Adolescent pregnancy and low birth weight in the Peruvian Amazon

Julia Anne Ryan

Department of Epidemiology, Biostatistics, and Occupational Health

McGill University, Montreal

September, 2009

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Master of Science

Abstract

Objective: To compare low birth weight (LBW) (< 2,500g) between infants born to adolescent and adult mothers in Iquitos, Peru.

Methods: A random sample of 4,467 birth records was collected. Multivariate analyses were performed to compare both the proportion of LBW and mean birth weight of newborns of adolescents (10-14 yrs, 15-19 yrs) and adults (≥ 20 yrs) and then for primiparous mothers only.

Results: For all mothers, all adolescents had significantly greater odds of having a LBW infant than adults. For primiparous mothers, the same was true only for 10-14 year-olds. There were significant differences in mean birth weight between adults and both early and late adolescent age groups.

Discussion: Results provide evidence for increased risk of LBW in adolescents, especially early adolescents. Further research is needed on elucidating the basis of this disparity, especially in terms of physiological and behavioural determinants.

Résumé

Objectif : Comparer le faible poids de naissance (FPN) (< 2,500g) entre les nouveaux-nés d'adolescentes et ceux d'adultes à Iquitos, Pérou.

Méthodes : Un échantillon aléatoire de 4,467 dossiers de naissance a été rassemblé. Les analyses multivariables ont été exécutées pour comparer la proportion de FPN et la moyenne poids de naissance parmi les nouveaux-nés d'adolescentes (10-14 ans, 15-19 ans) et ceux d'adultes (≥ 20 ans) et ensuite en considérant que les mères primigestes.

Résultats : Parmi toutes mères, toutes adolescentes avaient des chances plus grandes d'avoir un nouveau-né de FPN que les adultes. Parmi les primigestes, ceci était vrai que pour le groupe 10-14 ans. La moyenne poids de naissance parmi tous les groupes d'adolescentes était significativement inférieure à celle des adultes.

Discussion : Ces résultats fournis des preuves du risque accru de FPN parmi les adolescentes, surtout les adolescentes plus jeunes (10-14 ans). L'étude supplémentaire est requise pour établir si cette divergence est fonction de physiologie ou comportement.

Preface

Dissemination of Results

Results from this thesis, which investigated characteristics of adolescent pregnancy in the Peruvian Amazon, have been disseminated in various formats and at numerous scientific meetings.

Manuscript #2: Comparison of antenatal care coverage in early adolescents, late adolescents, and adult pregnant women in the Peruvian Amazon, is presented as an appendix in this thesis (Appendix 4). In this thesis, results of Manuscript #2 are referred to first and are presented as an appendix because research on antenatal care utilization patterns was carried out prior to that of the main research question (low birth weight). Results from Manuscript #2 were presented as an oral presentation at the 15th Annual Canadian Conference on International Health, held in Ottawa from October 26-29, 2008. This manuscript has also since been accepted for publication in the International Journal of Gynecology and Obstetrics.

Preliminary results from the main research question investigating adolescent pregnancy and low birth weight were presented at the Canadian Society for Epidemiology and Biostatistics National Student Conference held in Ottawa, May 23-24, 2009. Complete results were presented at the Canadian Public Health Association 2009 Annual Conference held in Winnipeg, June 7-10, 2009. Finally, Manuscript #1 (Chapter 5 in the thesis): A comparison of low birth weight among newborns of early adolescent, late

adolescent, and adult mothers in the Peruvian Amazon, was recently submitted for publication to the Journal of Adolescent Health.

A third manuscript is planned that will be submitted to the Pan American Journal of Public Health (*Revista Panamericana de Salud Pública*) in Spanish. The rationale for this manuscript is to provide a single source comprising a summary of results and conclusions from all studies that have used this thesis's study population data abstracted from the birth registry at the Hospital Apoyo Iquitos, in Iquitos, Peru. These include results and conclusions both from Manuscript #1 and Manuscript #2 of this thesis. This manuscript will serve as an important resource for future studies conducted in Latin America and will contribute to advancing research in this region of the world.

Knowledge Translation

Findings from this thesis research will be communicated to the Hospital Apoyo Iquitos with the intention of providing health care providers and other members of the health sector with feedback on the status of adolescent pregnancy in the Amazon region of Peru. In this way, these results may stimulate an evaluation of health policies relating to pregnant adolescents or approaches to adolescent reproductive health in this region, especially those relating to early pregnant adolescents (10 to 14 years-old). Eventually, it is the hope that the dissemination of these results to the health sector will reduce reproductive health disparities between pregnant adolescents and adults in Iquitos and improve the health and well-being of adolescent mothers and their children.

Authors' Contribution

As the first author, I contributed to the development of the research question, the study design and methods, the statistical analyses, and the writing of the thesis and manuscript (Manuscript #1). With the support of local research assistants in Peru, I collected the data on which this thesis and manuscript are based at the Hospital Apoyo Iquitos in Iquitos, Peru, from May to July, 2008. My thesis supervisor, Dr. Theresa Gyorkos, was involved in all aspects and stages of this research, including discussions refining the study design and its implementation. She also provided input into the statistical analyses, manuscript preparation, and dissemination of study results. Dr. Martín Casapía provided access to workspace in Iquitos and facilitated access to the birth registries at the Hospital Apoyo Iquitos. He also provided feedback during manuscript preparation. Dr. Hermánn Silva, Director of the hospital, and Dr. Eder Aguilar, Chief of Obstetrics at the hospital, provided access to a workspace for data collection and facilitated access to the birth registries. Drs. Elham Rahme, Anita Gagnon, and Amee Manges, as members of my thesis supervisory committee, provided advice on the design and analysis of the study as well as feedback on the manuscript. Serene Joseph provided statistical support and guidance as well as assistance with manuscript revision.

I was also first author on a second manuscript investigating a separate research question addressed using the same study population. This manuscript is included in Appendix 4. As the first author, I contributed to the development of the research question, the study design and methods, the statistical analyses, and the writing of the manuscript (Manuscript #2). Dr. Theresa Gyorkos was involved in all aspects and stages of this

research, including discussions refining the study design and its implementation. She also provided input into the statistical analyses, manuscript preparation, and dissemination of study results. Dr. Martín Casapía provided access to workspace in Iquitos and facilitated access to the birth registries at the Hospital Apoyo Iquitos. He also provided feedback during abstract and manuscript preparation. Dr. Hermánn Silva, Director of the hospital, and Dr. Eder Aguilar, Chief of Obstetrics at the hospital, provided access to a workspace for data collection and facilitated access to the birth registries. Serene Joseph provided statistical support and guidance as well as assistance with manuscript revision.

Suggested Short Title

Adolescent mothers and low birth weight in Peru

Acknowledgements

I would like to extend my deepest gratitude to the following individuals and institutions for their support and guidance throughout all stages of my research. Every individual aspect and phase of this study was essential and vital to the completion of my thesis.

I thank Dr. Theresa Gyorkos for providing the opportunity to conduct primary research within a global health context, a true passion of mine. I thank her for her dedication and commitment to resolving conflict or difficulties that I encountered while in Iquitos. I will always be grateful for her continuous support and motivation to push my abilities to the limit. Her genuine interest in and enthusiasm for this research is an inspiration.

I thank Dr. Martín Casapía and all staff at the Associación Civil Selva Amazónica (ACSA) for providing a friendly and welcoming environment in which to work during my time in Iquitos. To the physicians at ACSA who attended to me during my unfortunate times of illness in Iquitos, I offer my utmost appreciation for providing their services and treatment. To Salome Chapiama, I extend gratitude for facilitating access to the Hospital Apoyo Iquitos, especially during a regional strike in the health sector lasting several weeks, which restricted access to the hospital and limited services to emergency and childbirth only. For facilitating access to the delivery ward and birth registries, especially during the strike, I thank Drs. Hermánn Silva and Eder Aguilar. To Evelyn Burga, I offer thanks for repeatedly providing transportation on her motorbike and for the countless hours of data collection within the hot, screaming delivery ward of the Hospital Apoyo Iquitos. I would also like to thank both Evelyn and Salome for travelling to many

different locations in Iquitos and surrounding areas to facilitate the creation of certain variables for my study. To Dr. Veronica Soto, I extend thanks for providing accommodation and generous hospitality during my stay in Iquitos. I also thank her and Señora Laura for caring for me during my times of sickness.

I extend gratitude to my thesis committee members, Drs. Elham Rahme, Anita Gagnon, and Amee Manges for their input and feedback in the design and implementation of my study. To Serene Joseph, I offer thanks for assistance with the execution and interpretation of statistical analyses, and for the revision of my writing throughout the duration of my research.

I would like to acknowledge the teaching staff in the Department of Epidemiology, Biostatistics, and Occupational Health at McGill University. Their expert knowledge of and proficiency in epidemiological methods provided a solid foundation from which I implemented and developed the skills they have taught me within my own research.

The financial support for this research, which was provided through several sources, was gratefully appreciated. The Canadian Institutes of Health Research (CIHR) Interdisciplinary Capacity Enhancement (ICE) Grant (#HOA 80064) to Dr. Gyorkos provided financial assistance for travel, accommodation, and research expenses in Peru. The CIHR Master's Award – Frederick Banting and Charles Best Canada Graduate Scholarship provided further financial assistance for this research. The McGill Centre for Research and Teaching on Women – Margaret Gillett Graduate Research Award also provided financial assistance for my research, which focused on Women's Studies.

Finally, the Millennium Manitoba Bursary provided financial support for tuition costs during my time at McGill University.

Lastly, I would like to thank my family and friends for providing continued encouragement and support for my studies and research, especially during times of difficulty. Without their constant faith and confidence in me, the completion of this thesis would not have been possible.

Dedication

Dedicated to improving the health and well-being of all adolescent mothers and their children around the world.

Table of Contents

List of Tables

Chapter 2: Literature Review

Chapter 5: Results

Manuscript #1: A comparison of low birth weight among newborns of early adolescent, late adolescent, and adult mothers in the Peruvian Amazon

List of Appendices

1. Introduction

1.1. Global Importance of Adolescent Pregnancy and Low Birth Weight

The burden of adolescent pregnancy is widespread, and is especially prevalent in the developing world (*WHO, 2007a*). In sub-Saharan Africa, over half of women will give birth before reaching the age of 20 (*WHO, 2007a*). Age-specific fertility rates vary from country to country, but are generally moderate to high in most regions of the developing world. Compared to the global fertility rate for adolescents aged 15-19 years of 54 births per 1,000 adolescents, there are 115 births per 1,000 adolescents in Africa and 75 births per 1,000 adolescents in Latin America and the Caribbean (*United Nations, 2004*).

Compared to pregnant adult women, adolescents are faced with increased risks of adverse pregnancy and delivery outcomes (*McIntyre, 2006*). The risk of maternal, perinatal, and neonatal mortality is higher among adolescents than adults (e.g. over 1,200 maternal deaths per 100,000 adolescents aged 15-19 years versus approximately 400 deaths per 100,000 women aged 20-34 in Ethiopia) (*McIntyre, 2006*). The source of this increased risk is multifaceted, determined by both physiological and sociological factors (*McIntyre, 2006*). These include a lack of access to health and antenatal care services, poverty, low socioeconomic status, and physiological immaturity (*McIntyre, 2006*).

Low birth weight (LBW) is also a widespread issue extending to all regions of the world. Asia maintains the highest proportion of LBW infants (18.3%), while high proportions are also found in Africa (14.3%) and Latin America and the Caribbean (10.0%) (*Wardlaw et al., 2004*). There is an even greater importance to consider young maternal age when

looking at LBW, as evidence suggests that adolescents are at an increased risk of delivering a LBW newborn compared to adults (*WHO, 2007a*). Some of the proposed sources for this disparity are similar to those associated with increased frequencies of adolescent childbearing, including poverty and low socioeconomic status (*Wardlaw et al., 2004*). Other distinct determinants include a deficient nutritional status, lifestyle factors (e.g. smoking, alcohol consumption), and inadequate gestational weight gain (*Wardlaw et al., 2004*).

In order to better understand the disparity between childbearing and LBW between adolescent and adult mothers, a focus on research in several specific areas that lack supportive evidence is vital. The World Health Organization has identified several research gaps in adolescent pregnancy (*WHO, 2007a*). Those addressed in this thesis include a need for disaggregated data by age and data on the use of services and pregnancy outcomes among early adolescents (< 15 years of age). The collection of individual data by age is essential to recognizing the period at which adolescents are most at risk of adverse pregnancy outcomes (*WHO, 2007a*). The current scarcity of this type of data also hinders the ability to identify potential sources of increased risk among early adolescents (< 15 years-old) (*WHO, 2007a*). There is a specific need for data on this particularly vulnerable group of adolescents, especially regarding their utilization of health care services and pregnancy outcomes that may differ from those of late adolescents (15-19 years) and adults (≥ 20 years) (*WHO, 2007a*).

1.2. Local Importance of Adolescent Pregnancy and Low Birth Weight

In Peru, both adolescent pregnancy and LBW are significant issues affecting this Latin American country. Between 10 and 20 percent of girls will deliver a child before age 18 (*Alan Guttmacher Institute, 1998*), while approximately 11% of infants are born under 2,500 grams (LBW) (*Wardlaw et al., 2004*).

There are limited studies that have addressed determinants and outcomes of adolescent pregnancy and LBW in Peru that complement the broad national demographic statistics. However, more comprehensive data have suggested that, in Peru, increased occurrence of unplanned adolescent pregnancies may be attributable to risky behaviours such as having a more liberal view of sexual activity and having a sexually active peer network (*Magnani et al., 2001*). In terms of LBW in Peru, it has been suggested that the occurrence of LBW is more common among poor mothers of low socioeconomic status (*UNICEF, 2004*) and among mothers with inadequate gestational weight gain and deficient nutrition (*Becerra et al., 1998; Frisancho et al., 1977a; Frisancho et al., 1977b*).

While the evidence base for determinants and outcomes of adolescent pregnancy and LBW in Peru is lacking, various data on the frequency of these events within each region of the country are available. Peru is divided into twenty-five regions, and proportions of both adolescent pregnancy and LBW are determined for each region, allowing for the comparison of their frequencies between regions. The study area of this thesis is the city of Iquitos, which lies in the region of Loreto, the largest and one of the poorest in the country. In 2006, over 66% of the population in Loreto was living below the poverty line (national average = 44.5%) (*Pan American Health Organization, 2009*). The poverty line

was determined by the minimum cost of satisfying basic necessities in Peru (*Instituto Nacional de Estadística e Informática del Perú, 2006*). In 2005, the proportion of adolescent pregnancy in the region of Loreto was 8.3%, which was higher than the national average of 5.1%. It was the region with the fourth-highest proportion in the country (after Tacna: 13.0%, Madre de Dios: 8.6%, Ucayali: 8.5%) (*Pan American Health Organization, 2009*). The proportion of LBW infants in Loreto (3.0%), however, was somewhat below the national average, which was 4.3% (range = 1.2 – 5.4%, according to 2005 demographic statistics) (*Pan American Health Organization, 2009*).

While these demographics portray the status of adolescent pregnancy and LBW from a population health perspective, additional evidence exists at an even more local level that further highlights the value and importance of conducting this type of research in Iquitos, Peru. Iquitos is an isolated city of approximately 500,000 inhabitants located in the Amazon Basin, reachable only by plane or by boat. To date, there has been no research conducted specifically in this area of Peru that has explored adolescent pregnancy and LBW. Adolescent pregnancy is a critical issue in Iquitos, as it has been identified as the second most important priority problem (after infant malnutrition) (*Casapia et al., 2007*). Local government and non-government sectors, community organizations, and academia maintain that adolescent pregnancy is a key public health issue in this region of Peru. While the proportion of LBW infants in the region of Loreto was 3.0% in 2005 according to national demographic statistics, unpublished data from the study hospital in Iquitos (Hospital Apoyo Iquitos) revealed that approximately 15% of deliveries in 2007 were attributed to adolescents less than 18 years of age (Gyorkos, unpublished data). This may suggest that the co-occurrence of LBW and adolescent pregnancy in Iquitos is a bigger

issue than national demographic statistics might be indicating, which reinforces the importance of conducting this research.

2. Literature Review

2.1. Adolescent Pregnancy

Adolescent pregnancy is a global issue. High rates of adolescent pregnancy are a concern in both the developed and developing world. While the majority of countries in the developed world maintain low rates of adolescent births (e.g. Switzerland: 5.7 births per 1,000 women aged 15-19; Japan: 3.9 births per 1,000 women aged 15-19), some have very high birth rates (e.g. United States: 54.3 births per 1,000 women aged 15-19; Armenia: 56.2 births per 1,000 women aged 15-19) (*Singh & Darroch, 2000*). These rare exceptions aside, the majority of births to adolescents occur within the developing world (*McIntyre, 2006*). The highest prevalence of adolescent pregnancy is observed in Africa. In 1995-2000, the fertility rate in Africa was 115 pregnancies per 1,000 women aged 15-19 years. For the entire world, this was 54 pregnancies per 1,000 women aged 15-19 years (*United Nations, 2004*).

Across the world each year, nearly 15 million newborns are delivered by adolescent girls between the ages of 15 and 19 years, constituting approximately ten percent of all deliveries around the world (*McIntyre, 2006*). These young mothers must cope with additional risks and challenges both during pregnancy and delivery with which older mothers are less commonly burdened. These lead to an increased incidence of maternal and infant morbidity and mortality (*McIntyre, 2006; WHO, 2007a*). The health risks associated with adolescent pregnancy are even more pronounced for younger adolescents (i.e. those who are less than 15 years-old) (*McIntyre, 2006*). In addition, as the majority of

adolescents are first-time mothers, they also are at risk of adverse health outcomes associated with primiparity (*McIntyre, 2006*).

While young maternal age is a primordial risk factor for additional maternal and infant risks associated with pregnancy and childbirth, other social and behavioural issues also play a role (*McIntyre, 2006*). Adolescents who become pregnant often have low educational attainment, low social status, and a lack of access to, or low use of, health care facilities (*WHO, 2007a*). Adolescents with no education are much more likely to become pregnant than adolescents with some education (*McDevitt, 1996*). Adolescents with primary school level education are more likely to become pregnant than adolescents with secondary level education or higher (*McDevitt, 1996*). Other social and behaviour issues that have been demonstrated to influence the occurrence of pregnancy in adolescence include an urban location of residence and early marriage, especially within the context of developing countries (*McDevitt, 1996; Singh & Samara, 1996*).

Numerous studies worldwide have explored the determinants of pregnancy during adolescence. The following three illustrate this issue from both developed and developing countries' perspectives. An American study investigated individual and family-level predictors of adolescent pregnancy among a sample of runaway/homeless youth in the United States (*Thompson et al., 2008*). Pregnant adolescents were compared with a group of non-pregnant adolescents from the same population, matched by age. Individual factors that were found to be significantly associated with adolescent pregnancy included being from an ethnic minority, quitting school, long periods of absence from the home, having a sexually transmitted disease, and feelings of abandonment. Family factors

included a single-parent household and emotional abuse from the mother. A case-control study by Gökçe *et al.* (2007) investigated adolescent pregnancy within an urban area of Turkey. Married pregnant adolescents aged 15-19 years were compared to married pregnant adults aged 20-29 years. Results from face-to-face interviews revealed several statistically significant predictors of adolescent pregnancy in this population: low socioeconomic status, family violence prior to marriage, familial opposition to adolescent marriage, low educational attainment, lack of social security, household with more than one person per room, unemployment, and sisters with a history of pregnancy during adolescence. Finally, a study by Were (2007) provided a thorough evaluation of risk factors and protective factors of adolescent pregnancy in Kenya based on interviews both with adolescents and key informants. Determinants of adolescent pregnancy included a lack of schooling, a lack of sex education, and a lack of contraceptive education. A protective effect was found for those who attended church meetings to receive sex and family life education.

While these studies all originate from different culture-specific settings, a general pattern of similar determinants of adolescent pregnancy is observed. It appears that low educational attainment, low socioeconomic status, and an unsupportive family life have the greatest influence on the occurrence of adolescent pregnancy, both in the developed and developing world.

2.2. Adolescent Pregnancy in Latin America

One third of women in Latin America and the Caribbean will give birth before they reach their twentieth birthday (*Alan Guttmacher Institute, 1998*). The age-specific fertility rate

for women aged 15-19 years is 75 births per 1,000. It is the region with the second highest adolescent fertility rate in the world, after Africa (*United Nations, 2004*).

There is an abundance of previous research that has explored determinants of adolescent pregnancy, specifically in this region of the world (*Buvinic, 1998; Flórez, 2005; Gigante et al., 2004; Guijarro et al., 1999; Lipovsek et al., 2002*). Similar models of the determinants of adolescent pregnancy have been identified in different Latin American countries. A Colombian study exploring determinants of adolescent pregnancy in two culturally different contexts (one city with the highest and one city with the lowest adolescent pregnancy rate in the country) found adolescent reproductive behaviour to be a function of low socioeconomic status and low educational attainment (*Flórez, 2005*). A case-control study from Brazil comparing parous and nulliparous adolescents in a birth cohort also found that low educational attainment and low socioeconomic status were associated with adolescent pregnancy (*Gigante et al., 2004*). A study comparing pregnant and non-pregnant adolescents in Bolivia found that a lack of a social support network as well as low levels of self-esteem were associated with adolescent pregnancy (*Lipovsek et al., 2002*). Similar results were found in a study from Ecuador comparing pregnant and non-pregnant adolescents. Pregnant adolescents were more likely to lack a supportive family network, to be unhappy, and to experience more educational and economic difficulties than non-pregnant adolescents (*Guijarro et al., 1999*). While these studies have all identified a lack of education, inadequate social support network, and low socioeconomic status as determinants of adolescent pregnancy, a multi-country study (Chile, Barbados, Guatemala, and Mexico) concluded that social factors (e.g. lack of a family support network) may not influence higher rates of pregnancy in adolescents as

much as economic factors (*Buvinic, 1998*). Among economically-deprived adolescent mothers, more education and higher household income were positively associated with their child's well-being, suggesting that the development of improved educational and earning prospects may interrupt the cycle of economic deprivation that these underprivileged mothers face. Overall, these studies illustrate a general paradigm of the determinants of adolescent pregnancy in Latin America that includes both social and economic factors (*Buvinic, 1998; Lipovsek et al., 2002*).

2.3. Adolescent Pregnancy in Peru

Peruvian national demographic data indicate that, between 2001 and 2004, the fertility rate for 15-19 year-olds was 61 births per 1,000 adolescents (*Instituto Nacional de Estadística e Informática del Perú, 2005*). Peruvian adolescents living in rural areas have a higher fertility rate than those living in urban areas (100 births per 1,000 adolescents and 47 births per 1,000 adolescents, respectively). Between 2000 and 2004, the proportion of adolescents who were already mothers or who were pregnant remained almost unchanged (13.0% in 2000 and 12.7% in 2004). Proportions are even higher for adolescents living in rural areas (20.3%) and those with the lowest income (27.0%) (*Instituto Nacional de Estadística e Informática del Perú, 2005*).

There is limited research on the determinants of adolescent pregnancy in Peru. No studies were found that compared characteristics of pregnant and non-pregnant adolescents. There are, however, studies that have examined potential relationships between various behavioural risk factors and negative health outcomes among adolescents in Peru (*Cáceres et al., 1997; Magnani et al., 2001*). One study observed that those who

experienced an unplanned pregnancy had a greater likelihood of having misconceptions about condom use and to have experienced episodes of sexual coercion (*Cáceres et al., 1997*). This suggests that culturally-specific social norms may contribute to the risk of unplanned pregnancy in Peru. While this study was conducted in the capital city of Lima, a second Peruvian study investigated determinants of early initiation of sexual activity and unprotected sex among high school students in nine large cities (*Magnani et al., 2001*). It was found that risky behaviours potentially leading to an unplanned adolescent pregnancy (e.g. unprotected sex) included a low socioeconomic status, living in the jungle region (a proxy for more a liberal outlook of sexual activity), being employed, and having a sexually active peer network (*Magnani et al., 2001*).

2.4. Low Birth Weight

Low birth weight (LBW: weight less than 2,500 grams), like adolescent pregnancy, is a worldwide concern, with LBW newborns accounting for 15.5% of all births (*Wardlaw et al., 2004*). This concern exists in both developed and developing countries; however, the burden is more pronounced in developing countries, with 95.6% of all LBW births occurring in these countries (*Wardlaw et al., 2004*). The region of the world with the highest occurrence of LBW newborns is South-central Asia, where 27.1% of infants are born with a LBW. The regions with the next highest proportions of LBW newborns are Western Africa and Western Asia (both 15.4%) (*Wardlaw et al., 2004*).

LBW develops from two sources: preterm birth (less than 37 weeks gestation) or intrauterine growth restriction (*Kramer, 1987*). Fetal and neonatal morbidity and mortality are strongly related to LBW. During development, children born with a LBW

may experience stunted growth, cognitive problems, and chronic diseases in later life (*Barker, 1992*). There is a multitude of factors that influence gestational age and growth of the fetus, which in turn have an effect on birth weight. Socioeconomic, behavioural, and physiological variables all contribute to gestational and delivery outcomes (*WHO, 2006*). It is difficult to accurately measure the magnitude of their individual effects on birth weight because of their dynamic interplay. For example, adequate nutrition during pregnancy is essential for optimal fetal growth and development. An impoverished diet may be the result of low socioeconomic status, which hinders access to an adequately nutritious diet during pregnancy. In this way, the physiological effects of a poor diet (e.g. inadequate gestational weight gain) are a function of poverty, a socioeconomic variable (*WHO, 2006*).

There are numerous studies that have investigated LBW in various regions of the world. The results of two such studies are outlined here in order to illustrate the situation from both a developed and developing country's perspective. Using national survey data, a study from India investigated the association between the mother's nutritional status and birth weight of her newborn (*Dharmalingam et al., 2009*). The authors concluded that nutritional status, as measured by the mother's body mass index, was the most important determinant of low birth weight. Other important determinants included safe drinking water, antenatal care utilization, and anemia. Another study examined the association between social factors and newborn birth weight in a population in Québec, Canada (*Dubois & Girard, 2006*). Results demonstrated that birth weight increased with higher levels of family socioeconomic status and with higher maternal body mass indices. Newborn birth weight was lower among mothers who smoked. Body mass index was the

most important indicator of LBW among mothers of higher socioeconomic status; however, maternal smoking was the most important indicator among mothers of lower socioeconomic status. Findings from these two studies may suggest that while many of the determinants of LBW may be similar in developed and developing countries, there are disparities reflective of local genetic, cultural, and environmental contexts.

2.5. Low Birth Weight in Latin America

The issue of LBW in Latin America is not as widespread as it is in Asia and Africa. The proportion of LBW infants born in Latin American and the Caribbean is 10.0% (*Wardlaw et al., 2004*). This proportion is 13.7% in the Caribbean, 10.1% in Central America, and 9.6% in South America (*Wardlaw et al., 2004*).

There are few recent studies from Latin America that have investigated the determinants of LBW. Four relatively current studies are outlined here. One of these was a case-control study investigating risk factors for LBW in Sancti Spíritus, Cuba (*Escobar et al., 2002*). Cases consisted of 764 singleton live births of less than 2,500 grams while controls consisted of 1,437 singleton live births of at least 2,500 grams, selected from the same hospital. Data were obtained from clinical histories, birth registries, and personal interviews with the mothers. Multivariate analyses revealed an increased likelihood of LBW for mothers with anemia, with a gestational weight gain of less than eight kilograms, and for mothers who smoked during pregnancy (*Escobar et al., 2002*). There was no association found between LBW and low educational attainment (incomplete primary school or less) or late attendance at first antenatal care visit.

A second study from Brazil examined maternal smoking and its association with LBW using a historical cohort design (*Horta et al., 1997*). All 5,166 live births delivered in 1993 in Pelotas, Brazil, were included in the cohort. Data were obtained from personal interviews with the mothers soon after the birth of their child. Smoking was found to be statistically significantly associated with LBW such that those who smoked during pregnancy had increased odds of delivering a LBW newborn compared to those who did not smoke during pregnancy, even after adjusting for several potential confounders (socioeconomic status, education, parity, pregnancy interval, previous LBW newborns, maternal height, and antenatal care). Further, newborns of mothers who smoked during pregnancy weighed less, on average, than newborns of mothers who did not smoke during pregnancy.

A third study from Ribeirão Preto, Brazil examined trends in LBW by comparing two birth cohorts from 1978-1979 (n = 6,750, a population survey) and 1994 (n = 2,990, a sample survey) (*Silva et al., 1998*). Multivariate logistic regression adjusted for newborn sex, maternal age (< 20 years, 20-34 years, ≥ 35 years), marital status (cohabiting, non-cohabiting), parity (1 birth, 2-4 births, ≥ 5 births), preterm birth (yes, no), antenatal care (< 4 visits, ≥ 4 visits), type of delivery (vaginal, cesarean), health care (public, private), smoking (yes, no), maternal education (< 4 years, 4-11 years, ≥ 12 years), and occupational group (lower managers, executives, academics; skilled and semi-skilled; unskilled/unemployed). In the 1978-1979 cohort, the following variables statistically significantly increased the likelihood of LBW: female sex, maternal age ≥ 35 years, preterm delivery, less than four antenatal care visits, maternal smoking, 4-11 years of education, skilled or semi-skilled occupational status, and unskilled/unemployed. In the

1994 cohort, the following variables statistically significantly increased the likelihood of LBW: preterm birth, cesarean delivery, and maternal smoking.

A final case-control study investigated risk factors for LBW in Natal, Brazil, while taking into account preterm delivery and intrauterine growth restriction (*Ferraz et al., 1990*). Cases consisted of 429 preterm newborns and 422 intrauterine growth-retarded (IUGR) singleton newborns. Controls consisted of 2,555 newborns of normal birth weight and gestational age. Adjusted odds ratios were estimated using logistic regression, and the proportion of LBW that may have been prevented was estimated using attributable risk percent (AR%). Preventable determinants of preterm birth were maternal age < 20 years (AR = 7.1%), maternal weight < 50 kilograms (AR = 20.5%), smoking during pregnancy (AR = 14.6%), < 5 antenatal care visits (AR = 28.1%), history of LBW (AR = 12.2%), gestational illness (AR = 15.5%), and vaginal bleeding in the first trimester (AR = 13.4%). Preventable determinants of IUGR were maternal weight < 50 kilograms (AR = 17.8%), maternal education < 4 years (AR = 11.6%), smoking during pregnancy (AR = 14.8%), < 5 antenatal care visits (AR = 11.6%), history of LBW (AR = 14.1%), gestational illness (AR = 6.0%), and primiparity (AR = 25.6%).

In general, therefore, Latin American studies have provided evidence documenting the association between LBW and several socio-demographic and clinical determinants. These include older maternal age, less education, less skilled occupation, maternal pre-pregnancy weight, low gestational weight gain, anemia, history of LBW, gestational illness, vaginal bleeding in the first trimester, primiparity, few antenatal care visits, smoking, preterm birth, caesarean delivery and female sex of the newborn.

2.6. Low Birth Weight in Peru

Data from Peruvian demographic health surveys indicate that about 11% of infants born in Peru are LBW (*Wardlaw et al., 2004*). The proportion of LBW newborns increases with decreasing socioeconomic status. In 2000, the proportion of LBW newborns among families who do not live in poverty was 9.7%, 12.8% for those living in poverty, and 14.1% for those living in extreme poverty (*UNICEF, 2004*). Here, extreme poverty was defined as a household with a total per capita expenditure of less than the cost of a Basic Nutritional Basket (a food basket designed by the Peruvian National Nutrition Institute that provides 13,013 calories and 379 grams of protein for a family of six), which varies from approximately $583 to $712 Canadian dollars annually, depending on the region of Peru *(World Bank, 1993*). Poverty was defined as a household with a total per capita expenditure of less than the cost of a Basic Consumption Basket, which includes a Basic Nutritional Basket in addition to supplementary funding for non-food expenses (*World Bank, 1993*). Examining these proportions in terms of socioeconomic quintiles reveals a similar pattern of decreasing proportions of LBW with increasing socioeconomic quintile (Q1: 12.9% LBW; Q2: 9.2% LBW; Q3: 6.9% LBW; Q4: 6.4% LBW; Q5: 5.6% LBW) (*UNICEF, 2004*).

Within Peru, approximately 33% of newborns are not weighed at birth due to inaccessibility to appropriate equipment if not born within a health facility (*Wardlaw et al., 2004*). Even if delivery occurs within a health facility and is attended by a skilled birth attendant, birth weight may still not be recorded (*Wardlaw et al., 2004*). However, within the developing world, Latin America and the Caribbean have the lowest proportion

of un-weighed newborns (17%) compared to other regions of the developing world (e.g. South Asia: 74%), and new statistical methods have been developed in order to more accurately estimate the actual proportion of LBW newborns (*Wardlaw et al., 2004*).

Few studies have examined determinants of LBW in Peru. Three studies are outlined here that highlight the most important risk factors that have been identified. One cross-sectional study investigated maternal anemia and its association with various other maternal factors in a sample of pregnant women from a jungle region of Peru between 1993 and 1995 (*Becerra et al., 1998*). Data were obtained from 1,015 antenatal care and delivery records of women from a regional hospital. The proportion of women with anemia was very high in this sample (70.1%), which is a function of the high prevalence of endemic intestinal parasitic diseases in this area of Peru (*Becerra et al., 1998*). Despite the known association between anemia and LBW (*Lops et al., 1995*), the high proportion of anemic pregnant women was not found to be associated with LBW in this sample. The authors identified pre-pregnancy weight, gestational weight gain, and parity to be statistically significantly associated with newborn birth weight such that an increase in these variables was associated with an increase in birth weight. While the design of this study permitted prevalence measurements and the interpretation of potential associations between anemia and maternal factors, causal associations cannot be inferred. Further, potential causes of the high prevalence of anemia among pregnant women in this population were not explored, which should be taken into account in order to better understand the high occurrences of anemia in conjunction with pregnancy in this jungle region of Peru. The two other studies were conducted using the same sample of newborns and their mothers from a hospital in the capital city of Lima (*Frisancho et al., 1977a;*

Frisancho et al., 1977b). The first of these studies employed a cross-sectional design to examine the effects of the mother's nutritional status on gestational growth of the fetus in a sample of 4,952 mothers and their newborns (*Frisancho et al., 1977a*). Pre-delivery maternal anthropometric measurements were taken (height, weight, arm circumference, and skinfold thickness), as were post-delivery newborn anthropometric measurements (birth weight; recumbent length; head, thorax, and upper arm circumference; and skinfold thickness). Maternal nutritional status was categorized based on anthropometric measurements (e.g. short stature and high muscle mass). Results suggested a positive association between the mother's calorie reserves and newborn birth weight, but not as strong of an association between calorie reserves and length of the newborn. Conversely, there was a positive association found between the mother's protein reserves and both newborn birth weight and antenatal linear growth. This study did adjust for maternal age and also considered parity (no significant variations in neonatal characteristics by parity of the mother). While maternal demographic characteristics were reported (income, food expense, and education), these were not considered in the analysis. The second of these studies also employed a cross-sectional design to examine the association of newborn skinfold thickness and muscle area with newborn birth weight and recumbent length in a sample of 4,952 infants (*Frisancho et al., 1977b*). Results indicated that newborns with higher fat and muscle were heavier and longer than newborns with lower fat and muscle. The same was true for newborns with high muscle and low fat compared to those with low muscle and high fat. Based on these results, the authors proposed that higher newborn calorie and protein reserves more strongly mediate birth weight and length than higher newborn calorie reserves alone. The authors concluded that newborn birth weight and length are more a function of the mother's nutritional status than of her height.

As the literature on the determinants of LBW in Peru is limited, the above studies do not offer a comprehensive description of the potential determinants of LBW that may affect pregnant women specifically in Peru. It is possible that many of the determinants of LBW mentioned in Section 2.5. with relation to Latin America as a region, may also be applied to Peru as a country. These include inadequate antenatal care, low educational attainment, maternal smoking, poverty, and low socioeconomic status. Potentially, these determinants may be applicable to many developing countries in Latin America (Brazil and Cuba), which may be more homogeneous in culture and economy than developing countries outside of Latin America.

2.7. Adolescent Pregnancy and Low Birth Weight

In both developed and developing countries, much previous research has found the occurrence of LBW to be more common among adolescent mothers than adult mothers (*Briggs et al., 2005; Buschman et al., 2001; Chen et al., 2007; Haldre et al., 2007; Hamada et al., 2004*). Further, there is an even greater risk of delivering a LBW newborn for younger (10-14 years-old) than for older adolescents 15 years and older (*Cooper et al., 1995*).

The main findings of this research are illustrated by the following studies. A retrospective chart review conducted in Kingston, Ontario, Canada in between 1996 and 2004 compared obstetric outcomes between primiparous pregnant adolescents and adult pregnant women (*Briggs et al., 2005*). The review included 207 adolescents ≤ 19 years and 415 adults ≥ 20 years. Inclusion criteria consisted of all singleton live births, women

with at least 24 weeks gestation, and women whose antenatal care was provided by a single obstetrician. Adolescent mothers had statistically significantly more LBW newborns (10.1%) than adult mothers (4.3%). However, maternal age was not a statistically significant predictor of LBW in the multivariate logistic regression model that also included gestational hypertension, smoking, pre-pregnancy body mass index, infant sex, and anemia. Only gestational age at delivery was statistically significant (OR = 3.28, 95%CI: 1.88, 5.70). However, an interpretation and plausible explanation of this association was not provided. The authors maintained that further investigation is necessary due to the low occurrence of LBW in the sample (6%) and the strong association between gestational age and the outcome (LBW). This may indicate that other factors are mediating this association such as antenatal care, socioeconomic factors, and inadequate weight gain, which were not accounted for in the study. The generalizability of these results to other Canadian populations may be limited because the sample consisted of almost exclusively one ethnic group who received antenatal care from the same obstetrician.

A retrospective case-control study from the United Kingdom examined gestational weight gain and LBW between adolescent (< 16 years, n = 104) and adult mothers (25-30 years, n = 150) (*Buschman et al., 2001*). Data were obtained from medical case notes from a hospital in Dundee, Scotland. Girls between 17 and 24 years of age were excluded because of their likelihood of having similar weight gain patterns as older women (i.e. 25-30 years) (*Frisancho et al., 1983*). The mean birth weight of newborns born to adolescent mothers was less than that of newborns born to adult mothers (3,200 grams and 3,510 grams, respectively) despite a similar gestational weight gain (mean body mass index

increase of six for adolescents and five for adults). Although the authors presented a rationale for the exclusion of women between 17 and 24 years-old, important differences may have been overlooked with the omission of this group of women, which is a limitation of this study.

An American retrospective cohort study was conducted using data from a nationally linked birth/infant death database, assembled from national health statistics from all 50 states (*Chen et al., 2007*). The study investigated whether pregnancy in adolescence was associated with an increased risk of adverse birth outcomes, while adjusting for several confounding factors. The cohort consisted of 3,886,364 primiparous women aged < 25 years who had a singleton live birth between 1995 and 2000. All adolescent age groups (10-15 years, 16-17 years, 18-19 years, and all adolescents 10-19 years) had an increased risk of delivering a LBW newborn (< 2,500 grams) compared to adults aged 20-24 years (RR = 1.33, 95%CI: 1.31, 1.36; RR = 1.17, 95%CI: 1.16, 1.19; RR = 1.08, 95%CI: 1.07, 1.09; RR = 1.14, 95%CI: 1.13, 1.14, respectively). The same was also true for very low birth weight as an outcome (< 1,500 grams). These multivariate models adjusted for gestational weight gain (< 0.16 kg/week, 0.16 to < 0.60 kg/week, ≥ 0.60 kg/week), race (white, black, other than white or black), marital status (married, unmarried), age-appropriate education, antenatal care (adequate, intermediate, or inadequate, classified according to a validated index), and smoking and alcohol use (yes, no). Even after restricting the analysis to white, married mothers with age-appropriate education, who had had adequate antenatal care, and who had not smoked nor consumed alcohol during pregnancy, adolescents still had an increased risk of delivering a LBW newborn (RR = 1.61, 95%CI: 1.41, 1.84; RR = 1.42, 95%CI: 1.35, 1.50; RR = 1.17, 95%CI: 1.13, 1.21;

RR = 1.24, 95%CI: 1.20, 1.27, respectively). The very large sample size of this study made it possible to detect small but meaningful differences between adolescent and adult pregnant women and increased the generalizability of the results to the entire American population.

A Moroccan case-control study investigated whether pregnant adolescents had increased risks of adverse birth outcomes compared to pregnant adults (*Hamada et al., 2004*). Cases (n = 311) were adolescents aged ≤ 18 years selected from a local maternity hospital. Controls (n = 155) were adults aged > 18 years randomly selected from the same maternity hospital. It is not clear whether data were obtained by personal interview or from hospital records. Results revealed a statistically significantly lower mean birth weight among newborns of adolescent mothers compared to those of adult mothers (3,074 grams and 3,199 grams, respectively). A statistically significantly higher frequency of LBW was found among unmarried compared to married adolescents (23.3% versus 9.6%). There were no other statistically significantly higher risks of adverse birth outcomes found among adolescents compared to adults.

Finally, a cross-sectional descriptive study from Kenya compared the occurrence of LBW (here, < 2,000 grams) between adolescent (< 20 years, n = 64) and adult (≥ 20 years, n = 78) mothers (*Wasunna & Mohammed, 2002*). Data were obtained directly from the mothers delivering at a local hospital by daily clinical assessment until discharge from hospital, death, or until one month in the delivery ward. The occurrences of prematurity ($p < 0.05$), very LBW < 1,500 grams (79.7% among adolescents and 39.7% among adults, $p < 0.01$), and multiple morbidity events ($p < 0.05$) were statistically significantly

greater among adolescent mothers than among adult mothers. The risk of respiratory distress was higher among newborns of adolescent mothers compared to newborns of adult mothers (RR = 1.25, 95%CI: 1.04, 1.50). While these results provide a description of the morbidity of newborns of adolescent mothers in Kenya, the authors did not take into account potential confounding factors that may have influenced their results such as age-appropriate education, gestational weight gain, and socioeconomic factors.

2.8. Adolescent Pregnancy and Low Birth Weight in Latin America

The region of Latin America is not always consistently defined. For this reason, the studies investigating adolescent pregnancy and LBW in Latin America outlined in Table 1 have been identified using the Pan-American Health Organization's definition of Latin America, which consists of Mexico, Brazil, and countries located within four other sub-regions: Isthmus of Central America, Latin Caribbean, Andean, and Southern Cone sub-regions[1] (*Pan American Health Organization, 2002*).

As summarized in Table 1, the majority of these Latin American studies found adolescent mothers to have a greater likelihood of delivering a LBW newborn or to deliver a newborn with a lower birth weight than newborns born to adult mothers. Only one of these Latin American studies found no association between maternal age and LBW (*Cantero, 2005*). A possible reason for why no difference was found between adolescents and adults in this Cuban study may be that a multivariate analysis was not done, such that

[1] Countries located within these sub-regions that comprise Latin America are as follows: Isthmus of Central America: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama; Latin Caribbean: Cuba, Haiti, Puerto Rico, and Dominican Republic; Andean: Bolivia, Colombia, Ecuador, Peru, and Venezuela; Southern Cone: Argentina, Chile, Paraguay, and Uruguay.

there was no adjustment for potential confounders (e.g. gestational age, parity). One other case-control study from Chile found no statistically significant difference in the proportion of LBW newborns between adolescent (1.5%, n = 894) and adult (1.1%, n = 806) mothers (*Pardo et al., 2003*). However, an analysis of variance that included age of the father, gestational age, number of previous pregnancies, abortions, and neonatal deaths revealed a statistically significant difference in mean birth weight between these two groups (3,171.5 grams and 3,294.1 grams, respectively).

Table 1. Summary of previous Latin American studies comparing low birth weight (LBW) between adolescent and adult mothers

Country	First Author	Year	Data Source	Results
Brazil	Machado	2006	73,820 birth records of primiparous women from 1998 birth cohort in Sao Paulo.	Adolescents 10-14 and 15-19 years-old had increased odds of LBW babies compared to 20-24 year-olds, after adjusting for delivery mode, plurality, sex, maternal education, number of prior losses, antenatal care, race, parity, and community development (OR = 2.01, $p < .001$; OR = 1.18, $p < .001$, respectively).
Brazil	Minagawa	2006	Random sample of 101 newborns from catchment area of hospital in Sao Paulo.	Maternal age of <20 years was significantly associated with the occurrence of LBW (frequency of LBW: 25% among <20 year-olds compared to 3.4% among 20-24 year-olds).
Brazil	Goldenberg	2005	7,672 live births records from 2001 birth cohort in Montes Claros.	Increased prevalence ratio (PR) for LBW among adolescents 10-14 years-old (PR = 7.4, 95%CI: 4.9, 11.1) and 15-19 years-old (PR = 2.6, 95%CI: 2.1, 3.3) compared to women ≥20 years-old, controlling for antenatal care.
Cuba	Cantero	2005	184 pregnant adolescents <20 (cases) and 439 pregnant 20-24 year-olds (controls) from a local hospital in Havana.	Proportion of LBW was similar between adolescent (4.8%) and adult (4.9%) groups.
Ecuador	Hidalgo	2005	Matched (on gestational age) case-control study of adolescents ≤15 years (n = 201) vs. adults 20-24 (n = 201) years-old delivering at hospital in Guayaquil, restricted to low socio-economic status.	Adolescent group had a significantly lower mean birth weight (2,837.6 ± 454 g vs. 3,017 ± 547 g) and a higher incidence of LBW (19.9% vs. 11.4%, OR = 1.92, 95%CI: 1.0, 3.5) compared to the adult group.

Latin America[a]	Conde-Agudelo	2005	854,377 records of women <25 years-old during 1985-2003 from Perinatal Information System database of the Latin American Center for Perinatology and Human Development.	After adjusting for 16 major confounders, all three adolescent age groups (≤15, 16-17, and 18-19 years) had significantly higher odds of LBW (OR = 1.62, 95%CI: 1.54, 1.71; OR = 1.27, 95%CI: 1.23, 1.32; OR = 1.20, 95%CI: 1.17, 1.28, respectively) and very LBW (OR = 1.25, 95%CI: 1.12, 1.39; OR = 1.24, 95%CI: 1.16, 1.33; OR = 1.10, 95%CI: 1.05, 1.15, respectively) than the adult age group (20-24 years).
Chile	Pardo	2003	Data extracted from Latin American Collaborative Study for Congenital Malformations database between 1982-2001 for 894 adolescents (10-19 years-old) and 806 adults (≥20 years-old).	There was no significant difference in the proportion of LBW babies between the adolescent group (1.5%) and the adult group (1.1%). However, there was a statistically significant difference in mean birth weight between newborns of adolescent and adult mothers (3171.5g and 3294.1g, respectively).
Brazil	Costa	2002	A total of 2,194 birth records for adolescent mothers (10-19 years-old) and 3,085 adult mothers (20-24 years-old) extracted from the Information System on Live Births in 1998 in Feira de Santana.	The odds of LBW were significantly higher among adolescents 10-16 years-old compared to the odds of LBW among both 17-19 year-olds (OR = 1.36, 95%CI: 1.10, 1.68) and 20-24 year-olds (OR = 1.58, 95%CI: 1.29, 1.93) (adjusted for antenatal care, gestational age, and maternal education).
Brazil	Gama	2001	A random sample of adolescents 15-19 years-old and adults 20-24 years-old were extracted from the Information System of Live Births in Rio de Janeiro. 2,150 live births were selected from 1996-98 for each maternal age group.	Among women with a gestational age of <37 weeks, adolescents had significantly greater odds of LBW babies compared to adults (OR = 1.27, 95%CI: 1.05, 1.54). Among women with a gestational age of ≥37 weeks, adolescents still had significantly greater odds of LBW babies compared to adults (OR = 1.30, 95%CI: 1.03, 1.64). All odds ratios were adjusted for educational level of the mother and location of delivery (public or private

				institution).
Argentina	Bortman	1998	Perinatal Database used to extract 18,466 birth records from 29 hospitals from 1988-1995: 1,398 adolescents <17 years, 3,366 adolescents 17-19 years, 12,395 adults 20-35 years, and 1,307 adults ≥36 years.	Adolescents <17 and 17-19 years-old had increased odds of LBW babies compared to women 20-35 years-old (OR = 1.98, 95%CI: 1.64, 2.39; OR = 1.53, 95%CI: 1.33, 1.76, respectively). ORs were adjusted for marital status, maternal morbidity, BMI, and antenatal care.
Colombia	Linares	1998	Data extracted from the 1990 Prevalence, Demographics, and Health Survey for 278 adolescents aged 15-19 years, 1,432 adults aged 20-24 years, 3,019 aged 25-39 years, and 242 aged >39 years.	Compared to adults 25-39 years-old, adolescents 15-19 years-old had 2.17 times the odds of having a LBW baby (95%CI: 1.57, 3.00), adjusting for parity, education, marital status, area of residence, and socio-economic status.
Peru	Frisancho	1985	Included 1,256 pregnant women aged between 12 and 25 years delivering at maternity hospital in Lima.	Adolescents had smaller and thinner (determined by anthropometric measures) newborns compared to adults, despite similar nutritional status. Authors suggest that LBW is not a result of short gestation or low gynecologic age, but instead may be a function of greater nutritional requirements of rapidly growing adolescents compared to adults who are more fully developed.
Peru	Frisancho	1984	Included 412 pregnant adolescents between 13 and 15 years delivering at maternity hospital in Lima.	Still-growing adolescents had lighter weight newborns than adolescents who had completed growth. Authors suggest reduced birth weight due to fewer nutrients available to still-growing adolescents and/or due to inadequate ability of placenta to function for active fetal growth.

Peru	Frisancho	1983	Included 1,256 pregnant women aged between 12 and 25 years delivering at maternity hospital in Lima.	Biochemical and anthropometric measurements used to evaluate physiological maturity and nutritional status of mothers and infants. Newborns of adolescent mothers were smaller and thinner than newborns of adult mothers, adjusted for nutritional status. Adolescents may have greater nutritional requirements than adult mothers, which challenge growth needs of the fetus.

[a] Countries included: Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela.

The difference between early and late adolescents in terms of occurrence of LBW was demonstrated in many of these Latin American studies. The overall observation was that there is an increased risk of LBW for younger adolescents compared to older adolescents.

Another important facet of these Latin American studies is that they all, but for the Cuban study (*Cantero, 2005*), attempted to adjust for a number of potential physiological, socioeconomic, and behavioural confounders. Among the most prominent potential confounders considered were parity, gestational age, antenatal care, maternal and newborn anthropometry, maternal smoking, maternal education, and community development.

2.9. Adolescent Pregnancy and Low Birth Weight in Peru

With specific reference to Peru, only one author was found to have compared birth weight of newborns born to adolescent and adult mothers (*Frisancho et al., 1983; Frisancho et al., 1984; Frisancho et al., 1985*). These studies all utilized the same sample of women (n = 1,256) from a hospital in the capital city of Lima. The main conclusions were that: adolescents had smaller and thinner newborns than adult mothers even among those with a similar nutritional status, suggesting LBW to be a function of nutritional deficiency among adolescents (*Frisancho et al., 1983; Frisancho et al., 1985*); and that still growing adolescents (based on expected growth determined by the adolescent's parents' height) had lighter weight newborns than adolescents who had finished growing (*Frisancho et al., 1984*).

While these studies by Frisancho *et al.* provide evidence for differences in newborn birth weight between adolescent and adult mothers in Lima, Peru, no studies were found that investigated this issue in the Amazon region of Peru. The economic and cultural diversity of Peru presents a challenge in generalizing results of individual studies to the country as a whole or to other regions within the country. The city of Iquitos, located within one of the poorest regions of the country within the Amazon rainforest, is isolated from the rest of the country. It has a distinct culture and behaviour. While the association between adolescent pregnancy and LBW is robust in the developed world, evidence from developing countries, especially from rural and poorer regions, is more limited. A multidisciplinary and participatory workshop held in 2005 in the city of Iquitos identified adolescent pregnancy as the second most important priority problem in Iquitos (after infant malnutrition) (*Casapia et al., 2007*). Comparing LBW between adolescents and adults in this region would contribute to research on adolescent pregnancy and LBW in Peru and would also offer the first description of this issue within the Peruvian Amazon.

3. Study Objectives

The overall objective of this research was to compare birth weight of newborns born to adolescent mothers with that of newborns born to adult mothers. Adolescents were sub-divided into early (10-14 years) and late (15-19 years) because disaggregated data on adolescents in previous research are limited, and studies involving early adolescents, who may differ physiologically and psychologically from late adolescents, are highly valued (*WHO, 2007a*).

Specifically, the objectives of this study were to:

1) Compare the proportion of LBW newborns:
    a. of all adolescent mothers (< 20 years) with that of adult mothers (≥ 20 years).
    b. of early adolescent mothers (10-14 years) and late adolescent mothers (15-19 years) with that of adult mothers (≥ 20 years).
2) Compare the mean birth weight of newborns:
    a. of all adolescent mothers (< 20 years) with that of adult mothers (≥ 20 years).
    b. of early adolescent mothers (10-14 years) and late adolescent mothers (15-19 years) with that of adult mothers (≥ 20 years).

In accordance with methodological approaches employed in previous literature (*Briggs et al., 2005; Costa et al., 2002*), these comparisons were implemented using two sample populations:

1) All mothers who had had a singleton, live birth.

2) Primiparous mothers with a normal gestational age who had had a singleton, live birth.

4. Study Methodology

4.1. Study Design

A cross-sectional study was designed and conducted to examine the association between maternal age (i.e. adolescent and adult age groups) and low birth weight (LBW). Data on both exposures and outcomes were obtained from routinely recorded hospital registry logbooks spanning three years (2005, 2006, and 2007).

4.2. Study Area

Data were collected from the birth registries of the Hospital Apoyo Iquitos in the city of Iquitos, located within the Province of Maynas, in the Peruvian Amazon. This hospital is well located to serve inhabitants of Iquitos and those from surrounding areas. It is situated near a recently constructed highway connecting Iquitos to the town of Nauta, and it is at the junction of three major rivers (*Rio Itaya*, *Rio Nanay*, and *Rio Amazonas*), which are used for transportation. Because of its prime location close to these rivers, inhabitants of nearby districts within the Amazon region of Peru come to this hospital for care, as the rivers provide the fastest and most convenient mode of transportation. Its proximity and convenient setting has made the Hospital Apoyo Iquitos the most familiar and recognized hospital in this region of Peru (*Hospital Iquitos César Garayar García, 2009*). The hospital considers itself a leader in malaria, dengue fever, and other tropical disease research. It provides all primary care and emergency services as well as a full range of other medical service departments ranging from pediatrics to obstetrics to psychiatry (*Hospital Iquitos César Garayar García, 2009*). In terms of healthcare, salaried Peruvians

are covered by a national health plan called EsSalud (*Seguro Social de Salud del Peru* [Peruvian Social Health Insurance]). Residents who are unsalaried are covered under another national health plan through the Ministry of Health (this includes those unable to afford healthcare). Others may be covered through private insurance companies or the military healthcare plan (*Mitka, 1999*). While standard delivery is free, any additional and non-essential service requested by the woman that is not part of a typical delivery must be paid for (e.g. epidural) (unpublished information provided by the Hospital Apoyo Iquitos).

4.3. Study Population

The study population consisted of pregnant women delivering at the Hospital Apoyo Iquitos. Information on the pregnant women and their babies was recorded in the hospital's birth registry. This includes demographic and clinical information on the pregnant women (e.g. address, gestational age, parity), the labour and delivery (e.g. type of delivery), and the newborn infant (e.g. birth weight, sex). From this administrative database, a random sample of women was selected from the 2005, 2006, and 2007 birth registries.

4.3.1. Mothers: Routinely Recorded Variables

The following presents a list of the maternal variables routinely recorded in the hospital's birth registry:

- Date and hour of admission
- Age of mother
- Address of mother

- Number of pregnancies
- Number of pregnancies to term
- Number of preterm pregnancies
- Number of abortions (spontaneous or induced)
- Number of live children
- Location of antenatal care
- Number of antenatal care visits
- Whether woman was referred to hospital for delivery
- Diagnosis at admission:
    - Parity
    - Gestational age (*secondary source for gestational age variable*)
    - Stage of labour upon admission
    - Complications of labour presented upon admission to hospital
- Type of delivery (eutocic or dystocic)
- Cause of dystocia, where appropriate
- Attendant at birth
- Description of amniotic fluid
- Gestational age as measured by date of late menstrual period (*primary source for gestational age variable*)
- Drug treatment received during delivery
- Description of puerperium (normal or abnormal)
- Cause of abnormal puerperium, where appropriate
- Whether woman accepted post-delivery contraception counsel
- Type of contraception prescribed

- Date of hospital discharge
- Date and result of syphilis test
- Date and result of HIV test
- Drug treatment received upon discharge

4.3.2. Newborns: Routinely Recorded Variables

The following presents a list of the infant variables routinely recorded in the hospital's birth registry:

- Date and hour of birth
- Newborn sex
- APGAR score at one minute
- APGAR score at five minutes
- Birth weight (in grams)
- Stillbirths
- Cause of stillbirth
- Neonatal deaths

4.4. Definitions

4.4.1. Adolescent

The term adolescent lacks a clear standard definition. In this study, the WHO definition was used, which includes anyone between the ages of 10 and 19 (*WHO, 2007a*). Adolescents were subdivided into early (10-14 years) and late (15-19 years) age groups in

order to investigate possible differences between younger and older adolescents. Adults included all women ≥ 20 years old.

4.4.2. Low Birth Weight

The definition of low birth weight (LBW) was a birth weight of less than 2,500 grams (*Wardlaw et al., 2004*).

4.4.3. Gestational Age

A normal gestational age was defined as ≥ 37 weeks gestation (*WHO, 2007b*). The method of measurement for gestational age was not consistent under the diagnosis at admission variable (e.g. sometimes recorded using date of last menstrual period, ultrasound, or no method recorded). Because date of last menstrual period (LMP) was considered the most consistently and routinely recorded measurement of gestational age, this variable was used in all analyses. In instances where LMP was missing from a woman's delivery record, gestational age as recorded from the woman's diagnosis at admission was used. In instances where information for both of these variables was absent, gestational age was recorded as missing.

4.4.4. Antenatal Care

As defined by the Peruvian Ministry of Health (MOH), antenatal care attendance was classified according to the appropriate number of visits a woman should have had according to her gestational age (*Ministerio de Salud del Perú, 2004*). The MOH recommendations are as follows: at least one visit for women at < 22 weeks; at least two visits for women between 22 and 24 weeks; at least three visits for women between 25

and 29 weeks; at least four visits for women between 30 and 35 weeks; at least five visits for women between 36 and 40 weeks; and at least six visits for women who are at 41 weeks or more (*Ministerio de Salud del Perú, 2004*).

4.4.5. Location of the Mother's Residence

The location of the mother's residence was categorized into rural, peri-urban, and urban. In this population, rural location is defined as a region a distance away from the city where no municipal services of water and sanitation are available (the water source is usually the river) and where electricity is not constant. An urban location is defined as an area where constant municipal water and sanitation services are available. A peri-urban location is defined as a region between the rural and urban zones where there may be a constant source of electricity and water but inadequate sanitation services. The designation of these locations originated from the mother's address of residence, which was recorded in the birth registry. Local research assistants categorized the addresses into rural, peri-urban, and urban areas according to their geographic location within the city of Iquitos and surrounding areas. In instances where the address could not be categorized using existing knowledge, research assistants travelled to the geographic location of the address in order to make an accurate categorization.

4.5. Sample Size

The sample size was based on an expected proportion of LBW for adult women of 8% and that for adolescents of 18% (*Larocque et al., 2006*), with a power of 0.80 and an alpha of 0.05. Using this information, the estimated number of adolescents that would be required was calculated to be 177. The only prior information available on the proportion

of adolescents delivering at the Hospital Apoyo Iquitos was obtained from unpublished data from the Hospital Apoyo Iquitos, indicating that approximately 15% of deliveries per year are attributed to adolescents less than 18 years of age. To obtain 177 adolescents from the birth registry, approximately 1,180 women would need to be selected from the birth registry. These numbers were obtained for the 2005, 2006, and 2007 birth registries. The Hospital Apoyo Iquitos records approximately 5,000 deliveries per year, with information on 24 deliveries being entered on each page of the registry. This totals approximately 208 pages of birth records per year. To compensate for incomplete records and possible exclusions, seven entries were randomly selected per page, using a list of random integers between 1 and 24.

4.6. Data Recording and Cleaning

Data were abstracted directly from the birth registries onto a password-protected laptop computer within the delivery ward and archives area of the Hospital Apoyo from May to July, 2008. The birth registries were never removed from the hospital. To ensure quality of the data and to minimize data entry errors, approximately 14% of the data were double-checked at the end of each day of data collection. Subsequent to data abstraction, data were cleaned and recoded, where appropriate (in Montreal, Canada). Manual data cleaning consisted of generating descriptive statistics and searching for outliers or any unusual entries. If the inconsistency could not be resolved by cross-referencing with other variables in the database, the local research assistant and project coordinator in Peru were consulted until concordance was reached.

4.7. Statistical Analyses

All multiple births and stillbirths were excluded from data analysis because of their known association with LBW. Stillbirths and multiple births are more likely to have a lower birth weight than singleton, live births, independent of other potentially mediating factors such as maternal age or socioeconomic status (*Briggs et al., 2005; Wardlaw et al., 2004; WHO, 2006; WHO, 2007a*). Descriptive statistics for all variables included in the analysis were obtained prior to generating statistical models. Potential covariates that were considered include sex of the newborn, antenatal care attendance, location of the mother's residence, history of malaria and malaria at delivery, history of HIV and HIV at delivery, history of syphilis and syphilis at delivery, APGAR score at one and at five minutes, and attendant at delivery. Three of these variables were not reliably nor consistently recorded in the registry and therefore were excluded from analysis (malaria, HIV, syphilis). APGAR scores and attendant at delivery were excluded because of very low variability (the majority of APGAR scores were normal and almost all births were attended by a midwife). While maternal smoking has been shown to be an important risk factor for LBW (*Horta et al., 1997; Wardlaw et al., 2004*), it is not common in Peru (*Sanchez et al., 2006*) and is of negligible occurrence in Iquitos. Therefore, it was not considered in the statistical model as a potential cultural determinant of LBW.

Unadjusted logistic regression models were used to compare the proportion of newborns with LBW between adolescent and adult mothers. Multiple logistic regression models were then constructed, which adjusted for sex of the newborn, antenatal care attendance (none, inadequate, or adequate), and area of the mother's residence (rural, peri-urban, or urban). A subsequent set of analyses was then performed that restricted the sample population to primiparous mothers with a normal gestational age who had a singleton,

live birth. This comparison group was selected in accordance with methodological approaches employed in much of the previous literature (*Briggs et al., 2005; Costa et al., 2002; Gama et al., 2001; Gortzak-Uzan et al., 2001; Hidalgo et al., 2005; Machado, 2006*).

To investigate possible differences in mean birth weight between comparison groups, linear regression, for all mothers and then only for primiparous mothers with a normal gestational age, was performed.

The primary independent variable for all analyses was maternal age group, (first all adolescents < 20 years compared to adults ≥ 20 years, then stratified into early adolescents 10-14 years and late adolescents 15-19 years compared to ≥ 20 years). Because of the possibility of effect measure modification and also to examine the differences between adolescent age groups, the multivariate models were stratified into early and late adolescent age groups. The covariates included in these analyses were interpreted using results from this stratified adolescent age model. Any women who had missing data were excluded from analysis. Confidence intervals were used to evaluate the precision of resulting point estimates. Analyses were performed using SPSS software (Version 17.0, Chicago, Illinois, USA).

To consider the possibility of a time trend in the proportion of LBW by year of birth, chi-square and Fisher's exact tests were performed for each maternal age group by year (2005, 2006, and 2007). A chi-square test for trend was used for the 15-19 and ≥ 20 year-

olds. Fisher's exact test was used for the 10-14 year-olds because of three cells with an expected count of less than five.

4.8. Ethics Approval

Ethics approval was obtained both from the Hospital Apoyo Iquitos, in Iquitos, Peru, and from the Ethics Review Board of the McGill University Health Centre in Montreal, Canada (Appendices 1 and 2).

5. Study Results

The following manuscript provides an overview of the high prevalence of adolescent pregnancy and low birth weight throughout the world and more specifically in Latin America. Determinants of adolescent pregnancy and risk factors for low birth weight are briefly discussed before introducing the issue from a Peruvian perspective. Multivariate analyses comparing birth weight of newborns born to adolescent and adult mothers in the city of Iquitos, Peru, are presented.

This manuscript was recently submitted to the Journal of Adolescent Health and is prepared according to the particular specifications of this Journal. Results will be used to inform local health authorities about the status of adolescent pregnancy and low birth weight within the region of Iquitos, Peru. This investigation also provides support for recognized research gaps in adolescent pregnancy as outlined by the World Health Organization (*WHO, 2007a*).

5.1. Manuscript #1

Title: A comparison of low birth weight among newborns born to early adolescent, late adolescent, and adult mothers in the Peruvian Amazon

Authors: Julia A Ryan BA[1,2], Martín Casapía MD, MPH[3], Eder Aguilar MD[4], Hermánn Silva MD[4], Elham Rahme PhD[1,2], Anita J Gagnon PhD, RN[5], Amee R Manges PhD[1], Serene A Joseph MSc[2], Theresa W Gyorkos PhD[1,2]

Institutions: [1]Department of Epidemiology, Biostatistics, & Occupational Health, McGill University, Montreal, Canada; [2]Division of Clinical Epidemiology, McGill University Health Centre, Montreal, Canada; [3]Asociación Civil Selva Amazónica, Iquitos, Peru; [4]Hospital Apoyo Iquitos, Iquitos, Peru; [5]School of Nursing, and Department of Gynecology and Obstetrics, McGill University/McGill University Health Centre, Montreal, Canada

Correspondence and requests for reprints: Dr. Theresa W. Gyorkos, Division of Clinical Epidemiology, McGill University Health Centre, Royal Victoria Hospital Campus, V Building, 687 Pine Avenue West, Montreal, Quebec, Canada H3G 1A1, Phone: 514-934-1934 ext. 44721, Fax: 514-934-8293, e-mail: theresa.gyorkos@mcgill.ca

Sources of Support: Canadian Institutes of Health Research (CIHR) Interdisciplinary Capacity Enhancement grant (#HOA 80064); CIHR Master's Award – Frederick Banting and Charles Best Canada Graduate Scholarship; Centre for Research and Teaching on

Women - Margaret Gillett Graduate Research Award; Research at the Research Institute of the McGill University Health Centre is funded in part by a grant from the Fonds de la recherche en santé du Québec.

Acknowledgements: Assistance from the staff at the Asociación Civil Selva Amazónica, the Hospital Apoyo Iquitos, and Evelyn Burga is gratefully acknowledged.

Abstract

Purpose: To compare low birth weight (LBW, < 2,500 grams) between infants born to adolescent and adult mothers in Iquitos, Peru.

Methods: A random sample of 4,467 records of women who delivered at the Hospital Apoyo Iquitos between 2005 and 2007 was collected from hospital birth registries. Multivariate logistic and linear regression analyses were performed to compare LBW in newborns of adolescents (10-14 yrs, 15-19 yrs) and adults (≥ 20 yrs) and then for primiparous mothers with a normal gestational age, adjusting for newborn sex, antenatal care, and location of the mother's residence.

Results: A total of 4,384 mothers had had a singleton live birth and 1,501 were primiparous with a normal gestational age. Early and late adolescents had significantly greater odds of having a LBW infant than adults (OR = 2.28, 95%CI: 1.09, 4.78; OR = 1.67, 95%CI: 1.30, 2.14, respectively). For primiparous mothers with a normal gestational age, the same was true only for early adolescents (OR = 3.07, 95%CI: 1.09, 8.61). There were significant differences in mean birth weight between adults (3178.7g) and both adolescent age groups overall (10-14 yrs: 2848.9g; 15-19 yrs: 2998.3g) and for primiparous mothers with a normal gestational age (10-14 yrs: 2900.8g; 15-19 yrs: 3059.2g; ≥ 20 yrs: 3151.8g).

Conclusions: Results suggest there is an important difference between adolescent and adult mothers in terms of newborn birth weight, especially among early adolescents. Future research on LBW and possibly other adverse birth outcomes should consider early adolescents as a separate sub-group of higher risk.

Keywords: Adolescent pregnancy; Low birth weight; Peru; Disparities; Reproductive health

Introduction

Adolescent Pregnancy

Every year, throughout the world nearly 15 million newborns are delivered by adolescents between 15 and 19 years-old, which comprises about ten percent of all deliveries worldwide [1]. One third of women in Latin America and the Caribbean will give birth before they reach their twentieth birthday [2]. The age-specific fertility rate for women aged 15-19 years is 75 births per 1,000 adolescents. It is the region with the second highest adolescent fertility rate in the world, after Africa [3]. In Peru, the fertility rate for 15-19 year-olds was 61 births per 1,000 adolescents between 2001 and 2004, and the rate was higher for those living in rural areas than those living in urban areas (100 versus 47 births per 1,000 adolescents, respectively) [4]. Between 2000 and 2004, there was almost no change in the proportion of adolescents who were already mothers or who were pregnant (13.0% in 2000 and 12.7% in 2004) [4].

Apart from young maternal age, other social and behavioural determinants also contribute to adverse maternal and infant risks associated with pregnancy and childbirth, including low educational attainment, low social status, and a lack of access to or low use of health care facilities [1, 5]. Other determinants include an urban location of residence and early marriage, especially within developing countries [6, 7]. Similar models of the

determinants of adolescent pregnancy have been identified in different Latin American countries. A Colombian study found adolescent reproductive behaviour to be a function of low socioeconomic status and low educational attainment [8]. A case-control study from Brazil comparing parous and nulliparous adolescents in a birth cohort also found that low educational attainment and low socioeconomic status were associated with adolescent pregnancy [9]. Similar results were found in a study from Ecuador comparing pregnant and non-pregnant adolescents. Pregnant adolescents were more likely to lack a supportive family network, to be unhappy, and to experience more educational and economic difficulties than non-pregnant adolescents [10]. Research on the determinants of adolescent pregnancy is very limited in Peru.

Low Birth Weight

The burden of low birth weight (LBW) is higher in the developing world, with 95.6% of all LBW births occurring in low and middle-income countries [11]. Although LBW in Latin America and the Caribbean is not as frequent as it is in other parts of the world (e.g. Asia and Africa), it still accounts for an important proportion of all births (10.0%) [11]. Data from Peruvian demographic health surveys indicate that about 11% of infants born are LBW [11].

LBW can arise from two conditions: preterm birth (< 37 weeks gestation) or intrauterine growth restriction [12]. Fetal and neonatal morbidity and mortality are strongly related to LBW. During development, children who were born with a LBW may experience stunted growth, cognitive problems, and chronic diseases in later life [13]. A multitude of

determinants influence gestational age and growth of the fetus, which in turn cause LBW [14]. These include socioeconomic, behavioural, and physiological determinants such as nutrition, poverty, and gestational weight gain [14]. The dynamic interplay of these variables hinders the ability to accurately measure their individual effects [14].

Studies investigating LBW in Latin America have found several determinants that increase the likelihood of delivering a LBW infant. These include anemia, smoking during pregnancy, low gestational weight gain, inadequate antenatal care, low educational attainment, and low socioeconomic status [15-18]. Few studies have investigated LBW in Peru. Two studies found that higher calorie and protein reserves (i.e. the mother's nutritional status) had a positive effect on infant birth weight, concluding that the mother's nutritional status is a key determinant of newborn birth weight [19, 20].

Adolescent Pregnancy and Low Birth Weight in Latin America

The majority of studies that have investigated adolescent pregnancy and LBW in Latin America have found adolescent mothers to have a greater likelihood of delivering a LBW newborn compared to adult mothers [21-33]. Only one study found no association between maternal age and LBW. This may have been because no multivariate models were used, thus limiting adequate interpretation of the results [34].

Only three studies were found from Peru (all from the same study population in Lima), all of which concluded that adolescents had smaller and thinner newborns than adult mothers even with a similar nutritional status, suggesting that adolescents may have greater

nutritional requirements than adults in order to attain an optimal birth weight [25, 26]; and that still growing adolescents had lighter newborns than adolescents who had finished growing [24]. No Peruvian study has previously investigated LBW between adolescent and adult age groups nor has such a study been conducted in the Amazon region.

Methods

Study Design and Population

A cross-sectional study was conducted to examine the association between maternal age and low birth weight (LBW). The study population consisted of pregnant women delivering at the Hospital Apoyo Iquitos, located in the Peruvian Amazon. Information on the pregnant women and their babies was recorded in the hospital's birth registry. This hand-written paper logbook includes demographic and clinical information on the pregnant women (e.g. address, gestational age, parity), the labour and delivery (e.g. type of delivery), and the newborn infant (e.g. birth weight, sex). A random sample of women was selected from the 2005, 2006, and 2007 birth registries.

Sample Size

The sample size was based on an expected proportion of LBW for adult women of 8% and that for adolescents of 18% [35], with a power of 0.80 and an alpha of 0.05. Using this information, the estimated number of adolescents that would be required was calculated to be 177. The only prior information available on the proportion of

adolescents delivering at the Hospital Apoyo Iquitos was obtained from unpublished data from the Hospital Apoyo Iquitos, indicating that approximately 15% of deliveries per year are attributed to adolescents less than 18 years of age. To obtain 177 adolescents from the birth registry, approximately 1,180 women would need to be selected. These numbers were obtained for the 2005, 2006, and 2007 birth registries. The hospital records approximately 5,000 deliveries per year with information on 24 deliveries being entered on each page of the registry, totalling approximately 208 pages of birth records per year. To compensate for incomplete records and possible exclusions, seven entries were randomly selected per page, using a list of random integers between 1 and 24.

Definitions

In this study, the WHO definition of adolescent was used, which includes anyone between the ages of 10 and 19 [5]. Adolescents were subdivided into early (10-14 years) and late (15-19 years) age groups in order to investigate possible differences between younger and older adolescents. Adults included all women ≥ 20 years-old. LBW was defined as a birth weight of less than 2,500 grams [11]. A normal gestational age was defined as ≥ 37 weeks gestation [5]. As defined by the Peruvian Ministry of Health, antenatal care attendance was classified according to the appropriate number of visits a woman should have had for her gestational age [36]. The recommendations are outlined as follows: at least one visit for women at < 22 weeks; at least two visits for women between 22 and 24 weeks; at least three visits for women between 25 and 29 weeks; at least four visits for women between 30 and 35 weeks; at least five visits for women between 36 and 40 weeks; and at least six visits for women who are at 41 weeks or more

[36]. The location of the mother's residence was categorized into rural, peri-urban, and urban. In this population, rural location is defined as a region a distance away from the city where no municipal services of water and sanitation are available (the water source is usually the river) and where electricity is not constant. An urban location is defined as an area where constant municipal water and sanitation services are available. A peri-urban location is defined as a region between the rural and urban zones where there may be a constant source of electricity and water but inadequate sanitation services.

Statistical Analyses

All multiple births and stillbirths were excluded from data analysis because these births are more likely to have a lower birth weight than singleton, live births, independent of other determinants such as maternal age [5]. Unadjusted logistic regression models were used to compare the proportion of newborns with LBW between adolescent and adult mothers. Multiple logistic regression models were then constructed, which adjusted for sex of the newborn, antenatal care attendance (none, inadequate, or adequate), and area of the mother's residence (rural, peri-urban, or urban). A subsequent set of analyses was then performed that restricted the sample population to primiparous women with a normal gestational age who had a singleton, live birth.

To investigate possible differences in mean birth weight between maternal comparison groups, linear regression, for all mothers and then only for primiparous mothers with a normal gestational age, was also performed.

The primary independent variable for all analyses was maternal age group, (first all adolescents < 20 years compared to adults ≥ 20 years, then stratified into early adolescents 10-14 years and late adolescents 15-19 years compared to adults ≥ 20 years). Because of the possibility of effect measure modification and also to examine the differences between adolescent age groups, the multivariate models were stratified into early and late adolescent age groups. The covariates included in these analyses were interpreted using results from this stratified adolescent age model. Any women who had missing data were excluded from analysis. Confidence intervals were used to determine significance of results. Analyses were performed using SPSS software (Version 17.0, Chicago, Illinois, USA).

To consider the possibility of a time trend in the proportion of LBW by year of birth, a chi-square test for trend was performed for each maternal age group by year (2005, 2006, and 2007). Fisher's exact test was used in cases where the expected cell count was less than five.

Ethics approval was obtained both from the Hospital Apoyo Iquitos in Iquitos, Peru, and from the Ethics Review Board of the McGill University Health Centre in Montreal, Canada.

Results

Descriptive Characteristics

Descriptive statistics categorized by maternal age groups are outlined in Table 1. Almost all early and late adolescents were primiparous whereas most adults were multiparous. Over three-quarters of mothers in each age category had a normal gestational age. More than half of all mothers had adequate antenatal care. More than half of all mothers lived in urban areas. Fewer lived in rural areas, and the least number of mothers lived in peri-urban areas. The proportion of male and female newborns was fairly evenly distributed in each age group. Among all mothers, mean birth weight was highest among adults (3178.7 ± 493.3g) and lowest among 10-14 year-olds (2848.9 ± 453.3g). Among primiparous mothers with a normal gestational age, mean birth weight was highest among adults (3151.8 ± 396.5g) and lowest among early adolescents (2990.8 ± 352.4g). Among all mothers and primiparous mothers with a normal gestational age, the proportion of LBW infants was highest among early adolescent mothers (16.4% compared to 10.8% (15-19 years) and 6.9% (≥ 20 years) among all mothers, and 12.8% compared to 6.7% (15-19 years) and 4.7% (≥ 20 years) among primiparous mothers with a normal gestational age).

Comparison of the Proportion of Low Birth Weight between Adolescent and Adult Mothers

Table 2a outlines the results of the crude and adjusted logistic regression analyses for all mothers examining the association between the proportion of LBW newborns born to adolescent and adult mothers. In the crude analysis, all adolescent age groups had statistically significantly increased odds of LBW compared to mothers ≥ 20 years-old. After adjusting for sex of the newborn, antenatal care, and location of the mother's residence, the adjusted odds ratios remained statistically significant. Among all mothers,

those who had no antenatal care and inadequate antenatal care had statistically significantly increased odds of having a LBW newborn compared to mothers with adequate antenatal care (OR = 1.92, 95%CI: 1.23, 3.00 and OR = 2.27, 95%CI: 1.75, 2.95, respectively).

Table 2b outlines the results of the crude and adjusted logistic regression analyses for primiparous women with a normal gestational age examining the association between the proportion of LBW newborns born to adolescent and adult mothers. The crude analysis revealed that only the 10-14 year-olds had statistically significantly increased odds of having a LBW newborn compared to adults ≥ 20 years-old (OR = 3.00, 95% CI: 1.18, 7.63). The adjusted analysis revealed almost identical adjusted odds ratios. Again, the 10-14 year-olds were the only age group with a statistically significantly result (OR = 3.07, 95% CI: 1.09, 8.61). Among the covariates, female newborns had increased odds of being LBW compared to male newborns (OR = 1.62, 95%CI: 1.03, 2.56).

Comparison of Mean Birth Weight between Adolescent and Adult Mothers

Table 3a outlines the results of the crude and adjusted linear regression analyses for all women examining differences in mean birth weight of newborns born to adolescent and adult mothers. In the crude analysis, the mean birth weight of newborns born to adolescents in all age groups was statistically significantly lower than that of newborns born to adults. After adjusting for sex of the newborn, antenatal care, and location of the mother's residence, the differences in mean birth weight decreased slightly, but all

remained statistically significant (180.3g less for all adolescents, 281.2g less for early adolescents, and 174.7g less for late adolescents).

Among all mothers, female newborns had a mean birth weight that was 110.15g less than that of male newborns. Newborns of mothers who had inadequate antenatal care had a mean birth weight that was 163.58g less than that of newborns of mothers who had adequate antenatal care. Newborns of mothers who had had no antenatal care visits had a mean birth weight that was 149.79g less that that of newborns of mothers who had adequate antenatal care.

Table 3b outlines the results of the crude and adjusted linear regression analysis for primiparous women with a normal gestational age examining the differences in mean birth weight of newborns born to adolescent and adult mothers. In the crude analysis, the mean birth weight of newborns born to adolescents in all age groups was statistically significantly lower than that of newborns born to adults. After adjusting for the same covariates, the differences in mean birth weight all decreased slightly but remained statistically significant (88.00g less for all adolescents, 211.96g less for early adolescents, and 81.30g less for late adolescents).

Sex of the newborn and inadequate antenatal care were statistically significant covariates. The difference in mean birth weight for these covariates was reduced compared to the differences in the analysis with all mothers (96.55g less for female newborns and 91.98g less for newborns of mothers who had inadequate antenatal care).

Comparison of the Proportion of Low Birth Weight by Adolescent Age Group and Year

No difference in the proportion of LBW was observed among the three study years for any adolescent or adult age group and no consistent trend was observed (Table 4).

Discussion

In this investigation of adolescents and LBW infants in Iquitos, Peru, adolescents had increased odds of delivering a LBW infant compared to adult mothers. After taking into account parity and gestational age and, after adjusting for sex of the newborn, antenatal care, and location of the mother's residence, this association held only for the 10-14 year-old age group. The investigation of mean birth weight revealed that newborns of mothers in both adolescent age groups had statistically significantly lower mean birth weights than those of adult mothers, even after adjusting for the same confounders and restricting the analysis to primiparous mothers with a normal gestational age.

Results of this study add to the evidence base for adolescent mothers having a significantly increased risk of delivering a LBW infant compared to adult mothers. Many previous Latin American studies have obtained similar results. A Brazilian study also found adolescents to have increased odds of delivering LBW newborns compared to adults 20-24 years-old (OR = 2.01, $p < 0.001$ for 10-14 year-olds and OR = 1.18, $p < 0.001$ for 15-19 year-olds) [31]. Similarly, another study by Conde-Agudelo *et al.* from multiple Latin American countries found adolescents to have increased odds of delivering LBW newborns compared to adults 20-24 years-old (OR = 1.25, 95% CI: 1.22, 1.28)

[22]. Conversely, a Cuban study did not find a statistically significant difference in the proportion of LBW infants among adolescents and adults; however, no adjusted analyses had been undertaken [34].

Consensus on the sources of this disparity has not been reached [5]. Some investigators maintain that physiological determinants more strongly influence the difference between adolescent and adult mothers' newborn birth weight [25, 37]. Others suggest that the disparity is more a function of sociological and environmental differences between adolescents and adults [38, 39]. In our study, while newborn sex is a physiological factor, antenatal care and location of the mother's residence are sociological and environmental variables. We also considered physiological determinants, namely parity and gestational age. Our results were similar for both the analysis with all mothers and that considering only primiparous mothers with a normal gestational age. There does appear to be an important difference between adolescent and adult mothers in this population, especially with respect to early adolescents, suggesting that young maternal age does affect birth weight. However, it is possible that the disparity in LBW is also being mediated by other determinants that were not accounted for in our models.

We found that the proportions of LBW differed between early and late adolescents. Some researchers have suggested that the additional nutritional requirements of younger adolescents are largely responsible for the increased incidence of LBW in this group of adolescents [25]. While consensus has not been reached on the determinants influencing the disparity between early and late adolescents, it is important to consider these groups separately in epidemiological research.

Consistent with previous research, no or inadequate antenatal care attendance was significantly associated with birth weight in the analysis with all mothers [21]. However, the odds of LBW were greater for those with inadequate antenatal care than for those with none (OR = 2.27 and 1.92, respectively), which is inconsistent with previous research [21]. This was an unexpected result. It may be that women who attend an inadequate number of antenatal care visits for their gestational age may be more likely to also experience inadequacies in other domains such as inadequate gestational weight gain or a nutritional deficiency. In contrast, women who attend no antenatal care visits may simply choose not to attend antenatal care and may not experience inadequacies in other domains. A clear understanding of this phenomenon warrants further study. After restricting the sample to primiparous mothers with a normal gestational age, inadequate antenatal care was no longer associated with LBW. Parity and gestational age may have a greater influence on LBW compared to antenatal care such that the physiology of the mother may be playing a greater role in determining the birth weight of her child than her behaviour.

Female newborns were more likely to be LBW and to have a lower mean birth weight than male newborns, which has been recognized in previous research [14, 31]. This has been explained as a function of androgen action that causes male newborns to be heavier on average than female newborns [40].

Location of the mother's residence was not a significant risk factor for LBW. This result is inconsistent with a Colombian study, which found women from urban areas to be far

less likely to deliver a LBW infant than women from rural areas [30]. It may be that geographic areas in our study population are more homogeneous than in Colombia.

Strengths and Limitations

The study's sample size was large, which made it possible to identify small but important differences in newborn birth weight between adolescent and adult mothers. Our study considered birth weight both as a continuous and a dichotomous variable, allowing for the detection of differences in proportions of LBW and mean birth weight in each maternal age group. Stratifying early and late adolescent age groups permitted the evaluation of important differences between these two age categories. The random sample of mothers increases the generalizability of our results to all mothers within the catchment area of the study hospital, which encompasses urban, peri-urban, and rural neighbourhoods in and around the city of Iquitos. These results may also provide evidence applicable in other developing countries.

This study was limited by the type and quality of information available in the birth registries. Therefore, it was not possible to include other covariates that also may have influenced newborn birth weight. Valuable physiological indicators associated with LBW such as the anthropometry of the mother and infant, gynecologic age, nutritional status, pregnancy growth and weight gain were not routinely recorded.

Conclusion

Our results suggest there are important differences between adolescent and adult mothers with respect to the birth weight of their newborn, especially for early adolescents. This result provides a strong rationale for studying these two groups separately in future research. Our results also contribute to the known global research gaps in adolescent pregnancy as delineated by the World Health Organization, especially from poorer regions of developing countries [3]. Finally, these findings provide an important gateway for future investigations of LBW in similar settings in other developing countries.

Table 1

Characteristics of adolescent (n = 1,193) and adult (n = 3,191) mothers delivering at the Hospital Apoyo Iquitos, Iquitos, Peru, 2005-2007.

Age Group (in Years)	10–14		15–19		< 20		≥ 20	
	All[a]	Primiparous[b]	All	Primiparous	All	Primiparous	All	Primiparous
N[c]	64	50	1,129	814	1,193	864	3,191	637
Mean Age (in Years) (SD)	13.8 (0.6)	13.8 (0.6)	17.4 (1.3)	17.3 (1.3)	17.2 (1.5)	17.1 (1.5)	27.0 (5.6)	23.0 (3.4)
Parity								
Primiparous	63	–	922	–	985	–	703	–
Multiparous	1		202		203		2,481	
Gestational Age								
Low (< 37 weeks)	13	–	133	–	146	–	291	–
Normal (≥ 37 weeks)	50		987		1,037		2,867	
Antenatal Care[d]								
None	8	6	51	33	59	39	196	18
Inadequate	18	9	210	125	228	134	536	75

Adequate	38	35	827	631	865	666	2,339	528
Location of Mother's Residence								
Rural	17	14	140	96	157	110	310	38
Peri-Urban	12	8	284	200	296	208	669	98
Urban	31	24	645	474	676	498	2,040	465
Sex of Newborn								
Male	29	23	574	408	603	431	1,599	326
Female	33	25	548	400	581	425	1,555	297
Mean Birth Weight (in Grams) (SD)	2,848.9 (453.3)	2,900.8 (352.4)	2,998.3 (494.8)	3,059.2 (385.4)	2,990.6 (493.7)	3,050.5 (385.2)	3,178.7 (493.3)	3,151.8 (396.5)
Low Birth Weight								
No (≥ 2,500g)	51	41	999	754	1,050	795	2,921	594
Yes (< 2,500g)	10	6	121	54	131	60	215	29

[a] Refers to all mothers who had a singleton, live birth.

[b] Refers to primiparous mothers with a normal gestational age (≥ 37 weeks) who had a singleton, live birth.

[c] Denominators differed for each variable due to missing values. Proportion of missing values never exceeded 8%.

[d] None refers to mothers who never attended antenatal care. Inadequate refers to mothers with fewer than the recommended number of visits for their gestational age. Adequate refers to mothers with the appropriate number of visits (or more) for their gestational age.

Table 2

Comparison of the proportion of low birth weight newborns (< 2,500g) born to adolescent (n = 1,193) and adult (n = 3,191) mothers delivering at the Hospital Apoyo Iquitos, Iquitos, Peru, 2005-2007 (*see proportions of low birth weight by age group in Table 1*).

			95% CI				95% CI	
	N[a]	Crude OR	Lower	Upper	N	Adjusted OR[b]	Lower	Upper
a. All Mothers[c]								
≥ 20 years	3,136	referent			2,870	referent		
< 20 years	1,181	1.70	1.35	2.13	1,084	1.70	1.33	2.17
10–14 years	61	2.66	1.33	5.32	58	2.28	1.09	4.78
15–19 years	1,120	1.65	1.30	2.08	1,026	1.67	1.30	2.14
b. Primiparous Mothers[d]								
≥ 20 years	623	referent			573	referent		
< 20 years	855	1.55	0.98	2.44	784	1.55	0.97	2.50
10–14 years	47	3.00	1.18	7.63	44	3.07	1.09	8.61

15–19 years	808	1.47	0.92	2.33	740	1.48	0.92	2.40

[a] Number of mothers included in the analysis (does not add up to total because of missing data). Missing data never exceed 12% in any of the age groups.

[b] Adjusted for sex of newborn, antenatal care (none, adequate, or inadequate), and location of mother's residence (urban, peri-urban, or rural).

[c] Refers to all mothers who had a singleton, live birth.

[d] Refers to primiparous mothers with a normal gestational age (≥ 37 weeks) who had a singleton, live birth.

Table 3

Comparison of mean birth weight of newborns born to adolescent (n = 1,193) and adult (n = 3,191) mothers delivering at the Hospital Apoyo Iquitos, Iquitos, Peru, 2005-2007 (*see mean birth weight by age group in Table 1*).

			95% CI				95% CI	
	N[a]	Crude ß[b]	Lower	Upper	N	Adjusted ß[c]	Lower	Upper
a. All Mothers[d]								
≥ 20 years	3,136	referent			2,870	referent		
< 20 years	1,181	-0.17	-0.20	-0.14	1,084	-0.16	-0.19	-0.13
10–14 years	61	-0.08	-0.11	-0.05	58	-0.07	-0.10	-0.04
15–19 years	1,120	-0.16	-0.19	-0.13	1,026	-0.15	-0.18	-0.12
b. Primiparous Mothers[e]								
≥ 20 years	623	referent			573	referent		
< 20 years	855	-0.13	-0.18	-0.08	784	-0.11	-0.16	-0.06
10–14 years	47	-0.11	-0.16	-0.06	44	-0.10	-0.15	-0.04
15–19 years	808	-0.12	-0.17	-0.07	740	-0.10	-0.16	-0.05

[a] Number of mothers included in the analysis (does not add up to total because of missing data). Missing data never exceed 12% in any of the age groups.

[b] Beta refers to standardized coefficient.

[c] Adjusted for sex of newborn, antenatal care (none, adequate, or inadequate), and location of mother's residence (urban, peri-urban, or rural).

[d] Refers to all mothers who had a singleton, live birth.

[e] Refers to primiparous mothers with a normal gestational age (≥ 37 weeks) who had a singleton, live birth.

Table 4

Proportion of adolescents and adults delivering a LBW newborn by year, at the Hospital Apoyo Iquitos, Iquitos, Peru, 2005-2007 (n = 4,384).

Age Group	Year			p_{trend}[b]
	2005	2006	2007	
N[a]	1,556	1,356	1,472	
10–14 years (%)	19.0	13.0	17.6	0.911
15–19 years (%)	11.0	12.6	8.8	0.256
≥ 20 years (%)	6.7	6.2	7.7	0.385

[a] Total number of mothers sampled in each year.

[b] Chi-square for trend was used for the 15-19 and ≥ 20 year-olds. Fisher's exact test was used for the 10-14 year-olds because of three cells with an expected count < 5.

References

[1] McIntyre P. Pregnant adolescents: Delivering on global promises of hope. Geneva: World Health Organization; 2006 [Online]. Available at: http://whqlibdoc.who.int/publications/2006/9241593784_eng.pdf. Accessed August 21, 2008.

[2] Alan Guttmacher Institute. Into a new world: Young women's sexual and reproductive lives. New York: Alan Guttmacher Institute; 1998 [Online]. Available at: http://www.guttmacher.org/pubs/new_world_engl.html. Accessed August 23, 2008.

[3] United Nations. World population monitoring 2002. Reproductive rights and reproductive health. New York: United Nations; 2004 [Online]. Available at: http://www.un.org/esa/population/publications/2003monitoring/WorldPopMonitoring_2002.pdf. Accessed March 15, 2009.

[4] Instituto Nacional de Estadística e Informática. Encuesta demográfica y de salud familiar (ENDES) continua 2004–2005. Lima: Instituto Nacional de Estadística e Informática del Perú; 2005 [Online]. Available at: http://www.comunidadsaludable.org/doc/ESTUDIOS/ENDES%20CONTINUA%202004.pdf. Accessed October 13, 2008.

[5] World Health Organization. Adolescent pregnancy – Unmet needs and undone deeds. A review of the literature and programmes. Geneva: World Health Organization; 2007 [Online]. Available at:

http://whqlibdoc.who.int/publications/2007/9789241595650_eng.pdf. Accessed August 23, 2008.

[6] McDevitt TM. World population profile: 1996. Washington DC: U. S. Bureau of the Census; 1996 [Online]. Available at: http://www.7bn.net/ipc/prod/wp96/wp96.pdf. Accessed March 13, 2009.

[7] Singh S, Samara R. Early marriage among women in developing countries. Int Fam Plan Perspect 1996;22:148-57,75.

[8] Flórez CE. [Socioeconomic and contextual determinants of reproductive activity among adolescent women in Colombia]. Rev Panam Salud Publica 2005;18(6):388-402.

[9] Gigante DP, Victoria CG, Gonçalves H, et al. Risk factors for childbearing during adolescence in a population-based birth cohort in southern Brazil. Rev Panam Salud Publica 2004;16(1):1-10.

[10] Guijarro S, Naranjo J, Padilla M, et al. Family risk factors associated with adolescent pregnancy: Study of a group of adolescent girls and their families in Ecuador. J Adolesc Health 1999;25(2):166-72.

[11] Wardlaw T, Blanc A, Zupan J, et al. Low birthweight: Country, regional and global estimates. New York: United Nations Children's Fund and World Health Organization; 2004 [Online]. Available at: http://www.unicef.org/publications/files/low_birthweight_from_EY.pdf. Accessed October 12, 2008.

[12] Kramer MS. Determinants of low birth weight: Methodological assessment and meta-analysis. Bull World Health Organ 1987;65(5):663-737.

[13] Barker DJP (ed.). Fetal and infant origins of disease. London: BMJ Books, 1992.

[14] World Health Organization. Promoting optimal fetal development - Report of a technical consultation. WHO technical consultation towards the development of a strategy for promoting optimal fetal development (Geneva, 2003). Geneva: World Health Organization; 2006 [Online]. Available at: http://www.who.int/nutrition/publications/fetal_dev_report_EN.pdf. Accessed August 24, 2008.

[15] Escobar JA, Darias LS, Espinosa MA, et al. [Risk factors for low birthweight in a Cuban hospital, 1997-2000]. Rev Panam Salud Publica 2002;12(3):180-4.

[16] Horta BL, Victora CG, Menezes AM, et al. Low birthweight, preterm births and intrauterine growth retardation in relation to maternal smoking. Paediatr Perinat Epidemiol 1997;11(2):140-51.

[17] Neel NR, Alvarez JO. Maternal risk factors for low birth weight and intrauterine growth retardation in a Guatemalan population. Bull Pan Am Health Organ 1991;25(2):152-65.

[18] Vega J, Sáez G, Smith M, et al. [Risk factors for low birth weight and intrauterine growth retardation in Santiago, Chile]. Rev Med Chil 1993;121(10):1210-9.

[19] Frisancho AR, Klayman JE, Matos J. Newborn body composition and its relationship to linear growth. Am J Clin Nutr 1977;30(5):704-11.

[20] Frisancho AR, Klayman JE, Matos J. Influence of maternal nutritional status on prenatal growth in a Peruvian urban population. Am J Phys Anthropol 1977;46(2):265-74.

[21] Bortman M. [Risk factors for low birthweight]. Rev Panam Salud Publica 1998;3(5):314-21.

[22] Conde-Agudelo A, Belizán JM, Lammers C. Maternal-perinatal morbidity and mortality associated with adolescent pregnancy in Latin America: Cross-sectional study. Am J Obstet Gynecol 2005;192:342-9.

[23] Costa MC, Santos CA, Sobrinho CL, et al. [Childbirth and live newborns of adolescent and young adult mothers in the municipality of Feira de Santana, Bahia State, Brazil, 1998]. Cad Saude Publica 2002;18(3):715-22.

[24] Frisancho AR, Matos J, Bollettino LA. Influence of growth status and placental function on birth weight of infants born to young still-growing teenagers. Am J Clin Nutr 1984;40(4):801-7.

[25] Frisancho AR, Matos J, Flegel P. Maternal nutritional status and adolescent pregnancy outcome. Am J Clin Nutr 1983;38(5):739-46.

[26] Frisancho AR, Matos J, Leonard WR, et al. Developmental and nutritional determinants of pregnancy outcome among teenagers. Am J Phys Anthropol 1985;66(3):247-61.

[27] Gama SG, Szwarcwald CL, Leal M, et al. [The pregnancy during adolescence as a risk factor for low birth weight, Brazil]. Rev Saude Publica 2001;35(1):74-80.

[28] Goldenberg P, Figueiredo MC, Silva RS. [Adolescent pregnancy, prenatal care, and perinatal outcomes in Montes Claros, Minas Gerais, Brazil]. Cad Saude Publica 2005;21(4):1077-86.

[29] Hidalgo LA, Chedraui PA, Chávez MJ. Obstetrical and neonatal outcome in young adolescents of low socio-economic status: A case-control study. Arch Gynecol Obstet 2005;271(207-11).

[30] Linares JR, Romero GE, Moreno H. [Risk factors in maternal and child health among Colombian teenage mothers]. Rev Panam Salud Publica 1998;4(2):80-6.

[31] Machado CJ. Impact of maternal age on birth outcomes: A population-based study of primiparous Brazilian women in the city of São Paulo. J Biosoc Sci 2006;38:523-35.

[32] Minagawa AT, Biagoline RE, Fujimori E, et al. [Low birth weight and prenatal maternal conditions]. Rev Esc Enferm USP 2006;40(4):548-54.

[33] Pardo RA, Nazer J, Cifuentes L. [Prevalence of congenital malformations at birth among teenage mothers]. Rev Med Chil 2003;131(10):1165-72.

[34] Cantero VS. [Pregnancy and adolescence. Perinatal results]. Rev Cubana Obstet Ginecol 2005;31(2) [Online]. Available at: http://bvs.sld.cu/revistas/gin/vol31_2_05/gin01205.pdf. Accessed February 25, 2009.

[35] Larocque R, Casapia M, Gotuzzo E, et al. A double-blind randomized controlled trial of antenatal mebendazole to reduce low birthweight in a hookworm-endemic area of Peru. Trop Med Int Health 2006;11(10):1485-95.

[36] Ministerio de Salud del Perú. Guías nacionales de atención integral de la salud sexual y reproductiva. Lima: Ministerio de Salud del Perú; 2004 [Online]. Available at: http://www.minsa.gob.pe/portal/AOE/guias_atencionintegrali_dela_salud_sexual_y_reproductiva.pdf. Accessed March 11, 2009.

[37] Scholl TO, Decker E, Karp RJ, et al. Early adolescent pregnancy: A comparative study of pregnancy outcome in young adolescents and mature women. J Adolesc Health Care 1984;5:167-71.

[38] Chan DL, Sullivan EA. Teenage smoking in pregnancy and birthweight: A population study, 2001–2004. Med J Aust 2008;188(7):392-6.

[39] Scholl TO, Hediger ML, Belsky DH. Prenatal care and maternal health during adolescent pregnancy: A review and meta-analysis. J Adolesc Health 1994;15:444-56.

[40] de Zegher F, Francois I, Boehmer AL, et al. Androgens and fetal growth. Horm Res 1998;50(4):243-4.

6. Discussion

Through this research, additional scientific evidence is provided demonstrating that adolescent mothers are more at risk of delivering a LBW infant compared to adult mothers. Our results concur with previous Latin American research (*Conde-Agudelo et al., 2005; Gama et al., 2001; Goldenberg et al., 2005; Linares et al., 1998; Machado, 2006*). Because our study population originated from a relatively poorer and more isolated region of Peru, our results also contribute new data from a more vulnerable population to the existing evidence base.

The results we obtained were similar for both the entire study population of all mothers and that of primiparous mothers only. This lends strength to the conclusion that there is an important difference between adolescent and adult mothers in this population of pregnant women. This is especially apparent with respect to early adolescents, suggesting that, independent of parity and gestational age, young maternal age affects newborn birth weight.

These results provide critical evidence for the recognized global research gaps in adolescent pregnancy outlined by the World Health Organization (*WHO, 2007a*). Additionally, the results of Manuscript #2 in Appendix 4, comparing antenatal care coverage between adolescent and adult mothers, also contribute to the data on universal access to reproductive health services for young people around the world as identified by the World Health Organization (*WHO, 2007d*). Our results suggest that previous research may have overlooked important data on early adolescent pregnancy and that further

research inclusive of this adolescent age group is warranted. This type of research would contribute to the achievement of Millennium Development Goal (MDG) 5, which is to improve maternal health (*United Nations, 2008*). It is encouraging to note that antenatal care attendance is increasing around the world (*United Nations, 2008*). In Latin America and the Caribbean between 1990 and 2005, the proportion of women of reproductive age who attended at least one antenatal care visit administered by skilled health personnel increased from 77% to 95%. Based on our analyses, further emphasis must now be placed on the number of antenatal care visits attended throughout the pregnancy (*United Nations, 2008*).

Our results show important differences between early and late adolescents in terms of LBW. Even though confidence intervals were near the null value, among all mothers, there is a suggestion that late adolescents may have a similar likelihood of delivering a LBW newborn as adult mothers, unlike early adolescents, whose likelihood was greatly increased. This association may have been even more pronounced with a larger sample size. This relationship also held among primiparous mothers with a normal gestational age. The source of this distinction between early and late adolescents remains obscure. Some researchers have suggested that the additional nutritional requirements of younger adolescents are largely responsible for the increased incidence of LBW among this group of adolescents (*Frisancho et al., 1983; Scholl et al., 1994b*). However, it has also been proposed that the physiological differences of younger adolescents, such as biologic immaturity and low gynecologic age, are associated with preterm delivery (*Hediger et al., 1997*) and LBW (*Scholl et al., 1989*). A proposed interaction between preterm birth, LBW, and small-for-gestational age infants complicates the understanding of the source

of the difference in LBW between early and late adolescents (*Treffers et al., 2001a*). Still other researchers believe that the disparity is more a function of sociological and environmental differences between adolescents and adults (*Chan & Sullivan, 2008; Scholl et al., 1994a*). In general, it is evident that consensus has not been reached on the factors surrounding the disparity in LBW (*WHO, 2007a*).

Consistent with the results of our study, numerous other Latin American studies have also found an increased risk of LBW among pregnant adolescents compared to adults, even after taking into consideration physiological determinants (*Bortman, 1998; Frisancho et al., 1983; Machado, 2006*). Further investigation into the dynamics of these relationships is critical. It remains certain that a disparity does exist between early and late adolescent age and that these groups should be regarded separately in the further exploration of reproductive health issues. A proposed standardization of the definition of early and late adolescent age would create a norm for future investigations and policies that would facilitate their implementation, interpretation, and monitoring across diverse health sectors and organizations.

6.1. Strengths and Limitations

The study's sample size was large, which made it possible to identify small but important differences in newborn birth weight between adolescent and adult mothers. Our study considered birth weight both as a continuous and a binary variable, allowing for the detection of differences in proportions of LBW and mean birth weight in each maternal age group. Our analysis was performed on stratified early and late adolescent age groups, which permitted the evaluation of important differences between these two age

categories. The ability to control for fundamentally important determinants of LBW minimized confounding by these variables. Finally, this study consisted of a random sample of mothers. This increases the generalizability of our results to all mothers within the catchment area of the study hospital, which encompasses urban, peri-urban, and rural neighbourhoods in and around the city of Iquitos. As this sample consisted of a randomly selected sample of women from the birth registry and missing data did not exceed 8% in any instance, it is unlikely that missing data would have significantly influenced the results of the study. These results may also provide evidence applicable to other populations in similar sociological and environmental settings in other developing countries.

This study was limited by the type and quality of information recorded in the birth registries. Therefore, it was not possible to include other determinants that also may have influenced newborn birth weight. Physiological variables known to be associated with LBW such as the anthropometry of the mother and infant, gynecologic age, nutritional status, pregnancy growth and weight gain were not routinely recorded. Other useful behavioural determinants not recorded were the timing of the first antenatal care visit (*Escobar et al., 2002; Tierney-Gumaer & Reifsnider, 2008*), alcohol use, and maternal education. In addition, important maternal morbidity risk factors associated with LBW could not be considered because they were not routinely and reliably recorded in the birth registry. These included anemia, malaria, hypertension, and the co-occurrence of other illnesses or infections (*Wardlaw et al., 2004*). Further, it is important to acknowledge the implications of including gestational age in a statistical model. Its inclusion may limit the opportunity to assess the effect of other important risk factors that may act as intermediate

variables. In the study hospital, aside from a core of routinely entered data, there are no comprehensive guidelines or standard practice regarding the recording of what might be considered to be useful supplementary information. Dialogue with relevant hospital authorities is necessary to improve data recording which would benefit both clinical practice and future research.

6.2. Future Research

A more comprehensive analysis that includes additional relevant determinants and risk factors would provide a clearer interpretation of the relationship between young maternal age and LBW. Routine data obtained at specific intervals throughout pregnancy might include an assessment of behavioural and psychosocial variables such as education, nutrition, behaviours, antenatal care, and family and social support. Following women during pregnancy would also allow for the inclusion of women who may not deliver in hospital. Consideration should also be given to including a qualitative evaluation of the different needs of adolescents compared to adult women. This would identify barriers adolescents may be encountering during pregnancy that may not be affecting adult women but that may impact on adverse health outcomes like LBW.

6.3. Conclusion

Our results suggest there are important differences between adolescent and adult mothers with respect to the birth weight of their newborn, with a higher risk among early adolescents. The differences observed in LBW outcome between early and late pregnant adolescents suggest that these two groups should be studied separately in future research. These results contribute to recognized global research gaps in adolescent pregnancy as

delineated by the World Health Organization. Finally, these findings support the need for future investigations of LBW in underserved populations in other developing countries.

7. References

**The following list also includes references used in Appendix 4.*

Alan Guttmacher Institute. Into a new world: Young women's sexual and reproductive lives. New York: Alan Guttmacher Institute; 1998 [accessed online, March 16, 2009 from: http://www.guttmacher.org/pubs/new_world_engl.html].

Barker DJP (ed.). Fetal and infant origins of disease. London: BMJ Books, 1992.

Becerra C, Gonzales GF, Villena A, de la Cruz D, Florián A. [Prevalence of anemia in pregnancy, Pucallpa Regional Hospital, Perú]. Rev Panam Salud Publica 1998;3(5):285-92.

Bortman M. [Risk factors for low birthweight]. Rev Panam Salud Publica 1998;3(5):314-21.

Briggs MM, Hopman WM, Jamieson MA. Comparing pregnancy in adolescents and adults: Obstetric outcomes and prevalence of anemia. J Obstet Gynaecol Can 2005;29(7):546-55.

Buekens P, Hernández P, Infante C. [Prenatal care in Latin America]. Salud Publica Mex 1990;32(6):673-84.

Buschman NA, Foster G, Vickers P. Adolescent girls and their babies: Achieving optimal birthweight. Gestational weight gain and pregnancy outcome in terms of gestation at delivery and infant birth weight: A comparison between adolescents under 16 and adult women. Child Care Health Dev 2001;27(2):163-71.

Buvinic M. The costs of adolescent childbearing: Evidence from Chile, Barbados, Guatemala, and Mexico. Stud Fam Plann 1998;29(2):201-9.

Cáceres CF, Marín BV, Hudes ES, Reingold AL, Rosasco AM. Young people and the structure of sexual risks in Lima. AIDS 1997;11(Suppl 1):S67-77.

Cantero VS. [Pregnancy and adolescence. Perinatal results]. Rev Cubana Obstet Ginecol 2005;31(2) [accessed online, February 25, 2009 from: http://bvs.sld.cu/revistas/gin/vol31_2_05/gin01205.pdf]

Casapia M, Joseph SA, Gyorkos TW. Multidisciplinary and participatory workshops with stakeholders in a community of extreme poverty in the Peruvian Amazon: Development of priority concerns and potential health, nutrition and education interventions. Int J Equity Health 2007;6:6. DOI:10.1186/1475-9276-6-6.

Chan DL, Sullivan EA. Teenage smoking in pregnancy and birthweight: A population study, 2001–2004. Med J Aust 2008;188(7):392-6.

Chen XK, Wen SW, Fleming N, Demissie K, Rhoads GG, Walker M. Teenage pregnancy and adverse birth outcomes: A large population based retrospective cohort study. Int J Epidemiol 2007;36(2):368-73.

Conde-Agudelo A, Belizán JM, Lammers C. Maternal-perinatal morbidity and mortality associated with adolescent pregnancy in Latin America: Cross-sectional study. Am J Obstet Gynecol 2005;192:342-9.

Cooper LG, Leland NL, Alexander G. Effect of maternal age on birth outcomes among young adolescents. Soc Biol 1995;42(1-2):22-35.

Costa MC, Santos CA, Sobrinho CL, Freitas JO, Ferreira KA, Silva MA, et al. [Childbirth and live newborns of adolescent and young adult mothers in the municipality of Feira de Santana, Bahia State, Brazil, 1998]. Cad Saude Publica 2002;18(3):715-22.

de Zegher F, Francois I, Boehmer AL, Saggese G, Müller J, Hiort O, et al. Androgens and fetal growth. Horm Res 1998;50(4):243-4.

Dharmalingam A, Navaneetham K, Krishnakumar CS. Nutritional status of mothers and low birth weight in India. Matern Child Health J 2009;[Epub ahead of print].

Dubois L, Girard M. Determinants of birthweight inequalities: Population-based study. Pediatr Int 2006;48:470-8.

Escobar JA, Darias LS, Espinosa MA, Castañeda Lde R, Herrera YG, García NP, et al. [Risk factors for low birthweight in a Cuban hospital, 1997-2000]. Rev Panam Salud Publica 2002;12(3):180-4.

Ferraz EM, Gray RH, Cunha TM. Determinants of preterm delivery and intrauterine growth retardation in north-east Brazil. Int J Epidemiol 1990;19(1):101-8.

Flórez CE. [Socioeconomic and contextual determinants of reproductive activity among adolescent women in Colombia]. Rev Panam Salud Publica 2005;18(6):388-402.

Frisancho AR, Klayman JE, Matos J. Influence of maternal nutritional status on prenatal growth in a Peruvian urban population. Am J Phys Anthropol 1977a;46(2):265-74.

Frisancho AR, Klayman JE, Matos J. Newborn body composition and its relationship to linear growth. Am J Clin Nutr 1977b;30(5):704-11.

Frisancho AR, Matos J, Flegel P. Maternal nutritional status and adolescent pregnancy outcome. Am J Clin Nutr 1983;38(5):739-46.

Frisancho AR, Matos J, Bollettino LA. Influence of growth status and placental function on birth weight of infants born to young still-growing teenagers. Am J Clin Nutr 1984;40(4):801-7.

Frisancho AR, Matos J, Leonard WR, Yaroch LA. Developmental and nutritional determinants of pregnancy outcome among teenagers. Am J Phys Anthropol 1985;66(3):247-61.

Gama SG, Szwarcwald CL, Leal M, Theme Filha MM. [The pregnancy during adolescence as a risk factor for low birth weight, Brazil]. Rev Saude Publica 2001;35(1):74-80.

Gigante DP, Victoria CG, Gonçalves H, Lima RC, Barros FC, Rasmussen KM. Risk factors for childbearing during adolescence in a population-based birth cohort in southern Brazil. Rev Panam Salud Publica 2004;16(1):1-10.

Gökçe B, Özşahin A, Zencir M. Determinants of adolescent pregnancy in an urban area in Turkey: A population-based case-control study. J Biosoc Sci 2007;39:301-11.

Goldenberg P, Figueiredo MC, Silva RS. [Adolescent pregnancy, prenatal care, and perinatal outcomes in Montes Claros, Minas Gerais, Brazil]. Cad Saude Publica 2005;21(4):1077-86.

Gortzak-Uzan L, Hallak M, Press F, Katz M, Shoham-Vardi I. Teenage pregnancy: Risk factors for adverse perinatal outcome. J Matern Fetal Med 2001;10:393-7.

Guijarro S, Naranjo J, Padilla M, Gutiérez R, Lammers C, Blum RW. Family risk factors associated with adolescent pregnancy: Study of a group of adolescent girls and their families in Ecuador. J Adolesc Health 1999;25(2):166-72.

Haldre K, Rahu K, Karro H, Rahu M. Is a poor pregnancy outcome related to young maternal age? A study of teenagers in Estonia during the period of major socio-economic changes (from 1992 to 2002). Eur J Obstet Gynecol Reprod Biol 2007;131(1):45-51.

Hamada H, Zaki A, Nejjar H, Filali A, Chraibi C, Bezad R, et al. [Pregnancy and delivery in adolescents: characteristics and profile of 311 cases]. J Gynecol Obstet Biol Reprod (Paris) 2004;33(7):607-14.

Hediger ML, Scholl TO, Schall JI, Krueger PM. Young maternal age and preterm labor. Ann Epidemiol 1997;7(6):400-6.

Hidalgo LA, Chedraui PA, Chávez MJ. Obstetrical and neonatal outcome in young adolescents of low socio-economic status: A case control study. Arch Gynecol Obstet 2005;271:207-11.

Horta BL, Victora CG, Menezes AM, Halpern R, Barros FC. Low birthweight, preterm births and intrauterine growth retardation in relation to maternal smoking. Paediatr Perinat Epidemiol 1997;11(2):140-51.

Hospital Iquitos César Garayar García. Nuestra institución. Iquitos, Peru. 2009 [accessed online, April 23, 2009, from: http://www.hospitaliquitos.gob.pe/].

Instituto Nacional de Estadística e Informática del Perú. Encuesta demográfica y de salud familiar (ENDES) continua 2004–2005. Lima: Instituto Nacional de Estadística e Informática del Perú; 2005 [accessed online, October 13, 2008 from: http://www.comunidadsaludable.org/doc/ESTUDIOS/ENDES%20CONTINUA%202004.pdf].

Instituto Nacional de Estadística e Informática del Perú. Informe técnico. Medición de la pobreza 2004, 2005, y 2006. Lima: Instituto Nacional de Estadística e Informática del Perú; 2006 [accessed online, June 17, 2009 from: http://www1.inei.gob.pe/web/Boletin/Attach/7008.pdf].

Kramer MS. Determinants of low birth weight: Methodological assessment and meta-analysis. Bull World Health Organ 1987;65(5):663-737.

Larocque R, Casapia M, Gotuzzo E, MacLean JD, Soto JC, Rahme E, et al. A double-blind randomized controlled trial of antenatal mebendazole to reduce low birthweight in a hookworm-endemic area of Peru. Trop Med Int Health 2006;11(10):1485-95.

Linares JR, Romero GE, Moreno H. [Risk factors in maternal and child health among Colombian teenage mothers]. Rev Panam Salud Publica 1998;4(2):80-6.

Lipovsek V, Karim AM, Gutiérrez EZ, Magnani RJ, Castro Gomez Mdel C. Correlates of adolescent pregnancy in La Paz, Bolivia: Findings from a quantitative-qualitative study. Adolescence 2002;37(146):335-52.

Lops VR, Hunter LP, Dixon LR. Anemia in pregnancy. Am Fam Physician 1995;51:1189-97.

Machado CJ. Impact of maternal age on birth outcomes: A population-based study of primiparous Brazilian women in the city of São Paulo. J Biosoc Sci 2006;38:523-35.

Magnani RJ, Seiber EE, Gutierrez EZ, Vereau D. Correlates of sexual activity and condom use among secondary-school students in urban Peru. Stud Fam Plann 2001;32(1):53-66.

McDevitt TM. World population profile: 1996. Washington DC: U. S. Bureau of the Census; 1996 [accessed online, March 13, 2009 from: http://www.7bn.net/ipc/prod/wp96/wp96.pdf].

McDonald TP, Coburn AF. Predictors of prenatal care utilization. Soc Sci Med 1988;27(2):167-72.

McIntyre P. Pregnant adolescents: Delivering on global promises of hope. Geneva: World Health Organization; 2006 [accessed online, May 20, 2008 from: http://whqlibdoc.who.int/publications/2006/9241593784_eng.pdf].

Menacker FM, Martin JA, MacDorman MF, Ventura SJ. Births to 10-14 year-old mothers, 1990-2002: Trends and health outcomes: National Vital Statistics

Reports – Centers for Disease Control and Prevention; 2004:52(7) [accessed online, May 20, 2008, from: http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_07.pdf].

Minagawa AT, Biagoline RE, Fujimori E, de Oliveira IM, Moreira AP, Ortega LD. [Low birth weight and prenatal maternal conditions]. Rev Esc Enferm USP 2006;40(4):548-54.

Ministerio de Salud del Perú. Guías nacionales de atención integral de la salud sexual y reproductiva. Lima: Ministerio de Salud del Perú; 2004 [accessed online, March 11, 2009 from: http://www.minsa.gob.pe/portal/AOE/guias_atencionintegrali_dela_salud_sexual_y_reproductiva.pdf].

Mitka M. Heading for better health care in Peru. JAMA 1999;282(6):517-8.

Neel NR, Alvarez JO. Maternal risk factors for low birth weight and intrauterine growth retardation in a Guatemalan population. Bull Pan Am Health Organ 1991;25(2):152-65.

Pan American Health Organization. Análisis de Salud y Sistemas de Información (AIS). Iniciativa regional de datos básicos en salud; Atlas de indicadores básicos de salud, 2001 - Países integrantes de las subregiones de las Américas. 2002 [accessed online, April 15, 2009 from: http://paho-hq-chat1.paho.org/spanish/atlas/0_L%EDmites%20subregionales%20y%20contexto%20ambiental/subregiones%20AMRO/index.html].

Pan American Health Organization. Datos básicos en salud - Mapa interactivo: Indicadores básicos de salud. 2009 [accessed online, March 15, 2009 from: http://new.paho.org/per/index.php?option=com_content&task=view&id=116&Itemid=409].

Pardo RA, Nazer J, Cifuentes L. [Prevalence of congenital malformations at birth among teenage mothers]. Rev Med Chil 2003;131(10):1165-72.

Reynolds HW, Wong EL, Tucker H. Adolescents' use of maternal and child health services in developing countries. Int Fam Plan Perspect 2003;32(1):6-16.

Sanchez SE, Pacora PN, Farfan JH, Fernandez A, Qiu C, Ananth CV, et al. Risk factors of abruptio placentae among Peruvian women. Am J Obstet Gynecol 2007;194(1):225-30.

Scholl TO, Decker E, Karp RJ, Greene G, De Sales M. Early adolescent pregnancy: A comparative study of pregnancy outcome in young adolescents and mature women. J Adolesc Health Care 1984;5:167-71.

Scholl TO, Hediger ML, Salmon RW, Belsky DH, Ances IG. Association between low gynaecological age and preterm birth. Paediatr Perinat Epidemiol 1989;3:357-66.

Scholl TO, Hediger ML, Belsky DH. Prenatal care and maternal health during adolescent pregnancy: A review and meta-analysis. J Adolesc Health 1994a;15:444-56.

Scholl TO, Hediger ML, Schall JI, Khoo C, Fischer RL. Maternal growth during pregnancy and the competition for nutrients. Am J Clin Nutr 1994b;60:183-8.

Silva AAM, Barbieri MA, Gomes UA, Bettiol H. Trends in low birth weight: A comparison of two birth cohorts separated by a 15-year interval in Ribeirao Preto, Brazil. Bull World Health Organ 1998;76(1):73-84.

Singh S, Samara R. Early marriage among women in developing countries. Int Fam Plan Perspect 1996;22:148-57,75.

Singh S, Darroch JE. Adolescent pregnancy and childbearing: Levels and trends in developed countries. Fam Plann Perspect 2000;32(1):14-23.

Thompson SJ, Bender KA, Lewis CM, Watkins R. Runaway and pregnant: Risk factors associated with pregnancy in a national sample of runaway/homeless female adolescents. J Adolesc Health 2008;43:125-32.

Tierney-Gumaer R, Reifsnider E. Risk factors for low birth weight infants of Hispanic, African American, and white women in Bexar County, Texas. Public Health Nurs 2008;25(5):390-400.

Treffers PE, Olukoya AA, Ferguson BJ, Liljestrand J. Special communication from the World Health Organization: Care for adolescent pregnancy and childbirth. Int J Gynaecol Obstet 2001a;75:111-21.

Treffers PE, Olukoya AA, Ferguson BJ, Liljestrand J. Care for adolescent pregnancy and childbirth. Int J Gynaecol Obstet 2001b:75(2):111-21.

United Nations. The millennium development goals report 2008. New York: United Nations; 2008 [accessed online, July 3, 2009 from: http://www.undp.org/publications/MDG_Report_2008_En.pdf].

United Nations. World population monitoring 2002. Reproductive rights and reproductive health. New York: United Nations; 2004 [accessed online, March 15, 2009 from: http://www.un.org/esa/population/publications/2003monitoring/WorldPopMonitoring_2002.pdf].

United Nations Children's Fund (UNICEF). Focus on adapting maternity services to the cultures of rural Peru. State of the world's children 2009: Maternal and newborn health. New York: United Nations Children's Fund; 2008 [accessed online, May 24, 2009 from: http://www.unicef.org/sowc09/docs/SOWC09-FullReport-EN.pdf].

United Nations Children's Fund (UNICEF). El estado de la niñez en el Perú. Lima: United Nations Children's Fund; 2004 [accessed online, May 25, 2009 from: http://latinamerica.dpi.org/UNICEF-EstadoNinez_000.pdf.pdf].

Vega J, Sáez G, Smith M, Agurto M, Morris NM. [Risk factors for low birth weight and intrauterine growth retardation in Santiago, Chile]. Rev Med Chil 1993;121(10):1210-9.

Wardlaw T, Blanc A, Zupan J, Ahman E. Low birthweight: Country, regional and global estimates. New York: United Nations Children's Fund and World Health Organization; 2004 [accessed online, October 12, 2008 from: http://www.unicef.org/publications/files/low_birthweight_from_EY.pdf].

Wasunna A, Mohammed K. Morbidity and outcome of low birthweight babies of adolescent mothers at Kenyatta National Hospital, Nairobi. East Afr Med J 2002;79(10):539-42.

Were M. Determinants of teenage pregnancies: The case of Busia District in Kenya. Econ Hum Biol 2007;5(2):322-39.

World Bank. Basic information - Peru: Living standards measurement survey (PLSS) 1991: The World Bank. Poverty and Human Resources Division; 1993 [accessed online, April 23, 2009 from: http://siteresources.worldbank.org/INTLSMS/Resources/3358986-1181743055198/3877319-1181853574791/pe91_e.pdf].

World Health Organization (WHO). Promoting optimal fetal development - Report of a technical consultation. WHO technical consultation towards the development of a strategy for promoting optimal fetal development (Geneva, 2003). Geneva: World Health Organization; 2006 [accessed online, August 24, 2008 from: http://www.who.int/nutrition/publications/fetal_dev_report_EN.pdf].

World Health Organization (WHO). Adolescent pregnancy – Unmet needs and undone deeds. A review of the literature and programmes. Geneva: World Health Organization; 2007a [accessed online, May 20, 2008 from: http://whqlibdoc.who.int/publications/2007/9789241595650_eng.pdf].

World Health Organization (WHO). International Statistical Classification of Diseases and Related Health Problems - 10th Revision, World Health Organization. 2007b

[accessed online, March 15, 2009 from: http://www.who.int/classifications/apps/icd/icd10online/].

World Health Organization (WHO). Introduction – Access to health services for young people for preventing HIV and improving sexual and reproductive health. Geneva: Department of Child and Adolescent Health and Development, World Health Organization; 2007c [accessed online, May 20, 2008 from: http://www.who.int/child_adolescent_health/data/media/adolescent_health_service_indicators_all.pdf].

World Health Organization (WHO). Data on universal access to reproductive health for young people – Reproductive health indicator 14: Antenatal care coverage. Geneva: Department of Child and Adolescent Health and Development, World Health Organization; 2007d [accessed online, May 20, 2008 from: http://www.who.int/child_adolescent_health/data/media/adolescent_health_service_indicators_14.pdf].

World Health Organization (WHO). WHO antenatal care randomized controlled trial: Manual for the implementation of the new model. Geneva: World Health Organization; 2002 [accessed online, May 20, 2008 from: http://whqlibdoc.who.int/hq/2001/WHO_RHR_01.30.pdf].

8. Appendices

Appendix 1: Ethics Approval – Canada

Centre universitaire de santé McGill
McGill University Health Centre
Les meilleurs soins pour la vie
The Best Care for Life

May 15, 2008

Dr. Theresa Gyorkos
Department of Medicine
Division of Clinical Epidemiology
McGill University Health Centre
Montreal General Hospital

RE: GEN#08-007 entitled "Improving health in communities of extreme poverty: A multidisciplinary and participatory approach using health, nutrition and education interventions: An interdisciplinary Capacity Enhancement (ICE) Grant."

Dear Dr. Gyorkos:

The research proposal entitled above received Full Board review at the convened meeting of the MUHC-Montreal General Hospital Research Ethics Committee on April 29, 2007, and was found ethically acceptable for conduct at the MUHC, and was entered accordingly into the minutes of the Research Ethics Board (REB) meeting. At the MUHC, sponsored research activities that require US federal assurance are conducted under Federal Wide Assurance (FWA) 00000840.

We previously granted conditional approval for Ms. Julia Ryan to initiate the quantitative aspect of the study (review of hospital birth registry data (existing data)) in Peru, conditional to obtaining ethics approval from the local REB in Peru.

At this time, we are pleased to inform you that the revised documents were found ethically acceptable, and we hereby grant you conditional approval for the qualitative aspect, e.g., one-on-one interviews, conditional to obtaining ethics approval from the local REB in Peru.

Final approval for both aspects of the aforementioned study is pending ethics approval from the local REB in Peru.

The Research Ethics Boards (REBs) of the McGill University Health Centre are registered REBs working under the published guidelines of the Tri-Council Policy Statement, in compliance with the "Plan d'action ministériel en éthique de la recherche et en intégrité scientifique" (MSSS, Qc) and the Food and Drugs Act (17 June, 2001); and acting in conformity with standards set forth in the (US) Code of Federal Regulations governing human subjects research, functions in a manner consistent with internationally accepted principles of good clinical practice. We wish to advise you that this document completely satisfies the requirement for Research Ethics Board Attestation as stipulated by Health Canada.

Should any revision to the study, or other unanticipated development occur prior to the next required review, you must advise the REB without delay.

We trust this meets with your complete satisfaction.

Sincerely,

Denis Cournoyer, M. D.
Co-Chairman
GEN Research Ethics Board
(Genetics/Population Research/Investigator Initiated Studies)
MUHC-Montreal General Hospital

Appendix 2: Ethics Approval – Peru

GOBIERNO REGIONAL DE LORETO
DIRECCIÓN REGIONAL DE SALUD
HOSPITAL IQUITOS "CESAR GARAYAR GARCÍA"

"AÑO DE LAS CUMBRES MUNDIALES EN EL PERU"

AUTORIZACION

Visto el Informe del Comité de Bioética, se **AUTORIZA** a la Srta. Julia Ryan, presento su proyecto de tesis titulado: **"Determinación del embarazo en adolescentes y resultados del parto en la Amazonia Peruana"**

Atentamente,

DIRECCION DE SALUD Gerencia de la Calidad Dirección Ejecutiva

GOBIERNO REGIONAL DE LORETO
Dirección Regional de Salud
Hospital Iquitos "César Garayar García"

Dr. HERMAN [illegible] DELGADO
DIRECTOR EJECUTIVO
C.M.P. N° 19456 - R.N.E. N° 2613

C.c.
Gerencia de la Calidad
Dpto. Gerencia de la
Archivo

Appendix 3: Complete Results for Research Presented in Manuscript #1: A comparison of low birth weight among newborns of early adolescent, late adolescent, and adult mothers in the Peruvian Amazon

Note: Because only condensed results were presented in Manuscript #1: '*A comparison of low birth weight among newborns of early adolescent, late adolescent, and adult mothers in the Peruvian Amazon*', an unabridged version of the results of the thesis are presented in the following appendix. In order to avoid duplication of tables, this appendix refers to the results tables presented in Manuscript #1 (Tables 1-4).

Results

All Mothers: Maternal Descriptive Characteristics

Descriptive statistics categorized by maternal age groups are outlined in Table 1 (see Manuscript #1, pp. 62-64). The mean age for early adolescent, late adolescent, and adult mothers was 13.8, 17.4, and 27.0 years-old, respectively. The majority of both early and late adolescent mothers were primiparous (98.4% and 82.0%, respectively) whereas most adult mothers were multiparous (77.9%). More than three-quarters of mothers in each age category had a normal gestational age; however, the proportion was lowest among early adolescents (79.4% of early adolescents, 88.1% of late adolescents, and 90.8% of adults). The proportion of mothers who had had no antenatal care visits was 12.5% for early adolescents, 4.7% for late adolescents, and 6.4% for adults. The proportion with inadequate antenatal care was 28.1% for early adolescents, 19.3% for late adolescents, and 17.5% for adults. The proportion with adequate antenatal care was 59.4% for early adolescents, 76.0% for late adolescents, and 76.2% for adults. More than half of the women in each age group lived in urban areas (51.7% of early adolescents, 60.3% of late adolescents, and 67.6% of adults). Fewer of the mothers in each age group lived in rural areas (28.3% of early adolescents, 13.1% of late adolescents, and 10.3% of adults). The remaining 20% of early adolescents, 26.6% of late adolescents, and 22.2% of adults lived in peri-urban areas.

All Mothers: Newborn Descriptive Characteristics

The proportion of male and female newborns was fairly evenly distributed in each age group. The mean birth weight of newborns born to adult mothers was 3,178.7 grams. The mean birth weight was lowest for newborns born to early adolescent mothers (2,848.9 grams) while the mean birth weight for newborns born to late adolescent mothers was slightly higher at 2,998.3 grams. The proportion of low birth weight infants was highest among early adolescent mothers (16.4%). This proportion was 10.8% for late adolescents and 6.9% for adults.

Primiparous Mothers with a Normal Gestational Age: Maternal Descriptive Characteristics

The mean age for early adolescent, late adolescent, and adult mothers was 13.8, 17.3, and 23.0 years-old, respectively. Most mothers had a normal gestational age, regardless of age (80.6% of early adolescents, 88.7% of late adolescents, and 91.4% of adults). The proportion of mothers who had had no antenatal care visits was 12.0% for early adolescents, 4.2% for late adolescents, and 2.9% for adults. The proportion with inadequate antenatal care was 18.0% for early adolescents, 15.8% for late adolescents, and 12.1% for adults. The proportion with adequate antenatal care was 70.0%, 80.0%, and 85.0%, respectively. More than half of the women in each age group lived in urban areas (52.1% of early adolescents, 61.6% of late adolescents, and 77.4% of adults). Fewer of the mothers in each age group lived in rural areas (30.4% of early adolescents, 12.5% of late adolescents, and 6.3% of adults). The remaining 17.4% of early adolescents, 26.0% of late adolescents, and 16.3% of adults lived in peri-urban areas.

Primiparous Mothers with a Normal Gestational Age: Newborn Descriptive Characteristics

The proportion of male and female newborns was fairly evenly distributed in each age group. The mean birth weight of newborns born to adult mothers was 3,151.8 grams. Early adolescents had newborns with the lowest mean birth weight (2,900.8 grams) while the mean was considerably higher for late adolescents (3,059.2 grams). The proportion of LBW newborns was highest among early adolescent mothers (12.8%). These proportions decreased slightly for late adolescent mothers (6.7%) and for adult mothers (4.7%).

Comparison of the Proportion of Low Birth Weight between Adolescent and Adult Mothers

Table 2a (see Manuscript #1, pp. 65-66) outlines the results of the crude and adjusted logistic regression analysis for all mothers examining the association between the proportion of LBW newborns born to adolescent and adult mothers. In the crude analysis, all adolescent age groups had statistically significantly increased odds of LBW newborns compared to the adult reference group, mothers ≥ 20 years-old (< 20 years: OR = 1.70, 95% CI: 1.35, 2.13; 10-14 years: OR = 2.66, 95% CI: 1.33, 5.32; 15-19 years: OR = 1.65, 95% CI: 1.30, 2.08). After adjusting for sex of the newborn, antenatal care, and location of the mother's residence, the adjusted odds ratios changed slightly (< 20 years: OR = 1.70, 95% CI: 1.33, 2.17; 10-14 years: OR = 2.28, 95% CI: 1.09, 4.78; 15-19 years: OR = 1.67, 95% CI: 1.30, 2.14).

Among all mothers, the only statistically significant covariate in the adjusted analysis was antenatal care. Mothers who had no antenatal care and inadequate antenatal care had statistically significantly increased odds of having a LBW newborn compared to mothers with adequate antenatal care (OR = 1.92, 95% CI: 1.23, 3.00; OR = 2.27, 95% CI: 1.75, 2.95, respectively).

Table 2b (see Manuscript #1, pp. 65-66) outlines the results of the crude and adjusted logistic regression analysis for primiparous women with a normal gestational age examining the association between the proportion of LBW newborns born to adolescent and adult mothers. The crude analysis reveals that only the 10-14 year-olds had statistically significantly increased odds of having a LBW newborn compared to adults ≥ 20 years-old (OR = 3.00, 95% CI: 1.18, 7.63). The results for both all adolescents combined (< 20 year-olds) and late adolescents (15-19 year-olds) were not statistically significant. The adjusted analysis revealed almost identical adjusted odds ratios as the crude analysis. Again, the 10-14 year-olds were the only age group with a statistically significant result, showing increased odds of having a LBW newborn compared to adult mothers ≥ 20 years (OR = 3.07, 95% CI: 1.09, 8.61). The only statistically significant covariate in the adjusted analysis was sex of the newborn, with female newborns having increased odds of being LBW compared to male newborns (OR = 1.62, 95% CI: 1.03, 2.56).

Comparison of Mean Birth Weight between Adolescent and Adult Mothers

Table 3a (see Manuscript #1, pp. 67-68) outlines the results of the crude and adjusted linear regression analysis for all women examining differences in mean birth weight of newborns born to adolescent and adult mothers. In the crude analysis, the mean birth weight of newborns born to adolescents < 20 years-old was 188.12 grams less than that of adult mothers (ß = -0.17, 95% CI: -0.20, -0.14). Looking at the stratified adolescent age groups, the mean birth weight of newborns born to early adolescent mothers was 329.77 grams less than that of adult mothers (ß = -0.08, 95% CI: -0.11, -0.05), and the mean birth weight of newborns born to late adolescents was 180.39 grams less than that of adult mothers (ß = -0.16, 95% CI: -0.19, -0.13). After adjusting for sex of the newborn, antenatal care, and location of the mother's residence, the differences in mean birth weight decreased slightly, but all remained statistically significant (180.30 grams less for all adolescents, 281.17 grams less for early adolescents, and 174.67 grams less for late adolescents).

Among all mothers, female newborns had a mean birth weight that was 110.15 grams less than that of male newborns (ß = -0.11, 95% CI: -0.14, -0.08). Newborns of mothers who had inadequate antenatal care had a mean birth weight that was 163.58 grams less than that of newborns of mothers who had adequate antenatal care (ß = -0.13, 95% CI: -0.16, -0.10). Newborns of mothers who had had no antenatal care visits had a mean birth weight that was 149.79 grams less that that of newborns of mothers who had adequate antenatal care (ß = -0.07, 95% CI: -0.10, -0.04).

Table 3b (see Manuscript #1, pp. 67-68) outlines the results of the crude and adjusted linear regression analysis for primiparous women with a normal gestational age

examining the differences in mean birth weight of newborns born to adolescent and adult mothers. In the crude analysis, the mean birth weight of newborns born to adolescents < 20 years-old was 101.34 grams less than that of adult mothers (ß = -0.13, 95% CI: -0.18, -0.08). Looking at the stratified adolescent age groups, the mean birth weight of newborns born to early adolescent mothers was 250.96 grams less than that of adult mothers (ß = -0.11, 95% CI: -0.16, -0.06), and the mean birth weight of newborns born to late adolescents was 92.64 grams less than that of adult mothers (ß = -0.12, 95% CI: -0.17, -0.07). After adjusting for sex of the newborn, antenatal care, and location of the mother's residence, the differences in mean birth weight all decreased slightly but remained statistically significant (88.00 grams less for all adolescents, 211.96 grams less for early adolescents, and 81.30 grams less for late adolescents).

The same covariates remained statistically significant as in the analysis with all mothers (Table 3a, i.e. sex of the newborn and antenatal care) with the exception of mothers who had had no antenatal care visits, which was no longer statistically significant. The difference in mean birth weight for these statistically significant covariates was reduced compared to the differences in the analysis with all mothers (96.55 grams less for female newborns (ß = -0.12, 95% CI: -0.17, -0.07) and 91.98 grams less for newborns of mothers who had inadequate antenatal care (ß = -0.08, 95% CI: -0.13, -0.03)).

Comparison of the Proportion of Low Birth Weight by Adolescent Age Group and Year

No difference in the proportion of LBW was observed among the three study years (2005, 2006, and 2007) for any adolescent or adult age group (see Table 4, Manuscript #1, p. 69).

Appendix 4: Manuscript #2: Comparison of antenatal care coverage in early adolescents, late adolescents, and adult pregnant women in the Peruvian Amazon

Note: The following manuscript provides an overview of antenatal care coverage in Peru and specifically in the city of Iquitos, located in the Amazon Basin of Peru. A multivariate analysis comparing antenatal care coverage between adolescent and adult pregnant women in the city of Iquitos, Peru, is presented.

This manuscript was accepted for publication in the International Journal of Gynecology and Obstetrics and is prepared according to the particular specifications of this Journal. Results will be used to inform local health authorities about the status of antenatal care coverage and utilization in the region of Iquitos, Peru. This investigation also provides evidence for the World Health Organization's Reproductive Health Indicator #14: *Data on Universal Access to Reproductive Health for Young People*, which monitors access to antenatal care coverage and strives to improve sexual and reproductive health of young people between 15-24 years-old.

Title: Comparison of antenatal care coverage in early adolescents, late adolescents, and adult pregnant women in the Peruvian Amazon

Authors: Julia A Ryan BA[a,b], Martín Casapía MD, MPH[c], Eder Aguilar MD[d], Hermánn Silva MD[d], Serene A Joseph MSc[b], Theresa W Gyorkos PhD[a,b]

Institutions: [a]Department of Epidemiology, Biostatistics and Occupational Health, McGill University, Montreal, Quebec, Canada; [b]Division of Clinical Epidemiology, McGill University Health Centre, Montreal, Quebec, Canada; [c]Asociación Civil Selva Amazónica, Iquitos, Loreto, Peru; [d]Hospital Apoyo Iquitos, Iquitos, Loreto, Peru

Corresponding author: Dr. Theresa W. Gyorkos, Division of Clinical Epidemiology, McGill University Health Centre, Royal Victoria Hospital Campus, V Building, 687 Pine Avenue West, Montreal, Quebec, Canada H3A 1A1, Phone: 514-934-1934 ext. 44721, Fax: 514-934-8293, E-mail: theresa.gyorkos@mcgill.ca

Keywords: antenatal care, adolescent pregnancy, Peru, Millennium Development Goals

Synopsis: Early adolescents received less antenatal care than late adolescents. However, results indicate higher attendance in all groups compared to results from other Latin American studies.

Word count: 2,576

Running head: ADOLESCENT ANTENATAL CARE – PERU

Sources of support: Canadian Institutes of Health Research (CIHR) Interdisciplinary Capacity Enhancement grant (#HOA 80064); CIHR Master's Award – Frederick Banting and Charles Best Canada Graduate Scholarship; Centre for Research and Teaching on Women - Margaret Gillett Graduate Research Award; Research at the Research Institute of the McGill University Health Centre is funded in part by a grant from the Fonds de la recherche en santé du Québec.

Abstract

Objective: To compare antenatal care coverage between adolescent (i.e. early and late) and adult pregnant women in Iquitos, Peru.

Methods: A random sample of 4,467 birth records was collected. Multivariate analyses were performed to compare antenatal care coverage in all adolescent (10-14 yrs, 15-19 yrs) and adult (≥ 20 yrs) age groups and then for primiparous women only.

Results: The mean number of visits was 5.0 for those 10-14 years, 6.1 for those 15-19 years, and 6.2 for those ≥ 20 years. Of primiparous women, the means were 5.1, 6.2, and 6.8, respectively. The proportion and number of visits of primiparous 10-14 year-olds was statistically significantly lower than that of primiparous ≥ 20 year-olds.

Conclusion: All women attended antenatal care more frequently than WHO's recommended four visits however early adolescents attended significantly less often than late adolescents or adult women. Further study of this inequality is warranted to adequately inform local health services.

Introduction

Adolescent pregnancies occur worldwide. The majority of the resulting births, however, occur in the developing world. In 1995-2000, these births accounted for over 90% of all adolescent pregnancies [1]. Evidence to date suggests that maternal morbidity and mortality are increased in adolescent pregnancy, compared to adult pregnancies [1-4], especially for early adolescents (i.e. those aged 10-14 years-old) [5, 6]. In order to facilitate the measurement of access to reproductive health care services with specific reference to the adolescent population, World Health Organization (WHO) and the United Nations have adopted a series of four Reproductive Health Indicators (RHIs). These indicators constitute one section of 16 health indicators created to examine access to health services for youth aged 15-24 years-old worldwide. The RHIs were created with reference to Millennium Development Goal 5, which focuses on maternal health [7]. In particular, RHIs 13 through 16 monitor contraceptive use, antenatal care, fertility rate, and family planning, respectively.

Utilization of antenatal care services has not been extensively researched, and evidence that does exist, is mixed [1, 8]. However, the majority of previous research has shown that younger adolescents (10-17 years-old) both access antenatal care services later in pregnancy and attend fewer antenatal care visits than older adolescents (18-19 years-old) and adult women [1, 4, 8-12]. This relationship has been found to be especially strong for early adolescents aged 10-14 years [5, 6] compared to that of 15-19 year-olds or all adolescents combined (<20 years-old) [1].

Various reasons for the delay of pregnant adolescents' antenatal care-seeking behaviour have been proposed. These include: lack of knowledge about the availability of

antenatal care services offered; lack of authority for decision-making depending on cultural practices; other cultural or social stigma issues (e.g. being unmarried, wanting to hide the pregnancy); and financial barriers (e.g. a lack of medical insurance, transportation costs, poverty and being unemployed (with some still attending school)) [8,12,13].

Latin America has a high incidence of adolescent pregnancy, where females younger than age 20 account for roughly one third of all pregnancies [1]. One 2003 study investigating antenatal care utilization in several countries revealed that the likelihood of attending antenatal care was lower among adolescents aged 18 and under compared to women aged 19-23 years; however, the difference was not statistically significant [11]. An earlier study from Colombia (in 1998) found that adolescents aged 15-19 years were less likely to receive antenatal care before the fifth month of pregnancy compared to adults aged 25-39 years [9]. Similarly, adolescents aged 15-19 years were less likely to attend at least one antenatal care visit during their pregnancy compared to adults aged 25-39 years [9].

In 2005 and 2006, multidisciplinary and participatory workshops were conducted in Iquitos, the largest city in the Peruvian Amazon, one of the poorest regions of the country. These workshops identified adolescent pregnancy as the second most important priority problem (after infant malnutrition) [14]. No antenatal care utilization patterns of adolescent or adult pregnant women have been published from this region. Therefore, the objectives of this study were: i) to document antenatal care coverage among adolescent and adult pregnant women in Iquitos and ii) to compare antenatal care coverage between adolescent and adult age groups.

Methods

The WHO definition of an adolescent is defined as anyone between the ages of 10 and 19 [1]. In RHI 14, the original definition of antenatal care coverage is "the proportion of women attended, at least once during pregnancy, by skilled health personnel for reasons relating to pregnancy" [15]. The numerator is expressed as "The number of pregnant women attended, at least once during their pregnancy, by skilled personnel for reasons related to pregnancy during a fixed period", and the denominator, as "The total number of live births during the same period" [15].

Ethics approval was obtained from the Ethics Review Boards of the McGill University Health Centre (Montreal, Canada) and the Hospital Apoyo Iquitos (Iquitos, Peru).

Data were collected from the Hospital Apoyo Iquitos's birth registry. The registry contains routine delivery/birth data for all women delivering at this hospital. Entries are recorded manually, on paper in a logbook, ordered consecutively by date. There are approximately 5,000 births per year at this hospital. To ensure as accurate a representation of the population as possible, entries from the 2005, 2006 and 2007 registries were randomly selected.

The sample size calculation specified a power of 0.80 and an alpha of 0.05, the expected proportion of adult women with low birth weight infants as 8%, and that for adolescents at 18% [16]. It was determined that 177 adolescents would be needed per year which, given that adolescents comprised approximately 15% of all deliveries (unpublished data, Hospital Apoyo Iquitos), and that missing data might account for an

additional 25% of entries, meant that approximately 1,400 entries would need to be selected per year.

Records of women with multiple births and stillbirths were excluded from analyses. Proportions and means were calculated for categorical and continuous variables, respectively. Unadjusted logistic regression was used to compare attendance (yes/no) at an antenatal care facility between adolescent and adult pregnant women. Adjusted odds ratios were then obtained using location of the woman's residence as a covariate (urban, peri-urban, or rural). The primary independent variable of interest was age group (10-14 years (early adolescents), 15-19 years (late adolescents) and ≥ 20 years (adults)). Poisson regression was used to compare the number of antenatal care visits between the age groups, which included only those women who attended at least one antenatal care visit. Again, the primary independent variable of interest was age group. Four covariates were used in the Poisson regression: 1) continued attendance at more than one location for antenatal care (one location or two or more locations), 2) type of antenatal care facility (hospital, health centre, or health post), 3) location of antenatal care facility (urban, peri-urban, or rural), and 4) location of woman's residence (urban, peri-urban, or rural). In this population, a health centre provides more comprehensive medical services, while a health post provides more limited, but essential, medical services. An urban location is defined as a zone having municipal services of water and sanitation and a constant source of electricity; rural, as a zone far from the city where there are no municipal services of water and sanitation (the water source is usually the river) and where electricity is not constant; and peri-urban as a zone between the rural and urban zones where there may be a constant source of electricity and water but no organized sanitation services. Analyses were performed using SAS software (Version 9.1) (SAS Institute Inc., Cary, NC, USA).

Results

Data were collected from a total of 4467 women. Those with multiple births (n = 40) and stillbirths (n = 43) were excluded from analyses, resulting in an effective sample size of n = 4,384. Table 1 shows the combined 3-year descriptive statistics for all, and primiparous only, pregnant women, by age group. The mean age for all mothers with a singleton, live birth (n = 4384) was 24.3 years (SD = 6.5, range = 10–48). The mean age for all primiparous mothers with a singleton, live birth (n = 1688) was 19.6 years (SD = 3.9, range = 10–40).

Most adolescents (10-19 years) were primiparous (82.9%) whereas most adults (≥20 years) were multiparous (77.9%). For all women, the mean number of antenatal care visits was at least six for all age categories except for 10-14 year-olds, where it was five visits. The proportion attending antenatal care visits was very high (range = 87.5% – 95.6%), with only the 10-14 year age group below 90%. Other covariates were similarly distributed between the late adolescent and adult age groups, with early adolescents having a different profile reflecting the higher proportion residing in rural areas. The 10-14 year age group was also the only age group which showed a decreasing trend in antenatal care coverage from 2005 to 2007 (although, because of small numbers, this was not statistically significant (p = 0.865)) (Table 2).

Among all pregnant women (Table 3a), the adjusted odds of attending antenatal care were statistically significantly lower for 10-14 year-olds than for ≥ 20 year-olds (OR = 0.46; 95%CI: 0.21, 0.98) . The odds of attending antenatal care were statistically

significantly higher for 15-19 year-olds than that for ≥ 20 year-olds (OR = 1.51; 95% CI: 1.07, 2.12).

Among primiparous pregnant women only (Table 3b), the adjusted odds of attending antenatal care among 10-14 year-olds were statistically significantly lower than that for ≥ 20 year-olds (OR = 0.25; 95% CI: 0.10, 0.62).

Regarding the continuous variable, number of antenatal care visits, among all pregnant women who attended antenatal care, 10-14 year-olds were found to have statistically fewer visits than adult women (RR = 0.87; 95% CI: 0.78, 0.98) (Table 4). Among primiparous pregnant women, both adolescent age groups attended antenatal care significantly less often than the adult age group (RR=0.83; 95% CI: 0.74, 0.94 and RR = 0.92; 95%CI: 0.89, 0.96), respectively.

Continued attendance at more than one antenatal care facility was found to increase the frequency of attendance compared to attendance at only one facility while peri-urban location of the woman's residence was found to decrease the frequency of attendance compared to women living in urban areas.

Discussion

It is encouraging to observe that a high proportion (87.5%) of early adolescents in this population is not only attending antenatal care, but that the number of visits exceeds four. This is more than WHO's recommendation for the minimum number of antenatal care visits throughout the duration of pregnancy [17]. However, compared to either late adolescents or adult pregnant women, early adolescents in our study were found to have significantly less antenatal care coverage. This finding also holds when analyses are

restricted to primiparous women. Results from a Brazilian study also found that early adolescents (10-14 years) were not receiving adequate antenatal care (i.e. attending a significantly fewer number of visits than both late adolescents 15-19 years and adults aged ≥20) [5].

Location of residence was not a determinant of whether or not a woman attended antenatal care facilities, but it did influence the frequency of visits. One other study found antenatal care attendance to be higher in urban than in rural areas of Peru [18]. Rural areas are mainly served by health posts whereas peri-urban and urban areas are served by health centers and hospitals. Access to antenatal care services may be more difficult in rural areas because of distance to a health post and also because of transportation challenges (e.g. during the rainy season) and cost [19]. These results suggest that additional antenatal care services may be required by pregnant women in rural areas.

Regarding the number of antenatal care visits, it is possible that women who attend more than one facility for antenatal care simply have greater opportunity to attend than those who attend at only one location. For example, having two locations to choose from may increase the availability of appointment times or hours of operation available. Women living in peri-urban areas may have less of an opportunity to visit antenatal care facilities than women who live in urban areas because of greater distance.

Despite the observed inequalities between early pregnant adolescents and both late pregnant adolescents and adult pregnant women in our study population, it is encouraging to note that the inequalities are still not as disparate in this population as in many others throughout the world [10, 11, 13]. Our results confirm WHO's observation that antenatal care is generally well attended by adolescents in Latin America [15]. There may be several reasons for this. It could be the result of cultural norms that attach less stigma to

pregnancy in adolescence. This would explain the relatively equal attendance between late adolescents and adult women. Perhaps there is less negative stigma attached to pregnant late adolescents in this population, compared to early adolescents. Perhaps early adolescents fear being stigmatized by their families and community more so than late adolescents, for whom pregnancy may be more acceptable. It is possible that, although pregnancy is welcomed in the community, it may take longer for it to be accepted by parents and families of pregnant early adolescents than pregnant late adolescents. It may also be more difficult for 10-14 year-olds to access services because of travel costs (e.g. no money for moto-taxi to get to a health facility) or because they cannot go to a facility during the day because they are in school. In both developed and developing countries, adolescents may lack financial resources, may be burdened by interrupted schooling, and may be stigmatized by staff who openly oppose adolescent pregnancy [13].

Although it appears that early adolescents in this population received less health care attention than late adolescents, our results indicate higher attendance in all age groups compared to results of other Latin American studies, and specifically Peru, especially for the proportion of adolescents attending antenatal care. One 2006 study that compared the use of antenatal care services among adolescents and adults using demographic and health survey data found that the percentage of women accessing antenatal care services in Latin America ranged from 72%, 71%, 75%, and 74% for 15-16, 17, 18, and 19-23 year-old age groups, respectively [11]. In Peru, these proportions were 40%, 42%, 49%, and 47% for the same age groups [11], which is markedly lower than the proportions found in our study. As Iquitos is a city isolated geographically from the rest of Peru, inequalities between the current study population and other populations in Peru may reflect cultural or social practices that differ between regions of the country.

Our large sample size made it possible to detect small, yet meaningful, differences in antenatal care coverage between adolescent and adult pregnant women. Because our results are also based on a random sample of women, they are likely to be generalizable to all pregnant women in the catchment area of the study hospital, which serves large urban, peri-urban, and rural populations around Iquitos. It may also be that these results reflect a wider pattern of antenatal care coverage between adolescent and adult pregnant women in other resource-poor settings in other developing countries.

This study was limited by the number and type of variables recorded routinely in the birth registry. Therefore, it was not feasible to adjust for other determinants that may have influenced antenatal care coverage and utilization patterns (such as timing of the first antenatal care visit, woman's education and socioeconomic status, among others). Poor recall of antenatal care indicators by pregnant women at the time of hospital admission for delivery may have introduced some misclassification; however, this would be expected to be non-differential between age groups.

Future research might include a more complete assessment of social and cultural determinants of antenatal care use in adolescent and adult age groups. The specific needs of early adolescents should be addressed. It would also be informative to evaluate the quality of antenatal care that is provided. Antenatal care utilization by women who deliver at home has not previously been studied. Lastly, it would be informative to ascertain whether there were any differential outcomes in terms of delivery and neonatal health between pregnant adolescents and adults.

Conclusion

There is an on-going debate as to whether, and in what way, antenatal care should be different for adolescent than for adult pregnant women in either developing or developed countries. The observed inequality in antenatal care coverage suggests that further attention is required, especially for pregnant early adolescents.

References

[1] World Health Organization. Adolescent pregnancy – Unmet needs and undone deeds. A review of the literature and programmes. Geneva: World Health Organization; 2007 [accessed online, August 23, 2008 from: http://whqlibdoc.who.int/publications/2007/9789241595650_eng.pdf].

[2] Chen XK, Wen SW, Fleming N, Demissie K, Rhoads GG, Walker M. Teenage pregnancy and adverse birth outcomes: a large population based retrospective cohort study. Int J Epidemiol 2007;36(2):368-73.

[3] Hidalgo LA, Chedraui PA, Chavez MJ. Obstetrical and neonatal outcome in young adolescents of low socio-economic status: A case control study. Arch Gynecol Obstet 2005;271(3):207-11.

[4] Conde-Agudelo A, Belizan JM, Lammers C. Maternal-perinatal morbidity and mortality associated with adolescent pregnancy in Latin America: Cross-sectional study. Am J Obstet Gynecol 2005;192(2):342-9.

[5] Goldenberg P, Figueiredo Mdo C, Silva Rde S. [Adolescent pregnancy, prenatal care, and perinatal outcomes in Montes Claros, Minas Gerais, Brazil]. Cad Saude Publica 2005;21(4):1077-86.

[6] Menacker FM, Martin JA, MacDorman MF, Ventura SJ. Births to 10–14 year-old mothers, 1990–2002: Trends and health outcomes: National Vital Statistics Reports - Centers for Disease Control and Prevention; 2004 [accessed online, May 20, 2008 from: http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_07.pdf].

[7] World Health Organization. Introduction – Access to health services for young people for preventing HIV and improving sexual and reproductive health. Geneva: Department of Child and Adolescent Health and Development (CAH) World Health Organization; 2007 [accessed online, May 20, 2008 from: http://www.who.int/child_adolescent_health/data/media/adolescent_health_service_indicators_all.pdf].

[8] Scholl TO, Hediger ML, Belsky DH. Prenatal care and maternal health during adolescent pregnancy: A review and meta-analysis. J Adolesc Health 1994;15(6):444-56.

[9] Linares JR, Romero GE, Moreno H. [Risk factors for maternal and infant health in adolescent mothers in Colombia]. Pan Am J Public Health 1998;4(2):80-6.

[10] McDonald TP, Coburn AF. Predictors of prenatal care utilization. Soc Sci Med 1988;27(2):167-72.

[11] Reynolds HW, Wong EL, Tucker H. Adolescents' use of maternal and child health services in developing countries. Int Fam Plan Perspect 2003;32(1):6-16.

[12] McIntyre P. Pregnant adolescents – Delivering on global promises of hope. Geneva: World Health Organization; 2006 [accessed online, May 20, 2008 from: http://whqlibdoc.who.int/publications/2006/9241593784_eng.pdf].

[13] Treffers PE, Olukoya AA, Ferguson BJ, Liljestrand J. Care for adolescent pregnancy and childbirth. Int J Gynaecol Obstet 2001;75(2):111-21.

[14] Casapia M, Joseph SA, Gyorkos TW. Multidisciplinary and participatory workshops with stakeholders in a community of extreme poverty in the Peruvian Amazon: Development of priority concerns and potential health, nutrition and education interventions. Int J Equity Health 2007;6:6. DOI:10.1186/1475-9276-6-6.

[15] World Health Organization. Data on universal access to reproductive health for young people – Reproductive health indicator 14: Antenatal care coverage. Geneva: Department of Child and Adolescent Health and Development, World Health Organization; 2007 [accessed online, May 20, 2008 from: http://www.who.int/child_adolescent_health/data/media/adolescent_health_service_indicators_14.pdf].

[16] Larocque R, Casapia M, Gotuzzo E, MacLean JD, Soto JC, Rahme E, et al. A double-blind randomized controlled trial of antenatal mebendazole to reduce low birthweight in a hookworm-endemic area of Peru. Trop Med Int Health 2006;11(10):1485-95.

[17] World Health Organization. WHO antenatal care randomized controlled trial: manual for the implementation of the new model. Geneva: World Health Organization; 2002 [accessed online, May 20, 2008 from: http://whqlibdoc.who.int/hq/2001/WHO_RHR_01.30.pdf].

[18] Buekens P, Hernandez P, Infante C. [Prenatal care in Latin America]. Salud Publica Mex 1990;32(6):673-84.

[19] United Nations Children's Fund (UNICEF). Focus on adapting maternity services to the cultures of rural Peru. State of the world's children 2009: Maternal and newborn health. New York: United Nations Children's Fund; 2008 [accessed online, May 24, 2009 from: http://www.unicef.org/sowc09/docs/SOWC09-FullReport-EN.pdf].

Table 1

Characteristics of adolescent (n = 1,193) and adult (n = 3,191) pregnant women delivering at the Hospital Apoyo Iquitos, Iquitos, Peru, 2005-2007.

Age Group (in Years)	10–14		15–19		<20		≥20	
	All	Primiparous	All	Primiparous	All	Primiparous	All	Primiparous
N[a]	64	63	1,129	922	1,193	985	3,191	703
Mean Age in Years (SD)	13.8 (0.6)	13.8 (0.6)	17.4 (1.3)	17.3 (1.3)	17.2 (1.5)	17.1 (1.5)	27.0 (5.6)	23.1 (3.5)
Parity (%)								
Primiparous	98.4	–	82.0	–	82.9	–	22.1	–
Multiparous	1.6		18.0		17.1		77.9	
Location of Woman's Residence (%)								
Urban	51.7	52.5	60.3	61.2	59.9	60.6	67.5	76.5
Peri-Urban	20.0	18.6	26.6	25.9	26.2	25.5	22.2	16.4
Rural	28.3	28.8	13.1	12.9	13.9	13.9	10.3	7.1
Mean AC[b]Visits (SD)	5.0 (3.1)	5.1 (3.1)	6.1 (2.8)	6.2 (2.8)	6.0 (2.8)	6.1 (2.8)	6.2 (2.9)	6.8 (2.7)
Attending AC (%)								
No	12.5	12.7	4.4	4.3	4.9	4.8	6.2	3.2
Yes	87.5	87.3	95.6	95.7	95.1	95.2	93.8	96.8
Location of AC Facility (%)								
Urban	9.1	9.3	13.7	13.6	13.4	13.3	18.3	20.2
Peri-Urban	72.7	72.2	75.5	76.3	75.4	76.1	74.1	74.7
Rural	18.2	18.5	10.8	10.1	11.2	10.6	7.6	5.1
Type of AC Facility (%)								
Hospital	5.5	5.6	4.7	4.5	4.7	4.6	7.2	7.6
Health Centre	61.8	63.0	75.8	76.8	75.1	76.0	74.4	76.9
Health Post	32.7	31.5	19.5	18.6	20.2	19.4	18.4	15.5
Continued Attendance at More than One AC Facility (%)								
More than one facility	7.1	7.3	2.4	2.6	2.7	2.9	3.0	3.4
One facility	92.9	92.7	97.6	97.4	97.3	97.1	97.0	96.6

[a] N = Number of women. Denominators differed for each variable due to missing values; however, the proportion of missing values for any one variable never exceeded 8%.

[b] AC = Antenatal care.

Table 2

Proportion of adolescents (n = 1,193) and adults (n = 3,191) attending antenatal care by year, at the Hospital Apoyo Iquitos, Peru.

Age	Year[a]		
	2005	2006	2007
10 to 14	90.5	87.0	85.0
15 to 19	96.5	93.9	96.2
≥20	93.4	92.9	95.0

[a] χ^2 for trend was not significant ($p > .05$).

Table 3

Comparison of attendance at antenatal care facilities between adolescent (n = 1,193) and adult (n = 3,191) pregnant women delivering at the Hospital Apoyo Iquitos, Iquitos, Peru, 2005-2007.

			95% CI				95% CI	
	N[a]	Crude OR	Lower	Upper	N	Adjusted OR[b]	Lower	Upper
a. All Women								
≥20 years	3,126	referent			2,973	referent		
<20 years	1,175	1.30	0.96	1.76	1,116	1.35	0.98	1.85
10–14 years	64	0.46	0.22	0.99	60	0.46	0.21	0.98
15–19 years	1,111	1.43	1.04	1.98	1,056	1.51	1.07	2.12
b. Primiparous Women								
≥20 years	696	referent			654	referent		
<20 years	970	0.64	0.38	1.07	922	0.77	0.45	1.33
10–14 years	93	0.22	0.10	0.53	59	0.25	0.10	0.62
15–19 years	907	0.73	0.43	1.24	863	0.88	0.50	1.54

[a] N = Number of women.

[b] Adjusted for location of woman's residence (urban, peri-urban, or rural).

Table 4

Comparison of number of antenatal care visits between pregnant adolescents 10-14 (n = 64), 15-19 (n = 1,129), and adult (n = 3,191) women delivering at the Hospital Apoyo Iquitos, Iquitos, Peru, 2005-2007.

	All Women				Primiparous Women			
	N[a]	RR[b]	95% CI		N	RR	95% CI	
Variable			Lower	Upper			Lower	Upper
Age Group								
≥20 years	2,659	referent			605	referent		
10–14 years	51	0.87	0.78	0.98	50	0.83	0.74	0.94
15–19 years	958	0.98	0.95	1.00	783	0.92	0.89	0.96
Continued Attendance at >1 AC[c] Facility								
1 AC Facility	3,554	referent			1,391	referent		
>1 AC Facility	114	1.19	1.11	1.27	47	1.21	1.09	1.34
Type of AC Facility								
Health Centre	2,754	referent			1,104	referent		
Hospital	232	1.00	0.93	1.06	83	0.95	0.85	1.05
Health Post	682	1.00	0.96	1.04	251	0.98	0.92	1.04
Location of AC Facility								
Peri-Urban	2,746	referent			1,088	referent		
Urban	610	1.03	0.99	1.08	231	1.04	0.97	1.11
Rural	312	1.03	0.97	1.10	119	0.99	0.89	1.11
Location of Woman's Residence								
Urban	2406	referent			969	referent		
Rural	398	0.99	0.93	1.04	152	0.98	0.90	1.08
Peri-Urban	864	0.96	0.93	0.99	317	0.98	0.93	1.03

[a] N = Number of women.

[b] RR = Adjusted rate ratios, expressed as the exponent of the estimate.

[c] AC = Antenatal care.

Request for reprints: TW Gyorkos, Division of Clinical Epidemiology, Research Institute of the McGill University Health Centre, Royal Victoria Hospital – V Building (Rm. V2.18), 687 Pine Avenue West, Montreal, Quebec, Canada H3A 1A1, Phone: 514-934-1934 x44721, Fax: 514-934-8293, E-mail: theresa.gyorkos@mcgill.ca