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Linking Health, Nutrition and Wages: The Evolution of Age at Menarche and Labor Earnings Among Adult Mexican Women

By

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Introduction:

The potential of a nation to achieve economic growth and development is reflected in the health and nutritional status of the population. For the individual, and particularly at low levels of income, health may be an essential determinant of productive capacity in the labor market, and hence of earnings and the capacity to escape poverty.

The relationship between health, nutrition and income has been an important element in theories of economic development, particularly as expressed in nutrition-based efficiency wages (Leibenstein, 1957; Rozensweig, 1988; Strauss, 1998). Economic history has also been advanced considerably by recent efforts to deepen and extend the analysis of the relationships between long-run changes in the health of populations and the process of economic development and structural transformation (Fogel, 1994; Steckel, 1995). Recently, knowledge of the link between health and income has been enriched by empirical evidence of the causal impact of health on wages and productivity among poorer populations (Strauss and Thomas, 1998). The relationship between labor productivity and health is now being explored in an integrated human capital framework (Schultz, 1997; Schultz and Tansel, 1997; Schultz, 1996; Strauss and Thomas, 1997). Models of economic growth have been extended to include the importance of health as a human capital input (Barro, 1995). These breakthroughs are a product of both advances in economic theory and in the quality of data. The surge in research in this topic also reflects increasing recognition of the opportunities, and challenges, for formulating relevant and effective health policies.

This study uses a human capital framework to evaluate the impact on labor market productivity of investments in health and nutrition in Mexico. The research extends the existing literature by proposing age at menarche as an effective indicator for analyzing the impact on productivity in the labor market of health and nutritional investments during childhood and adolescence. As in the case of adult height and body mass index, indicators that have been widely used in the analysis of the health-productivity relationship, menarche is a variable that reflects the secular increase in the level of economic development of many countries in the region (Brundtland and Walløe, 1973; Marshall, 1978; Malcolm, 1978; Wyshak and Frisch, 1982; Wyshak, 1983, Manniche, 1983; Wellens et al., 1990; Hulanicka and Walizko, 1991; Liestol and Rosenberg, 1995). Age at menarche has shown a steady decrease of approximately 3-4 months per decade in many countries over the past 150 years. This decrease is a reflection of a variety of socioeconomic factors and in particular nutritional status as a child. Despite the parallels between menarche and adult height as indicators of cumulative health status, age at menarche has apparently not been previously incorporated into the analysis of the impact of health on economic development.

The paper considers the correlates of age at menarche in the framework of a reduced form health production function. Particular emphasis is placed on the importance of policy-sensitive health variables as determinants of age at menarche, and hence long-run female health. Hourly wages are used to measure the impact on labor market productivity of investment in health and nutrition early in the life cycle. Age at menarche is presented as a proxy for certain aspects of the health and nutritional components of human capital. The integrated human capital framework that underlies the theoretical model is developed in Schultz (1997), and applied in such works as Schultz (1996), Schultz and Tansel (1997) and Strauss and Thomas (1997).

The first section of the paper provides a brief introduction to the recent evolution of health in Mexico. The following section discusses menarche as an indicator of health and nutritional status. The third section provides an overview of the data used in the analysis. The next part summarizes the model and the estimation strategy following Schultz (1996) and Schultz and Tansel (1997). Section five provides descriptive statistics, with particular emphasis on the distribution of menarche by cohort, level of education, and hourly wages. The results of the first-stage, reduced form estimates of the health production function are given in section six. The next section presents the instrumental variable estimates of the wage regressions, emphasizing the relationship between age at menarche and wages. The conclusions and policy recommendations are given in the final section.

The model uses an instrumental variable approach given the significant degree of measurement error that is inherent in retrospective information on menarche. The instruments used to identify menarche are based on the availability of personal health services, public services, housing quality, average levels education, and access to educational facilities in the community. A number of variables are included in the wage function to control for variation that is related to genetic and other determinants of menarche. These variables are expected to be uncorrelated with the reproducible component of health human capital.

It is important to note that the measure of the impact of age at menarche on labor market productivity is a lower bound estimate of the welfare impact of ill health (Schultz and Tansel, 1997). First, age at menarche measures only a few of many dimensions of health. In particular, it is a cumulative measure reflecting investments in early nutritional status and other investments in childhood health. In addition, labor market productivity and wages reflect only one aspect of the myriad implications of adult ill health in terms of personal and family welfare.

It is useful to clarify that in this paper and given the nature of the data, menarche is considered as the onset of the first menstrual cycle. Puberty is a collective term that summarizes a set of morphological and physiological processes that are the result of complex developmental processes in the central nervous and endocrine systems. In women, these processes include: the adolescent growth spurt, the development of secondary reproductive organs and sex characteristics, changes in body composition, and development of the circulatory and respiratory systems leading to increases in strength and endurance. Menarche is a relatively late event in physical development that typically occurs after the adolescent growth spurt and typically following the peak in growth (Marshall, 1978; Tanner, 1962).

I. The Transformation of Health and Nutrition in Mexico

Mexico is a particularly interesting case for the study of the evolution of age at menarche. While the country is well into its epidemiological transition, the process has been characterized as 'protracted and polarized' (Frenk et al., 1989). This is a reflection of inequalities that include both income and access to resources such as health services. Mexico faces combined challenge. The backlog of 'pre-transitional' diseases, many of which are infectious or based on nutritional deficiencies, related to infant and maternal mortality, and preventable with relatively inexpensive public health interventions are juxtaposed with an increasing health burden from chronic, non-infectious illness. These are the diseases that disproportionately affect the poor (Frenk et al, 1989; Frenk, Lozano and Bobadilla, 1994).

As has been the case in many Latin American countries, the decline in mortality in Mexico has occurred quickly. Life expectancy almost doubled between the early 1900's and 1950, and is currently over 70 years. Infant mortality has dropped considerably from 323 per 1000 live births in 1910 to close to 40 in the last decade (Frenk et al., 1989; Bobadilla et al., 1993). Similarly, the proportions of deaths related to maternal mortality and malnutrition have declined substantially (Frenk, González Block and Lozano, 1994).

While historical data on nutrition are scarce, there is evidence that the prevalence of malnutrition is has been rising in some rural areas and declining in others. Overall, the proportion of rural children age 1 to 5 with normal height for age increased from 49% in 1974 to 52% in 1996. Further, the both mortality and morbidity attributable to nutritional deficiencies declined based on data from 1990 to 1996 (Salud Pública de México, 1998; Avila et al, 1998). Figures for the region are both more accessible and more dramatic. The prevalence of nutritional deficiency dropped from affecting 19% of the population of Latin America and the Caribbean in the period 1969 to 1971, to 15% in 1990-1992 and is projected to reach 7% in 2010 (FAO, 1996).

Health indicators for Mexico, while clearly demonstrating a tendency to improve, are less advanced than they should be when considered as a function of the country's level of economic development. The reduction in the proportion of deaths attributable to infectious disease has been slower than in many other Latin American countries. The figure went from 30% in 1960 to 13% in 1985. By comparison, in Argentina, Cuba, Costa Rica and Chile the figure is now well below 10% (Frenk, Lozano y Bobadilla, 1994). Similarly, the ratio of deaths from infectious and parasitic diseases to deaths from non-transmissible diseases is approximately unity, while the figures are below 0.5 for several other countries with similar levels of per capita income.

The differences within and between regions and municipalities reflect the high degree of inequality in both health status and the distribution of health services. Infant mortality in the southern, poorer states showed figures of approximately 147 in the early 1960s and 92 in the 1980s. In the wealthier, northern region the figures are 92 and 28, respectively. The ratio of infant mortality between the southern and northern regions went from 1.6 to 3.3 over the same period (Bobadilla et al., 1993). The differences within states also suggest important inequalities based on rural versus urban residence.

The health situation that has resulted from this prolonged and polarized epidemiological transition places a heavy burden on a relatively extensive, but inefficient, health system. The Mexican system is dualistic. The poor and uninsured have access to the public health system run by the Secretariat of Health. In contrast, the insured, working population has the right to use the Mexican Social Security Institute which covers close to half of the labor force and their families. Despite this coverage, many people use and pay out-of-pocket for private services. This is an indicator of overlap in, inefficiencies of, and dissatisfaction with, the system (Zurita, Nigenda, Ramírez, 1997; Knaul, Parker and Ramírez, 1997; Frenk, González Block, Lozano et al., 1994).

Further, the distribution of health services parallels and hence often intensifies the existing inequalities in the health status of the population. For example, Frenk et al. (1995 and 1997) show that there are approximately 200 inhabitants per physician in Mexico City, a figure that exceeds the average in many developed countries. The figures are, however, much higher in the poorer states and in the rural areas. In Oaxaca there are an estimated 1120 inhabitants per doctor, and in Chiapas there are 1370. In partial recognition and response to the deficiencies in the health system, reforms have been initiated at the IMSS and a system-wide process of decentralization is well underway (Frenk, 1997).

II. Menarche as a measure of health and nutritional status:

Fogel (1994) and Steckel (1995) highlight the secular improvements in mortality and morbidity, and their relationship to a complex set of factors associated with economic development. These factors include improvements in nutritional status, medical technology, access to health care and better education, public health facilities and hygiene.

Height and weight have traditionally been used as predictors of morbidity and mortality risk among children. More recently, adult height and body mass index (BMI) have been put forward as indicators of the probability of dying or of developing chronic diseases at middle and late ages (Fogel, 1994; Strauss and Thomas, 1997; Schultz, 1996), and as measures of living standards (Steckel, 1995).

Adult height and BMI measure different aspects of nutrition and health. Adult height is considered an indicator of nutritional status during infancy, childhood and adolescence. BMI is a measure of current nutritional status. This evidence is analyzed and extended in Fogel (1994), who documents the secular increase in average height and BMI in several European countries between the seventeenth and nineteenth centuries. This evidence is used to develop an argument for the importance of physiological factors in economic growth.

The research summarized in this paper adds another dimension to the existing literature on the importance of health as a reproducible form of human capital. In this paper, age at menarche is used as an indicator of the result of investments in nutrition and health during childhood and adolescence. This parallels the work that other researchers have undertaken using adult height as an indicator. The logic of the association between menarche or adult height and investments in health and nutrition is based on the idea that, in a fixed population that does not experience variation in its mix of biological groups, changes over time in average height or age at menarche may be attributed to changes in reproducible human capital investments and changes in disease environments (Schultz, 1996; Fogel, 1994; Steckel, 1995). Further, a number of studies have shown the significant impact on labor productivity of investment in health and nutrition as measured by height and BMI in an integrated human capital framework. These include Schultz (1996) for C^te d'Ivoire and Ghana, and Thomas and Strauss (1997) for urban Brazil.

Several authors have pointed to the importance of average age at menarche as an overall, comparative indicator of population health, timing of maturation and nutritional status (Hediger and Stine, 1987; Malcolm, 1978). Further, there is a close link between adult height, the timing of the adolescent growth spurt, height for age and age of menarche that has been documented in a variety of countries and settings (Malcolm, 1978). Trussel and Steckel (1978) use data on height velocity for female slaves transported within the United States in the 1800s to predict probable age at menarche. Díaz de Mathman, Landa Rico and Ramos Galván (1968) find that Mexican adolescents are significantly older at menarche when they are malnourished, as compared to the well nourished. Yoneyama, Nagata and Sakamoto (1988) found that age at menarche was an important predictor of adult height in a study of Japanese girls.

Some evidence suggests that age at menarche may be an important complementary indicator to adult height, and possibly a more accurate tracer of early nutritional status in certain cases. Specifically, 'catch-up' growth may allow certain individuals to attain a normal height, given the expectations of their genetic group, despite having suffered from malnutrition or poor health during childhood (Floud, 1994). Catch-up growth will reduce the effectiveness of adult height as a measure of cumulative health status, to the extent that malnutrition and ill health are expected to have effects on productivity that are independent of completed height. A delay in menarche, on the other hand, may be a more dependable tracer of malnutrition and ill health during childhood and adolescence because it is a one-time event that occurs during puberty. For example, Eveleth (1978) citing the study by Dreizen et al (1967) suggests that girls suffering from chronic malnutrition in a poor, rural area of the United States were delayed in age at menarche and skeletal maturation as compared to a control group. The completed height of these two groups was not significantly different, although the malnourished group was shorter than the control group during the period of adolescent growth. Laska-Meirzajewska (1970) found that age at first menstruation was more sensitive to external conditions related to socioeconomic status and family well being than height or weight among a sample of Polish girls. Further, Liestøl and Rosenberg (1995) suggest that menarcheal age, possibly related to changes in weight, may be more sensitive than height to regional differences in poverty among schoolchildren in Oslo.

Both age at menarche and adult height have demonstrated secular improvements. These improvements are likely to be closely related to increased nutritional standards (Trussell and Steckel, 1978). Marshall (1978) evaluates a group of studies of age at menarche and concludes that, despite differences in data quality, they are remarkably consistent in illustrating an average decline of 3 to 4 months per decade over the past 100 years. The secular decline is also evident over the past 100 to 150 years in a variety of developed countries based on aggregate trends (Wyshak and Frisch, 1982). The estimated rate of decline is between 2 and 3 months per decade. Brundtland and Walløe (1973) cite evidence from North America, Japan and Europe to show that girls have been maturing faster over the past 50 years at a rate of about 4 to 5 months per decade. More recent studies have confirmed this tendency for well nourished women in the United States born since 1920 (Wyshak, 1983), Denmark since the 1940s (Manniche, 1983), Flemish women in the nineteenth century (Wellens et al., 1990), Poland since approximately 1950 (Hulanicka and Walizko, 1991), and Norway among school children since the 1920s (Brundtland and Walløe, 1973; Liestol and Rosenberg, 1995). Further, these studies suggest that the trend is coming to a halt among some well-nourished groups of high economic status in developed countries coincident with a threshold age at menarche (Brundtland and Walløe, 1973).

The determinants of age at menarche can be divided into genetic and environmental factors, where the latter are widely thought to reflect nutritional differences. The literature on adolescent growth widely concurs in establishing the link between malnourishment in infancy and childhood, later age at menarche and a slowdown in growth (Díaz de Mathman, Landa Rico and Ramos Galván (1968); Marshall, 1978; Eveleth, 1978; Frisch and Revelle, 1970; Maclure et al., 1991; Liestol, 1982; Trussell and Steckel, 1978). Environmental factors such as socioeconomic status, urban residence, number of siblings, birth order, racial differences, climate, altitude, physical activity, psychological stress, season of year and presence of a related male in the family, have all been put forward, with the former two being the most consistently associated with menarche (Eveleth, 1978; Marshall, 1978; Malcolm, 1978; Moisan, Meyer and Gingras, 1990; Weir et al, 1971; Komlos, 1989; Ulijaszek, Evans and Miller, 1991; Bojlén and Weis Bentzon, 1971; Valenzuela, Nuñez, and Tapia, 1991; Delgado and Hurtado, 1990; Cumming, 1990; Treloar and Martin, 1990; Graber, Brooks-Gunn and Warren, 1995; Bielicki et al, 1986). Racial differences also figure prominently in many of these studies. These partially reflect variation in socioeconomic and climatic factors, but may also have an important genetic component.

Heredity-related or genetic factors may dominate among well-nourished populations (Stark, Peckham, and Moynihan, 1989) and appear to be more important among later cohorts (Treloar and Martin, 1990). This is supported both by important population differences and by studies comparing twins to other siblings. These studies show much larger differences in age at menarche between non-twins (Eveleth, 1978; Marshall, 1978).

In summary, literature from a variety of countries demonstrates a secular decline in the age at menarche throughout the world. This research suggests that, while a variety of environmental and genetic factors may make the analysis less precise, menarche is earlier among healthier and better-nourished girls and adolescents. For the purposes of the research presented below, the crucial hypothesis developed in this section of the paper is that age at menarche is a plausible proxy for measuring part of the differences in adult labor market productivity among women that result from investments in nutrition and health during childhood and adolescence.

III. Data:

The main data source for this study is the National Family Planning Survey (NFPS, *Encuesta Nacional de Planificación Familiar*), undertaken by *Consejo Nacional de Población* (CONAPO) in 1995. The NFPS includes an individual, a household and a community questionnaire. The individual survey is directed toward the target population of women aged 15 to 54 who are living permanently or temporarily in the household included in the survey. This part of the NFPS was answered directly by each woman and includes detailed fertility and marital histories, as well as socioeconomic characteristics and work activity. The household questionnaire considers socio-economic characteristics, family structure, work activities and condition of the dwelling. The community survey was carried out in *localidades* (primarily those with less than 5000 inhabitants[1]) and was directed at a community leader. This part of the NFPS includes information on basic characteristics of the community including information on access to and use of health and educational facilities.

[1] While the questionnaire and manuals report that the community segment was exclusively directed at *localidades* with a maximum of 2500 inhabitants, the data analysis shows a large proportion contain between 2500 and 5000 inhabitants according to the responses of the community

The sampling frame of the NFPS is designed to overrepresent the poorest, most rural states. In particular, 9 states account for 90% of the sample. The information for the other 23 and most populous states is given by the remaining observations, which amount to approximately 1000 cases in the overall sample of women and 300 female wage earners. The survey includes expansion factors that are designed to restore the balance between States and to provide appropriate estimates for the country as a whole. Still, given the low number of observations for the 23 undersampled states, the analysis of age at menarche using the expansion factors proved to be somewhat unstable. As a result, the information provided in this paper is based on the unexpanded figures, which implies that the estimates do not necessarily reflect the distributions within the population as a whole.[2] In order to account for the important geographic differences in socio-economic status and the availability of health services, the regressions include either a dummy variable for rural versus urban residence (rural=1) and another for the overrepresented states (Chiapas, Guanajato, Guerrero, Hidalgo, Mexico, Michoacan, Oaxaca, Puebla and Veracruz=1), or a full set of State dummies.

It is important to highlight that in the NFPS, women who are interviewed in the individual survey self-report all variables.[3] This clearly improves the quality of the data in the sense that the self-reported responses are likely to be more correct. In particular, the labor market variables are reported both as part of the household survey, and in many cases by a proxy respondent, and then repeated by the individual as own-respondent. Comparing the two responses suggests that they differ substantially. For this reason, the data in this research is based on the self-reported information.[4]

There are two severe restrictions in terms of the data available from the NFPS. First, the only measure of adult health is menarche so that it is impossible to be more encompassing of the impact of different aspects of health status on wages. Further, the data includes no information on place of birth or migration.

In addition to the information available from the community segment of the NSFP, this research uses two sources of municipality-level information. This first is the *Indicadores Socioeconómicos e Indice de Marginación*

leaders.

[2] The descriptive figures using expansion factors are available from the author upon request.

[3] The fact that only self-reported information is accepted in the survey also generates a sampling problem. Approximately 10% of women aged 18 to 54 identified in the household survey are excluded from the individual data that includes age at menarche. They are excluded for the most part because they could not be located for the interview. This introduces a particular form of selection bias into the research, because the women who were identified in the household survey and not found for the individual interview are more likely to be younger, working, more educated and to earn a higher income (see Appendix 1, Table 1). This bias cannot be explicitly dealt with using the econometric techniques applied in this paper given that age at menarche, as the key variable, is missing for these women. Given that women with these characteristics tend to be younger at menarche according to the available sample, the results of the impact of menarche on productivity may be biased downward.

[4] It would be interesting to conduct a more careful analysis of these differences in the future as a means of bounding the possible error in household surveys where proxy respondents are common.

Muncipal generated by CONAPO in conjunction with the *Comisión Nacional del Agua* in 1993 and based on the results of the *XI Censo General de Población* undertaken by the *Instituto Nacional de Estadística, Geografia e Informática* (INEGI) in 1990. These indicators are disseminated as the *Sistema del Indice de Marginación Municipal (SIMM).* This data was compiled with the purpose of developing an indicator of marginality applicable to all of the municipalities in Mexico. It includes, as proportions of the inhabitants of each municipality: the illiterate adult population, the adult population without complete primary education, those without electricity, those whose homes have earth floors, those who lack toilet and drainage facilities, those without running water, those living in overcrowded homes, individuals in *localidades* with less than 5000 inhabitants, and the working population earning less than 2 minimum salaries[5] per month.

The second source of information at the municipality level is a data base jointly developed by researchers at the *Colegio de México*, the *Consejo Nacional de Población (CONAPO)* and Johns Hopkins University based on the records of the Secretariat of Health (*Secretaría de Salud*) and the Mexican Social Security Institute (*IMSS, Instituto Mexicano del Seguro Social)* (Wong et al., 1997). This database also includes information on private sector health services and personnel taken from the Economic Census undertaken by INEGI. The information on altitude comes from the *Sistema de Información Municipal en Bases de Datos (SIMBAD)* compiled by INEGI and is based on cartographic data (INEGI, 1995). All three data sets were merged with the NFPS at the level of the municipality, with information available for both the urban and rural areas.

IV. The theoretical and empirical framework for modeling health production and labor productivity:

Schultz (1997 and 1996) models household demand for human capital as a derived demand for the services of these human capital stocks. Summarizing this work, household demand for input (j) for individual (i) is given as:

$$I_{ij} = a_j Y_i + ß_j X_i + \mu_{ij}, \qquad j= \text{H or M, E, R and B} \qquad (1)$$

where a critical distinction is between the Y and the X variables. The Y variables affect the demand for human capital through the impact on wage structures and hence via the incentive for investing in human capital, as well as through other channels. By contrast, the X variables affect the demand for human capital without having an effect on wage opportunities. The error term is given by μ.

[5] The minimum salary is a government-imposed floor on wages that applies in the formal sector of the economy.

The inputs in an integrated framework include indicators of early investments in nutrition and health (H for adult height or M for age at menarche) (Fogel, 1994 and discussion above), education (E) (Becker, 1993; Mincer, 1974; Griliches, 1977), migration from region of birth (R) (Schultz, 1982), and body mass index (B for BMI) as an indicator of adult nutritional status and current health (Fogel, 1994; Strauss and Thomas, 1997). In this paper, and given data limitations, only age at menarche and education are considered.

The girl and her family maximize a single period utility function that includes health (h*), proxied by menarche (m*), the non-health-related consumption bundle (C) and annual time allocated to non-wage activities (H2):

$$U = U(h^*, C, H_2) \qquad (2)$$

Equation (5) is maximized subject to the budget, time and health production constraints:

$$RI = HI^*P_1 + C^*P_2 = W^*H_1 + V \qquad (3)$$

$$T = H_1 + H_2 \qquad (4)$$

where RI is market income, P's are market prices, W is the wage rate and V is annual household income from non-human wealth. Total available time (T) is divided into wage work (H1) and non-wage activities.

Cumulative health status is produced over the individual's lifetime and begins with parents' and own investment in nutrition, disease-preventing interventions and practices, and in health conserving behaviors. These health inputs (HI), and heterogeneous endowments of the individual (G) unaffected by family or individual behavior, combine to determine the individual's cumulative health status (h*), proxied by age at menarche (m*):

$$h^* = f(m^*) \qquad (5)$$

$$\text{where, } m^* = m^*(HI, G, \varepsilon) \qquad (6)$$

In equation (6), ε is the error term in the health function. The estimates of the determinants of age at menarche are used as the first stage of the estimation of the wage function.

Expanding on the Mincerian semi-logarithmic framework (Mincer, 1974), the hourly wage of the individual is a function of her cumulative health status as proxied by age at menarche, acquired skills related to education, experience as a quadratic function of aging, the vector of exogenous variables (Y) that are included additively, and other unobserved forms of human capital transfers and genetic endowments:

$$W_i = \Sigma^{n}_{j=1}(d_j I_{ij}) + t Y_i + \phi_i \quad (7)$$

This paper includes only reduced form estimates of the health production function in equation 2.

The econometric strategy is based on an errors-in-variables model identified using instrumental variables. This parallels Schultz (1996), Schultz and Tansel (1997) and Strauss and Thomas (1997). The two stage, instrumental variables approach is designed to correct for the downward bias of the estimated effect of health on wages due to the errors in measuring age at menarche. Reported age at menarche may diverge from true age at menarche by a measurement error (e):

$$m_i = m_i^* + e_i \quad (8)$$

where e is assumed to be a random variable that is uncorrelated with the other determinants of health or modeled aspects of behavior. Note that it is the correlation between ϕ and e that gives rise to bias due to heterogeneity or simultaneity in estimating the wage function. The correlation between the error in the wage function and unobserved health heterogeneity leads to simultaneous equation bias if the observed health inputs are related to the unobserved health heterogeneity. To correct for this problem it is necessary to include in the health demand function, variables that affect health input demand, such as prices or access to health services, yet are not correlated with the health heterogeneity. These variables generate a series of exclusion restrictions that permit identification of the unbiased wage function.

There is ample evidence to support the hypothesis that age at menarche is measured with considerable error, particularly using the type of retrospective data available for this research. The literature on measuring age at menarche highlights the issue of recall error in this type of data. Of the existing means of determining age at menarche, the cross-sectional retrospective method is considered inferior to longitudinal (repeated questioning of adolescents) or status quo (proportion of adolescents who have menstruated by a given age) methods (Marshall, 1978; Brundtland and Walløe, 1973). Several studies have measured the recall error by comparing the results from these different methods. Most notably for this study, Cravioto et al (1987) found that among adolescents from rural Mexico the correlation coefficient between age at menarche from longitudinal data and from recall data collected four years after menarche was only .61. Similarly, only 70% of the adolescents could recall the age at menarche within one year of the actual date. In a study of Swedish teens, Bergsten-Brucefors (1976) found that four years after menarche, only 63% could recall age at menarche within 3 months of the correct date. Hediger and Stine (1987) discuss studies showing that recall capacity falls off rapidly four to five years after the event and then stabilizes. They highlight the finding by Bean et al. (1979) that in a group of US women, an average of 34 years after the event, approximately 90% were able to recall age at menarche within one year. In their own work, Hediger and Stine (1987) find that using information on a group of US adolescents, about half of the sample have low recall ability while the other half remember relatively accurately for several years after the event. They suggest that the probability of recall is not as closely related to the length of time since the event as in other studies.

Recall bias is likely to be associated with three other types of error in the data used in this study. First, age at menarche is reported in completed years so that there will be a consistent downward bias in the mean age. Women are likely to state age based on the preceding birthday although they began to menstruate in the second half of the year (Marshall, 1978). As the data from the NFPS does not record month at menarche it is impossible to correct for this bias directly.

Second, there are many conflicting feelings associated with adolescence and therefore with menstruation that may induce young women to provide inaccurate information, particularly if menarche was very early, very late or especially traumatic. It is difficult to judge the nature or direction of the bias as some women may experience negative feelings and embarrassment causing them to downplay late or early events, while others may do the same due to the positive feelings associated with particular cultural or religious practices (Hediger and Stine, 1987; Amann, G., 1986; Ruble and Brooks-Gunn, 1982). To the extent that older women are less likely to suffer from embarrassment than teens, recall data such as that used here may be more accurate.

Another source of error may be due to women not clearly identifying the onset of menstruation. The particular question used in the NFPS is related to how old the person was when they first menstruated. The exact wording is: *Cuántos años tenía usted cuando le bajó la regla por primera vez*? Given the uneven pattern that is common at the onset of menstruation, it is possible that the women might not associate the first incidence of bleeding with menstruation if it was either very mild or not closely followed in time by another occurrence. There may also be some misinformation and confusion associated with the differences between menstruation, other aspects of puberty and such events as fertility, pregnancy and marriage.

Finally, another source of error may be related to 'telescoping'. Women may tend to report a later, or an earlier, age at menarche as they get older, or as the event becomes more distant in time. This is related to the perception that an event occurred 'a certain number of years in the past'. While the direction of the error may be randomly distributed, it is possible that the accuracy of recall is related to some other factor such as intelligence, education or literacy. Further, these factors may also be related to a woman's ability to interact with the health system. This source of error may therefore by more problematic that those outlined above, as it may be systematically correlated with the instrument set. Unfortunately, additional data on the accuracy of recall would be necessary to evaluate the severity of this problem.

As mentioned above, in order to control for the bias due to simultaneity and measurement error, the econometric analysis in this paper is based on an instrumental variables approach. The instrument set consists of community health infrastructure and water and sanitation conditions, as well as the level of education in the community. These variables are assumed to affect the demand for health human capital inputs, and to be uncorrelated with unobserved health heterogeneity or measurement error, thus identifying the wage equation. The instruments are selected using the results of the literature review, the descriptive analysis and the regressions of the production function of health measured by age at menarche. The specification of the instrumental variables approach to the errors-in-variables is evaluated using Hausman tests (Hausman, 1978; Greene, 1997). In addition, the robustness of the instrumental variable estimate is explored by varying the instrument set.

The other human capital inputs that can be measured using the NSFP are education and post-schooling, potential years of experience. Education is analyzed using both a linear specification in years and using dummy variables for levels. In the latter, zero years of education is the excluded category and the dummies represent some or complete primary education (1 to 6 years), some or complete secondary education include preparatory and technical schools (7 to 12 years), and higher education including non-university training (13 or more years). Experience in the wage equations is formulated in the traditional Mincerian fashion as age less years of education less 6, and included as a quadratic (Mincer, 1974).

Another potential source of bias in the analysis of the impact of health, measured by age at menarche, on wages results from what Schultz (1996) refers to as aggregation. This bias arises when inputs that have different productive effects on wages are combined in a single indicator. In a cross-section, the fraction of the variance in menarche that can be explained by environmental factors may have either a smaller or a larger impact on productivity than the fraction that is largely unaccounted for and based in part on genetic variability. Aggregating the two sources of variation in the single measure of age at menarche may provide misleading results as to the impact on productivity of changes in variables that affect only the environmental aspects of menarche.

This form of bias is partially offset by including, in both the wage and human capital demand functions, a series of variables that are related to the genetic component of age at menarche and to environmental factors. These controls are included in order to avoid relying on intergroup genetic variation to identify the wage effects of the reproducible component of health human capital (Schultz, 1996).The independent, exogenous control variables are selected based on the results of the literature review and the findings for the determinants of age at menarche discussed below. Individual characteristics include age and place of residence. Using the information from the rural, *localidad* survey included in the NFPS, the proportion of the population that do not speak Spanish (this information is not available for the individual), and distance in kilometers to the nearest and most frequented market are also used. As mentioned above, this information is only available for small, rural communities. For the larger municipalities and cities, these two variables are coded as zero. The controls also include altitude in meters above sea level for each municipality, and a dummy for rural residence and another for the poorer states that are over-represented in the sample.

The sample is restricted to include women who declared age at menarche between 10 and 17 years, based on the fact that the proportion who declared menarche at below age 10 or above age 18 is very low. In addition, this restriction makes it possible to exclude from the production function and wage equations women aged 17 and younger. The restriction of age at menarche to 10 to 17 is useful for the later extension to the wage function as it guarantees a completed profile of menarche for the women aged 18 and over at the time if the survey. The exclusion of these youths from the wage equation is also supported by the fact that many are still in school and not earning a wage. This restriction reduces the sample by only 1%.

Table 1: Mean and Standard Deviation
[Women ages 18-54, menarche between ages 10 and 17]

Variables	All		Wage Earners	
	Mean	SD	Mean	SD
Ln Hourly Wages			**1.477032**	**1.04837**
Menarche	**13.146**	**1.343**	**13.127**	**1.373**
Ln menarche	**2.571**	**0.102**	**2.569**	**0.105**
Menarche^2	**174.629**	**35.714**	**174.193**	**36.435**
(Menarche) x (Years of Education)	**75.819**	**53.797**	**91.732**	**60.431**
Community level policy variables				
Public Health Services				
% of population with earth floor	33.958	24.135	30.742	22.902
% of population without toilet or drainage facilities	34.654	24.050	31.877	24.372
% of population living in overcrowded conditions	65.289	10.590	63.673	10.665
% of population without running water	30.755	23.415	27.988	22.292
Personal Health Services				
Distance in km to nearest non-private health center (urban = 0 kms.) [1/]	2.429	6.579	1.308	4.445
- Dummy distance to health center missing (1 = missing values) [3/]	0.137	0.343	0.083	0.275
Number of physicians per capita in "localidad" or municipality (*100)	0.001	0.001	0.001	0.001
Dummy for the presence of a community health in "localidad"	0.679	0.467	0.743	0.437
Educational Capital				
% of population over age 15 with incomplete primary education	48.881	17.657	45.751	17.915
% of population over age 15 that is illiterate	20.763	13.808	19.196	13.448
Distance in Km to nearest secondary school (urban = 0)	12.622	17.864	8.717	15.813
- Dummy distance to school missing (1 = missing) [3/]	0.361	0.480	0.254	0.435
Dummy for no secondary school in the "localidad"	0.454	0.498	0.318	0.466
Other human capital variables				
Education in years	5.811	4.115	7.049	4.631
Experience (= age - education - 6)	18.983	11.971	18.740	11.872
Experience^2	503.653	529.992	492.070	516.056
Controls for ethnicity and residence				
% of population in "localidad" who do not speak Spanish(*100)	0.042	0.150	0.023	0.104
- Dummy for missing values (1 = missing value) [3/]	0.025	0.156	0.022	0.145
Altitude (thousands of meters above sea level)	1.408	1.452	1.401	1.451
- Dummy for missing values (1 = missing value) [3/]	0.016	0.127	0.013	0.113
Dummy rural-urban (rural=1)	1.588	0.492	0.452	0.498
Dummy oversampled states (o. s. = 1)[2/]	0.918	0.274	0.921	0.270
Distance to most common market (km, urban=0)	10.016	15.102	7.652	13.969
- Dummy distance to market missing (1 = missing values) [3/]	0.020	0.139	0.008	0.087
Age of Woman	31.779	9.846	32.779	9.584
n	**10,839**		**3,158**	

1/ See text for explanation

2/ Oversampled states: Chiapas, Estado de México, Guanajuato, Guerrero, Hidalgo, Michoacán, Oaxaca, Puebla and Veracruz

3/ Applies only to rural areasas the variable is assumed to be zero for urban areas.

Just under 30% of the adult women in the sample work and earn a positive wage, suggesting the need to identify, and correct for, sample selection bias using full information maximum likelihood estimates of the two stage technique originally developed by Heckman (1979). Unfortunately, the available data do not include sufficient information on exogenous determinants of labor force participation to identify the selection equation. The only exogenous measures of wealth included in the survey are the physical characteristics of the home and the sample correction term is repeatedly insignificant when identified based on these variables. For this reason, the analysis does not include a correction for sample selection. Based on the selection-corrected regressions that were undertaken, this omission is unlikely to bias the findings regarding the impact of age at menarche on productivity and wages.[6] The results of the sample selection corrected model are presented in an Appendix.

It is important to mention two general points regarding the regression analysis. First, all of the standard errors are calculated using the robust, White heteroskedasticity consistent, estimator (White, 1980; Greene, 1993). Further, all of the instrumental and exogenous control variables that suffer from a small number of missing values are recoded with the median value. A dummy value for each variable is added to signal that the observations originally had a missing value. This guarantees comparability across regressions as the number of observations remains constant.

The wage regression uses hourly wages as the dependent variable. The adjustment to hourly wages is done by converting hours worked, when reported by day or month, to hours worked per week using days worked last week. Similarly, when labor earnings are reported by a period other than the week, they are first adjusted to weeks and then divided by hours worked per week.[7]

The means and standard deviations of all variables are reported in Table 1 for the full sample of 18 to 54 year old women, as well as for those with positive wages and for the sample of women living with their mother. The figures are presented without expansion factors given the sampling features of the survey discussed above.

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[6] The instrumental variable wage equations were also calculated using a selection equation for labor force participation. The selection term was identified by including a series of arguably endogenous variables in the participation equations. In particular, a dummy variable for marriage, as well as a series of indirect indicators of wealth (measured by physical characteristics of the home and access to services) were included in the probit regression. The results of including the sample selection term derived from this analysis have very little impact on the magnitude, sign or level of significance of the menarche variable in the wage equations. The analysis was again repeated using only the measures of the physical characteristics of the home. Using this estimation strategy, the sample selection term is repeatedly insignificant suggesting that the identifying variables are too weak to permit a precise estimation of the characteristics of exclusion from the labor force. Schultz and Tansel (1997) find that the selectivity correction term is insignificant in predicting the impact of disabled days on productivity using data from the Cote d Ivoire and Ghana.

[7] It is important to note that the information on hours refers to the principal job, while labor earnings refers to all jobs. There is no way to adjust for this difference as the survey does not mention the total number of jobs. Still, the proportion of women in the National Urban Employment Surveys (undertaken by INEGI on a quarterly basis) who report a second job is very low.

V. Patterns in the age at menarche in Mexico:

The mean age in the sample of women in the NFPS who experienced menarche between ages 10 and 17 is 13.1 years with a standard deviation of 1.3 (Figure 1, Table 2). The distribution of age at menarche is concentrated in the ages 12, 13 and 14 years. Further, only 1.2% of the 521 sample youth aged 15 said that they had not yet menstruated. The average age of 13.1 years coincides relatively closely with figures collected for the 1960s and 1970s for certain European countries, although in several other developed countries including the United States, average ages approach 12.5 years (Marshall, 1978). By comparison, Díaz de Mathman, Landa Rico and Ramos Galván (1968) reported an average age of 12 years (confidence interval of +/- 13 months) among well nourished, and of 13.4 years (confidence interval of +/- 10 months) in poorly nourished young women from Mexico City. The overall average was 12.8 years (confidence interval of +/- 16 months). Using the *status quo* method, Jacobo and Malacara (1985) found an age at menarche of 12.8 years (confidence interval of +/- 1.3 years) in a population of urban, Mexican adolescents with no significant difference based on socio-economic status.

There is small, but consistent negative correlation between menarche and age cohort (Table 3). The time trend in age at menarche across birth cohorts is measured with more precision following Schultz (1996), by regressing menarche on age and controlling for the proportion of the population in a community that does not speak Spanish, the only available information on ethnic background. The OLS linear trend suggests a rate of decline of slightly less than one month per decade in Mexico (b=.011, t=8.54). The finding of a long-run decline is consistent with other studies summarized above that show a secular decline over the past 100 to 150 years in a variety of countries (Wyshak and Frisch, 1982; Marshall, 1978). Still, the rate of decline is one-quarter to one-half the reported fall in developed countries. [8]

Increases in education are also associated with a slightly more pronounced decline in age at menarche (Table 3). Women with no formal education report an average age of menarche of 13.3 years as compared to 13.2, 13.0 and 12.8 years for women with at least some primary, secondary or higher education, respectively. This partly explains the cohort effect, as education levels have increased substantially in Mexico over the past decades. Still, the inverse relationship between menarche and education is also evident within cohorts (Table 4).

[8] A large part of this divergence is likely to be attributable to differences in data collection strategies.

Figure 1: Distribution at menarchy.
Ages 18 - 54.

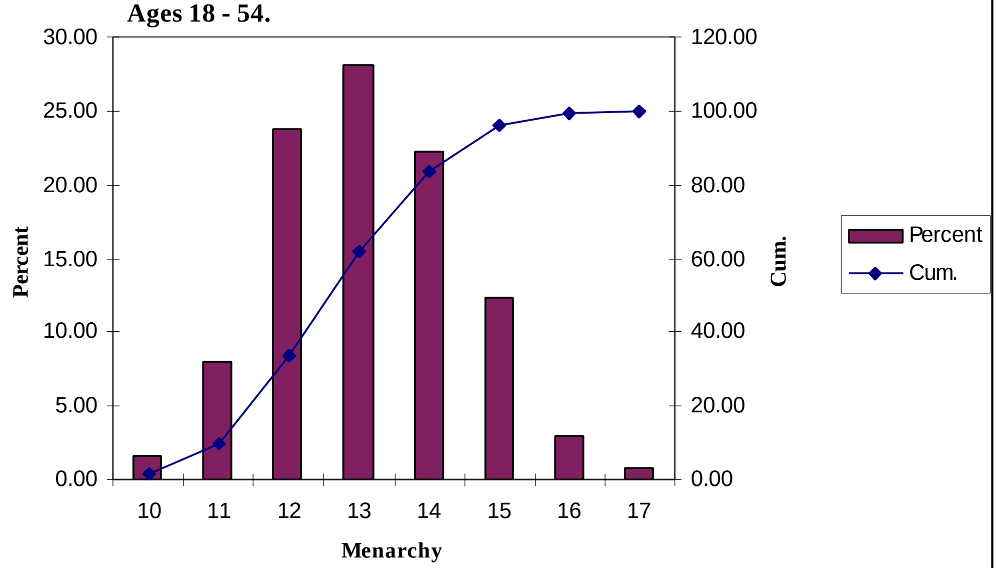

Table 2.

Menarche	**Freq.**	**Percent**	**Cum.**
10	184	1.69	1.69
11	871	7.99	9.68
12	2,596	23.82	33.50
13	3,066	28.13	61.63
14	2,423	22.23	83.86
15	1,345	12.34	96.20
16	323	2.96	99.17
17	91	0.83	100.00
Total	10,899	100.00	

Mean	13.14
Std. Dev.	1.34
Kurtosis	2.81
Obs.	10,899

Table 3.
Age at Menarche By Age Cohort, Level of Education and Rural- Urban Residence

	Age at Menarche				
	Mean	**Mode**	**Std. Dev.**	**Skewness**	**Kurtosis**
Age Cohort					
18 - 24	13.03	13	1.32	0.30	2.88
25 - 34	13.10	13	1.35	0.19	2.92
35 - 44	13.23	13	1.34	0.15	2.79
45 - 54	13.35	14	1.36	-0.07	2.66
Years of Education					
0	13.27	13	1.31	0.03	2.79
1- 6	13.23	13	1.31	0.16	2.82
7 - 12	12.99	13	1.38	0.30	2.89
13 +	12.83	12	1.41	0.35	2.80
Residence					
Rural	13.00	13	1.37	0.21	2.81
Urban	13.24	13	1.73	0.18	2.80

Table 4.
Age at Menarche by Age Cohort and Level of Education.

	Age at Menarche				
	Mean	Std. Dev.	Skewness	Kurtosis	C
Age Cohort:					
18 - 24					
Years of Education					
0	13.11	1.21	-0.08	2.65	
1 - 6	13.14	1.28	0.32	2.95	
7 - 12	12.95	1.36	0.32	2.84	
13 +	12.81	1.35	0.57	3.12	
25 - 34					
Years of Education					
0	13.20	1.30	0.08	3.02	
1 - 6	13.21	1.30	0.19	2.94	
7 - 12	12.97	1.40	0.31	2.98	
13 +	12.84	1.41	0.20	2.58	
35 - 44					
Years of Education					
0	13.30	1.32	0.10	2.91	
1 - 6	13.25	1.33	0.13	2.70	
7 - 12	13.17	1.35	0.25	2.99	
13 +	12.80	1.51	0.50	2.89	
45 - 54					
Years of Education					
0	13.33	1.34	-0.06	2.53	
1 - 6	13.39	1.33	-0.09	2.79	
7 - 12	13.23	1.55	0.15	2.40	
13 +	12.97	1.42	-0.13	2.58	

Rural residence is associated with being older at menarche. The figure is 13.2 as compared to 13.0 years in the urban areas.[9] This is a lower bound estimate as it is based on current residence. It is likely that half of the sample of women living in the urban areas at the time of the survey were rural residents during infancy and childhood or at the time of menarche. The higher figure is related to a variety of factors including the greater prevalence of malnutrition, the scarcity of health services in the rural areas as well as selective migration, poverty and educational achievement.

Menarche shows a weak, but steadily declining pattern with respect to the distribution of hourly labor income (Figure 2, Table 5). Women in the lowest wage quartile have a reported mean age of 13.3 years as compared to 13.0 in the highest decile. It is interesting to note that the average age at menarche is virtually identical among labor force participants and those who do not work.

In summary, the tabulations show that, in cross-sectional data, menarche tends to be inversely related to age, education and wages, and to be lower in urban areas. While the trends tend to be small, the patterns are consistent both overall and within cohorts. The findings coincide with the expected link to malnutrition, and to the socio-economic determinants of age at menarche cited above.

VI. The determinants of age at menarche and the instrument set

A reduced-form, health production function is estimated in this section to evaluate individual, community and regional determinants of age at menarche. The variables include both exogenous controls, and variables that are excluded in the second stage and used as instruments in the wage equation.

The instrument set is comprised of 11 variables related to the accessibility of pubic and health services, the quality of housing, and the level and availability of educational resources. This assumes that the present distribution of services and resources is correlated with the distribution that prevailed at the time when, and in the place where, the woman grew up and experienced menarche.

The first four instruments are indicators of the lack of availability of basic services in the community and poor quality of housing. These factors should be associated with an older age at menarche as they indicate higher health risks and poverty. The variables included in the instrument set are the proportion of individuals in each

[9] Although there are only 6 cases of 15 year olds who have not menstruated, it is interesting to note that the proportion is higher in the rural areas.

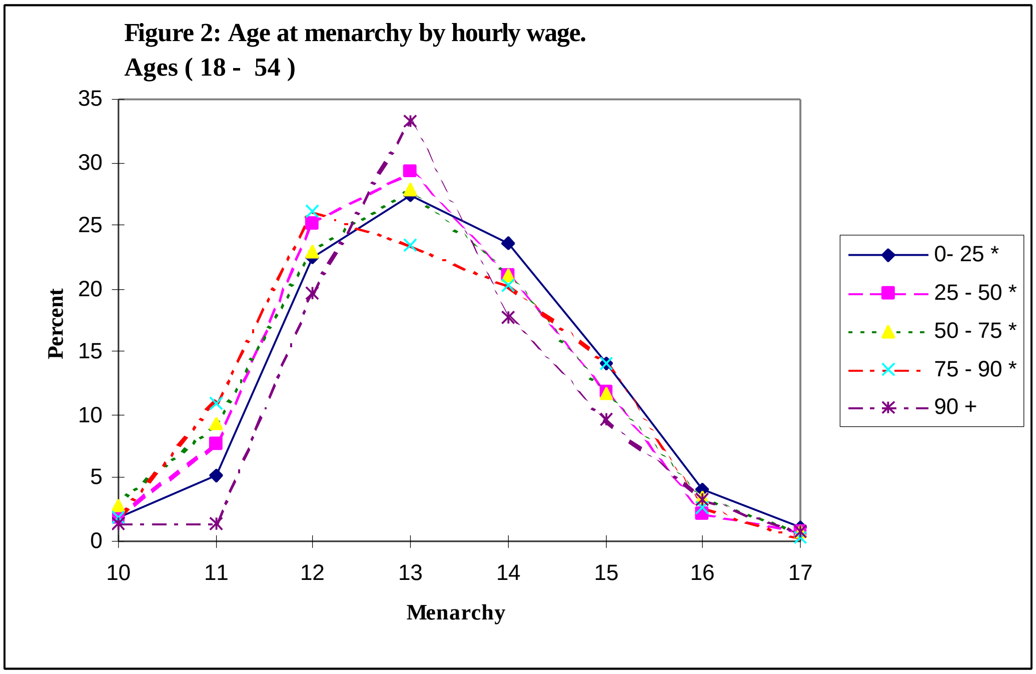

Table 5.

Wage Percentiles:	0 - 25	26 - 50	51 - 75	76 - 90	91 +
Mean	13.25	13.08	13.18	13.02	12.99
Std. Dev.	1.30	1.36	1.42	1.39	1.43
Skewness	0.17	0.11	0.14	0.30	0.23
Kurtosis	2.68	2.79	2.74	2.85	2.68
Obs.	770	835	762	476	313

municipality whose homes have an earthen floor; who do not have an indoor drainage or sanitary facilities; that live in overcrowded conditions; and, that do not have access to running water. This information comes from the *Sistema del Indice de Marginación Municipal (SIMM).*

Increasing availability and access to health services should be negatively correlated with age at menarche. Three instruments are used as indicators of the availability or accessibility of personal health services. The first variable is distance from the *localidad* to the nearest health center in kilometers using data from the NFPS. The sign is expected to be positive. This variable is somewhat difficult to interpret given the multiplicity of providers of personal health services discussed in the first section of the paper. Services may be provided through the Secretariat of Health, the social security system, state and other public welfare systems, pharmacies, and, to a lesser degree in the rural areas, private clinics and individual physicians and practitioners. The survey includes information on all of the public and social security clinics although no information is given on distance to private clinics. The variable is designed to measure the distance to the nearest public or social security clinic. While the uninsured are theoretically unable to use social security clinics, many of the units in the rural areas form part of the *IMSS Solidaridad* system which is open to the general public and targeted towards the poor and uninsured.[10]

The other two instrumental variables for the accessibility of personal health services are related to the presence of trained practitioners. The number of physicians per capita is constructed by combining the information from the community survey of the NFPS with the information on municipalities. Thus, physicians per capita is calculated for all individuals living in *localidades* using the NSFP, and for residents of larger conglomerates using the information at the level of the municipality.[11] This variable enters into the second set of instruments in addition to the variables for earth floors, drainage and distance to clinics.[12] A dummy variable indicating the presence of a community health worker at the level of the *localidad* is derived from the NFPS data. This variable is expected to be particularly important in the smaller and poorer communities. Both variables are expected to be negatively related to age at menarche.

Education is considered an important input in enhancing the ability of the individual and the family to make more efficient use of health technology (World Bank, 1993). Given the externalities that apply to public health services, the impact of education is likely to operate at the level of both the individual and the community. For this reason, measures of the level of education and access to educational services of the community constitute another group of instruments. The average level of education is measured as the proportion of the population with incomplete primary schooling, and the proportion over age 15 who report that they are illiterate using data

[10] For a more detailed discussion of the organization and usage patterns of the different parts of the system see Frenk, González Block, Lozano et al. (1994) or Secretaría de Salud (1994).

[11] Physicians include only those individuals who have completed their medical training and obtained their license. Students undertaking their social service are not counted.

[12] Another instrumental variable for health services that was explored in the composite indicator of accessibility of health services developed in Wong et al (1997). This indicator uses factor analysis to optimally combine information on health personnel, clinics and hospitals within a 10-kilometer radius of the political center (*cabecera*) of each municipality. The coefficients are somewhat difficult to interpret given that the women under consideration in this study may not live in the *cabeceras* and the results of the instrumental variable regressions do not differ substantially from those reported below.

from the *SIMM*. Access to education, under the assumption that the present allocation of educational services is related to earlier patterns, is measured by the distance in kilometers to the nearest secondary school and a dummy if the *localidad* has no secondary school. These data come from the community model of the NFPS. Each of these measures is expected to be associated with being older at menarche.

The empirical results suggest that, as hypothesized, the public service and housing variables are significant in the regression of wages on age at menarche (Table 6). The largest and most significant effect is through the presence of sanitary facilities and the proportion of the population with an earth floor. The marginal impact of overcrowding and running water is insignificant. Of particular interest are the findings that the personal health service variables have almost no significant impact. Only the variable for physicians is significant at the 10% level in the rural areas. The sign, as hypothesized, is negative. The variables measuring the average level of education in the community are also generally insignificant. One surprising result is the negative, significant coefficient on illiteracy in the urban areas. This could be related to multicolinearity. The measure of distance to the nearest secondary school is positive, and significant in the rural equation. The rest of the measures are generally insignificant

Based on the results of the F-tests reported at the bottom of the table, the instrument set is jointly significant for the regression on the full sample, as well as for the each of the rural and urban areas. Further, the public service and housing variables are also jointly significant in each of the regressions. The group of personal health service variables is much weaker and is significant at the 11% level only for the full sample. The educational capital variables are also weak, although they are jointly significant at the 4% level for the full sample.

The coefficients on the control variables support the descriptive results presented in the first section. Education, and especially age, are also important determinants of menarche. Coincident with the descriptive results, menarche decreases with level of education and is earlier among younger cohorts. It is somewhat challenging to interpret the role of the education variable given that menarche and secondary school are likely to be coincident. It is probable that this variable is measuring issues related to the educational capital of the family in which the women grew up. Further, the fact that all of the education variables, both at the level of the woman and the community, are only significant in the urban areas may be related to differential migration. It is probable that more educated women are more likely to move from rural to urban areas.

Table 6. Determinants of Age at Menarchy by residence,
Dependent Variable: Age at Menarchy [restricted to 10-17], OLS regressions (absolute value of t in parenthesis)
sample: women ages 18 - 54; menarche between ages 10 - 17

Independent Variables	All	Urban	Rural
Community level policy variables (instrumental variables)			
Public Services and Quality of Housing			
% of population with earth floor (*100)	0.473	1.233	0.297
	(3.61)	(4.04)	(2.02)
% of population without toilet or drainage facilities (*100)	0.404	0.630	0.397
	(3.50)	(2.42)	(2.98)
% of population living in overcrowded conditions (*100)	0.150	0.343	-0.023
	(0.57)	(0.79)	(0.07)
% of population without running water (*100)	0.028	-0.326	0.074
	(0.31)	(1.58)	(0.68)
Personal Health Services			
Distance in km to nearest non-private health center (urban = 0 kms.) (*100)	0.091		0.125
	(0.35)		(0.48)
- Dummy distance to health center missing (1 = missing values[4/])	-0.097		-0.087
	(2.15)		(1.90)
Number of physicians per capita in "localidad" or municipality (1/100)	-0.288	-0.264	-0.369
	(1.61)	(0.63)	(1.76)
Dummy for the presence of a community health worker in "localidad"	0.037		0.029
	(1.03)		(0.77)
Educational Capital			
% of population over age 15 with incomplete primary education (*100)	-0.167	-0.399	-0.343
	(0.71)	(0.90)	(1.11)
% of population over age 15 that is illiterate (*100)	-0.284	-1.428	0.316
	(1.08)	(3.04)	(0.97)
Distance in Km to nearest secondary school (urban = 0) (*100)	0.148		0.195
	(1.44)		(1.85)
- Dummy distance to school missing (1 = missing values[4/])	-0.049		-0.046
	(1.07)		(1.00)
Dummy for no secondary school in the "localidad"	-0.096		-0.083
	(1.56)		(1.35)
Other human capital variables			
Education in years (*10)	-0.122	-0.247	0.012
	(3.18)	(4.56)	(0.21)
Age of Woman (*100)	-0.147	0.172	-0.159
	(0.16)	(0.12)	(0.13)
Age of Woman ^2 (*100)	0.014	0.005	0.018
	(1.04)	(0.24)	(1.06)
Controls for ethnicity and residence			
% of population in "localidad" who do not speak Spanish	-0.038		-0.071
	(0.37)		(0.65)
- Dummy for missing values (1 = missing values[4/])	-0.447		-0.464
	(4.24)		(4.30)
Altitude (thousands of meters above sea level)	0.009	-0.015	0.008
	(0.92)	(0.55)	(0.72)
- Dummy values for altitude missing (1 = missing values[4/])	-0.096		-0.142
	(0.91)		(1.30)
Dummy rural-urban (rural=1)	0.250		
	(4.35)		
Dummy oversampled states (o. s. = 1)[1/]	0.126	0.137	0.129
	(2.48)	(1.95)	(1.68)
Distance to most common market (km, urban=0) (*100)	-0.372		-0.318
	(2.97)		(2.39)
- Dummy distance to market missing (1 = missing values[4/])	0.292		0.323
	(2.50)		(2.76)
Constant	12.659	12.796	12.903
	(60.93)	(37.41)	(47.33)
F Statistic	15.16	11.87	7.53
R^2	0.03	0.03	0.03
n	10,831	4,459	6,372
Wald Test of Joint Significance:			
All community-level policy variables	9.26	7.8	5.77
	(0.00 , 13)	(0.00 , 7)	(0.00 , 13)
Public Service and Quality of Housing Variables	9.77	6.46	4.89
	(0.00 , 4)	(0.00 , 4)	(0.00 , 4)
Personal Health Service Variables	1.91	0.4	1.68
	(0.12 , 4)	(0.53 , 1)	(0.15 , 4)
Educational Capital Variables	2.39	6.81	1.71
	(0.04 , 5)	(0.00 , 2)	(0.13 , 5)
Age and Age^2	16.63	2.71	17.96
	(0.00, 2)	(0.07, 2)	(0.00, 2)

1/ Oversampled states: Chiapas, Estado de México, Guanajuato, Guerrero, Hidalgo, Michoacán, Oaxaca, Puebla and Veracruz

2/ Wald Test of joint significance, F-statistic with probability at 10% de significance and degrees of freedom in parenthesis.

3/ Standard Errors are calculated using robust (Huber, White, Sandwich) estimator of variance provided with STATA

4/ Applies only to rural areas because the variable is assumed to be zero for urban areas.

The age variable is presented using a quadratic specification in order to more closely approximate the specification used later on in the wage equation. While each of the terms in the quadratic specification is insignificant, the Wald tests of joint significance show that age is an important determinant of menarche. The linear specification (not presented in the table) suggests that an increase of one year in age is associated with an increase of one month in the age at menarche for the complete sample. The effect is larger and more significant in the rural areas, reaching approximately 1.5 months per year. In the urban areas, the effect is only one half of a month.

The results for the control variables for ethnicity and residence also reinforce the descriptive results. Age at menarche is older in rural areas and older in the oversampled, poorer states.[13] The variable for distance to the nearest market is negative and significant, again suggesting that more urbanized areas have younger ages of menarche. Further, ease of contact with other populations and with a flow of goods and services may both reflect higher incomes and better access to health care services. Finally, the term for the missing values on the variable for the proportion of the population that does not speak Spanish is negative and significant. This is likely to reflect the fact that the information is missing for a few larger *municipios* that are registered in the ENPF as *localidades*, yet are registered with much larger populations in other sources.

The findings of this section underscore the importance of a variety of individual factors in explaining the evolution in age at menarche. There is a strong, positive association with the age of the women, rural residence, and living in a poorer state. This is likely to reflect the important improvements over time and with economic development of nutritional and health status. Further, the community-level variables have a significant overall impact on age at menarche. Still, personal health services show a negligible impact, while public services and housing are the dominant determinants.

VII. Wage Regressions

This section develops the empirical estimates of the impact of investment in the health and nutrition of women on wages, by using variation in the age at menarche as the proxy for health and nutrition. While earlier sections of this paper developed arguments to support the existence of an important link between childhood and adolescent nutritional status, labor market productivity, and age at menarche, it is not clear as to the functional form of the associations. While there may be a linear relationship between wages and menarche, it is also possible that this linkage involves returns to scale, or is mediated by complementarity between health and education. Given this potentially non-linear relationship, a variety of specifications of the menarche variable in the wage equation are explored in this section. In particular, the regressions are run using a linear, a logarithmic, a quadratic and an interaction with education as different specifications for the menarche variable.

The results of the instrumental variable estimates of the impact of age at menarche on the wage

[13] The regressions on the determinants of menarche were repeated excluding the dummy for missing values of the variable for the population who do not speak Spanish. The variable for not speaking Spanish remains insignificant and negative, and the other variables in the regression show no significant change either in sign or in magnitude. The only notable impact is that the variable indicating missing values for distance to the nearest market becomes insignificant, suggesting some degree of multicollinearity between the indicators of missing values.

equations for the full sample are given in Table 7. As a point of reference, the OLS result is given for the double logarithmic specification and the menarche variable is insignificant.[14] This, contrasted with the significant results for the instrumental variable regressions, suggests the presence of downward attenuation bias due to errors of measurement.

The first column of the instrumental variable regressions refers to the double logarithmic, the second to the linear and the third to the quadratic specification of the functional relationship between menarche and wages. The fourth column presents the results including a linear term for menarche and an interaction term with years of education. The final column includes both a quadratic specification of the menarche variable and the education interaction term.

The effect of age at menarche, in both the double (Column I) and the semi-logarithmic specifications (Column II), is negative and significant. The quadratic function (Column III) also shows an inverse relationship between menarche and wages. Further, the three functions give very similar results in terms of the marginal impact of menarche on wages. The coefficients in the semi-logarithmic equation indicate that a decrease in the age at menarche of one year is associated with an increase of 26% in hourly wages. The results of the double logarithmic specification suggest that a fall of 1% in menarche results in an increase of 3.54% in wages. This figure is very similar to the coefficient for the linear specification in that a decline of one year in menarche is equivalent to a change of 7.63% at the mean age of menarche of 13.15 years, resulting in an increase of 24% in wages. Further, the quadratic specification suggests that a change of one year in menarche is associated with a 23% difference in wages at the mean age at menarche.

[14] Other OLS regressions were also run, although they are not reported. The relationship between menarche and wages is negative and significant in a simple OLS regression with no other control variables. Adding education and experience to the human capital equation reduces the impact of menarche and renders the coefficient statistically insignificant.

Table 7: Wage Functions[1/] with varying specifications of the Menarche Variable Estimated by Instrumental Variables[2/].
Sample: women ages 18 to 54, menarche between ages 10 to 17
(absolute value of t in parenthesis)

Independent Variables	OLS	Instrumental Variable				
		(1)	(II)	(III)	(IV)	(V)
Menarchy (estimated by instrumental variables)						
Ln Menarche	**0.089**	**-3.524**				
	(0.56)	**(2.44)**				
Menarche			**-0.261**	**-7.258**	**-0.569**	**-6.688**
			(2.35)	**(2.26)**	**(2.31)**	**(2.01)**
Menarche^2				**0.266**		**0.240**
				(2.18)		**(1.84)**
(Menarche) X (Years of Education)					**0.047**	**0.019**
					(1.44)	**(0.49)**
Other Human Capital Variables						
Education in years	0.135	0.130	0.131	0.117	-0.484	-0.127
	(29.51)	(24.50)	(25.06)	(13.04)	(1.13)	(0.26)
Experience (age - education in years - 6) (x 10)	0.34	0.375	0.375	0.363	0.336	0.349
	(6.60)	(6.41)	(6.41)	(5.18)	(5.06)	(4.78)
Experience ^ 2 (x 1000)	-0.414	-0.438	-0.435	-0.503	-0.324	-0.452
	(3.44)	(3.34)	(3.33)	(3.25)	(1.97)	(2.46)
Control for ethnicity and residence						
% of population in "localidad" who do not speak Spanish	-0.527	-0.503	-0.498	-0.655	-0.546	-0.659
	(2.24)	(2.11)	(2.09)	(2.45)	(2.23)	(2.51)
- Dummy for missing values (1 = missing values[3/])	-0.033	-0.164	-0.165	-0.007	-0.060	0.020
	(0.24)	(1.09)	(1.09)	(0.04)	(0.35)	(0.10)
Altitude (thousands of meters above sea level)	0.012	-0.013	-0.013	-0.012	-0.003	-0.008
	(0.72)	(0.79)	(0.79)	(0.68)	(0.14)	(0.42)
- Dummy for missing values (1 = missing values[3/])	0.077	-0.098	-0.091	-0.107	-0.151	-0.130
	(0.46)	(0.53)	(0.49)	(0.47)	(0.79)	(0.57)
Dummy rural-urban (rural=1)	-0.025	0.062	0.061	0.007	0.064	0.014
	(0.56)	(1.06)	(1.03)	(0.10)	(1.05)	(0.19)
Dummy oversampled states (o.s = 1)[4/]	-0.132	-0.038	-0.041	-0.046	-0.046	-0.047
	(2.56)	(0.57)	(0.62)	(0.54)	(0.69)	(0.59)
Distance to most common market (km, urban=0) (x 100)	0.026	-0.020	-0.030	0.259	-0.105	0.200
	(0.17)	(0.12)	(0.17)	(1.13)	(0.57)	(0.77)
- Dummy distance to market missing (1=missing values[3/])	-0.163	-0.145	-0.140	-0.300	-0.267	-0.335
	(0.75)	(0.65)	(0.62)	(1.21)	(1.07)	(1.33)
Constant	0.021	9.170	3.546	49.147	7.599	46.251
	(0.05)	(2.51)	(2.53)	(2.35)	(2.36)	(2.18)
n = 3,155						
R^2	0.26					
F Statistic	99.61	83.12	84.22	51.29	73.41	53.81
Hausman Test:		6.714	6.177	5.648	7.242	9.503
(Prob > Chi^2, Degrees of Freedom)		(0.01, 1)	(0.01, 1)	(0.01, 2)	(0.03, 2)	(0.001, 3)
Over Identification Test		33.37	33.92	34.51	32.65	23.58
(Prob > Chi^2, Degrees of Freedom = 13)		(0.00)	(0.00)	(0.00)	(0.00)	(0.04)

F Test for Joint Significance of instruments using sample of positive wage earnings: 3.77 (Prob > F = 0.00, d.f. = 13)

1/ Standard Errors are calculated using robust (Huber, White, Sandwich) estimator of variance provided with STATA. There is no correction for sample selection as the inverse mills ratio is insignificant using available identifying variables. Hourly positive wages of salaried and unsalaried workers using weekly wages as the base.

2/ The Instrumental Variables are: % of population in municipality with earth floor in their homes and distance to the nearest non private health center.
% of population without running water, % of population over age 15 with incomplete primary education, % of population over age 15 that is illiterate,
Distance in km to nearest non-private health center (urban = 0 kms.), Dummy distance to health center missing (1 = missing values), Number of physicians in "localidad" or municipality,
Dummy for the presence of a community health in "localidad", Distance in Km to nearest secondary school (urban = 0), Dummy distance to school missing (1 = missing values),
Dummy for no secondary school in the "localidad", Controls for ethnicity and residence, % of population in "localidad" who do not speak Spanish,
Dummy for missing values (1 = missing value), Altitude (thousands of meters above sea level), Dummy for missing values (1 = missing value), Dummy rural-urban (rural=1),
Distance to most common market (km, urban=0), Dummy distance to market missing (1 = missing values), Dummy oversampled states (o. s. = 1)
Dummies for missing values are included for distance to nearest health clinic and for distance to nearest secondary school.

3/ Applies only to rural areas because distance is assumed to be zero for urban areas.

4/ Oversampled states: Chiapas, Estado de México, Guanajuato, Guerrero, Hidalgo, Michoacán, Oaxaca, Puebla and Veracruz between menarche and wages. Further, the three functions give very similar results in terms of the marginal impact of menarche on wages. The coefficients in the semi-logarithmic equation indicate that a decrease in the age at menarche of one year is associated with an increase of 26% in hourly wages. The results of the double logarithmic specification suggest that a fall of 1% in menarche results in an increase of 3.54% in wages. This figure is very similar to the coefficient for the linear specification in that a decline of one year in menarche is equivalent to a change of 7.63% at the mean age of menarche of 13.15 years, resulting in an increase of 24% in wages. Further, the quadratic specification suggests that a change of one year in menarche is associated with a 23% difference in wages at the mean age at menarche.

The quadratic specification of the menarche variable gives especially interesting results. The coefficient on the linear term is negative and significant while that of the squared terms is positive and significant. This suggests some non-linearity in the variable and that the gains to investments in childhood nutrition and health have a greater payoff at higher levels of nutritional status. In other words, the impact on wages is more pronounced at younger ages of menarche that correspond to healthier, better nourished women. **The function reaches a minimum between ages 13 and 14, and demonstrates a range with a positive slope between ages 17 and 14.**

The finding of higher returns among healthier and better nourished women contrasts with earlier work and must be interpreted with caution. Strauss (1986), for example, evaluates the impact of health on productivity in Sierra Leone, and finds decreasing returns to scale using calories as a measure of health. Further, the low explanatory power of the instruments, the lack of previous research using age at menarche, and the nature of the survey and its sample used in this research suggest the need to be careful in interpreting the result of increasing returns. Still, the finding does suggest many interesting hypotheses for further study. First, it is possible that menarche is a variable that is very non-linear in terms of the investment in health and nutrition required to gain a reduction at younger ages. Specifically, it may be the case that a small investment in health or nutrition results in a reduction from age 17 to age 16, but that further reductions around the age of 13 are related to much greater investment in nutritional and health status. Further, it may be that the earlier gains are related to genetic or other factors not well measured in the model. It is also possible that labor market productivity gains related to investment and nutrition are associated with a higher payoff at the upper end of the productivity distribution. Finally, the cross-sectional nature of the data may drive part of the results in the quadratic specification, suggesting that longitudinal data will be needed to develop a stronger explanation of non-linearities in the health, nutrition, labor market productivity nexus.

The last two specifications of the wage function include the interaction of age at menarche with years of schooling. The instrument set remains the same, and the linear term on years of education is treated as exogenous, while the menarche variable and the interaction term are treated as endogenous. The interaction term is added under the hypothesis that improvements in nutrition and health may operate through the individual's capacity to obtain educational capital (Mook and Leslie, 1984). The results of introducing this term are much weaker (Columns IV and V, Table 7). The menarche variable retains its negative sign and significance in both the semi-logarithmic (Column IV) and in the quadratic specifications (Column V). The magnitude of the coefficient increases with the addition of the interaction term in the semi-logarithmic case, yet the coefficients for the quadratic are similar to Column III without the interaction term. The coefficients on the interaction term are insignificant. Further, the coefficient on the exogenous, years of education variable becomes insignificant. These results may reflect the need to endogenize both education and menarche, as well as to use additional variables to measure health inputs. Neither of these techniques is feasible with the existing data set.

The results for the other variables in the regressions are consistent with human capital theory. The experience terms display increasing returns to scale in all of the regressions. The returns to education vary between 12 and 13%. The insignificance of the rural, and of the oversampled state, dummies is surprising given the results of the first stage of the regression. Still, this may be due to differential rural to urban migration, or to the special characteristics of the sample of the NFPS. When the regressions are repeated on the urban and rural samples separately, the impact of menarche is stronger for the urban areas. Given that the urban areas and the more urbanized states are underrepresented in the sample, it is possible that these types of differences are understated. It is also possible that the other independent variables explain a large part of the rural-urban differences in wages.

The Hausman tests are generally significant and reject the hypothesis of exogeneity. This is a particularly strong finding given that Hausman tests may be indecisive if the OLS estimates are imprecise, or if the instrumental variables do not explain a significant portion of the variance in the endogenous variable of interest (Staiger and Stock, 1998; Valdivia, 1998, Thomas and Strauss, 1997). Still, the overidentification tests reject the equality of coefficients, suggesting some misspecification of the instrumental variables.

Although the set of instruments is jointly significant even for the restricted sample of positive wage earners, it is important to highlight the limitations of these variables. First, the explanatory power of the overall regression is very low. While this is not unusual in estimates of health production functions (see for example Schultz and Tansel, 1997), it is worrisome. Recent studies on the validity of instrumental variable estimation with weak instruments suggest that results may be biased (Bound, Jaeger and Baker, 1995). Further, the available instruments for this study are all indicators of community-level factors and refer to current conditions. In the absence of information on migratory histories, it is impossible to analyze how closely these are correlated with the conditions in the place and at the time when the women was growing up. Given these considerations, the robustness of the findings are tested by repeating the analysis using a variety of instrument sets, including state-level fixed effects, including information on the mother for a subset of the woman under study, and restricting the sample to younger cohorts. The results of these robustness tests are summarized below.

The sign of the menarche variable is quite robust to varying the instrument set, although the magnitude of the impact of menarche on wages increases when the number of instruments is reduced. These results are presented for the double logarithmic specification in Table 8. Further, the differences in the strength and magnitude of the coefficient underscore the unimportance of the personal health service variables (line 3), and the contrasting strength of the public service and housing variables (line 2), as determinants of age at menarche. This coincides with the findings from the estimates of the health production function presented in the previous section. Limiting the instruments to the four public service and housing variables (line 2), the effect of a 1% increase in age at menarche increases to 6.36%. The effect is 6.53% if only type of flooring and drainage facilities are used as instruments (line 5). Including personal health services and educational capital, it is 4.76% (line 10).

The results of the quadratic specification are also robust to varying the instrument set, although they are much more sensitive than in the case of the linear or logarithmic specification. Specifically, the coefficients lose individual significance with the exclusion of a large number of the instruments. They are robust in terms of significance and magnitude to the exclusion of any part of the instrument set other than the educational access and capital variables, as well as to dividing the sample between the rural and urban areas.

Table 8:

Impact of a 1% Increase in Menarche on Hourly Wages

Varying the Instrument Set 1/

Instrument Set	Coefficient of menarche (logarithmic specification) 1/	t-statistic for the coefficient
1. Complete set	-3.52	-2.44
2. Public Services and Housing Quality (including all 4 instruments)	-6.36	-3.25
3. Personal Health Services (including all 3 instruments)	-1.68	-0.36
4. Education Level and Educational Services (including all 4 instruments)	-5.63	-2.53
5. Public Services and Housing Quality (including only flooring and drainage)	-6.53	-3.17
6. Public Services and Housing Quality (including only flooring)	-8.42	-3.33
7. Public Services and Housing Quality (including only drainage)	-4.65	-2.18
8. Public Services and Housing Quality (including all 4 instruments), and Education Level and Educational Services (including all 4 instruments)	-3.75	-2.50
9. Public Services and Housing Quality (including all 4 instruments) and Personal Health Services (including all 3 instruments)	-5.61	-3.16
10. Personal Health (including all 3 instruments), Education Level and Educational Services (including all 4 instruments)	-4.67	-2.35

Note: 1/ The model is identical to Column (II) of the instrumental variable estimates presented in Table 7 with the exception of the variation in the instrument set. The dependent variable is the natural logarithm of hourly wages. Menarche is also presented as the natural logarithm.

The robustness of the instrumental variable wage equation was also tested by adding a full set of state dummies to the equations (Table 9). This latter specification provides a test for the validity of the instrumental variable instruments. Although the full set of dummies absorbs a substantial degree of the geographic variation that is not attributable to the accessibility of health services and local levels of education, the coefficient on the menarche variable is stable in sign, magnitude and significance.

To further test the strength of the model, both the analysis of the determinants of age at menarche and the wage equations were repeated for the sample of women who live with their mothers. For this small sample, it is possible to identify education of the mother, and for the further reduced sample of those whose mother is aged between 15 and 54, her age at menarche. While these are very select groups, the analysis provides additional insight into both the importance of family-level genetic and socio-economic determinants of age at menarche. The sign and significance of the menarche variable is robust to this respecification.[15]

The analysis was also repeated for the restricted sample of younger cohorts. This provides a strategy for testing the sensitivity of the results to issues related to differential migration. In particular, these regressions provide insight into the importance of using instruments based on current conditions at the community level, which are likely to differ from the situation experienced by the women under study when they experienced childhood and adolescence. Further, given that the probability of migration increases over time, it is also more likely that younger cohorts are resident in the place where they experienced puberty. The results of the wage regressions are very stable both to restricting the sample to women aged 44 and younger, as well as to a further reduction to include only women between the ages of 18 and 30. The signs, magnitudes and levels of significance of the impact of menarche on wages are similar to the results for the complete sample. This is true for all five specifications of the instrumental variable wage regression and for both age groups. Considering the quadratic specification for example, the coefficients are –9.9 (t-statistic=2.4) and .36 (t-statistic=2.3), and –8.9 (t-statistic=2.5) and .33 (t-statistic=2.5) for women aged 18 to 44 and aged 18 to 30, respectively.

The findings of this section support the hypothesized relationship between investments in health and nutrition, measured through age at menarche, and labor market productivity. The finding of higher wages among women who are younger at menarche, is robust to the inclusion of a number of control variables, as well as to changes in functional form and in the instrument set.

[15] These results are available from the author.

Table 9.
Wage Function[1/] with varying specifications of the Menarche Variable and Including Full Set of State Dummies [2/]
Estimated by Instrumental Variables [3/]
Sample: women ages 18 to 54, menarche between ages 10 to 17
(absolute value of t in parenthesis)

Independent Variables	OLS	Instrumental Variables (I)	(II)	(III)	(IV)	(V)
Menarchy (estimated by instrumental variables)						
Ln menarchy (restricted to 10-17)	**0.116**	**-3.264**				
	(0.73)	**(1.57)**				
Menarchy			**-0.238**	**-5.303**	**-0.632**	**-3.474**
			(1.51)	**(1.43)**	**(2.17)**	**(0.86)**
$Menarchy^2$				**0.190**		**0.110**
				(1.37)		**(0.71)**
Menarche and Years of Education					**0.055**	**0.041**
					(1.67)	**(1.10)**
Other Human Capital Variables						
Education in years	0.132	0.128	0.129	0.119	-0.593	-0.414
	(28.09)	(22.12)	(22.91)	(12.39)	(1.38)	(0.86)
Out of school experience	0.035	0.038	0.038	0.038	0.034	0.035
	(6.86)	(6.54)	(6.56)	(5.78)	(5.00)	(5.13)
Experience ^ 2 (x 100)	-0.043	0.000	0.000	0.000	0.000	0.000
	(3.62)	(3.42)	(3.42)	(3.33)	(1.87)	(2.09)
Controls For Ethnicity and Residence						
% of population in "localidad" who do not speak Spanish	-0.423	-0.417	-0.414	-0.485	-0.478	-0.503
	(1.76)	(1.71)	(1.70)	(1.89)	(1.88)	(1.98)
- Dummy for missing values (1 = missing value)[5/]	-0.043	-0.167	-0.166	-0.070	-0.052	-0.025
	(0.32)	(1.02)	(1.01)	(0.35)	(0.28)	(0.13)
Altitude (thousands of meters above sea level)	-0.027	-0.028	-0.028	-0.027	-0.012	-0.016
	(1.39)	(1.47)	(1.47)	(1.39)	(0.57)	(0.72)
- Dummy for missing values (1 = missing value)[5/]	-0.059	-0.188	-0.179	-0.269	-0.231	-0.270
	(0.34)	(0.97)	(0.93)	(1.16)	(1.15)	(1.23)
Dummy rural-urban (rural=1)	-0.030	0.046	0.044	0.030	0.059	0.047
	(0.68)	(0.67)	(0.64)	(0.40)	(0.80)	(0.62)
Distance to most common market (km) (x 100)	0.046	0.001	-0.007	0.193	-0.126	0.021
	(0.29)	(0.01)	(0.04)	(0.82)	(0.64)	(0.07)
Dummy distance to market missing (1 = missing value) [5/]	-0.188	-0.172	-0.167	-0.296	-0.293	-0.335
	(0.86)	(0.77)	(0.75)	(1.24)	(1.16)	(1.36)
Constant	-0.164	8.450	3.189	36.623	8.372	26.466
	(0.39)	(1.59)	(1.58)	(1.50)	(2.20)	(1.02)
n = 3,155						
R^2	0.2711					
F Statistic	45.43	40.69	41.50	28.15	35.22	38.04
Hausman Test:		6.176	6.050	4.024	4.546	6.536
(Prob > Chi^2, Degrees of Freedom)		(0.13, 1)	(0.01, 1)	(0.13, 2)	(0.10,2)	(0.09, 3)
Over Identification Tests		29.22	29.64	22.73	24.93	24.28
(Prob > Chi^2, Degrees of Freedom = 13)		(0.01)	(0.01)	(0.05)	(0.02)	(0.03)

F Test for Joint Significance of instruments using positive wage earners: 1.87 (Prob > F = .0291, d.f. = 13)

1/ Standard Errors are calculated using robust (Huber, White, Sandwich) estimator of variance provided with STATA. There is no correction for sample selection as the inverse mills ratio is insignificant using available identifying variables.

2/ Individual State dummies are included, but not reported.

3/ The instrumental variables are: % of population in municipality with earth floor in their homes and distance to the nearest non-private health center.
% of population without running water, % of population over age 15 with incomplete primary education, % of population over age 15 that is illiterate,
Distance in km to nearest non-private health center (urban = 0 kms.), Dummy distance to health center missing (1 = missing values), Number of physicians in "localidad" or municipality,
Dummy for the presence of a community health in "localidad", Distance in Km to nearest secondary school (urban = 0), Dummy distance to school missing (1 = missing values),
Dummy for no secondary school in the "localidad", Controls for ethnicity and residence, % of population in "localidad" who do not speak Spanish,
Dummy for missing values (1 = missing value), Altitude (thousands of meters above sea level), Dummy for missing values (1 = missing value), Dummy rural-urban (rural=1),
Distance to most common market (km, urban=0), Dummy distance to market missing (1 = missing values), Dummy oversampled states (o. s. = 1)
Dummies for missing values are included for distance to nearest health clinic and for distance to nearest secondary school.

4/ Oversampled states: Chiapas, Estado de México, Guanajuato, Guerrero, Hidalgo, Michoacán, Oaxaca, Puebla and Veracruz

5/ Applies only to rural areas because the variable is assumed to be zero for urban areas.

VIII: Conclusions

This paper proposes age at menarche as a factor that can be used to estimate labor market returns to childhood investments in health and nutrition. Measurement error, combined with simultaneity, however, suggest the need to use instrumental variable techniques when estimating such wage functions.

The retrospective recall data available for this study shows that average age at menarche has been decreasing in Mexico over the past 40 to 50 years. The decline has been somewhat slower than in the developed world. Factors associated with this decline include urbanization, increased levels of education and improved living conditions. In particular, variables that measure access to public services and the quality of housing appear to have an important impact. The proportion of the community with earth flooring in their homes, and the proportion that lack toilet or drainage facilities, are particularly strong correlates of menarche. Access to personal health services appears to have little marginal impact on the age at menarche.

The findings reported in this paper suggest that nutrition and cumulative health status, measured by age at menarche, have a significant effect on the labor market productivity of Mexican women. Younger ages of menarche are associated with higher wages. The overall effect is masked in an OLS wage equation due to the errors of recall, rounding by year and misreporting of the variable. The instrumental, errors-in-variables model suggests that a decline of one year in menarche is associated with an increase of 23-26% in wages. This figure is consistent using a double-logarithmic, semi-logarithmic, or quadratic specification of the menarche variable**. The results suggest the possibility of higher returns to some health investments among the healthier segments of the population.** This finding deserves further research as it contrasts with the existing evidence that suggests that health has a larger return at lower levels of health, and that the importance of health investments as inputs into labor productivity will decline with economic development (Strauss and Thomas, 1998).

Future research should use other data sets to include other human capital inputs. It will also be interesting to broaden the conceptualization of female health by considering additional measures of health and nutrition. These should be compared and combined with age at menarche. Further, it will be important to include additional information on the origin and migration patterns of the women in order to better identify the impact of health, education and other public services, as well as poverty and living conditions, during infancy and childhood on health outcomes.

The results of this paper lend support to the importance of investing in health and early nutrition, particularly through sanitation and housing conditions, in order to improve individual and family well being and to reduce poverty. Health has an important, independent impact as an investment in human capital investment in addition to education. Further, the findings suggest that for the purposes of economic analysis, age at menarche should be considered a complement to adult height as a measure of secular changes in the health and nutritional condition of women.

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Appendix 1, Table 1.
Differences between women included in the individual questionnaire and those not interviewed.

Variable:	Included	Excluded
Age		
Mean	31.91	30.18
Median	30	27
Obs.	11,058	1,392
Groups:		
18 - 24	3,246	564
25 - 35	3,615	389
35 - 44	2,604	244
45 - 54	1,588	195
Education		
Mean	5.80	6.57
Median	6	6
Obs.	11,049	1,374
Labor Force Participation		
Mean	0.29	0.37
Obs.	11,058	1,392
Weakly Wages		
Mean	263.47	265.31
Median	140	175
Obs.	3,273	535

Appendix 2: Wage Functions 1/ with Sample Selection Correction for Labor Force Participation
Log Menarche Estimated with Instrumental Variables 2/
Sample: women ages 18 to 54, menarche between ages 10 to 17
(absolute value of z in parenthesis)

Independent Variables	Probit for Labor Force Participation	OLS Wage Function	Instrumental Variable Wage Function 5/
Menarchy			
Ln Menarchy	**0.162**	**0.080**	**-3.639**
	(1.25)	**(0.50)**	**(2.53)**
Other Human Capital Variables			
Experience (age - years of education - 6)	0.039	0.030	0.037
	(8.79)	(3.19)	(3.51)
Experience ^ 2 (x 100)	-0.046	-0.035	-0.042
	(4.91)	(2.43)	(2.56)
Education in years	0.084	0.127	0.132
	(16.92)	(6.73)	(6.46)
Controls for Ethnicity and Residence			
% of population in "localidad" who do not speak Spanish	-0.359	-0.446	-0.480
	(3.23)	(2.27)	(1.86)
- Dummy for missing values (1 = missing value) 3/	0.375	-0.087	-0.173
	(3.41)	(0.56)	(1.00)
Altitude (thousands of meters above sea level)	0.012	-0.015	-0.015
	(1.20)	(1.26)	(0.92)
- Dummy for missing values (1 = missing value) 3/	0.123	0.099	-0.077
	(1.09)	(0.64)	(0.41)
Dummy rural-urban (rural=1)	-0.277	-0.003	0.050
	(7.55)	(0.04)	(0.58)
Dummy oversampled states (o.s. = 1) 4/	0.134	-0.145	-0.033
	(2.77)	(2.17)	(0.43)
Distance to most common market (km, urban=0) (x 100)	-0.142	0.075	0.024
	(1.27)	(0.49)	(0.14)
- Dummy distance to market missing (1 = missing values) 2/	-0.668	-0.095	-0.157
	(4.80)	(0.38)	(0.56)
Identification of Labor Force Participation			
If House has Interior Sewage Connection (Sewage = 1)	0.039		
	(1.14)		
Number of Bedrooms per Family Member	0.304		
	(4.52)		
If House has Own Kitchen (Kitchen = 1)	-0.119		
	(2.79)		
If House has Interior Running Water (Water = 1)	-0.058		
	(1.76)		
Inverse Mills Ratio 5/		-0.129	0.032
		(0.43)	(0.10)
Constant	-1.950	0.294	9.409
	(5.71)	(0.39)	(2.62)
F Statistic	848.81	83.70	33.82
(Prob > F, degrees of freedom) (Values for Chi2 given for Probit model)	(0.00, 16)	(0.00, 13)	(0.00, 13)
R^2		0.26	
n	10,774	3,133	3,133
Hausman Statistic: H = 7.22, degrees of freedom = 1, Prob > Chi^2 = .01			

1/ Standard Errors are calculated using robust (Huber, White, Sandwich) estimator of variance provided with STATA. Hourly positive wages of salaried and unsalaried workers using weekly wages as the base.
Hourly positive wages of all salaried and unsalaried workers, using weekly hours and wages as the base and dividing by weekly hours.

2/ The instrumental variables are: % of population with earth floor, % of population without toilet or drainage facilities, % of population living in overcrowded conditions, % of population without running water, % of population over age 15 with incomplete primary education, % of population over age 15 that is illiterate, Distance in km to nearest non-private health center (urban = 0 kms.), Dummy distance to health center missing (1 = missing values, rural), Number of physicians in "localidad" or municipality, Dummy for the presence of a community health in "localidad", Distance in Km to nearest secondary school (urban = 0), Dummy distance to school missing (1 = missing, rural), Dummy for no secondary school in the "localidad", Controls for ethnicity and residence, % of population in "localidad" who do not speak Spanish, Dummy for missing values (1 = missing value, rural), Altitude (meters above sea level), Dummy for missing values (1 = missing value, rural), Dummy rural-urban (rural=1), Distance to most common market (km, urban=0), Dummy distance to market missing (1 = missing values, rural), Dummy oversampled states (o. s. = 1)
Dummies for missing values are included for distance to nearest health clinic and for distance to nearest secondary school.

3/ Applies only to rural communities, because the variable is assumed to be zero for urban areas.

4/ Oversampled states: Chiapas, Estado de México, Guanajuato, Guerrero, Hidalgo, Michoacán, Oaxaca, Puebla and Veracruz

5/ The Inverse Mills Ratio is entered into the Instrumental Variable Wage Equation using a 2 step procedure