correlation with the onset of menarche as in prior evidence. Body weight, height, BMI, supra iliac and abdominal skinfolds have been shown to have a strong impact on early menarche.[30] Different theories suggest different explanations such as leptin protein from body fat, shorter height in girls due to earlier closure of epiphyseal plates and an increase in estrogen hormones in girls attributing to variation in the age of menarche.[16] The relationship between BMI and menarche age is controversial, thus, underweight girls with lower levels of fat have delayed menarche. On the other hand, excessive obesity hurts the mechanism of the hormone axis of the hypothalamus-pituitary by increasing body fat and decreasing the secretion of sex hormones,

even leptin delays the onset of menarche.[17] One reason may be that the girls who arrive early at menarche have had a high BMI and positive energy balance for a long period.[22] The other reason can be derived from the fact that fat-derived leptin protein secretion in obese girls is one of the causes of hypothalamus stimulation to increase the secretion of the GnRH hormone that activates the pituitary-ovarian axis and initiates puberty phenomenon.[18]

This study also showed that a high protein diet has no significant relation with age at menarche. A correlation, however, exists between dietary energy intake and carbohydrates and iron intake at the age of menarche.[19] On the contrary, some researchers showed that earlier onset of menarche was reported in girls who have a high protein diet intake. It is well known that undernutrition delays the onset of menarche.[20] The cause of inconsistent findings may be different nutritional assessment tools as well as individual biological differences.

This study showed that physical activity of less than 30 minutes or more than 3-5 hours per week is associated with a higher mean age of onset of menarche. An association has been reported for girls with high physical activity at a later age of reaching menarche.[23] Low exercise has been observed as associated with late menarche whereas if the low activity is related to obesity and higher BMI, then it leads to an earlier onset of menarche. This may be due to anovulatory cycles due to increased energy expenditure, hypothalamic dysfunction or changing hormonal levels in the blood.[21]

Socioeconomic factors include type of residency, parents educational and occupational level, family size and household income. This study found no significant correlation between the onset of menarche and socioeconomic factors. However, compared to previous studies. A study conducted in Punjab has shown that girls belonging to low SES had delayed onset of menarche as compared to those belonging to middle/high SES24.

Contrarily, one study conducted in the USA has shown a weak association between lower socioeconomic status (SES) with earlier onset.[25] Another study conducted in Mumbai; India has shown a correlation between higher age of onset with lower SES.[26] These differences may stem from the fact that they have all used different parameters to calculate SES. A standardized system for measuring socioeconomic status may resolve this issue.

This study showed a significant correlation between the father's occupation and with age of menarche. It is earlier reported that a father's education is associated with earlier menarche. Similarly, the father's occupation has also been observed as having the strongest impact on the age of menarche in girls.[27] This may be due to reduced stress in the family, better nutrition and a home environment due to a sense of security.

This research shows no correlation between stress including abuse and disturbed home environment whereas

in other studies, family disruption and family stress are associated with earlier onset of menarche.[28,29] This has been explained by the psychosocial acceleration phenomenon and high cortisol levels in response to psychosocial stress and probably the activation of reproductive centers which is still being investigated. Physical abuse speeds up the maturation process.[31,32]

This study has shown that psychological factors have no effects on the age of menarche. However, a study has recently shown that precocious puberty is related to the impact of COVID-19 as depression, anxiety and stress levels were seen to increase during the lockdown. However, enough data on this is not available.[33]

This study did not find any correlation between the number of siblings and the age of menarche which is inconsistent with a study conducted in the USA that states that the presence of sisters in the household while growing up, was associated with delayed menarche, however, the age of menarche was not affected by the number of brothers in the household.[34]

Early menarche has been associated with physical and psychosocial problems, including anxiety and depression, earlier sexual intercourse, substance use and suicidal behaviour. These outcomes may be attributed to adolescents associating negative physical and psychological changes with menstruation reflecting misconception, ignorance and the fear of being different from peers.[35]

Substantial evidence from multiple countries suggests that females who undergo early menarche are more vulnerable to early pregnancy, sexually transmitted infections and sexual violence.[36] Early menarche can lead to premature fusion of the epiphyseal growth plates and a final adult height shorter than the potential genetic height.[37]

Undergoing menarche at an early age leads to an increased prevalence of hypercholesterolemia, metabolic syndrome and type 2 diabetes mellitus in adulthood, increasing the risk of developing cardiovascular diseases such as hypertension, coronary heart disease and stroke.[38] Higher bone mineral density of the lumbar spine and femoral neck in older age has been seen in females who underwent early menarche, explained by the prolonged lifetime exposure to the protective effects of endogenous estrogens.[39] A study has demonstrated a 23% higher risk of developing breast cancer in patients with early menarche when compared with patients who experience delayed menstruation. This finding is enhanced by the observation that early menarche is accompanied by abdominal-type obesity and, thus, higher circulating levels of insulin, testosterone and insulin-like growth factor 1, which act as growth factors for mammary tissue proliferation and are likely to promote mammary gland carcinogenesis.[40] Delayed menarche has been shown to decrease mineral density in the forearm, spine and

proximal femur, resulting in osteoporosis and an increased risk of fractures later in life.[15]

Limitations

One of the limitations is that this study was conducted only in Karachi and may restrict the generalizability to other regions or populations in Pakistan. Furthermore, given the cross-sectional nature of the data, we were unable to establish any causal linkages between the outcome and exposure variables. In addition, the BMI measurements of participants at the time of data collection may not reflect their BMI at the time of menarche.

Our study was a multi-site research conducted at 4 different schools located in urban and rural areas of Karachi hence larger sample sizes accounted for more generalizable findings. The inclusion age for this research was 9-15 years which eliminated risk of recall bias which is likely to be present in middle age group women. A limitation of this study is the exclusion of out-of-school girls, those in private institutions, being homeschooled or attending madrassas. Information on menarche is essential for policymakers to improve health services and menstrual education for schoolgirls.

CONCLUSION

This study supports the significant influence of BMI and the father's occupation on age at menarche. All other biological, social and psychological factors did not show any correlation with age at menarche. Larger populations may be sampled for even better outcomes of a study of this sort. Health professionals must intervene and spread awareness about nutritional factors affecting menarche and how a balanced diet and nutrition education programs can play a significant role. Students' unions can campaign for equitable access to healthcare services, raise awareness about environmental health issues and organize workshops on menarche, menstrual hygiene and combat stigma related to these topics.

Teachers can facilitate open discussions and promote an inclusive and supportive learning environment. Healthcare infrastructure development should be prioritized by the local government. The government should integrate menstrual health education into school curricula. State policymakers and the Pakistani government should legislate socio-economic policies aimed at alleviating poverty and enhancing access to comprehensive healthcare and education for all citizens. By implementing such targeted interventions, we can collectively improve the understanding and management of age menarche issues among adolescent girls in Pakistan.

There are significant knowledge gaps in numerous girls regarding their biological maturation and thus, understanding their bodily changes and related consequences leaving them vulnerable to misinformation, myths and harmful practices which may result in severe effects for their physical and mental well-being.

This underscores the urgent need for comprehensive, culturally sensitive education which ought to be provided through outreach programs by female health care workers. Further research is warranted to elucidate the modifiable risk factors and underlying pathophysiology contributing to early menarche. This knowledge will inform evidence-based interventions aimed at preventing or delaying early menarche, thereby mitigating the risk of associated diseases.

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