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A COMPARATIVE STUDY OF ESTIMATED AGE AT MENARCHE USING DIFFERENT METHODS AMONG GIRLS FROM MERIDA, MEXICO

ABSTRACT: In cross-sectional studies among adolescents, estimation of age at menarche (AAM) is based on recall and status quo (SQ) data. Objectives: 1) To estimate median AAM using SQ data and to examine the differences with estimated values of AAM based on recall data. 2) To apply retrospective AAM data correction procedures used in earlier studies (AAM_{C1} and AAM_{C2}) and to observe the differences with self-reported information (uncorrected or AAM_{UC}) with respect to the estimation of early menarche (EM <12 years), intermediate menarche (IM, 12.0–13.9 years), and late menarche (LM ≥14 years). 3) To calculate SQ data-based maturation age (MA) and to observe the differences of MA among EM, IM, and LM girls. The method was cross-sectional and 9 to 17-year-old 536 girls (422 post-menarche) from Merida, Mexico participated in the study during 2008–2010. Probit analysis estimated median AAM (SQ data). The AAM correction was done using following methods. AAM_{C1} = number of days between birth and July 1 of the recalled year divided by 365.25. AAM_{C2} = half a year was systematically added to the recalled AAM. Results showed that mean value of age was 13.33 years and SQ data-based estimated median AAM was 11.34 years. Mean values of AAM (AAM_{UC} = 11.57 years, AAM_{C1} = 11.53 years, AAM_{C2} = 12.21 years) were different (paired); however, had high correlation ($p < 0.05$). The AAM_{C1} overestimated EM; AAM_{C2} underestimated EM, and overestimated LM (%). Mean value of MA of the girls was 15.28 ±2.15 years. The mean values of MA in EM, IM and LM groups were: 14.67 years, 15.89 years and 17.46 years respectively.

KEY WORDS: Menarche – Recall – Age correction – Status quo

INTRODUCTION

Menarche is a significant milestone in the life of a girl that marks the transition from adolescence to adulthood. Menarche is an outcome of several biological, neuroendocrinological, genetic, cultural, socioeconomic and environmental factors (Karapanou, Papadimitriou 2010). Age at menarche (AAM) is an

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estimate of maturation rate in adolescence. In human biology, epidemiology and demography research, AAM is an important indicator of population health and nutritional status; a start of exposure to endogenous estrogen and other hormones, fecundity etc. The AAM is predicted by childhood growth and body weight; early menarche (<12 years of age) is reported to be associated with several health complications in adulthood (Méndez-Domínguez 2010, Must *et al.* 2005).

The AAM is commonly recorded following three data collection procedures: retrospective (reported and/or corrected), status quo (SQ) and prospective (Zarów, Cichocka 2008). The first two data collection procedures or commonly called methods (Freedman *et al.* 2002, Karapanou, Papadimitriou 2010, Livson, McNeill 1962, Malina *et al.* 2004, Padez 2003, Padez, Rocha 2003, Zarów, Cichocka 2008) are used in cross-sectional studies. The retrospective data collection procedure is generally used among adolescents and adult women where respondents are asked to recall their menarche. The estimation of median AAM, using SQ data is commonly applied in studies among children and adolescents when the participants are asked about their current status, whether menstruating or not. The prospective data collection procedure is used in longitudinal cohort studies among adolescents when participants are tracked over a period of time with risk of missing data in follow-up studies.

As reported earlier, reliability of subjective recalled or retrospective information on menarcheal age is questionable (Schmidt-Pokrzywniak *et al.* 2016). Systematic errors of over- and under-estimation of recalled AAM are common; decreased variability in the distribution showing a general regression of recalled age to the center (Livson, McNeill 1962). It is more uncertain to record AAM correctly from adult women who had menarche long back during adolescence. Data of recent menarche among adolescents may be relatively reliable that is called short-term recall information (menarche within one year earlier to the date of survey) (Hediger, Stine 1987, Koo, Rohan 1997). There are available reports on correction of recall data of menarcheal age (Freedman *et al.* 2002, Padez 2003, Padez, Rocha 2003). In this regard, a parametric estimator of menarcheal age distribution on the basis of a realistic censoring model of recall phenomenon has been proposed (Salehabadi *et al.* 2015). In that study among 7 to 21-year-old girls from Kolkata, India during 2005–2011, the authors explained the advantage of the maximum likelihood estimator based on recall data over that based on SQ data. Recalled AAM and menopause information were found to be quite reliable also in earlier studies from Yucatan, Mexico (Dickinson *et al.* 1995).

Some studies had been done on menarche and pubertal growth among girls from central and northeastern Mexico (Aréchiga *et al.* 1999, Méndez-Estrada *et al.* 2006, Torres-Mejía *et al.* 2005), the state of Oaxaca (Malina *et al.* 2004), and the city of Merida, Yucatan (Datta Banik, Dickinson 2014, 2016, Datta Banik *et al.* 2015, Dickinson *et al.* 1995, Méndez-Domínguez 2010, Wolanski *et al.* 1993a, b, 1998, 2010). However, reports on comparative studies of AAM estimation methods from Mexican girls or women were not available that raised our interest.

The hypothesis of the present study was that use of corrected AAM data might have further implications on the estimation of early menarche (EM <12 years of age), intermediate menarche (IM between 12.0 and 13.9 years of age) and late menarche (LM ≥14 years of age). The selection of appropriate methods to estimate AAM is an important task particularly in those populations where health implications of timing of maturation are observable.

The aims of the present study were:

1) To estimate median AAM using status quo (SQ) data and to examine the differences with estimated values of AAM based on recall data.
2) To apply retrospective AAM data correction procedures used in earlier studies (Freedman *et al.* 2002, Padez 2003) and to observe the differences with self-reported information (uncorrected or AAM_{UC}) with respect to the estimation of EM, IM, and LM.
3) To calculate SQ data-based maturation age (MA) and to observe the differences of MA among EM, IM, and LM girls.

PARTICIPANTS AND METHODS

The present report is based on a cross-sectional study carried out during 2008-2010. The study was part of a research project (see Acknowledgements) that included girls between 9 and 17 years of age. As described earlier (Datta Banik *et al.* 2015), a nonprobability sample (Cochran 1977) of 540 girls was drawn from selected public and private schools in Merida, Yucatan, Mexico. The schools were located in the northern, southern, eastern, and western zones of the city of Merida and were selected at random from the available list of schools (Source: Secretary of Education of the State of Yucatan). However, the sample was not a representative one from Merida. Decimal age of the participants was calculated using date of birth and that of survey. In the study, retrospective information and SQ data on menarche were recorded from adolescents (9 to 17 years of age, n = 536, post-menarche = 422) (*Table 1*). Data of 4 girls were not available because they were not confident to recall the AAM.

Population backgrounds of the participants were heterogeneous, including Maya and non-Maya ethnicity (based on paternal and maternal surnames). Socioeconomic status including monthly family income of the participants ranged from approximately 100 to 1,875 U.S dollars per month that had been described earlier (Datta Banik *et al.* 2015). Fathers had occupations ranging from low- to medium-salaried technical jobs and general services (office assistants) to relatively high-paid professionals (entrepreneurs, administrators, and teachers). Mothers were either housewives or working (services and business).

A pre-tested and validated questionnaire was used in the interview (Dickinson *et al.* 1995, Wolanski *et al.* 1993a, b, 1998, 2010). The participant girls were asked whether they had ever had a menstrual period (explained verbally). Dichotomous responses (yes or no) were recorded as SQ data. The post-menarcheal girls were asked to recall the year and calendar month (near approximation) of their first menstruation. However, the respondents could not recall the exact date of menarche. The authors (HA and FD), along with trained co-workers (see Acknowledgements) confirmed the information from the mothers of the participants. In a recent report based on a study among 7 to 21-year-old girls from Kolkata, India during 2005–2011, the authors mentioned that some respondents recalled the date exactly, some recalled only the month or the year of the event, and some were unable to recall anything. The parametric and non-parametric estimator analyses showed partially recalled part of the data led to smaller confidence intervals of the survival function (Salehabadi *et al.* 2019).

The recall data of AAM correction was done following the methods reported earlier (Freedman *et al.* 2002, Padez 2003). The corrected AAM by the first method (AAM_{C1}) was calculated by dividing the number of days between birth and July 1 of the recalled year by 365.25 (Freedman *et al.* 2002). In the second method, AAM was estimated by asking the girl participants to recall their menarche and then corrected AAM (AAM_{C2}) was calculated by systematically adding 0.5 years to the age obtained (Padez 2003). Based on retrospective data of AAM (both self-reported and corrected), girls were grouped into EM (<12 years of age), intermediate menarche or IM (12.0 and 13.9 years of age) and LM (≥14 years of age) (Must *et al.* 2005).

The research project protocol was approved by the Bioethics Committee of the Center for Research and Advanced Studies (*Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional* or Cinvestav-IPN for its Spanish acronym), the Ministry of Education of the State of Yucatan, and the authority of the schools where data were collected. In some cases, interviews were taken visiting home of the participants. Written informed consent was obtained from the parents and/or legal guardians of the participants before the commencement of the study. All participants verbally agreed to take part in the interview.

The Microsoft® Excel and SPSS statistical software (version 13.00, Chicago, Illinois, USA) were used for data analysis. Descriptive statistics including mean, median, with 95% confidence interval (CI) and standard deviations (SD) were calculated for chronological age (years) and AAM (recall information, both uncorrected and corrected). Paired t-test was used to observe differences between the mean values of AAM (uncorrected and corrected); parametric and non-parametric bivariate correlation coefficients were calculated to estimate association and agreements between the values of AAM and categories (yes or no) of menarche (EM, IM, and LM), respectively. The median AAM was computed through probit analysis to model the proportion of post-menarcheal girls (SQ data) as a function, considering chronological age (years) as a covariate.

As a part of the study, it was also interesting to explore an estimation of maturation age (MA) of the girls and to see the differences of mean values of MA in EM, IM, and LM groups. The MA was calculated as: chronological age + (median AAM of the reference value – median AAM based on probit analysis of SQ data) (Wang, Adair 2001). In absence of any reference value of median AAM from Mexico (regional and national), we used the median value of AAM as reference from a relatively recent report from Yucatan (Méndez-Domínguez 2010) that was 12.28 years. This value was little different from the reference value of median AAM (12.8 years) (WHO 1995) that was used in earlier report (Wang, Adair 2001). Statistical tests were two-sided and significance was set at $\alpha = 0.05$.

TABLE 1: Descriptive statistics of age at menarche (mean and standard deviation) and proportion of attained menarche by age (years). SD: Standard deviation.

Age (years)	Age range	n	Mean (SD)	Attained menarche (%)
9	9.08 – 9.96	52	9.54 (0.32)	17.31
10	10.00 – 10.94	61	10.52 (0.26)	42.62
11	11.03 – 11.99	66	11.50 (0.26)	63.64
12	12.03 – 12.99	84	12.48 (0.27)	91.67
13	13.00 – 13.97	63	13.45 (0.29)	92.06
14	14.01 – 14.98	46	14.40 (0.29)	100.00
15	15.01 – 15.98	55	15.53 (0.26)	100.00
16	16.06 – 16.98	66	16.50 (0.26)	100.00
17	17.00 – 17.89	43	17.35 (0.28)	100.00

RESULTS

Mean age of the girls (n = 536) was 13.33 ±2.46 years (range: 9.08 to 17.89 years). Relatively fewer girls had menarche at 9 years (17.31%) and all girls were post-menarcheal above 14 years of age (*Table 1*). Median AAM was 11.34 years (SD = 0.13, CI 11.06–11.59 years) based on SQ data. The distribution of data for probit analysis did not differ from normality (Pearson chi-square = 5.70, p = 0.56). Among the participants, 30.9% had short-term recalled menarche (<12 months). Mean values of recalled AAM (uncorrected) was 11.57 ±1.20 years whereas mean values of corrected AAM based on methods proposed in earlier reports were 11.53 ±1.21 years (Freedman *et al.* 2002) and 12.21 ±1.32 years (Padez 2003) (*Table 2*).

Paired difference of mean values between uncorrected (AAM_{UC}) and corrected AAM (AAM_{C1}) was estimated to be lower (0.03 years) (Freedman *et al.* 2002) than the difference between uncorrected (AAM_{UC}) and corrected AAM_{C2} (0.64 years) (Padez 2003). The paired difference of mean values of corrected AAM (AAM_{C1} vs. AAM_{C2}), estimated using two methods (Freedman *et al.* 2002, Padez 2003) was also 0.64 years. The differences of mean values were significant ($p<0.05$). The EM estimated in the sample was 47.15% (AAM_{UC}), 60% (AAM_{C1}, Freedman *et al.* 2002) and 25.93% (AAM_{C2}, Padez 2003). The LM estimated by the corresponding methods were 3.95%, 2.96% and 14.81% respectively. Chi-squared test showed significant differences ($p < 0.05$) between the estimates of uncorrected and corrected methods

TABLE 2: Descriptive statistics of estimated age at menarche (AAM) of girls (n = 536, post-menarche = 422) in years, using different methods for retrospective data. AAM: Age at menarche; AAM_{UC} = Age at menarche (uncorrected); AAM_{C1} = Age at menarche corrected (based on Freedman *et al.* 2002); AAM_{C2} = Age at menarche corrected (based on Padez 2003); SQ: Status quo; EM: Early menarche, <12 years; IM: Intermediate menarche, 12–13.99 years; LM: Late menarche, ≥14 years; NA: Not available.

Statistic	SQ (probit analysis)	AAM_{UC}	AAM_{C1}	AAM_{C2}
Median AAM (years)	11.34	12.00	11.59	12.00
Mean AAM (years)	NA	11.57	11.53	12.21
SD of mean	NA	1.20	1.21	1.32
95% CI (upperbound)	10.59	11.45	11.41	12.08
95% CI (lowerbound)	10.06	11.68	11.65	12.34
EM (%)	NA	47.16	60.00	25.93
IM (%)	NA	48.89	37.04	59.26
LM (%)	NA	3.95	2.96	14.81

(based on Padez 2003) and between the estimated values using two reported methods for AAM correction (AAM_{C1} vs. AAM_{C2}; Freedman *et al.* 2002 vs Padez 2003). Pearson's correlation coefficients between three values of AAM (AAM_{UC}, AAM_{C1}, and AAM_{C2}) were remarkably high ($r > 0.86$) and thereby significant ($p < 0.05$). The EM, IM and LM estimated by uncorrected and corrected AAM had high correlations (Spearman's rho, $p<0.05$) (*Table 3*). Intraclass correlation coefficients between the estimates of EM, IM, and LM were: AAM_{UC}, AAM_{C1}, and AAM_{C2} = 0.75; AAM_{UC} and AAM_{C1} = 0.83; AAM_{UC} and AAM_{C2} = 0.70; AAM_{C1} and AAM_{C2} = 0.45. The mean value of maturation age (MA) of the girls was 15.28 ±2.15 years (95% CI between 15.17 and 15.59 years). The mean values of MA in EM, IM and LM groups were: 14.67 ±2.33 years, 15.89 ±1.73 years and 17.46 ±1.27 years respectively.

DISCUSSION

Mean value of AAM was 11.57 years among the girls from Merida, Mexico that was lower than the mean AAM reported over two decades before from the city of Merida (12.09 years) and the neighborhoods close to the port of Progreso (12.24 years), both in Yucatan (Wolanski *et al.* 1993a, b). We find an apparent decline of AAM over time.

Globally, secular trend data showed there was a declining pattern of AAM in most countries (Karapanou, Papadimitriou 2010). In the earlier report (Wolanski *et al.* 1993a), comparative data of mean values of AAM from other Mexican States during the 1980s and 1990s were presented. The mean values of AAM were ranging between 12.0 and 14.5 years. In the same report, data from Chile and Venezuela also showed mean of AAM >12 years. The mean AAM value in the present study was lower than that reported earlier from some other Latin American countries: mean AAM 12.63 years was reported from the city of El Yopal, Colombia (Ireton *et al.* 2011), and 12.70 years from Santiago, Chile (Hernández *et al.* 2007).

A study from two neighborhoods of Mexico City, reported median age at menarche of 12.64 and 12.39 years, based on SQ data (Aréchiga *et al.* 1999). In the same report, mean values of AAM from other studies in Mexico were found to be >12 years of age. Malina *et al.* (2004) reported secular change of AAM between 1978 and 2000 in a rural Zapotec-speaking community from Oaxaca in southern Mexico: the median value of AAM of 9 to 18-year-old girls was 14.8 years in 1978 and 13.0 years in 2000. In a study from northwest of Mexico, school going girls of 7 to 17 years of age had a median AAM of 12.06 years (based on SQ data) (Méndez-Estrada *et al.* 2006). Another study also reported a consistent trend of decline in mean values of AAM in Mexico over decades (Marván *et al.* 2016). The report was based on a study on secular change of AAM; data from 8 to 17-year-old girl students in Mexico City and the city of Xalapa were compared with that of women born between 1904 and 1999 and grew up in Mexico City (based on the reports of Mexican National Health Survey). The authors reported mean value of AAM of girl students was much lower (11.40 years from Mexico City and 11.34 years from the city of Xalapa) than the values reported in earlier decades: ≤1940s: 12.95 years, 1950s: 12.58 years; 1960s and 1970s: 12.52 years; 1980s: 12.20 years and in 1990s: 11.52 years. Azcorra *et al.* (2018) in their study from the cities of Merida and Motul in Yucatan, Mexico reported a decline of mean AAM in two generations (246 dyads of Maya mothers and their daughters): among mothers (mean age 59.60 years)

TABLE 3: Differences in mean values and correlation between estimated uncorrected and corrected age at menarche. AAM = Age at menarche; AAM_{UC} = Age at menarche (uncorrected); AAM_{C1} = Age at menarche corrected (based on Freedman *et al.* 2002); AAM_{C2} = Age at menarche corrected (based on Padez 2003); SD: Standard deviation. *Non-parametric correlation between EM, IM and LM.

AAM	Paired t-test					Spearman's rho*	
	Mean difference			Pearson's correlation			
	Mean (SD)	t	p-value	r	p-value	t	p-value
AAM_{UC} vs AAM_{C1}	0.03 (0.24)	2.83	**0.005**	0.980	**<0.001**	0.792	**<0.001**
AAM_{UC} vs AAM_{C2}	0.64 (0.62)	19.87	**<0.001**	0.882	**<0.001**	0.625	**<0.001**
AAM_{C1} vs AAM_{C2}	0.64 (0.62)	20.78	**<0.001**	0.856	**<0.001**	0.564	**<0.001**

and their daughters (mean age 33.03 years); mean values of AAM were 12.53 years and 12.05 years respectively.

In the present study, median AAM estimated by probit analysis was remarkably lower (11.34 years). The distributions of AAM in cases of recall data (uncorrected and corrected) were different from that of SQ data; estimated median values of AAM (retrospective and SQ) were also different. The mean values of AAM estimated by recall data (both uncorrected and corrected) had bias for post-menarcheal girls whereas probit analysis had a probability distribution of menarche. No record of median AAM, using SQ data was available from the previous reports from Yucatan to compare with the results of the present study except one (Méndez-Domínguez 2010). The study among 444 girls of 9 to 17 years of age from Merida, Mexico reported median and mean AAM as 12.28 years and 12.06 years respectively that were much higher in comparison with the corresponding values reported in present study.

The uncorrected AAM (AAM_{UC}) and corrected AAM (AAM_{C1} and AAM_{C2}) using methods reported earlier (Freedman *et al.* 2002, Padez 2003) showed significant correlation between pairs (AAM_{UC}, AAM_{C1}, AAM_{C2}, and the estimated frequencies of EM, IM and LM). The least difference of mean values (0.03 years) of AAM and highest correlation coefficients (Pearson's r = 0.98, Spearman's rho = 0.79) were found between AAM_{UC} and the AAM_{C1} (Freedman *et al.* 2002). The correlation coefficients (both parametric and non-parametric) between AAM values and between the frequencies of EM, IM, LM were important to observe the agreements between values (continuous and categorical), estimated using uncorrected and corrected recall data. However, differences of mean values of AAM between two other pairs (AAM_{UC} and AAM_{C2}; AAM_{C1} and AAM_{C2}) were relatively higher (>0.6 years, $p < 0.05$) but the estimated AAM values (AAM_{C1} and AAM_{C2}) were significantly correlated ($p < 0.05$).

In literature, it was reported that EM was associated with several biological factors (genetic, nutrition, growth, health status) and socioeconomic backgrounds (Must *et al.* 2005). Studies from Mexico, based on the same database of the present study (using different sub-samples) reported that AAM had negative correlation with body fatness, overweight and obesity (Datta Banik, Dickinson 2014, 2016, Datta Banik *et al.* 2015). Conspicuous interrelationships between AAM, socioeconomic backgrounds and nutritional status were also reported from Mexico and other Latin American countries (Hernández *et al.* 2007, Méndez-Domínguez 2010, Torres-Mejía *et al.* 2005). Therefore, estimation of EM based on AAM is very important in public health nutrition research to prevent and manage obesity-related problems in adolescent girls. It is also important to take early and appropriate measures to avoid further health complications in adulthood like breast cancer and cardiovascular diseases that are reported to be associated with EM in adolescence (Méndez-Domínguez 2010, Must *et al.* 2005). Late maturation also had several health implications like lower bone mineral density and thereby higher risk for osteoporosis (Karapanou, Papadimitriou 2010). In our study, EM frequency estimated by AAM_{C1} (Freedman *et al.* 2002) was also higher than the calculated values using AAM_{UC}. However, LM frequency estimated by the two methods differed by only 1%. The corrected mean $AAM_{C2,}$ based on other method (Padez 2003) underestimated EM and overestimated LM when compared with the corresponding frequencies based on AAM_{UC}.

Using the same database of the present study, a recently published article reported height growth estimation using the Preece-Baines Model 1 (Datta Banik *et al.* 2017). The study included 500 girls of 9 to 17 years of age; an estimated age at maximum increment of height in girls was 11.01 ±1.15 years. If we consider the general biological principle that menarche occurs sometimes after the spurt in height growth (Ulijaszek *et al.* 1998), then estimated mean AAM_{UC} in the present context (11.57 years) corresponds to the estimated age at peak height velocity (11 years) of the girls (Datta Banik *et al.* 2017). The mean values of corrected AAM (AAM_{C1} and AAM_{C2}) based on reported methods (Freedman *et al.* 2002, Padez 2003) were also higher than the estimated age at peak height velocity.

CONCLUSION

The present study is a report on comparative statement of estimated AAM, using different data and statistical methods in a sample of 9 to 17-year-old girls from Merida, Mexico. No earlier report of this kind from Mexico is available. Median AAM estimated by probit analysis (SQ data) was lower than median and mean values of estimated AAM using recall data (uncorrected and corrected). Following the method of age correction (Freedman *et al.* 2002), the estimated mean value of

AAM_{C1} was closer to the mean AAM_{UC}. Despite having high correlation between the AAM values, based on uncorrected data and the corrected estimates (AAM_{C1} following Freedman *et al.* 2002, and AAM_{C2} following Padez 2003), the frequencies of EM and LM varied significantly between the results obtained using different methods. In the present sample, we had 31% short-term recall data of AAM when the maximum time interval between menarche and the reporting day (date of survey) was less than 12 months. We would propose that the correction of recall data in such cases are not necessary using either AAM_{C1} or AAM_{C2} in order to maintain precise information of menarche.

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