The Effect of Breastfeeding On

Child Obesity in Colombia

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I. Introduction

There exists an interesting distinction in the literature when it comes to classifying a person's weight status. Obesity and overweight are both measures of a person's body weight relative to his/her height, often described using Body Mass Index, or BMI. Being above the 85th percentile for height and weight makes someone overweight, while being at the 95th percentile or higher is considered obese. For adults, having a BMI between 25 and 30 indicates overweight, while a BMI above 30 indicates obesity.[1] These are widely recognized cutoffs from the Centers for Disease Control (CDC) for measuring overweight, used by researchers and groups like the World Health Organization (WHO). It is difficult to compute BMI values for children, however, so only the percentile markers are used. For the purposes of this paper, I will use the term "overweight" to also include obesity–in other words, rather than cutting off the definition of overweight at the 95th percentile, I will refer to all individuals with a weight-for-height percentile at the 85th percentile or higher as "overweight."

Over the past few decades, these measures of weight status have become increasingly important as the prevalence of weight gain has become a major epidemic worldwide for both adults and children: more than 1 out of every 6 people on the planet is overweight, and this number is increasing with time.[2] According to estimates from the WHO, global obesity has more than doubled since 1980.[3] This is a rapid increase, and one that has carried drastic consequences: the year 2000 marked the first time in human history where there were more

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[1] "Obesity and Overweight for Professionals: Data and Statistics: U.S. Obesity Trends | DNPAO | CDC." *CDC: Centers for Disease Control and Prevention*, n.d. http://www.cdc.gov/obesity/data/trends.html.
[2] "Obesity and Overweight." *WHO Media Center*. World Health Organization, Mar. 2011. Web. 09 Feb. 2012. <http://www.who.int/mediacentre/factsheets/fs311/en/index.html>.
[3] Ibid.

people overweight than underweight.[4] Furthermore, as of 2008, 32.2% of adult men and 35.5% of adult women were categorized as obese.[5] There are currently more than 1 billion overweight adults worldwide, with at least 300 million individuals who qualify as clinically obese.[6] The majority of the world's population now lives in countries where overweight and obesity kill more people than starvation and underweight.[7]

The prevalence of childhood obesity in particular has increased at an alarming rate. In the U.S., overweight doubled among children aged 6-11 and tripled among those ages 7-12 from 1976-2000.[8] Worldwide, similar doubling rates of overweight have been observed, particularly among developing countries that have been experiencing a Westernization of behavior and diet.[9] The WHO estimates that as of 2010, there are over 42 million overweight children under the age of five.[10]

Child obesity is a specific concern because early obesity can have severe ramifications for health later in life. Not only that, but malnutrition during early development and childhood are predisposing factors for many other associated diseases. Research also suggests that the factors that affect intrauterine and early growth also influence the risk of later developing obesity and its comorbidities in adulthood.[11] About 70% of obese adolescents grow up to become obese adults, making them a target population in the global

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[4] Gardner, Gary T, Brian Halweil, and Jane A. Peterson. *Underfed and Overfed: The Global Epidemic of Malnutrition*. Washington, DC: Worldwatch Institute, 2000.
[5] Flegal, Katherine M., Margaret D. Carroll, Cynthia L. Ogden, and Lester R. Curtin. "Prevalence and Trends in Obesity among US Adults, 1999-2008." *Journal of the American Medical Association* 303.3 (2010): 235-41.
[6] "Obesity and Overweight." *WHO Media Center*. World Health Organization, Mar. 2011. Web. 09 Feb. 2012. <http://www.who.int/mediacentre/factsheets/fs311/en/index.html>.
[7] Ibid.
[8] Speiser, P.W., M.C.J. Rudolf, H. Anhalt, C. Camacho-Hubner, F. Chiarelli, A. Eliakim, M. Freemark, et al. "Childhood Obesity." *Journal of Clinical Endocrinology & Metabolism* 90, no. 3 (2005): 1871.
[9] Deckelbaum, R.J., and C.L. Williams. "Childhood Obesity: The Health Issue." *Obesity* 9 (2001): 239S–243S.
[10] "WHO | Global Strategy on Diet, Physical Activity and Health." *Child Overweight and Obesity*. World Health Organization. Web. <http://www.who.int/dietphysicalactivity/childhood/en/>
[11] Deckelbaum, R.J., and C.L. Williams. "Childhood Obesity: The Health Issue."

campaign against obesity and its many associated negative externalities.[12] Even individuals who were overweight as children but then lost the weight before adulthood still exhibit increased morbidity and mortality rates. In addition to being more prone to obesity as adults, obese children suffer from many of the same health problems as obese adults, including some conditions that are unique to obese children. In the U.S., one of every four overweight children in the 6- to 12-year age group of suffers from impaired glucose tolerance, and 60% of these children exhibit at least one risk factor for heart disease. In fact, child obesity has the potential to undo the progress medical science has achieved over the past few decades in reducing deaths due to cardiovascular problems through monitoring and controlling hypertension, smoking, and hyperlipidemia.[13] In countries where young children are still displaying signs of malnutrition and other nutritional deficiencies, overweight is only adding an extra burden to both health and health care costs.[14]

Due to the increasing prevalence of overweight and its associated health problems, there is significant interest in the causes of weight gain and obesity. Existing research has examined the effects of biological, socioeconomic, and other environmental factors on child overweight. Research on child overweight focuses particularly on parental and environmental factors, since children usually have less agency in choices about food intake and physical activity, which are the major determinants of caloric balance and thus weight.

Until recently, obesity was traditionally confined to being a problem of developed countries, which were the only countries with populations who could afford enough extra

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[12] Dehghan, Mahshid, Noori Akhtar-Danesh, and Anwar T. Merchant. "Childhood Obesity, Prevalence and Prevention." *Nutrition Journal* 4.1 (2005).
[13] Miller, J., A. Rosenbloom, and J. Silverstein. "Childhood Obesity." *Journal of Clinical Endocrinology & Metabolism* 89, no. 9 (2004): 4211.
[14] Delpeuch, F., and B. Maire. "Obesity and Developing Countries of the South." *Med Trop (Mars)* 54.7 (1997): 380-88.

food to gain excess weight. However, recent trends reveal that obesity is shifting to become an issue in developing countries as well. Latin America and the Caribbean are areas of particular concern: in some regions, over 60% of the population is overweight, and over 30% is obese.[15] This exceeds even the prevalence in the U.S., where over one-third of the population is obese. Even so, obesity is widely considered a major problem in the U.S. and has been the motivation for policies that target possible deterrents of obesity, including nutritional information, food choices, and physical activity. Considering this, it seems surprising that overweight has not received more attention among Latin American policymakers.

Policymakers have tried to isolate behaviors that help to prevent obesity and other similar health problems. Breastfeeding is one low-cost, high-benefit solution that many organizations and governments have turned to for achieving improved child health outcomes from a very young age. There are major nutritional benefits from breastfeeding compared to milk substitutes and baby formula, as will be explained in further detail later. During the 1970s and 1980s, several countries in Latin America launched campaigns to encourage breastfeeding. For instance, Colombia launched a nine-month mass media campaign from 1979-1980 to try and encourage mothers to breastfeed.[16] Various parts of the campaign involved using medical professionals and educational agents to reach pregnant and feeding mothers, changing university course curricula, and distributing various printed materials. Radio, films, and television were also employed to advertise the advantages of breastfeeding. Legislative changes took place as well: the Ministry of Health passed a resolution prohibiting

[15] Filozof, C., C. Gonzalez, M. Sereday, C. Mazza, and J. Braguinsky. "Obesity Prevalence and Trends in Latin-American Countries."
[16] Restrepo, S. "A Multi-media Strategy for a Breastfeeding Campaign in Colombia." *Educational Broadcasting International* 14, no. 1 (March 1981): 30–34.

the use of milk substitutes, and regulated the promotion and packaging of milk substitutes by a decree. The resolution also encouraged breastfeeding in all medical centers.

In 2003, the World Health Organization introduced their Global Strategy for Infant and Young Child Feeding.[17] One of the main tenets of this document was a call to action to ensure that "All mothers…have access to skilled support to initiate and sustain exclusive breastfeeding for 6 months and ensure the timely introduction of adequate and safe complementary foods with continued breastfeeding up to two years or beyond." This move was designed to reduce infant mortality, improve physical and neurological development, and also protect against obesity. One response to these recommendations has been the joint campaign of the WHO and UNICEF known as the Baby-Friendly Hospital Initiative. Launched in 1991, the initiative was designed to encourage breastfeeding in countries around the globe by making hospitals more conducive to educating mothers and encouraging breastfeeding. According to UNICEF's March 2002 update to their Baby-Friendly Hospital Initiative, Colombia had 53 participating hospitals, one of the highest numbers for Latin America and the Caribbean.[18] Though there were few major initiatives after 1980 explicitly involving breastfeeding, Colombia did eventually adopt new policies in addition to participating in the Baby-Friendly Hospital Initiative. In 2009, the city of Bogotá announced the introduction of over 150 Family-Friendly Rooms, or "Salas Amigas de la Familia Lactante" (literally "rooms friendly to breastfeeding families"), or "breastfeeding-friendly rooms," dubbed SAFL for short.[19] Launched with a large media campaign and even celebrity

[17] "Global Strategy for Infant and Young Child Feeding." *Geneva, Switzerland: World Health Organization* (2003).
[18] *Current Status of Baby-Friendly Hospital Initiative*. UNICEF, March 2002. http://www.unicef.org/programme/breastfeeding/assets/statusbfhi.pdf.
[19] "Salas Amigas De La Familia Lactante." Secretará Distrital De Integración Social De Bogotá, 2011. Web. 8 Dec. 2011. <http://www.integracionsocial.gov.co/ >.

endorsements, this initiative marked a major effort to increase breastfeeding duration.

The Ministry of Social Protection cited the WHO's Global Strategy for Infant and Young Child feeding as a motivation for creating the SAFL's.[20] Similarly, many experts have recommended policies to encourage breastfeeding among mothers, especially in developing countries, where nutrition is often a critical concern. However, the actual effectiveness of breastfeeding as a means of improving child obesity is potentially questionable.

Though child obesity and overweight are becoming increasing problems for the developing world, the existing body of research remains vastly focused on data from developed countries, leaving areas like Latin America very understudied. Research conducted in developed countries have found small but significant associations between exclusive breastfeeding and lowered obesity. This body of research has been fairly rigorous, with randomized samples, varying forms of analyses, and numerous internal tests for validity. However, the majority of studies conducted thus far have been in the U.S. or Europe. The few non-European cases that do exist have found little to no relationship between breastfeeding and child obesity. For instance, one study attempted to identify causal effects between breastfeeding and child BMI by comparing cohorts of mothers and infants from different countries but found no protective effect.[21]

Given that there is so little existing research, it is important to establish a clear relationship between breastfeeding and infant health outcomes in developing countries before making any further policy changes. The link between breastfeeding and child obesity in particular remains unexplored in the literature for developing countries in general. Latin

[20] "Government Support for Breastfeeding in Colombia." *News from the IBFAN World: Latin America & the Caribbean*. The International Baby Food Action Network, 2009. Web. 8 Dec. 2011. <http://www.ibfan.org/newsletters-world-latin_america-colombia_law.html>.
[21] Brion, Marie-Jo A., et al. "What are the Causal Effects of Breastfeeding on IQ, Obesity and Blood Pressure? Evidence from Comparing High-Income with Middle-Income Cohorts."

America is one area that merits attention, since the prevalence of obesity has been growing at ever-increasing rates, and is shifting as a burden of high-income individuals to low-income groups.

This thesis uses data from Colombia to explore the effects of breastfeeding on child overweight in a Latin American country. Though a large proportion of Colombian mothers do breastfeed their babies, Colombia does not have a strong track record for following WHO guidelines and sustaining exclusive breastfeeding for the full six months. According to DHS data from 2005, the median duration of exclusive breastfeeding in Colombia was a mere 2.2 months in 2005; the median total breastfeeding duration was 14.9 months.[22] Since so few mothers followed the six-month recommendation of exclusive breastfeeding, it will be interesting and useful to examine the effect of following the 6-month cutoff on child weight.

I will focus on children up to the age of five, since this is a critical period of both physical and neurological development for children. This paper will seek to address the following questions:

1) How does breastfeeding initiation timing affect child weight outcomes– specifically, incidence of overweight and obesity?
2) How does breastfeeding duration affect child weight outcomes? What is the dose-response relationship, if any?

I will be using Demographic and Health Survey data from Colombia to examine the effects of breastfeeding on child obesity. Colombia is the country with the most recent data available for analysis, and also one of the countries with the highest number of surveys, making it a prime candidate for a study of the effects of breastfeeding on child overweight.

[22] Díaz, Carmen Elena, Rossana López, Indira Herrera, Diana Arena, Carolina Giraldo, and Laura Gonzáles. "Factors Associated with Breastfeeding in Children Less Than One Year of Age in the City of Cartagena, Colombia." *Colombia Médica* 42, no. 2 (2011): 26–34.

Also, while DHS data has been used for other papers about child health outcomes, the link between breastfeeding and obesity has not yet been thoroughly examined using these data. I will focus on both obesity and overweight since obesity is a very narrowly-defined outcome and overweight is a precursor to obesity. A better understanding of the relationship between breastfeeding and overweight will also be helpful in exploring the effect of breastfeeding on obesity. This paper will help to provide a look at this relationship in a new country–Colombia–in a generally understudied but critical region: Latin America.

I hypothesize that there will be a significant protective effect of breastfeeding against child overweight and obesity, for both breastfeeding initiation and duration. However, this is an uncertain hypothesis since there is so little research specific to Latin America, and I am basing this assertion entirely on the strength of the rest of the body of literature, which is quite sound. This will be explored further in the Literature Review.

II. Literature Review

Overview of Obesity and Its Costs

Child overweight is increasingly important because of its health ramifications. Obesity is associated with many health problems as well as higher mortality rates. Fontaine et al (2003) calculated the number of years of life lost due to obesity, and found that being obese represents up to a 22% reduction in expected remaining life span for men; there was a lesser but similar effect for women.[23] A calculation by Flegal et al (2005) found that being obese was associated with 111,909 excess deaths in the U.S.[24] Obesity also means increased susceptibility to a long list of chronic conditions, including hypertension, stroke, stomach ulcers, chronic liver disease, cardiovascular disease, type-2 diabetes, hypercholesterolemia, musculoskeletal diseases like arthritis and chronic back problems, gallbladder diseases, sleep apnea, and even certain types of cancer (colon, liver, kidney, endometrial, and esophageal).[25] In addition, several major cardiovascular risk factors have been consistently associated with obesity: abnormalities in left ventricular mass and/or function and endothelial function, high blood pressure, hyperinsulinaemia and/or insulin resistance, and dyslipidaemia.[26] Obesity is also associated with various visceral, orthopedic, neurologic, and dermatologic factors.[27] Because most of these conditions are chronic—and are also preventable—only further contributes to obesity's role as a popular topic of research.

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[23] Fontaine, Kevin R., David T. Redden, Chenxi Wang, Andrew O. Westfall, and David B. Allison. "Years of Life Lost Due to Obesity." *The Journal of the American Medical Association* 289.2 (2003): 187-93.
[24] Flegal, Katherine M., Barry I. Graubard, David F. Williamson, and Mitchell H. Gail. "Excess Deaths Associated with Underweight, Overweight, and Obesity." *The Journal of the American Medical Association* 293.15 (2005): 1861-7.
[25] Rosin, Odelia. "The Economic Causes of Obesity: A Survey." *Journal of Economic Surveys* 22.4 (2008): 617-47.
[26] Reilly, JJ, E. Methven, ZC McDowell, B. Hacking, D. Alexander, L. Stewart, and CJ Kelnar. "Health Consequences of Obesity." *Archives of Disease in Childhood*88.9 (2003): 748-52.
[27] Speiser, P.W., M.C.J. Rudolf, H. Anhalt, C. Camacho-Hubner, F. Chiarelli, A. Eliakim, M. Freemark, et al. "Childhood Obesity." *Journal of Clinical Endocrinology & Metabolism* 90, no. 3 (2005): 1871.

Children who are overweight or obese face these health risks as well. Hyperlipidiemia, hypertension, and abnormal glucose tolerance occur more frequently in obese youth than normal-weight youth.[28] Other health conditions associated with childhood obesity include asthma, increased mortality risk, and a doubling of the risk of developing type-1 diabetes.[29,30] Again, these are all chronic conditions, so if they set in at a younger age that leaves more time for the individual's health to deteriorate. This has a twofold effect on society as a whole: first, obesity damages the production potential of a society because the many chronic conditions that are associated with it impair the human capital of the working population. Laborers who get sick are unable to work as many hours per year, and are thus unable to contribute as much to production.

In addition, these various health conditions contribute directly to increasing health care costs, which are borne by society either through higher medical insurance premiums or more expensive medical procedures. Estimates of the costs associated with obesity are formidable. The U.S. Surgeon General's office estimated the total economic cost of obesity in the U.S. at $117 billion in 2000.[31] Sturm (2002) found that obesity is associated with greater increases in medical costs than smoking and drinking combined.[32] Obesity not only contributes to significant health care costs, but it also inflicts detrimental social and economic consequences as well: Gortmaker (1993) found that women who were overweight had

[28] Dietz, William H. "Health Consequences of Obesity in Youth: Childhood Predictors of Adult Disease." *Pediatrics* 101.3 (1998): 518-25.
[29] Reilly, JJ, E. Methven, ZC McDowell, B. Hacking, D. Alexander, L. Stewart, and CJ Kelnar. "Health Consequences of Obesity."
[30] Dietz, William H. "Health Consequences of Obesity in Youth: Childhood Predictors of Adult Disease."
[31] Rosin, Odelia. "The Economic Causes of Obesity: A Survey."
[32] Sturm, Roland. "The Effects Of Obesity, Smoking, And Drinking On Medical Problems And Costs." *Health Affairs* 21 (2002): 245.

completed fewer years of school, and were less likely to be married later in life.[33] They also had lower household incomes and higher rates of household poverty than women who had not been overweight. These effects were independent of baseline socioeconomic status and aptitude test scores.

What makes obesity an additional source of concern is its tendency to be intergenerational. In addition to being genetically inheritable, obesity is often passed from parent to child due to behavioral tendencies and habits regarding food intake and physical activity, which are two major determinants of weight. A longitudinal study with a British cohort of 11,407 subjects conducted follow ups of children over 33 years and found that at each age, the mean BMI of the children increased as their parental BMI increased.[34] Children with two obese parents were at the highest risk for obesity, and also showed the strongest tracking of child to adult BMI, as indicated by partial correlation coefficients.

Economics of Child Health Production

Michael Grossman's human capital model is useful in this context, to explain the influence parents can have on their children's health.[35] The model dictates that people inherit a certain stock of health at birth that depreciates as they age. Once the health stock falls beneath a certain cutoff, the person dies. However, this stock can also be bolstered by "investments" like healthy eating or exercise. This mechanism enables individuals to essentially determine their own lifespans, as well as their quality of health. By controlling

[33] Gortmaker, Steven L., Aviva Must, James M. Perrin, Arthur M. Sobol, and William H. Dietz. "Social and Economic Consequences of Overweight in Adolescence and Young Adulthood." *New England Journal of Medicine* 329.14 (1993): 1008-012

[34] Lake, Julie K, Chris Power, and Tim J Cole. "Child to Adult Body Mass Index in the 1958 British Birth Cohort: Associations with Parental Obesity." *Archives of Disease in Childhood* 77, no. 5 (November 1, 1997): 376–380.

[35] Grossman, Michael. "The Human Capital Model." *Handbook of Health Economics*. Ed. A.J. Cuyler and J.P. Newhouse. Vol. 1. Elsevier Science B.V., 2000. 348-408.

both the volume and quantity of the food they consume, people can influence their own health outcomes. The Grossman model requires some modifications when applied to child health, since young children are usually not the primary decisionmakers for choosing the correct "investments" for determining their health: instead, their parents are the ones making those choices about food, exercise, and more. This is especially true of infants and very young children, so it is important that parents have the best information possible in order to maximize their child's health.

These investment decisions are affected by the "shadow price" of health, which is negatively correlated with the amount of health demanded. This shadow price generally falls with more education, which is consistent with data that has demonstrated that individuals with more education are usually less likely to be obese–however, that is based on research from developed countries, and developing countries could be a different case. Household income level also has the potential to affect the relative price of health, for a family working with a smaller budget might prefer to spend less money on food–by buying items with higher energy-density, but lower nutritional value–and instead spend the money elsewhere to improve quality of life in other areas.

A mother's decision about when and how to feed her baby is one key investment decision for determining the child's health. Her breastfeeding initiation and duration choices–and whether she breastfeeds at all–will be influenced by her perceived price of breastfeeding relative to the value of the child's health. Breastfeeding can also be viewed as one option among many for how the mother chooses to allocate her time–a full list might include housework, economic activity, child care, and more, in addition to breastfeeding. Both actual market prices and shadow prices of each option relative to the value of her time will

influence her decision process. Variables like sex, education, age, employment opportunities, and health of potential substitutes (both family and non-family) determine these costs. If, for instance, the mother can work outside the home and earn a higher wage by having an older child substitute for housework or secondary child care duties, she will choose to take the outside job. As with financial investments, the mother will make the decisions that will earn her the highest return on her time and resources.

Breastfeeding is distinct because it is a particularly time-consuming action that can only be performed by the mother. Popkin (1983) found that mothers require more time for breastfeeding than bottle-feeding. Not only that, but the time it takes to bottle feed is fairly consistent across different people, making it easier to find a substitute for the mother when feeding the child.[36] In their study of breastfeeding in Malaysia, Butz & DeVanzo (1981) found that the availability of servants and other relatives increased the probability of ever breast-feeding a child, but reduced the duration of the breastfeeding.[37]

It is especially important to understand how parental decisions affect child health in developing countries, where child health is a major concern. Datar et al (2006) tested whether parents reinforce or compensate for the initial endowments of health that their children are born with, using birth weight as a proxy for this health endowment.[38] Breastfeeding initiation and duration are some of the specific parental investments that were tracked; others included immunizations, preschool attendance, well-baby visits, and kindergarten entry age. Results indicated that children with heavier birth weights receive higher levels of most parental

[36]Popkin, B.M., R.E. Bilsborrow, J.S. Akin, and M.E. Yamamoto. "Part 1: Breast-feeding Determinants in Low-income Countries." *Medical Anthropology* 7, no. 1 (1983): 1–31.
[37]Qtd. in ibid.
[38] Datar, A., M.R. Kilburn, and D.S. Loughran. "Health Endowments and Parental Investments in Infancy and Early Childhood." *RAND Labor and Population Working Paper Series, WR-367. RAND Corporation, Santa Monica, CA* (2006).

investments. This suggests that parental investment can contribute to widening the disparities between initial health endowments.

Obesity in Latin America

Obesity is shifting from a burden exclusive to developed countries to one that plagues developing countries as well.[39] Undernutrition and underweight were once primary child health concerns in developing countries, but now overnutrition and overweight are becoming major issues. In some countries there even exists a "dual burden" of both underweight and overweight.[40] Caballero et al (2002) note, "This association of earlier undernutrition with adult obesity has critical implications for developing countries, where intrauterine growth retardation and stunting during early childhood are common."[41] Today, the majority of overweight children - close to 35 million of the total 42 million - live in developing countries.[42] Though obesity is increasingly becoming a problem of the developing world, the majority of the existing research base only contains evidence from developed countries. There is a distinct need for a more thorough examination of obesity and its determinants in developing countries as well, especially for child obesity.

Latin America, for instance, is one area that merits attention because of the rapidly rising rates of overweight in the region. One study of obesity in Latin America found between of the 20 countries studied, 17 of the 20 countries studied had obesity prevalence

[39] Delpeuch, F., and B. Maire. "Obesity and Developing Countries of the South." *Med Trop (Mars)* 54.7 (1997): 380-88.
[40] Doak, C.M., L.S. Adair, C. Monteiro, and B.M. Popkin. "Overweight and Underweight Coexist Within Households in Brazil, China and Russia." *The Journal of Nutrition* 130, no. 12 (2000): 2965–2971.
[41] Caballero, Benjamin, and Barry M. Popkin. *The Nutrition Transition: Diet and Disease in the Developing World*. Amsterdam; Boston: Academic Press, 2002.
[42] "Global Strategy for Infant and Young Child Feeding." *Geneva, Switzerland: World Health Organization*.

greater than 20%.[43] Another study reported very high preobesity prevalence, with over 60% of the population from one area of Argentina displaying BMIs at or above 25. This same BMI measure was seen in 35% of the population in Brazil, 53% in Peru, 60% in Mexico, and 68% in Paraguay[44]. Children were not exempt from these trends–the prevalence of obesity was also high among Latin-American children: according to 1995 data, Colombia had an overweight prevalence of 12.2%, and an obesity rate of 1.8%.[45] The highest prevalence of child obesity was in Argentina, with an average obesity prevalence of 10.4%. These numbers are exhibiting strong increasing trends, with an especially high concentration of obesity among women in the majority of the countries.

A unique aspect of the obesity phenomenon in Latin America has been its shift as a burden of the upper income classes to the lower income classes in some countries. Several studies by Monteiro et al (2004) explore this trend, finding that as a country's GDP grows, lower-socioeconomic status groups lose ground against obesity.[46] In fact, examining data from 1975-2008, they found that obesity rates in higher-income groups were decreasing for the first time.[47] Brazil, for instance, has seen marked increases in the prevalence of obesity in every population group, except for high-income groups from urban regions, which actually saw a decrease in obesity prevalence from 12.8% to 9.2% from 1989-1997.[48] Among lower-income groups, obesity was still rising enough for the overall obesity in the country to be

[43] Braguinsky, J. "Obesity Prevalence in Latin America]." In *Anales Del Sistema Sanitario De Navarra*, 25:109, 2002.
[44] Filozof, C., C. Gonzalez, M. Sereday, C. Mazza, and J. Braguinsky. "Obesity Prevalence and Trends in Latin-American Countries."
[45] Ibid.
[46] Monteiro CA, et al. "Obesity and Inequities in Health in the Developing World." *International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity* 28.9 (2004): 1181-6.
[47] Monteiro CA, Conde WL, and Popkin BM. "Income-Specific Trends in Obesity in Brazil: 1975-2003." *American Journal of Public Health* 97.10 (2007): 1808-12.
[48] Filozof, C., C. Gonzalez, M. Sereday, C. Mazza, and J. Braguinsky. "Obesity Prevalence and Trends in Latin-American Countries."

increasing as a whole.[49] However, this research was only specific to Brazil, and it would be interesting to see if this observation also holds true for other countries like Colombia. As a whole, Latin American populations are transitioning from being underweight to overweight, for as countries emerge from poverty and expand economically, they also experience increasing trends in obesity. [50] Middle income countries, on the other hand, tend to display decreasing obesity as income increases, especially in women.

Determinants of Overweight

Before discussing the potential relationship between breastfeeding and overweight, it is important to discuss some of the other determinants of overweight and obesity that have been the subject of other research in the literature. Several studies have cited genetics as a cause for obesity, and there is indeed evidence that suggests the existence of a hereditary component to obesity. Using data from twins who had been reared apart or together, Stunkard et al (1990) found that genetic factors were far more influential in determining weight outcomes than environmental factors.[51] While genes definitely play a role in determining body mass, the trends of the past few decades are changing too quickly to be solely attributable to genetic mutations, which are so minute they would require centuries to accumulate enough to cause such a drastic change.[52] As a result, many other studies do include variables that account for the influence of genetics on obesity, but their prime focus is usually elsewhere, like on environmental variables.

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[49] Monteiro CA, Conde WL, and Popkin BM. "Income-Specific Trends in Obesity in Brazil: 1975-2003."
[50] Uauy R, Albala C, and Kain J. "Obesity Trends in Latin America: Transiting from Under- to Overweight." *The Journal of nutrition* 131.3 (2001).
[51] Stunkard, Albert J., Jennifer R. Harris, Nancy L. Pedersen, and Gerald E. McClearn. "The Body-Mass Index of Twins Who Have Been Reared Apart." *New England Journal of Medicine* 322.21 (1990): 1483-487.
[52] Anderson, Patricia M., and Kristin F. Butcher. "Childhood Obesity: Trends and Potential Causes." *The Future of Children* 16.1 (Spring 2006): 19-45. Brookings Institution Press.

Regardless of the exact interaction of environmental factors with genetics, numerous studies have found that maternal overweight is significantly associated with child overweight.[53] For example, Bergmann et al (2003) conducted a study about the potential protective effect of breastfeeding against child overweight and found maternal overweight to actually be one of the most important risk factors for overweight and adiposity.[54] This is consistent with research like that of Classen et al (2010), who found strong, significant associations between parental and child BMI, especially among individuals with already elevated BMI values.[55] Similarly, in a cross-sectional study of randomly selected children, Gibson et al (2007) found maternal BMI to be one of only two significant predictors of z-scores for the children's BMI.[56] Not only is the mother's weight status important, but the child's initial weight plays a key part as well. Higher birth weight has been associated with an increased risk of obesity later in life, and a study by Singhal et al (2003) found an increase in birth weight of one standard deviation was significantly associated with a 2-3% increase in fat-free mass in adolescents, though no similar increase in fat mass was found.[57]

Socioeconomic indicators also play a key role in influencing obesity: Fernald (2007) found education, occupation, household assets, and quality of housing conditions all

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[53] Locard, E., N. Mamelle, A. Billette, M. Miginiac, F. Munoz, S. Rey, and others. "Risk Factors of Obesity in a Five Year Old Population. Parental Versus Environmental Factors." *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* 16, no. 10 (1992): 721.

[54] Bergmann, K E, R L Bergmann, R von Kries, O. B|[ouml]|hm, R. Richter, J W Dudenhausen, and U. Wahn. "Early Determinants of Childhood Overweight and Adiposity in a Birth Cohort Study: Role of Breast-feeding." *International Journal of Obesity* 27, no. 2 (February 1, 2003): 162–172.

[55] Classen, T.J. "Measures of the Intergenerational Transmission of Body Mass Index Between Mothers and Their Children in the United States, 1981-2004." *Economics & Human Biology* 8, no. 1 (2010): 30–43.

[56] Gibson, LY, SM Byrne, EA Davis, E Blair, P Jacoby, and SR Zubrick. "The Role of Family and Maternal Factors in Childhood Obesity." *Med J Aust* 186, no. 11 (2007): 591–5.

[57] Singhal, Atul, Jonathan Wells, Tim J Cole, Mary Fewtrell, and Alan Lucas. "Programming of Lean Body Mass: A Link Between Birth Weight, Obesity, and Cardiovascular Disease?" *The American Journal of Clinical Nutrition* 77, no. 3 (March 1, 2003): 726–730.

contributed significantly and independently to BMI.[58] Populations with the highest poverty rates and least education also tend to be those with the most obesity.[59] A focus group conducted with low-income mothers in the U.S. revealed several trends that seem to make low-income mothers more conducive to having overweight children: mothers believed that infant weight was the best sign of good parenting, and thus desired a heavier child.[60] Mothers also used food as a reward or a way to calm a fussy baby, turning food as a way to influence child behavior. In addition, mothers often introduced solid food into their child's diet earlier than was deemed optimal for fear that their child was going hungry.

In a global comparison of obesity prevalence, Delpeuch and Maire (2004) found obesity to be higher in urban areas than rural ones.[61] Similarly, Martorell et al's (2000) study of obesity in developing countries found that child overweight was more common in urban areas, but a unique result was that obesity was more likely among children of mothers with more education.[62] In this study of 71 national surveys from 50 countries, every country exhibited more overweight among better-educated women. In the U.S. and other developed countries, more maternal education is usually associated with *less* obesity.[63]

Decisions and behaviors of the child's parents are key to determining their ultimate susceptibility. Anderson et al (2003) used the National Health and Nutrition Survey data set

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[58] Fernald, L.C.H. "Socio-economic Status and Body Mass Index in Low-income Mexican Adults." *Social Science & Medicine* 64, no. 10 (2007): 2030–2042.
[59] Drewnowski, Adam, and SE Specter. "Poverty and Obesity: the Role of Energy Density and Energy Costs." *American Journal of Clinical Nutrition* 79 (2004): 6-16.
[60] Baughcum, A.E., K.A. Burklow, C.M. Deeks, S.W. Powers, and R.C. Whitaker. "Maternal Feeding Practices and Childhood Obesity: a Focus Group Study of Low-income Mothers." *Archives of Pediatrics and Adolescent Medicine* 152, no. 10 (1998): 1010.
[61] Qtd. In Drewnowski, Adam, and SE Specter. "Poverty and Obesity: the Role of Energy Density and Energy Costs."
[62] Martorell, R., K.L. Kettel, M.L. Hughes, L.M. Grummer-Strawn, and others. "Overweight and Obesity in Preschool Children from Developing Countries." *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* 24, no. 8 (2000): 959.
[63] Lamerz, A., J. Kuepper-Nybelen, C. Wehle, N. Bruning, G. Trost-Brinkhues, H. Brenner, J. Hebebrand, and B. Herpertz-Dahlmann. "Social Class, Parental Education, and Obesity Prevalence in a Study of Six-year-old Children in Germany." *International Journal of Obesity* 29, no. 4 (April 1, 2005): 373–380.

to look at the effects of maternal working hours on childhood obesity, and found that mothers who worked more hours were more likely to have overweight children, but this effect only held for higher-income groups.[64] Similarly, Hawkins et al (2007) investigated the relationship between maternal employment and overweight in three-year-old children and found that children were more likely to be overweight for every 10 hours the mother worked each week - but this was only significant with household incomes of $57,750 or higher.[65] Family size is also a significant covariate: Ravelli and Belmont (1979) found adolescents from single-child families were uniquely at risk for obesity, especially among families from the non-manual laboring groups.[66] Most studies conclude that there are many factors that influence overweight, so the challenge for health policymakers is to find ways to prevent or reduce obesity, especially for children.

Benefits of Breastfeeding

One low-cost, high-benefit solution that policy makers have looked to in order to prevent overweight and the many negative health and societal externalities that come with it has been breastfeeding, which is frequently associated with positive child health outcomes. Breast milk contains important nutrients for infant development and especially for bolstering immune systems. According to Dr. Nancy Butte (2009, 2001), "Human milk is exquisitely fitted for optimal infant growth and development and may uniquely modulate neuroendocrine and immunologic pathways involved in the regulation of body weight" because the nutrient composition of breast milk is be both qualitatively and quantitatively distinct from baby

[64] Anderson, Patricia M., Kristin F. Butcher, and Philip B. Levine. "Economic Perspectives on Childhood Obesity." *Economic Perspectives - Federal Reserve Bank of Chicago* 27 (2003): 30-48.
[65] Hawkins, S S, T J Cole, and C. Law. "Maternal Employment and Early Childhood Overweight: Findings from the UK Millennium Cohort Study." *International Journal of Obesity* 32, no. 1 (July 17, 2007): 30–38.
[66] Ravelli, G. P, and Lillian Belmont. "Obesity in Nineteen-Year-Old Men: Family Size and Birth Order Associations." *American Journal of Epidemiology* 109, no. 1 (January 1, 1979): 66–70.

formula, since it contains "bioactive substances that may influence adipocyte differentiation and proliferation".[67,68] Early nutrition can have effects on health much later in life, including susceptibility to obesity and other chronic conditions. Epidemiologist David Barker was one of the first to explore the link between fetal growth patterns and the risk of developing various chronic diseases as adults. He identified a connection between death from cardiovascular disease and low birth weight, when most research at the time emphasized the importance of childhood environmental factors instead of neonatal conditions.[69]

Many studies have confirmed that breastfeeding results in better health outcomes for infants as opposed to using formula or other milk alternatives. Belfield et al (2010) used very careful econometric analysis to adjust for potential confounding factors and obtained results that breastfeeding and not formula-feeding at birth were associated with increased probabilities of excellent health at 9 months.[70] Using simultaneous equations models and propensity score measures, they explored the causal effect of breastfeeding on early childhood development by examining various health, physical, and cognitive outcomes with respect to breastfeeding and formula-feeding intensities. They also controlled for an extensive list of potential confounding factors that could also promote child development. At 24 and 54 months, breastfed babies were protected against obesity and exhibited better cognitive outcomes. In addition, breastfeeding for at least 6 months improved motor scores at 9 months.

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[67] Butte NF. "Impact of Infant Feeding Practices on Childhood Obesity." *The Journal of nutrition* 139.2 (2009).
[68] Butte, N.F. "The Role of Breastfeeding in Obesity." *Pediatric Clinics of North America* 48, no. 1 (2001): 189–198.
[69] Barker, David J. "The Fetal and Infant Origins of Adult Disease." *BMJ* 301 (1990): 1111
[70] Belfield, Clive R., and Inas Rashad Kelly. *The Benefits of Breastfeeding Across the Early Years of Childhood* National Bureau of Economic Research, Inc, NBER Working Papers: 16496, 2010.

It is not breastfeeding alone that matters–duration is a key component to determining health outcomes as well. Babies who are breastfed for longer periods of time have exhibited better overall health, and usually have lower rates of infant mortality. A comprehensive review of over 9,000 abstracts of studies about the relationship between breastfeeding and infant and maternal health in developed countries concluded that breastfeeding is associated with a reduced risk of many adverse health outcomes in both infants and mothers, including a reduction in sudden infant death syndrome.[71] A study by Amin (1990) found breastfeeding type at various stages of life to be a significant predictor of infant mortality, even when control variables like mother's education, religion, and socioeconomic status were included in the model to account for endogeneity.[72] Infants who were breastfed at birth had better probabilities of survival relative to infants who were never breastfed or who received liquid supplements early in life. Marcotte et al (1990) found similar results in an Egyptian cohort, demonstrating this effect was not exclusive to U.S. population samples.[73] The risk of death for children under the age of five increased when children were weaned - up to 29% of Egyptian children's deaths could be attributed to early weaning.

In addition to improving health outcomes, breastfeeding has also been found to specifically contribute to improved cognitive development. Doyle et al (2010) identified a positive relationship between exclusive breastfeeding and cognitive ability and even went so far as to calculate the peak length of time required in order to maximize returns to exclusive breastfeeding: they found that positive returns to exclusive breastfeeding peak at six months,

[71] Ip, S., M. Chung, G. Raman, P. Chew, N. Magula, D. DeVine, T. Trikalinos, and J. Lau. "Breastfeeding and Maternal and Infant Health Outcomes in Developed Countries. Rockville, MD: Agency for Healthcare Research and Quality; 2007." *Evidence Report/technology Assessment* 153 (2009).
[72] Amin, S. "Infant Mortality and Breastmilk Supplementation in Bangladesh." *The Bangladesh Development Studies* 18, no. 4 (December 1990): 15–31.
[73] Marcotte, J., and J.B. Casterline. *Interrelations Among Child Mortality, Breastfeeding, and Fertility in Egypt, 1975-80*. The World Bank, 1990.

while non-exclusive breastfeeding continues to provide returns until the tenth or twelfth months of life.[74] To test if these results were robust over time, they also studied the effect of breastfeeding on cognitive development in two cohorts forty years apart and observed a significant relation between breastfeeding and cognitive performance. However, these results applied to a birth sample in the UK, and have not been verified for another population group.

Because of the many health improvements breastfeeding is said to impart, there are significant potential savings from increased breastfeeding initiation and duration. Bartick et al (2010) calculated the potential savings from increased breastfeeding rates and the diseases that could be prevented as a result. First, they calculated the costs of all pediatric diseases that are protected against by breastfeeding. By comparing those costs to projected costs if 90% of U.S. families complied with the recommendation of 6 months of exclusive breastfeeding, they found that the U.S. would save $13 billion per year and prevent an excess 911 deaths. Even just 80% compliance would result in $10.5 billion in savings and prevent 741 deaths.[75]

Determinants of Breastfeeding

It is important to review the factors that influence breastfeeding, in order to better understand how breastfeeding interacts with environmental factors and, ultimately, child weight. There is some research that specifically looks at determinants of breastfeeding in Latin America. A 2002 study of women from Guatemala City found that the most important determinant of exclusive breastfeeding was whether or not the child's mother worked outside the home: mothers who did not work outside the home were 3.2 times as likely to exclusively

[74] Doyle, Orla, and Kevin Denny. *The Causal Effect of Breastfeeding on Children's Cognitive Development: A Quasi-Experimental Design*. Geary Institute, University College Dublin, Working Papers: 201020, 2010.
[75] Bartick, M., and A. Reinhold. "The Burden of Suboptimal Breastfeeding in the United States: A Pediatric Cost Analysis." *PEDIATRICS -SPRINGFIELD-* 125.5 (2010): 1049.

breastfeed their babies.[76] A study of low-income women from Brazil, Mexico, and Honduras Perez-Escamilla found maternal unemployment, lower socioeconomic status, having a female infant, and higher birth weight were positively associated with exclusive breastfeeding, implying that wealthier working mothers were more likely to breastfeed exclusively.[77]

Maternal employment and where the child is raised interact to determine the child's likelihood of being breastfed. Baker and Milligan (2008) examined the effect of maternity leave mandates on breastfeeding duration using data from Canada, where there was a significant increase in maternity leave mandates.[78] Their results indicated large parallel increases in both the attainment of key breastfeeding duration thresholds and mothers' time off from work after giving birth, implying that mothers who continue working may struggle to achieve similar breastfeeding duration as those who take leave. Women in rural areas are more likely to initiate breastfeeding, and to continue breastfeeding for longer durations than their urban counterparts.[79] Due to the greater availability of employment opportunities in cities, mothers living in urban areas are more likely to have income from market labor, making it more difficult to reconcile work schedules with child care and breastfeeding.[80] Rural women are more likely to have more flexible work schedules if they work at home or in agricultural settings. Also, if the opportunity cost of using time to breastfeed exceeds that

[76] Dearden, K., M. Altaye, I. Maza, M. Oliva, M. Stone-Jimenez, A.L. Morrow, and B.R. Burkhalte. "Determinants of Optimal Breast-feeding in Peri-urban Guatemala City, Guatemala." *Revista Panamericana De Salud Pública* 12, no. 3 (2002): 185–192.
[77] Perez-Escamilla, R., C. Lutter, A.M. Segall, A. Rivera, S. Trevino-Siller, and T. Sanghvi. "Exclusive Breast-feeding Duration Is Associated with Attitudinal, Socioeconomic and Biocultural Determinants in Three Latin American Countries." *The Journal of Nutrition* 125, no. 12 (1995): 2972–2984.
[78]Baker, Michael, and Kevin Milligan. "Maternal Employment, Breastfeeding, and Health: Evidence from Maternity Leave Mandates." *Journal of Health Economics* 27, no. 4 (July 2008): 871–887.
[79] Huffman, S.L. "Determinants of Breastfeeding in Developing Countries: Overview and Policy Implications." *Studies in Family Planning* 15, no. 4 (1984): 170–183.
[80] Popkin, B.M., R.E. Bilsborrow, J.S. Akin, and M.E. Yamamoto. "Part 1: Breast-feeding Determinants in Low-income Countries."

of working, the mother will choose to work and resort to breast milk alternatives or supplements instead. If women view breast milk and baby formula as perfect substitutes, and the price of formula is cheaper than the price of the mother's time lost by having to breastfeed her baby, then the rational decision will be to choose formula.

One frequent reason women cited for ceasing breastfeeding was an insufficiency of milk, which was more common among urban women than rural.[81] This also contributes to the lower rates of breastfeeding in urban areas. Huffman points to suckling patterns as a culprit for this: sociocultural factors in rural areas are more conducive to supportive environments that help mothers develop optimal breastfeeding strategies and practices. The health care system is also important in influencing mothers' decision to breastfeed, because babies who are born in hospitals are less likely to be breastfed if their mother is not informed by the medical staff about proper breastfeeding practices.

Ethnicity can also play a part: a study by Hurley et al (2008) compared breastfeeding behaviors among low-income women in the USA and found Hispanic mothers more likely to initiate breastfeeding than African American or white mothers (91% initiation vs 65% and 61%, respectively).[82] Hispanic mothers also breastfed for the longest duration, at a mean of 5 months, while African American mothers breastfed for a mere 3.5 months on average, and white mothers had an even shorter mean duration of 3 months of breastfeeding.

Maternal health variables can also affect their infant feeding decisions. Donath and Amir (2000) found that mothers who were overweight - those with a BMI measure between

[81] Perez-Escamilla, R., C. Lutter, A.M. Segall, A. Rivera, S. Trevino-Siller, and T. Sanghvi. "Exclusive Breast-feeding Duration Is Associated with Attitudinal, Socioeconomic and Biocultural Determinants in Three Latin American Countries."

[82] Hurley, K.M., M.M. Black, M.A. Papas, and A.M. Quigg. "Variation in Breastfeeding Behaviours, Perceptions, and Experiences by Race/ethnicity Among a Low-income Statewide Sample of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Participants in the United States." *Maternal & Child Nutrition* 4, no. 2 (2008): 95–105.

20 and 25 - were less likely to initiate breastfeeding and also breastfed for significantly shorter times than mothers who were not obese.[83] Other family variables are important as well: Diaz et al's (2011) study of 23,109 Colombian children less than one year old found that breastfeeding was associated with not using a feeding bottle, nuclear family membership, and having a male head of household.[84] Median duration of breastfeeding was only 2 months.

Some researchers have suggested that socio-cultural factors can influence a woman's decision to breastfeed. In cities, for instance, it can be harder to find a support group to share strategies and tips about optimal breastfeeding practices. Breastfeeding might also be seen as less modern, which could cause mothers trying to adopt habits and lifestyles of developed countries to abandon breastfeeding.

Several governments in Latin America have adopted policies to try and promote breastfeeding as a way to improve maternal and infant health. Educational programs have been shown to enhance breastfeeding, which has led many countries to implement programs to foster environments more favorable to breastfeeding. For instance, Brazil has a National Breast-feeding Program that ran a media campaign based on research that revealed women's breastfeeding decisions were being affected by psychological blocks.[85] The use of support groups is another popular strategy: El Salvador's Centro de Apoyo de Lactancia de la Materna (CALMA) trains health counselors; Nicaragua has a support group named Genesis II, an offshoot of the National Women's Organization, which organizes activities including

[83] Donath, Sm, and Lh Amir. "Does Maternal Obesity Adversely Affect Breastfeeding Initiation and Duration?" *Journal of Paediatrics and Child Health* 36, no. 5 (October 1, 2000): 482–486.
[84] Díaz, Carmen Elena, Rossana López, Indira Herrera, Diana Arena, Carolina Giraldo, and Laura Gonzáles. "Factors Associated with Breastfeeding in Children Less Than One Year of Age in the City of Cartagena, Colombia."
[85] Huffman, S.L. "Determinants of Breastfeeding in Developing Countries: Overview and Policy Implications." *Studies in Family Planning* 15, no. 4 (1984): 170–183.

radio promotions, counseling in breastfeeding, pre-natal classes, training of breastfeeding counselors, and the production of a newsletter to help professionals in hospitals.[86]

As mentioned before, Colombia also launched a media campaign in 1979 in an attempt to encourage breastfeeding. Less than a year afterwards, the Ministry of Health adopted "an official resolution to encourage breastfeeding in all of its facilities and the President signed a decree regulating the promotion and packaging of milk substitutes."[87] The effectiveness of this campaign seemed questionable at first, as a 1980 survey found lower levels of breastfeeding duration and a higher proportion of women who did not engage in breastfeeding at all compared to 1976 numbers: mean duration fell from 11.3 months to 8.9 months.[88] However, surveys conducted in 1986 later found that breastfeeding duration had returned to around 1976 levels, and the proportion of women who never breastfed actually fell compared to 1976 levels, bringing the proportion of infants breastfed in their first year of life back to 94% from the 1980 level of 80%.[89] The 2009 introduction of the family-friendly rooms in Bogotá then marks the next major policy that Colombia enacted that directly addressed breastfeeding. While preventing overweight and obesity was not cited as a primary goal of the policy, it would be good to know if that could be one of the effects.

Effects of Breastfeeding on Child Overweight

Breastfeeding is thought to affect child weight, and many researchers have looked at the impact of breastfeeding on child obesity using data from developed countries. Thus far, breastfeeding has indeed been negatively associated with obesity and weight gain: when

[86] Huffman, S.L. "Determinants of Breastfeeding in Developing Countries: Overview and Policy Implications."
[87] Green, C.P. *Media Promotion of Breastfeeding: A Decade's Experience*. Nutrition Communication Project. U.S. Agency for International Development, 1989.
[88] Green, C.P. *Media Promotion of Breastfeeding: A Decade's Experience*.
[89] Ibid.

comparing 11 studies that examined the prevalence of overweight in children 3 years and older using sample sizes of at least 100 children per feeding group, Dewey (2003) found that 8 of the 11 showed breastfed babies facing a lower risk of overweight as children, even after controlling for potential confounders.[90] The studies that did not find this protective effect lacked information about the exclusivity of breastfeeding. Smilarly, Ip et al's (2007) extensive review of over 9,000 studies concerning the relationship between breastfeeding and infant health outcomes also found breastfeeding had a protective effect against obesity.[91]

A direct comparison of breastfed babies versus formula-fed babies by Armstrong et al (2002) using a cohort of 32,300 Scottish children who participated in the Child Health Surveillance Programme found that a significantly lower prevalence of obesity among the breastfed children, with an odds ratio of 0.78 for a BMI at or higher than the 95th percentile, and 0.73 at or above the 98th percentile.[92] Even after adjusting for the potential confounding variables of sex, socioeconomic status, and birth weight, the breastfed babies remained significantly associated with a reduced risk of obesity. Interestingly, there were no significant interactions between breastfeeding and either socioeconomic status or birth weight–an unusual finding, since socioeconomic status is usually considered a necessary control for both breastfeeding and weight.

While some researchers looked at the impact of breastfeeding versus never breastfeeding at all, others examined the effect of breastfeeding duration and initiation time. Results from Harder et al (2005) suggest that longer breastfeeding duration is associated with

[90] Dewey, Kathryn. "Is Breastfeeding Protective Against Child Obesity?" *Journal of Human Lactation* 19.1 (2003): 9-18.
[91] Ip, Stanley, Mei Chung, Gowri Raman, Priscilla Chew, Nombulelo Magula, Deirdre DeVine, Thomas Trikalinos, and Joseph Lau. *Breastfeeding and Maternal and Infant Health Outcomes in Developed Countries*. Rockville, MD: U.S. Dept. of Health and Human Services, Public Health Service, Agency for Healthcare Research and Quality, 2007.
[92] Armstrong, J., J.J. Reilly, and others. "Breastfeeding and Lowering the Risk of Childhood Obesity." *The Lancet* 359, no. 9322 (2002): 2003–2004.

a decrease in the risk of overweight later in life, dependent on dose.[93] Both meta-regression and categorical analysis confirmed this dose-response association; more specifically, an extra month of breastfeeding was associated with a 4% decrease in the risk of overweight.[94] Similarly, Arenz et al (2004) looked at nine studies with over 69,000 total participants and found that breastfeeding significantly reduced the risk of childhood obesity; four of the studies reported a dose-dependent effect of breastfeeding duration on child obesity.[95] These results were checked with a funnel plot regression, which gave no indication of publication bias. Gillman et al (2001) used data from over 15,000 respondents of the Growing Up Today Study and found that infants who were breastfed for longer periods, or who ingested more breast milk than infant formula had a lower risk of being overweight during later childhood and adolescence.[96] The odds ratio for being overweight was 0.78 for children who had mostly been fed breastmilk compared to subjects who were fed only or mostly formula. These results were obtained after adjusting for age, gender, energy intake, maternal BMI, physical activity, television watching time, and other socioeconomic factors.

Bogen et al (2004) attempted to pin down the exact duration of breastfeeding that is necessary to have a protective effect against obesity, and found that breastfeeding was only associated with a reduced risk of obesity among white children whose mothers had not smoked during pregnancy.[97] Breastfeeding had to take place for at least 16 weeks without

[93] Harder, T., R. Bergmann, G. Kallischnigg, and A. Plagemann. "Duration of Breastfeeding and Risk of Overweight: a Meta-analysis." *American Journal of Epidemiology* 162, no. 5 (2005): 397.
[94] Harder, T., R. Bergmann, G. Kallischnigg, and A. Plagemann. "Duration of Breastfeeding and Risk of Overweight: a Meta-analysis."
[95] Arenz, S., R. Rückerl, B. Koletzko, and R. Von Kries. "Breast-feeding and Childhood Obesity—a Systematic Review." *International Journal of Obesity* 28, no. 10 (2004): 1247–1256.
[96] Gillman, M.W., S.L. Rifas-Shiman, C.A. Camargo, C.S. Berkey, A.L. Frazier, H.R.H. Rockett, A.E. Field, and G.A. Colditz. "Risk of Overweight Among Adolescents Who Were Breastfed as Infants." *JAMA: The Journal of the American Medical Association* 285, no. 19 (2001): 2461.
[97] Bogen, D.L., B.H. Hanusa, and R.C. Whitaker. "The Effect of Breast-feeding with and Without Formula Use on the Risk of Obesity at 4 Years of Age." *Obesity* 12, no. 9 (2004): 1527–1535.

formula or at least 26 weeks with formula in order for the protective effect to exist. Interestingly, there was no such protective effect among blacks. Using a six-month duration threshold, Crume et al (2011) studied the effect of adequate vs. inadequate breastfeeding on youth waist circumference, BMI, visceral abdominal fat (VAT) and subcutaneous (SAT) abdominal fat on 468 children. Adequate breastfeeding, defined as six or more months of breastfeeding, was associated with significantly lower BMI, adiposity, and waist circumference in children aged 6-13.[98]

Other studies have tested the effects of different breastfeeding durations. For instance, Griffiths et al (2009) found both breastfeeding initiation and duration were significantly associated with weight gain from infancy up through the age of three years, where infants who did not receive breast milk grew faster than those who were breastfed, and those breastfed less than four months also grew faster than those who were breastfed for four or more months.[99] Bergmann et al (2003) examined the potential protective effect of breastfeeding against later adiposity among 480 cases from a longitudinal birth cohort study by comparing height and weight measures from birth to those at age 6.[100] Using univariate comparisons and logistic regression analysis, infants who were bottle-fed from birth or breast-fed for less than three months were found to have significantly higher BMIs at 3 and 6 months of age than infants who had been breastfed for at least 3 months. At age 5, the prevalence of obesity among bottle-fed children was nearly double that of age 4, and by age 6 the prevalence had tripled. Breastfed children, on the other hand, saw only minor changes

[98] Crume T.L., et al. "Long-Term Impact of Neonatal Breastfeeding on Childhood Adiposity and Fat Distribution among Children Exposed to Diabetes in Utero." *Diabetes Care* 34.3 (2011): 641-5.
[99] Griffiths, L. J., et al. "Effects of Infant Feeding Practice on Weight Gain from Birth to 3 Years." *Archives of disease in childhood*. 94.8 (2009): 577-82.
[100] Bergmann, K E, R L Bergmann, R von Kries, O. Bl[ouml]lhm, R. Richter, J W Dudenhausen, and U. Wahn. "Early Determinants of Childhood Overweight and Adiposity in a Birth Cohort Study: Role of Breast-feeding." *International Journal of Obesity* 27, no. 2 (February 1, 2003): 162–172.

in obesity prevalence, creating a statistically significant difference from those of bottle-fed children. A logistical regression found maternal overweight, bottle-feeding, maternal smoking during pregnancy, and low social status to be the most important risk factors for overweight and adiposity at age six.[101] That these studies all found breastfeeding duration to be significantly associated with lower weight outcomes while using different duration cutoffs only lends more support to the hypothesis that longer breastfeeding duration is protective against child overweight.

The theory behind this potential protective effect of breastfeeding focuses on the behaviors of the infant: when breastfeeding, the child will stop feeding when s/he feels full. Bottle-feeding, on the other hand, can often cause parents to feed the baby until the bottle is empty, which might result in overfeeding. Li et al (2008) examined the effect of breastfeeding on child weight as well as the independent impact of infant-initiated bottle emptying on child weight outcomes, using a sample of 1,896 mothers from the Infant Feeding Practice Study II. After adjusting for various sociodemographic characteristics, infants fed with low and medium breastfeeding intensity (up to 80% of milk intake being breastmilk) were at least twice as likely to have excess weight during the second half of infancy compared to babies who were breastfed at high intensity (over 80% of the time).[102]

Bottle emptying does appear to have an effect on weight: the infants in the study who often emptied bottles in early infancy were 69% more likely to have excess weight in later infancy compared to babies who rarely emptied their bottles.[103] Two years later, Li et al

[101] Bergmann, K E, R L Bergmann, R von Kries, O. Bl[ouml]lhm, R. Richter, J W Dudenhausen, and U. Wahn. "Early Determinants of Childhood Overweight and Adiposity in a Birth Cohort Study: Role of Breast-feeding." *International Journal of Obesity* 27, no. 2 (February 1, 2003): 162–172.
[102] Li, R., S. B. Fein, and L. M. Grummer-Strawn. "Association of Breastfeeding Intensity and Bottle-Emptying Behaviors at Early Infancy With Infants' Risk for Excess Weight at Late Infancy." *Pediatrics* 122, no. Supplement (October 1, 2008): S77–S84.
[103] Li, R., S. B. Fein, and L. M. Grummer-Strawn. "Association of Breastfeeding Intensity and Bottle-

(2010) conducted a study to investigate whether or not bottle feeding seemed to induce a lack of self-regulation in infants when it came to milk intake: using data for 1,250 infants who participated in the 2005-07 Infant Feeding Practices Study II, they tested the impact of feeding mode and milk source during early infancy on self-regulation for milk consumption during late infancy.[104] Results from multivariate regression analysis indicated that infants who were bottle-fed more intensively in early infancy were two times more likely to empty the bottle or cup in later infancy than those who were bottle-fed less intensively: while only 27% of infants who were exclusively breastfed went on to empty bottles or cups in late infancy, 54% of infants who were both breastfed and bottle-fed emptied bottles in late infancy, and a whopping 68% of exclusively bottle-fed infants did so. Even considering baby formula and expressed milk separately resulted in similar dose-response relationships. In other words, if mothers breastfeed their babies instead of using bottles, the infants will go on to have better self-regulation behaviors that will help prevent them from over-feeding, and thus help to prevent excess weight gain.

While these results may seem to support the idea that breastfeeding can protect against overweight, this may not be a straightforward conclusion. For instance, the endogeneity of breastfeeding makes it difficult to isolate its relationship with specific child health outcomes, like overweight. Brion et al (2011) found that breastfeeding seemed to have a protective effect against child obesity for a British sample group, but cautioned that this could be due to confounding variables.[105] Nelson et al (2005) conducted an analysis of the

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Emptying Behaviors at Early Infancy With Infants' Risk for Excess Weight at Late Infancy."

[104] Li, Ruowei, Sara B Fein, and Laurence M Grummer-Strawn. "Do Infants Fed From Bottles Lack Self-Regulation of Milk Intake Compared With Directly Breastfed Infants?" *Pediatrics* 125, no. 6 (June 1, 2010): e1386–e1393.

[105] Brion, Marie-Jo A., et al. "What are the Causal Effects of Breastfeeding on IQ, Obesity and Blood Pressure? Evidence from Comparing High-Income with Middle-Income Cohorts."

effect of breastfeeding on overweight by using sibling pairs to reduce confounding: while they found a slight protective effect of breastfeeding against overweight for girls, and a similar but lesser effect for boys, analyzing sibling pairs "provided no evidence of breast-feeding effects on weight within discordant trends."[106] However, the overall body of evidence does appear strong, since they employed random sampling and large sample groups, controlled for many known covariates, and often conducted internal validity tests.

That being said, the vast majority of existing research was conducted using data from developed countries, and there is a need for more independent studies using information from developing countries before concluding anything about how breastfeeding affects obesity in a region like Latin America. This is especially important because the existing research about breastfeeding and overweight in developing countries have been far less persuasive about any protective effect of breastfeeding. When Brion et al (2011) conducted their same analysis to examine the effect of breastfeeding on child obesity on a Brazilian cohort, for instance, they found no such protective effects.[107] Similarly, Kwok et al (2009) examined evidence from Hong Kong and found that in a non-European setting, the protective features of breastfeeding against obesity disappeared.[108]

In general, most researchers have acknowledged that the protective effect of breastfeeding on child obesity is small though significant, and that other factors–like parental obesity and socioeconomic status–are more important in having a real effect on child obesity. Obesity in Latin America has been understudied, and thus far existing research about the

[106] Nelson, M.C., P. Gordon-Larsen, and L.S. Adair. "Are Adolescents Who Were Breast-fed Less Likely to Be Overweight?: Analyses of Sibling Pairs to Reduce Confounding." *Epidemiology* 16, no. 2 (2005): 247.
[107] Brion, Marie-Jo A., et al. "What are the Causal Effects of Breastfeeding on IQ, Obesity and Blood Pressure? Evidence from Comparing High-Income with Middle-Income Cohorts."
[108] Kwok M.K., et al. "Does Breastfeeding Protect Against Childhood Overweight? Hong Kong's 'Children of 1997' Birth Cohort." *International Journal of Epidemiology* 39.1 (2009): 297-305.

effects of breastfeeding on child obesity has been inconclusive or contradictory. However, it is important to examine the obesity trends in Latin America and their potential causes because obesity rates are increasing so quickly in Latin America.

Using data from Colombia, this thesis explores the effects of breastfeeding on child overweight in a very important context: Latin America. As has already been discussed, obesity and its determinants and consequences are greatly understudied in Latin America. Breastfeeding is also understudied - Colombia in particular has seen little new research on the topic since the 1980s. Overweight in Colombia has been rising consistently for the past few decades, so it is important to determine whether or not breastfeeding could be a viable solution to preventing obesity, especially in children. With an overweight prevalence of 53.8% in women and 44.9% in men, resulting in a 49.6% overall, Colombia actually falls on the lower end of the spectrum for overweight in Latin America. While 18.1% of both genders are obese in Colombia, Chile and Argentina both have obesity rates upward of 29%[109] Given recent trends of only increasing rates of obesity, soon Latin America may catch up to even the U.S., where over one-third (35.7%) of adults and approximately 17% of children and adolescents from ages 2-19 are obese, according to the CDC[110].

This paper will add a very recent study to the existing body of literature about obesity in Latin America, which is currently very lacking. In addition, it will examine the relationship of both breastfeeding initiation and duration on overweight in a new and specific context: Colombia. Since overweight and obesity are major health concerns in Latin America and many other parts of the developing world, my findings should provide some insight into

[109] "Country Statistics." *WHO Global Health Observatory Data Repository*. World Health Organization, 2011. Web. <http://apps.who.int/ghodata/?vid=6500>.
[110]"Obesity and Overweight for Professionals: Data and Statistics: U.S. Obesity Trends | DNPAO | CDC." *CDC: Centers for Disease Control and Prevention*, n.d. http://www.cdc.gov/obesity/data/trends.html.

how child obesity can be prevented, and whether or not breastfeeding is a viable solution for that.

III. Data

To address these questions about the effect of breastfeeding on overweight children under the age of 5, I will be using the Demographic and Health Survey data from Colombia for this paper. Beginning in 1984, the U.S. Agency for International Development began collecting population data from over 90 countries as part of a project to provide "[q]uality information to plan, monitor and improve population, health, and nutrition programs".[111] Conducted through a series of interviews with households across the country, these Demographic and Health Surveys are nationally representative and contain data on sociodemographic factors, household member health, medical care, feeding practices, and more. Monitoring and Evaluation to Assess and Use Results Demographic and Health Surveys (MEASURE DHS) including this one are used in policy planning to address issues of maternal and child health, among other things, and have "provided technical assistance to more than 260 surveys in over 90 countries, advancing global understanding of health and population trends in developing countries"[112].

DHS has conducted surveys in eleven Latin American countries: Bolivia, Brazil, Colombia, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Paraguay, and Peru. The number of surveys conducted in each country varies, so the quantity of data available for the region differs greatly from year to year.

The Colombian Demographic and Health Surveys are some of the most thorough and up-to-date data available for Latin America. While other DHS data sets include surveys from the 1980s or 1990s, Colombia contains more current data from 2000, 2005, and 2010, as well as data from 1995, 1990, and 1986. The only country with more surveys was Peru, with 7 in

[111] "Who We Are." *MEASURE DHS*. U.S. Agency for International Development. <http://www.measuredhs.com>.
[112] Ibid.

total, though the last two surveys are not yet available for analysis as they were continuous surveys. As such, Colombia is the best option for the most recent data available. I will be using the Colombian Demographic and Health Surveys from 2010 in order to provide a recent and applicable perspective on the relationship between breastfeeding and child weight outcomes. There is a distinct need for a Colombia-specific study about these topics: one of the only Colombia-specific studies I was able to find about breastfeeding dated back to 1981.[113]

There are currently various studies about obesity that use DHS data from other countries, but few of these have focused on Latin America. In addition, none of the studies using data from Colombia have looked at obesity and its potential causes, and do not discuss breastfeeding. This data set provides extensive information about household living conditions, maternal and child health, and reproduction in addition to basic demographic variables.

DHS is cross-sectional data, not longitudinal, so there is no information following specific individuals across time as each respondent was only surveyed once. However, the data still contains thorough retrospective reports of breastfeeding for the children of the mothers who were interviewed. I have chosen to use the "Children's Recode" subset of the data, which contains all of my variables of interest as a result of interviews with mothers about their children. The unit of observation here is one child.

I will be working with the 2010 data set, which surveyed 51,447 households, with a total population of 197,491 people. My group of interest will be the children who were born within the five years prior to the survey. Among the surveyed households, there were 17,756 children born in the last five years. However, I had to eliminate some observations due to

[113] Restrepo, S. "A Multi-media Strategy for a Breastfeeding Campaign in Colombia."

numerous reasons, which will be discussed in detail later. Table 1 shows the sample sizes for each of the regressions that appear in this paper.

The first group of regressions examines the effect of breastfeeding initiation on child weight outcomes for children up to age 5, and will be dubbed the "Initiation Regression Group". The second group looks at the effect of breastfeeding duration as measured in months on child weight for the same age group–this group will be referred to as the Duration Regression Group. Table 2 provides summary statistics for the samples used for both these regression groups, Sample A, which is made up of all the children for whom there is complete data for all relevant variables and covariates for the regressions. This came to a total of 14,656 observations. Sample A was limited only to children who were breastfed at some point, since that was key to answering the research questions posed. Sample B was used for Regressions 5-6, 13-14, and 17, known as the Siblings Fixed-Effects Regressions and is made up of siblings where at least one child was breastfed for at least six months and the other was not. There were a total of 1,257 observations in Sample B.

The six-month cutoff for breastfeeding comes from the WHO recommendations for infant feeding. Utilizing data from sibling pairs will provide useful information since the nature of the sample already controls for confounding variables which are identical for both siblings, like family size, wealth, education, etc. The results from this Siblings Fixed Effects Regression will be very reliable, since it controls for all confounding factors that siblings share that are explicitly corrected for in my other regressions.

Arriving at Sample A required dropping many observations from the initial 17,756 children for several reasons. Since this study is concerned with breastfeeding and weight outcomes of children who are still alive, 313 observations were dropped because the child

had died. Next, children whose weight and height information were missing or inconsistent also had to be dropped (N = 884). Also, children for whom there was incomplete information regarding breastfeeding initiation and duration were also dropped (n=454, n=49 respectively). Children who had never been breastfed or were breastfed for less than one month were also dropped (N = 376). An finally, an additional 1,618 observations were also dropped due to incomplete or missing information for other covariates, leaving a total of 14,656 observations for the final Sample A.

Sample B required a slightly different process for dropping. Like Sample A, children who had died were eliminated (N = 313). The same observations were also eliminated for missing breastfeeding initiation and duration information (N = 454, N = 49). The children who were never breastfed or breastfed for only a short time were kept for this sample in order to better compare the effect that different breastfeeding behaviors had on child overweight. An additional 15,683 were dropped because they failed to meet the following criteria: (1) have at least 2 children living in the household, (2) have at least one child who was breast-fed for six months, (3) also have one child who *not* breast-fed for six months, (4) have complete information for all other key variables. The final sample contains 1,257 observations, which is much smaller than the initial starting group but should be able to provide some useful results nonetheless, particularly since so many confounding factors are automatically controlled for due to the process by which the sample was selected.

IV. Measures

There are 4 major categories for the variables included in this paper: (1) weight outcome variables, (2) breastfeeding variables, (3) sociodemographic variables, and (4) family and health variables. Weight outcome variables include binary dependent variables that mark for overweight and obesity among the children. I adopted the CDC's metric for classifying child overweight and obesity: a weight-for-height percentile at or above the 95th percentile is considered obese, while a measure between the 85th and 95th percentile is deemed overweight.[114] I created a binary variable called "*obese*" that marked whether or not a child was obese at the time of the survey. I also created a binary variable named "*heavy*" that included both overweight and obese to account for potentially more subtle effects between the variables.

Breastfeeding initiation includes a marker indicating whether or not breastfeeding was begun immediately after birth. The duration variable includes a binary variable marking whether or not the baby was breastfed for at least six months. Once again, these cutoffs were taken from the WHO. The remaining variables are control variables that were included because they have been associated with both breastfeeding and child overweight: sociodemographic variable include the child's gender and age, ethnicity, the family's wealth level, the degree of urbanization of the child's place of residence, the mother's type of job, and maternal education measured in single years. Health and family variables include the child's birth weight, the mother's age at birth, whether the child was a single or multiple birth, and maternal BMI. These will all be discussed in the section to follow.

[114] "Obesity and Overweight for Professionals: Data and Statistics: U.S. Obesity Trends | DNPAO | CDC." *CDC: Centers for Disease Control and Prevention*, n.d. http://www.cdc.gov/obesity/data/trends.html.

First, basic demographic information like age, gender, and ethnicity were included. Mothers of different ethnic groups have exhibited varying breastfeeding initiation and duration tendencies, as discussed in the literature review.[115] In addition, black and Hispanic individuals have usually are usually more susceptible to obesity than Caucasian populations.[116] However, most studies that have considered ethnicity have done so in the U.S., and usually compare immigrant versus native-born mothers or white mothers versus mothers from different minority[117] groups–therefore, it will be useful to conduct analysis about the effect of ethnicity on weight and breastfeeding outcomes in other countries. I categorized ethnic groups in this paper with reference to the category of "Native Colombian." The other categories included are a group encompassing all individuals who are black, mulatto, or of African descent; and a final category that includes all other ethnicities.[118]

One variable that might appear to be missing from this analysis is household income, which is something that frequently correlates with overweight and/or breastfeeding. In the place of household income, DHS constructs a variable called the Wealth Index, which I included in my regressions. That socioeconomic status is correlated with health outcomes is a familiar conclusion. However, it is difficult to directly measure economic status, so most studies have been forced to use proxies in attempts to infer socioeconomic status from other variables like education level, family assets, or household construction materials (i.e. type of

[115] Hurley, K.M., M.M. Black, M.A. Papas, and A.M. Quigg. "Variation in Breastfeeding Behaviours, Perceptions, and Experiences by Race/ethnicity Among a Low-income Statewide Sample of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Participants in the United States."
[116] Shai, Iris, Rui Jiang, JoAnn E Manson, Meir J Stampfer, Walter C Willett, Graham A Colditz, and Frank B Hu. "Ethnicity, Obesity, and Risk of Type 2 Diabetes in Women A 20-Year Follow-up Study." *Diabetes Care* 29, no. 7 (July 1, 2006): 1585–1590.
[117] The term "minority" is used here to refer to populations that are minorities in the U.S.
[118] Other possible ethnic categories from the data included "gypsy," "Raizal from Archipelago," and "Palanquero from San Basilio." However, since there were very few children in either of those three groups, (<1% in each), I reclassified them as "Other". The individual breakdowns of the original ethnic distribution are still displayed in Tables 2-4.

flooring). Even household income can be a problematic variable because many people do not know their incomes, or will try to hide their true income amounts from interviewers for various reasons. Income sources can also become complicated, making it difficult to accurately report household income. Thus, DHS developed a wealth index that takes into account household assets (like water supply, radio, television, telephone, electricity, etc) and uses those as a proxy to create a distribution of wealth for the surveyed population. Respondents are then sorted into quintiles.[119] This is in line with recommendations from researchers like Popkin et al (1983), who list household assets as one of the key variables that must be accounted for when attempting to measure the effect of economic status on breastfeeding.[120]

Other environmental factors like area of residence also influence a child's weight and breastfeeding status. As has been mentioned earlier, children from urban areas are more likely to be obese and also less likely to be breastfed.[121] This data set exhibits the same distinction between urban and rural children, with a higher percentage of obese children living in urban areas.

Various measures about the child's mother were also included in the regressions, like maternal education. Most existing research in developed countries has found that mothers with more education tend to have children who are less likely to be obese, but developing countries are a different story: research by Martorell et al (1998) found children of mothers

[119] Rutstein, Shea Oscar, and Kiersten Johnston. *The DHS Wealth Index*. DHS Comparative Reports. e U.S. Agency for International Development, August 2004. http://www.childinfo.org/files/DHS_Wealth_Index_(DHS_Comparative_Reports).pdf.
[120] Popkin, B.M., R.E. Bilsborrow, J.S. Akin, and M.E. Yamamoto. "Part 1: Breast-feeding Determinants in Low-income Countries."
[121] Huffman, S.L. "Determinants of Breastfeeding in Developing Countries: Overview and Policy Implications."

with more years of education tended to be *more* susceptible to overweight.[122] Interestingly, some countries saw higher education contribute to lower incidences of obesity among the mothers themselves.

Maternal employment is another covariate of interest, for mothers who work longer hours each week are more likely to have overweight children, as was discussed in the literature review.[123] Breastfeeding outcomes are also influenced by the kind of work the mother does, since working mothers often have a harder time finding the time to breastfeed for a full six months, and those who are given more time off are more successful at breastfeeding for the entire recommended six months.[124] While DHS did not provide information about the number of hours the mother was working per week, there was data about the type of job she held. The mothers' responses were sorted into categories: (1) those who were not working; (2) mothers working in sales; (3) agricultural self-employed workers; (4) those employed in the services industry; and (5) the reference category for this paper: women working in professional, technical, clerical, or managerial positions, as well as skilled and unskilled manual labor.[125]

Various health and family variables also influence child overweight and whether or not they are breastfed, as well as how long they are breastfed. First, in a study about weight outcomes, it is important to consider the child's birth weight–specifically, whether or not s/he was born at a low birth weight. The WHO defines "low birth weight" as being born with a

[122] Martorell, R., L.K. Khan, M.L. Hughes, and L.M. Grummer-Strawn. "Obesity in Latin American Women and Children." *The Journal of Nutrition* 128, no. 9 (1998): 1464.
[123] Hawkins, S S, T J Cole, and C. Law. "Maternal Employment and Early Childhood Overweight: Findings from the UK Millennium Cohort Study." *International Journal of Obesity* 32, no. 1 (July 17, 2007): 30–38.
[124]Baker, Michael, and Kevin Milligan. "Maternal Employment, Breastfeeding, and Health: Evidence from Maternity Leave Mandates." *Journal of Health Economics* 27, no. 4 (July 2008): 871–887.
[125] These categories were coded for in the data set. I reclassified them by combining the profession/technical/ managerial category with the clerical and skilled/unskilled manual labor groups in order to reduce collinearity from subgroups that were too small.

weight of 2500 grams or lighter.[126] As has been mentioned, higher birth weight is correlated with a higher risk of obesity in adolescence and adulthood.[127] Birth weight is also important to consider in the context of breastfeeding because parents have exhibited a tendency to "invest" less in the health of children born with lower birth weight, and breastfeeding is a prime example of a potential health investment. [128] Since a significant portion of the mothers were unable to recall their child's weight at birth, I also created a dummy variable to indicate whether this information was missing to correct for any potential confounding effects, since infants born with higher birth weight could be more easily obese later in life.

The mother's age at birth is another variable included in the regressions because mother's age at birth was significantly associated with breastfeeding duration along with intended duration and maternal education in one study of breastfeeding duration.[129] Various other studies have found an earlier mother's age at menarche to be a significant predictor of weight gain during infancy and child weight, but as this was not available in the data set I only mother's age at birth.[130] Since the number of children in the household has also been significantly associated with a decreased risk of obesity, family size is also important.[131] It is worth noting, however, this research was all conducted using data from developed countries

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[126] "Indicator Definitions and Metadata: Low Birthweight Newborns (percentage)." *WHO Statistical Information System (WHOSIS)*, 2012. http://www.who.int/whosis/indicators/compendium/2008/2bwn/en/index.html.

[127] Singhal, Atul, Jonathan Wells, Tim J Cole, Mary Fewtrell, and Alan Lucas. "Programming of Lean Body Mass: A Link Between Birth Weight, Obesity, and Cardiovascular Disease?" *The American Journal of Clinical Nutrition* 77, no. 3 (March 1, 2003): 726–730.

[128] Datar, A., M.R. Kilburn, and D.S. Loughran. "Health Endowments and Parental Investments in Infancy and Early Childhood." *RAND Labor and Population Working Paper Series, WR-367. RAND Corporation, Santa Monica, CA* (2006).

[129] Quarles, Audrey, Phoebe D. Williams, Deborah A. Hoyle, Michele Brimeyer, and et al. "Mothers' Intention, Age, Education and the Duration and Management of Breastfeeding." *Maternal-Child Nursing Journal* 22, no. 3 (1994): 102–108.

[130] Ong, Ken K, Kate Northstone, Jonathan CK Wells, Carol Rubin, Andy R Ness, Jean Golding, and David B Dunger. "Earlier Mother's Age at Menarche Predicts Rapid Infancy Growth and Childhood Obesity." *PLoS Med* 4, no. 4 (April 24, 2007): e132.

[131] Ravelli, G. P, and Lillian Belmont. "Obesity in Nineteen-Year-Old Men: Family Size and Birth Order Associations." *American Journal of Epidemiology* 109, no. 1 (January 1, 1979): 66–70.

and it will be informative to see if these same associations hold for this sample.

Another important control variable is maternal weight and BMI. As has been mentioned, obesity is intergenerational on both a genetic as well as a behavioral level, and there exist numerous examples in the literature of instances where parental and child weight were related.[132,133] Maternal obesity also has a relationship with breastfeeding duration and initiation, something that has been the subject of many studies. Amir and Donath (2007) conducted a review of the evidence about the relationship between maternal obesity and breastfeeding initiation, intention, and duration. Three of the four studies about the onset of lactation found a significant relationship between obesity and delayed lactation. [134] The majority of studies about the relationship between maternal obesity and breastfeeding duration found that obese women tend to breastfeed for a shorter duration than normal-weight women, even after considering confounding factors. I will focus on maternal BMI instead of raw weight measures, to have a consistent way of comparing weight across different families, and to also take into consideration differences in height.

[132] Classen, T.J. "Measures of the Intergenerational Transmission of Body Mass Index Between Mothers and Their Children in the United States, 1981-2004." *Economics & Human Biology* 8, no. 1 (2010): 30–43.
[133] Gibson, LY, SM Byrne, EA Davis, E Blair, P Jacoby, and SR Zubrick. "The Role of Family and Maternal Factors in Childhood Obesity." *Med J Aust* 186, no. 11 (2007): 591–5.
[134] Amir, Lisa H, and Susan Donath. "A Systematic Review of Maternal Obesity and Breastfeeding Intention, Initiation and Duration." *BMC Pregnancy and Childbirth* 7, no. 1 (July 4, 2007): 9.

V. Analysis

First, I will provide some descriptive analysis of my data with summary statistics organized to compare obese with non-obese children, and then overweight with non-overweight children. After that, I will discuss the multivariate analysis I used to further examine the relationship between breastfeeding initiation and duration on child weight.

Table 1 contains summary statistics about the key variables in this paper for both samples. In Sample A, 6.04% of the children are obese. Sample B has an even lower prevalence of obesity at 5.25%, which could be attributable to the much smaller sample size. I also included the incidence of overweight as a reference, and in both populations the percentage of children who were overweight was more than double that of obesity, which is consistent with country-wide trends. In terms of breastfeeding, 79.24% of the children included in Sample A were breastfed for at least six months. Only 49.16% of Sample B, in contrast, met that cutoff. However, this is consistent with the way the sample was constructed, since at least one sibling was required to have been breastfed for six months or more while another sibling was breastfed for fewer than six months.

TABLE 1: SUMMARY STATISTICS FOR KEY VARIABLES OF SAMPLE A & B

	Observations	**Obese (N, Percentage)**	**Overweight (N, Percentage)**	**Breastfed for 6 Months (N, Percentage)**
Sample A	14,656	885, 6.04%	2,100, 14.33%	11,613, 79.24%
Sample B	1,257	66, 5.25%	210, 16.71%	618, 49.16 %

Summary Statistics

Table 2 displays summary statistics for the binary variables relevant to Sample A. First, 79.99% of non-obese children were breastfed for at least six months, while only 67.46% of obese children where breastfed for that amount of time. This suggests there may

be merit to the hypothesis that breastfeeding is associated with a lower incidence of overweight and obesity, but more rigorous analysis will be necessary to truly determine that. With regards to breastfeeding initiation, only 66.44% of obese children were breastfed immediately after birth compared to 69.25% of non-obese children.

The obese children were proportionately more female: 53.54% of the group was female. Among non-obese children, the majority was male (51.49%). There was little difference between the obese and non-obese groups in terms of single or multiple birth status: 98.87% of obese children were singletons compared to 98.61% of non-obese children. Low birth weight was a more differentiating factor: only 3.95% of obese children were born with low birth weight, while 5.32% of non-obese children fell in that category.

Obese and non-obese children also displayed differences in sociodemographic variables, such as the degree of urbanization in their homes. While 66.89% of obese children residing in urban areas, only 61.91% of non-obese children did. This is consistent with past research that has found a higher incidence of obesity in cities, due to reasons mentioned in the literature review.

The wealth index measures were also quite different between obese and non-obese children. Non-obese children display a consistent diminishing distribution among the various wealth classes, with the largest proportion of children in the poorest wealth group (38.67%) and smaller percentages up through the richest group, which contains 16.81% of the non-obese children. The obese children, on the other hand, are almost evenly distributed between the bottom two quintiles with 28.93% and 29.04% of obese children, respectively. Only 17.85% were of the middle group, while 24.18% were in the topmost group.

Though DHS did not contain information about maternal working hours, the surveys

did categorize the mothers' type of work. Of those children whose mothers were not working at the time of the survey, there was little difference between the two groups–15.03% of obese children and 15.60% of non-obese children had mothers who were not working. Every other group, however, had more of a dichotomy: 6.44% of obese children had mothers who were in professional, technical, or management positions compared to 4.87% of non-obese children; 8.02% of the mothers of obese children were in clerical work, while only 5.79% of non-obese children's mothers were; a whopping 25.65% of mothers of obese children were in sales, compared to only 21.64% of non-obese children. The last job three categories were more common among mothers of non-obese children than obese children: only 5.76% of obese children's mothers held jobs as self-employed agricultural workers compared to 8.82% of non-obese children; similarly, only 35.25% of the mothers of the obese group were in services compared to 39.18% of the non-obese group; finally, 3.84% of mothers with obese children worked as skilled and unskilled manual laborers while 4.12% of mothers with non-obese children did.

Table 3 displays summary statistics for the key continuous variables of this paper for Sample A.[135] It is clear that those children who were obese at the time of the survey had been breastfed for fewer months on average compared to the non-obese children: the mean breastfeeding duration for the obese group was 10.51 months, while the non-obese group had an average 13.32 months of breastfeeding. The only continuous sociodemographic variable included in Sample B was maternal education. There were also differences between the number of years of education the mother had received: 9.14 years for mothers of obese children, while mothers of non-obese children had only 7.98 years.

[135] I included breastfeeding duration in months in this table even though I did not include this measure as a covariate in the regressions in order to give an idea of overall breastfeeding practices beyond the six-month cutoff.

The rest of the table contains health and family variables that are important covariates of both breastfeeding and obesity, like maternal weight and BMI. Obese children had mothers with both higher weight and BMI compared to non-obese children, which further supports the concept that obesity is intergenerational. The average weight of mothers with obese children was 64.53 kilograms compared to only 60.40 kilograms for the mothers of non-obese children. This difference was also preserved when evaluating maternal BMI, which provides a way to compare weight across individuals of different heights. While the average BMI of both the obese child group and the not-obese group were in the overweight range at 26.53 and 25.10, respectively, the average BMI was still higher among the mothers of the obese children.

A few of the health and family variables were more similar between the obese and not obese groups: the average family size, measured in number of people in the household, was 5.45 among obese children and 5.67 among non-obese. In other words, obese children had slightly smaller families, on average. Also, the mother's age at birth was 25.72 years for obese children, slightly higher than the average age of 25.53 years for non-obese.

Tables 4 and 5 also contain summary statistics for the binary and continuous variables of Sample A, this time distinguishing between overweight and non-overweight children. The overall differences between the two groups were all very similar to that of the obese versus the non-obese groups, though most of the differences were of smaller magnitudes, which makes sense considering the definition of overweight is broader than that of obesity.

TABLE 2: SUMMARY STATISTICS OF BINARY BREASTFEEDING AND SOCIODEMOGRAPHIC VARIABLES IN SAMPLE A FOR (1) CHILDREN WHO WERE OBESE (885 OBSERVATIONS) AND (2) CHILDREN WHO WERE NOT OBESE (13,771 OBSERVATIONS)

	Prevalence Among Obese Children N, Percentage	**Prevalence Among Non-Obese Children N, Percentage**
By Breastfeeding Status		
breastfed at least 6 months	597, 67.46%	11,016, 79.99%
By Breastfeeding Initiation Time		
Breastfeeding was begun immediately after birth	588, 66.44%	9,537, 69.25%
By Child's Gender		
male	420, 47.46%	7,090, 51.49%
female	465, 52.54%	6,68, 148.51%
By Type of Birth		
single birth	875, 98.87%	13,579, 98.61%
By Birth Weight Classification		
low birth weight (<2500 grams)	35, 3.95%	732, 5.32%
By Degree of Urbanization		
urban	592, 66.89%	8,526, 61.91%
rural	293, 33.11%	5,245, 38.09%
By Wealth Index (quintiles)		
poorest	256, 28.93%	5,325, 38.67%
poorer	257, 29.04%	3,619, 26.28%
middle	158, 17.85%	2,512, 18.24%
richer & richest	214, 24.18%	2,315, 16.81%
By Mother's Occupation Type		
not working	133, 15.03%	2,148, 15.60%
prof., tech., manag.	57, 6.44%	670, 4.87%
clerical	71, 8.02%	797, 5.79%
sales	227, 25.65%	2,980, 21.64%
agric-self employed	51, 5.76%	1,214, 8.82%
services	312, 35.25%	5,395, 39.18%
skilled & unskilled manual	34, 3.84%	567, 4.12%

TABLE 3: SUMMARY STATISTICS OF CONTINUOUS BREASTFEEDING AND SOCIODEMOGRAPHIC VARIABLES FOR (1) CHILDREN WHO WERE OBESE (885 OBSERVATIONS) AND (2) CHILDREN WHO WERE NOT OBESE 13,771 OBSERVATIONS)

	Children who were Obese		**Children who were Not Obese**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Breastfeeding Duration (in months)	10.51	8.40	13.32	9.08
Mother's Weight (in kilograms)	64.63	13.65	60.40	12.12
Mother's BMI	26.53	5.07	25.10	4.98
Mother's Education (in years)	9.14	3.77	7.98	4.03
Family Size (in number of people)	5.45	2.37	5.67	2.43
Mother's Age at Birth (in years)	25.72	6.56	25.53	6.70

TABLE 4: SUMMARY STATISTICS OF BINARY BREASTFEEDING AND SOCIODEMOGRAPHIC VARIABLES IN SAMPLE A FOR (1) CHILDREN WHO WERE OVERWEIGHT (2,100 OBSERVATIONS) AND (2) CHILDREN WHO WERE NOT OVERWEIGHT (12,556 OBSERVATIONS)

	Prevalence Among Overweight Children N, Percentage	**Prevalence Among Non-Overweight Children N, Percentage**
By Breastfeeding Status		
breastfed at least 6 months	1,435, 68.33%	10,178, 81.06%
By Breastfeeding Initiation Time		
Breastfeeding was begun immediately after birth	1,405, 66.90%	8,720, 69.45%
By Child's Gender		
male	1,004, 47.81%	6,506, 51.82%
female	1,096, 52.19%	6,050, 48.18%
By Type of Birth		
single birth	2,081, 99.10%	12,373, 98.54%
By Birth Weight Classification		
low birth weight (<2500 grams)	82, 3.90%	685, 5.46%
By Degree of Urbanization		
urban	1,353, 64.43%	7,765, 61.84%
rural	747, 35.57%	4,791, 38.16%
By Wealth Index (quintiles)		
poorest	711, 33.86%	4,870, 38.79%
poorer	575, 27.38%	3,301, 26.29%
middle	379, 18.05%	2,291, 18.25%
richer & richest	435, 20.71%	2,094, 16.68%
By Mother's Occupation Type		
not working	317, 15.10%	1,964, 15.64 %
prof., tech., manag.	132, 6.29%	595, 4.74%
clerical	149, 7.10%	719, 5.73%
sales	487, 23.19%	2,720, 21.66%
agric-self employed	174, 8.29%	1,091, 8.69%
services	760, 36.19%	4,947, 39.40%
skilled & unskilledmanual	81, 3.86%	520, 4.14%

TABLE 5: SUMMARY STATISTICS OF CONTINUOUS BREASTFEEDING AND SOCIODEMOGRAPHIC VARIABLES FOR (1) CHILDREN WHO WERE OVERWEIGHT (2,100 OBSERVATIONS) AND (2) CHILDREN WHO WERE NOT OVERWEIGHT (12,556 OBSERVATIONS)

	Children who were Overweight		**Children who were Not Overweight**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Breastfeeding Duration (in months)	11.17	8.89	13.48	9.05
Mother's Weight (in kilograms)	63.92	13.01	60.11	12.04
Mother's BMI	26.36	4.89	24.99	4.98
Mother's Education (in years)	8.74	3.91	7.94	4.03
Family Size (in number of people)	5.55	2.43	5.68	2.43
Mother's Age at Birth (in years)	25.66	6.72	25.52	6.68

Tables 6 and 7 display summary statistics of the binary and continuous variables from the Siblings Fixed-Effects Regressions, run with Sample B. First, a much smaller proportion of the obese children had been breastfed for the recommended six months - only 27.27%. Among the non-obese children, 50.38% had been breastfed for at least six months. Initiation was actually split in the other direction, with a great proportion of children in the obese group meeting the immediate initiation recommendation: 72.73% of the children had been breastfed immediately after birth, while only 69.44% of the non-obese were. The sample is fairly evenly divided between male and female for both obese and non-obese groups; the obese group has a slightly larger majority of male children. Only a very low percentage of either group was born with a low birth weight, though a slightly higher percentage of non-obese children qualified as low birth weight (4.95% as opposed to the 3.03% of the obese group).

Table 7 contains descriptive statistics for the continuous variables in Sample B. There are not many listed, since many of the controls were all identical across each group of siblings. The mean breastfeeding duration among obese children was only 6.57 months, compared to 11.38 of the not-obese - almost a twofold difference. There was also a slight difference between the obese and not-obese children for the mother's age at birth: the mothers of the obese children were slightly older, with an average age of 26.68 years versus 24.57 for not-obese. Tables 8 and 9 contain summary statistics for Sample B, sorted by overweight and non-overweight children. The differences between the two groups were much the same as between the obese and non-obese groups, but generally of smaller magnitude.

TABLE 6: SUMMARY STATISTICS OF BINARY BREASTFEEDING AND SOCIODEMOGRAPHIC VARIABLES IN SAMPLE B FOR CHILDREN WHO WERE OBESE (N = 66) AND NOT OBESE (N = 1,191)

	Prevalence Among Obese Children N, Percentage	**Prevalence Among Non-Obese Children N, Percentage**
By Breastfeeding Status		
breastfed at least 6 months	18, 27.27%	600, 50.38%
By Breastfeeding Initiation Time		
Breastfeeding was begun immediately after birth	48, 72.73%	827, 69.44%
By Child's Gender		
male	37, 56.06%	604, 50.71%
female	29, 43.94%	587, 49.29%
By Type of Birth		
single birth	66, 100%	1,174, 98.57%
By Birth Weight Classification		
low birth weight (<2500 grams)	2, 3.03%	59, 4.95%

TABLE 7: SUMMARY STATISTICS OF CONTINUOUS BREASTFEEDING AND SOCIODEMOGRAPHIC VARIABLES IN SAMPLE B FOR CHILDREN WHO WERE OBESE (N = 66) AND NOT OBESE (N = 1,191)

	Children who were Obese		**Children who were Not Obese**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Breastfeeding Duration (in months)	6.27	6.57	11.38	17.21
Mother's Age at Birth (in years)	26.68	5.72	24.57	6.05

TABLE 8: SUMMARY STATISTICS OF BINARY BREASTFEEDING AND SOCIODEMOGRAPHIC VARIABLES IN SAMPLE B FOR CHILDREN WHO WERE OVERWEIGHT (N = 210) AND NOT OVERWEIGHT (N = 1,047)

	Prevalence Among Overweight Children N, Percentage	**Prevalence Among Non-Overweight Children N, Percentage**
By Breastfeeding Status		
breastfed at least 6 months	68, 32.38%	550, 52.53%
By Breastfeeding Initiation Time		
Breastfeeding was begun immediately after birth	143, 68.10%	732, 69.91%
By Child's Gender		
male	104, 49.52%	537, 51.29%
female	106, 50.48%	510, 48.71%
By Type of Birth		
single birth	209, 99.52%	1,031, 98.47%
By Birth Weight Classification		
low birth weight (<2500 grams)	9, 4.29%	52, 4.97%

TABLE 9: SUMMARY STATISTICS OF CONTINUOUS BREASTFEEDING AND SOCIODEMOGRAPHIC VARIABLES IN SAMPLE B FOR CHILDREN WHO WERE OVERWEIGHT (N = 210) AND NOT OVERWEIGHT (N = 1,047)

	Children who were Overweight		**Children who were Not Overweight**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Breastfeeding Duration (in months)	8.75	15.05	11.59	17.16
Mother's Age at Birth (in years)	25.64	5.58	24.49	6.12

Methodology

The methodology I employed for examining the effect of breastfeeding initiation and duration on weight outcomes for Colombian children was a series of regressions, one each for initiation and duration, respectively. For each set of regressions, there are probit regressions that assess the effect of breastfeeding and other variables on the likelihood the child was obese, another two probit regressions that look at the relationship of breastfeeding on the predicted probability of child overweight, OLS linear regressions with child weight-for-height percentile as a continuous dependent variable, and fixed-effects linear probability models looking at the influence of breastfeeding on the probability of child obesity. I always ran each regression once with just the breastfeeding and weight variables with the sociodemographic control variables, and then a second time, adding in the health and family controls.

Again, I used the CDC's definitions of obesity and overweight for this paper. A child with a weight-for-height percentile between the 85th and 95th percentiles was considered overweight, or "heavy," and a child at or above the 95th percentile was classified as obese. The reason I created a separate variable "heavy" was to include both overweight and obese in one category, since technically overweight does not include those children who are also

obese. For the rest of my paper, however, I will refer to the children who were "heavy" as overweight.

Since both *obese* and *heavy* are binary variables, I used probit regressions to assess the effect of breastfeeding on child weight outcomes. For the Initiation Regressions Group, I created a binary variable to indicate immediate breastfeeding initiation since that is the recommended time from the WHO. The initiation probit regression takes the form:

$$\Pr(\textit{obese} = 1 \mid I, X) = \Phi(\beta_0 + \beta_1 I + \beta_2 X + \varepsilon)$$

where I is a binary variable indicating whether breastfeeding was initiated immediately after birth or not, X includes various control variables discussed previously such as gender, maternal education and BMI, wealth index quintiles, etc., and Φ is the probit function.

For the Duration Regression Group, I used a binary variable that marked whether or not the child had been breast fed for at least six months, as per the WHO recommendation. Similar to the initiation probit, the duration probit regression looks like:

$$\Pr(\textit{obese} = 1 \mid D, X) = \Phi(\beta_0 + \beta_1 D + \beta_2 X + \varepsilon)$$

Where D is the binary variable that indicates breastfeeding duration and X contains the control variables.

Since existing studies have found the effects of breastfeeding on child obesity to be small though significant, I also used linear regressions in both regressions groups with child weight-for-height percentile as a continuous dependent variable, P. The other variables were the same, with the binary initiation variable I, the binary duration variable D, and the control variables contained within X:

$$P = \beta_0 + \beta_1 I + X + \varepsilon$$

$$P = \beta_0 + \beta_1 D + X + \varepsilon$$

I chose to use a linear regression in order to capture subtle differences in weight outcomes based on different breastfeeding behaviors, and to take advantage of my data, which offered me continuous variables for weight and weight-for-height percentiles. Restricting my model to one with a binary dependent variable (i.e. obese = 1) could result in a loss potential of information.

Endogeneity is a major source of concern when it comes to breastfeeding, but accounting for known covariates of breastfeeding should help to reduce the endogeneity of the results. For even more robust results, I also ran fixed-effects regressions on Sample B, where at least one child was breastfed for at least six months and the other was not. The Sibling Fixed-Effects Initiation Regression is a linear probability model of the form

$$\Pr(Y_{it} = 1 \mid I_{it}, X_{it}) = \beta_0 + \beta_1 I_{it} + \beta_2 X_{it} + \beta_3 N + u_i$$

Where Y was the binary variable *obese*, I was the initiation variable indicating instant initiation, X was a set of control variables, N was a variable that controlled for the siblings' household and mother using an identification code, and u was a constant. For the Siblings Fixed-Effects Duration Regression, I adopted a similar linear probability model:

$$\Pr(Y_{it} = 1 \mid D_{it}, X_{it}) = \beta_0 + \beta_1 D + \beta_2 N + u_i$$

where D was the 6-month breastfeeding duration binary variable and N was an identification variable. Since breastfeeding duration was consistently significant in contributing to a lesser chance of obesity and weight gain, I also included an OLS linear regression with child weight-for-height percentile as a continuous dependent variable using Sample B, again to take advantage of the availability of continuous weight data and to avoid a loss of information by just restricting my results to a binary indicator of obesity, especially since the sample is already so small. These results should be very robust, since the sample naturally

controls for so many potential confounding factors. This fixed-effects linear regression looks like:

$$P = \beta_0 + \beta_1 D + X + \varepsilon$$

As mentioned earlier, I include in my regressions several socioeconomic variables that have been correlated with obesity prevalence and breastfeeding in other research. The control variables included in this *X* are different from the ones of the other regressions. Since the observations in Sample B are siblings, there are many variables for which both siblings would have the same value–the variables eliminated from these fixed-effects regressions include wealth index measure, the degree of urbanization of the area where the child lives, the mother's occupation type, maternal education, maternal weight and BMI, and family size.

The control variables included in this paper fall under two categories: sociodemographic variables, and health and family variables. Again, the sociodemographic controls included the child's age and gender, ethnicity, wealth index measure, maternal education, whether the child lived in an urban or rural area, and the mother's type of employment. Health and family variables included whether or not the child was born with low birth weight, the size of the family, the mother's age at birth, and maternal BMI.

VI. RESULTS

Breastfeeding Initiation

To answer the first research question about the effects of breastfeeding initiation on child overweight and obesity, I ran 8 regressions. The results of these Initiation Regressions are reported in Tables 8 and 9. All of the results support my hypothesis that an earlier breastfeeding initiation time helps to protect against the risk of obesity, though these results were neither consistently significant nor of a great magnitude. Breastfeeding duration, which is discussed below, was a more decisive factor in determining weight outcomes. Regressions 1-4 and 7-8 were run using Sample A, while Regressions 5 and 6, the Siblings Fixed Effects Regression, were run on Sample B.

Regression 1 was a probit of breastfeeding initiation on the probability of obesity that only included the breastfeeding variables and sociodemographic controls. In Regression 2, health and family variables were also included. As visible in Table 5, the predicted probability of child obesity decreased by 0.48% and 0.42% in Regressions 1 and 2, respectively, if a mother breastfed her baby immediately after birth rather waiting until some later time. These results were not significant, however. This change in the magnitude of the marginal effect between Regression 1 to Regression 2 is likely due to the presence of omitted variable bias in Regression 1, which did not contain the health and family control variables. Indeed, some of these controls were significant in influencing the incidence of child obesity; this point is discussed below.

As mentioned before, this paper investigates the effects of breastfeeding on both child obesity and overweight. Thus, Regressions 3 and 4 were identical to Regressions 1 and 2, except with a binary dependent variable that indicated overweight rather than obesity. These

regressions may reveal some effects that the probit regressions of breastfeeding on obesity missed. As expected, breastfeeding initiation had a much larger impact on the probability of overweight compared to obesity - the marginal effect of commencing breastfeeding instantaneously was a 1.12% decrease in the child's probability of being overweight in Regression 3, which was almost triple the magnitude of the effect of immediate initiation on the likelihood of obesity in both Regressions 1 and 2. This initiation variable was also significant for overweight, but not obesity, which suggests immediate initiation has a very small protective effect that is enough to be significant for determining overweight but not obesity. In regression 4, immediate initiation was correlated with a 1.04% decrease in the likelihood of overweight, which is a smaller magnitude than the effect in Regression 3, and again likely indicative of omitted variable bias.

To account for this potential omitted variable bias, as well as the potential confounding effects of other covariates that were not explicitly controlled for in Regressions 1-4, I turned to the Siblings Fixed-Effects Models. Regressions 5 and 6 were linear probability models on obesity and overweight, respectively, using the siblings fixed-effects group, Sample B. With the fixed effects model, breastfeeding initiation had a very different effect on the probability of obesity: the marginal effect actually became positive, meaning immediate initiation was associated with a 0.44% *increase* in the probability of obesity. However, this is likely due to the small sample size, and it was not a significant result - the magnitude of this effect was also quite small. Once the dependent variable parameter was expanded to include overweight, the marginal effect was negative once again, and of a larger magnitude - immediate breastfeeding initiation led to a 1.89% reduction in the child's chance of overweight, which was a larger magnitude than any of the other initiation regressions.

I also ran linear regressions of breastfeeding initiation on child weight-for-height percentile outcomes (Regressions 7 and 8) in order to assess the more subtle effects of breastfeeding initiation child weight, Commencing breastfeeding instantaneously was significantly associated with a weight-for-height percentile 0.8 percentile points lower than that of a child who was breastfed sometime after in Regression 7, and 0.84 percentile points lower in Regression 8. It is interesting this change in magnitude was the opposite of what occurred in Regressions 1 and 2, which saw a reduction in the influence of instantaneous breastfeeding initiation when health and family covariates were included in the regression. However, the results from Regressions 1 and 2 regarding breastfeeding initiation were not significant, while the ones for Regressions 7 and 8 were. It is likely instantaneous initiation has a small protective effect against weight gain, but one that is not enough to translate into a protective effect against the predicted probability of obesity.

The results of all these regressions suggested that immediate breastfeeding initiation is indeed protective against later childhood weight gain, as per the WHO recommendation. Breastfeeding immediately after birth helped to reduce the risk of both obesity and overweight, though these results were only significant in contributing negatively to higher weight-for-height percentiles and the predicted probability of overweight.

As mentioned earlier, many of the covariates included in the regression were also significant in influencing weight outcomes. Being male had a negative effect on a child's likelihood of being obese or overweight compared to being female. This is consistent with findings of higher overweight and obesity prevalence among females.[136] Race was another sociodemographic factor that had a significant influence on weight outcomes: being black, or

[136] Braguinsky, J. "Obesity Prevalence in Latin America]." In *Anales Del Sistema Sanitario De Navarra*, 25:109, 2002.

of an Afro-Colombian descent had a negative effect on a child's probability of obesity or overweight as compared to being native Colombian. Children in the "Other" ethnicity category were also less likely to be obese or overweight compared to native Colombian children. This is an interesting result in light of the fact that African-American populations are usually more likely to be obese in the U.S. Being in a higher wealth quintile contributed to a significantly higher chance of being obese and overweight. This is consistent with findings by Martorell et al (1998), who observed a higher prevalence of overweight in children from households of higher socioeconomic status in Latin America.[137] Overweight was a slightly different story: wealth was only a significant contributor to the likelihood the child would be obese in Regression 4; once the health and family variables were included in Regression 5, wealth was no longer significant.

Urbanization was actually negatively associated with obesity, which was surprising considering a higher percentage of urban children were obese than rural ones, which is consistent with research that has found children from urban areas to be more susceptible to overweight and obesity.[138] However, this finding supports other research that has found increasing rates of breastfeeding overall in Latin America and the Caribbean, a result that was originally counterintuitive given the rapid urbanization occurring in the area but was ultimately attributed to the success of breastfeeding promotion campaigns and other educational programs.[139]

Maternal education was similarly associated with a significantly higher chance of obesity. Specifically, each extra year of education that the mother received was associated

[137] Martorell, R., L.K. Khan, M.L. Hughes, and L.M. Grummer-Strawn. "Obesity in Latin American Women and Children." *The Journal of Nutrition* 128, no. 9 (1998): 1464.
[138] Ibid.
[139] Pérez-Escamilla, Rafael. "Breastfeeding and the Nutritional Transition in the Latin American and Caribbean Region: a Success Story?" *Cad. Saúde Pública* 19, no. Sup 1 (2003): S119–S127.

with a 0.40% increase in the likelihood that the child was obese in Regression 4. Regressions 1-3 also displayed similar significant relationships between more years of education and an increased chance in weight gain. This is consistent with research of other developing countries, but not the U.S., demonstrating again the need for research in areas beyond the U.S. and other developed countries.

Maternal employment was never significant in contributing to the likelihood of obesity or overweight, but having a mother who was not working, or who worked in sales or services was positively correlated with being obese and overweight compared to the reference category of manual labor or a job in a professional, technical, or managerial capacity. Only those children whose mothers worked in the services industry had a reduced likelihood of obesity, though there was still a positive effect for overweight. All of these employment variables had very small magnitudes.

It makes sense that there seems to have been omitted variable bias in Regressions 1 and 3 since several of the health and family variables were also significant in determining whether or not the child was obese. Low birth weight was very significant for Regressions 2 and 4 in decreasing the chance of weight gain and obesity, which is consistent with findings that have found higher birth weight to be associated with an increased risk of obesity.[140] Similarly, family size was negatively associated with both the predicted probability of child obesity and height-for-weight percentile changes. This makes sense, since having more children in one family means there are more individuals vying for the same amount of resources within one household. Maternal BMI also had a consistently significant positive effect on the risk of obesity and overweight. This is supported by past research, which has

[140] Singhal, Atul, Jonathan Wells, Tim J Cole, Mary Fewtrell, and Alan Lucas. "Programming of Lean Body Mass: A Link Between Birth Weight, Obesity, and Cardiovascular Disease?" *The American Journal of Clinical Nutrition* 77, no. 3 (March 1, 2003): 726–730.

found strong associations between maternal obesity and child obesity: Baker et al (2004) found maternal obesity to be associated with shorter breastfeeding duration and higher instances of child overweight, a result that was due to the interaction between breastfeeding duration and the introduction of complementary foods.[141]

Regressions 5 and 6 are the Siblings Fixed Effects Regressions for breastfeeding initiation, which provide results that are much more robust against omitted variable bias and endogeneity due to the nature of the sample. In Regression 5, initiating breastfeeding immediately after birth was actually positively associated with the predicted probability of obesity, contributing a 0.60% increase in the chance of obesity. However, this was not significant, likely due to the small cell size. According to Regression 6, immediate initiation contributed to a 1.89% reduction in the child's likelihood of being overweight. The magnitude of this marginal effect was larger than the marginal effects from Regressions 3 and 4, which were also concerned with the chance of overweight. These results suggest that breastfeeding initiation is not significant in determining child obesity, and if it has any effect it will be one of very small magnitude. Overweight is a different story, however: immediate initiation has a larger negative effect on the child's predicted probability of being overweight, though this was never a significant result. The only significant covariate in either of the fixed-effects models for initiation was the mother's age at birth: in Regression 6, a 1% increase in the mother's age was associated with a 3.11% increase in the likelihood of overweight.

[141] Baker, J.L., K.F. Michaelsen, K.M. Rasmussen, and T.I.A. Sørensen. "Maternal Prepregnant Body Mass Index, Duration of Breastfeeding, and Timing of Complementary Food Introduction Are Associated with Infant Weight Gain." *The American Journal of Clinical Nutrition* 80, no. 6 (2004): 1579.

Breastfeeding Duration

The next series of regressions concern the second research question about the effects of breastfeeding duration on child weight outcomes. I ran 9 regressions total: Regressions 9 and 10 were probit regressions of six months of breastfeeding on the likelihood that the child was obese, while Regressions 11 and 12 were probit regressions with overweight as the binary dependent variable. For all these regressions, breastfeeding duration of six months or more was significantly associated with a reduced chance of being obese or overweight. Regressions 13 and 14 were fixed effects linear probability models, and the results for Regressions 9-14 can be found in Table 10. Regressions 15 and 16 were OLS regressions, and Regression 17 was a fixed effects linear regression–the results for these regressions are listed in Table 11.

In Regression 9, the effect of six months of breastfeeding was a 2.65% decrease in the chance of being obese; Regression 10 had a marginal effect of -2.49 percentage points. This reduction in the magnitude of the marginal effect was likely due to omitted variable bias, as in the earlier regressions. The effect of breastfeeding duration on the likelihood of overweight was almost triple the magnitude of its effect on obesity: Regression 12, the probit regression with all the relevant control variables, breastfeeding for at least six months was associated with a 7.21% decrease in the child's chance of being overweight, compared to a 2.49% decrease in the chance of obesity. The effect in Regression 11 was -7.37 percentage points.

Many of the same sociodemographic variables were significant in these regressions as in the initiation regression group. Factors that contributed to a significantly lower chance of obesity were: being male, living in an urban area, being born with low birth weight, and

having a larger family. Gender, low birth weight, and having a larger family were also significantly associated with a reduced chance of overweight. Native Colombian children were significantly more likely to be obese and overweight compared to the other ethnicity groups. Maternal education and household wealth were also associated with a significantly higher chance of being obese or gaining weight. One result that was unique to Regression 10 was the effect of mother's age at birth squared, which was significantly positively associated with the probability of weight gain. This was the only time this covariate was both significant and positive, but it had a very small magnitude of only 0.009 percentile points.

Health and family variables were also important. Maternal BMI was consistently significant, with heavier mothers more likely to have heavier children. Again, this can be indicative of a genetic component to obesity, or factors that affect the mother's decisionmaking patterns that extend to affect the weight of her child when she becomes the primary decision maker in matters of food intake.

Regressions 13 and 14 were the Siblings Fixed Effects Regressions for breastfeeding duration, which were run using Sample B. Regression 13 was a fixed effects Linear Probability model assessing the effect of breastfeeding for six months on the likelihood of obesity, while Regression 14 looked at the effect of breastfeeding duration on the risk of overweight. Unlike what happened with breastfeeding initiation, breastfeeding duration actually maintained its significant within the fixed-effects model. The marginal effect of breastfeeding for at least six months on the chance of being obese was -2.69 percentage points, which was actually larger than the magnitude of the effect in Regression 9. This is a noteworthy, since the sibling pairs sample provides very robust samples due to the many covariates that it controls for by nature of the sample's composition. In Regression 14, the

marginal effect of at least six months of breastfeeding was a 6.67% reduction in the chance of being overweight, which is slightly lower than the magnitudes from Regressions 11 and 12, but still a highly significant result. These results suggest that breastfeeding duration has a very significant protective effect against child obesity–much more significant than immediate initiation. Across all the regressions, breastfeeding for at least six months was significantly negatively associated with both the likelihood of being obese and with general child weight-for-height percentiles.

Regressions 15 and 16 were OLS regressions examining the effect of six months of breastfeeding on weight-for-height percentiles, run on Sample A. These results can be found in Table 11. Once again, breastfeeding duration was significantly associated with lower weight-for-height percentiles in both regressions. The marginal effect of breastfeeding a child for six months was a weight-for-height percentile 7.13 percentile points lower, according to Regression 16. To test this relationship in a more robust setting, I ran Regression 17, a fixed effects linear regression using Sample B. I added a linear regression using the sibling pairs sample for the Duration Regressions set because breastfeeding until at least the six month cutoff was so consistently significant, and I thought it would be useful to assess more subtle effects on weight-for-height percentiles directly. In this fixed effects model, breastfeeding for at least six months decreased the child's probability of being obese by 4.22 percentage points.

TABLE 10: PROBIT & LINEAR PROBABILITY MODEL REGRESSION OUTPUTS FOR BREASTFEEDING INITIATION

VARIABLES	(1) P(Obese)	(2) P(Obese)	(3) P(Heavy)	(4) P(Heavy)	Fixed Effects Model (5) P(Obese)	Fixed Effects Model (6) P(Heavy)
Breastfeeding initiation was instantaneous	-0.00482	-0.00418	-0.0112*	-0.0105*	0.00442	-0.0189
	(0.00412)	(0.00402)	(0.00630)	(0.00625)	(0.0137)	(0.0227)
Male (Binary)	-0.00888**	-0.00944***	-0.0203***	-0.0219***	0.00848	-0.0174
	(0.00376)	(0.00366)	(0.00574)	(0.00567)	(0.0126)	(0.0208)
Age of child (in months)	-0.00107***	-0.00103***	-0.00178***	-0.00180***	-0.00125***	-0.00335***
	(0.000109)	(0.000108)	(0.000167)	(0.000168)	(0.000342)	(0.000566)
Urban (binary)	-0.0105*	-0.0106**	-0.00955	-0.00965		
	(0.00555)	(0.00540)	(0.00811)	(0.00802)		
Wealth index (in quintiles)	0.00881***	0.00725***	0.00867**	0.00599		
	(0.00245)	(0.00241)	(0.00376)	(0.00377)		
Ethnicity:						
Black/Afro-Cuban Descent	-0.0145**	-0.0153**	-0.0250**	-0.0271***		
	(0.00633)	(0.00602)	(0.0103)	(0.01000)		
Other	-0.0154**	-0.0181***	-0.0231**	-0.0292***		
	(0.00627)	(0.00623)	(0.00906)	(0.00911)		
Maternal education (in years)	0.00308***	0.00193***	0.00559***	0.00404***		
	(0.000591)	(0.000632)	(0.000899)	(0.000979)		
Maternal Employment						
Not working	0.00150	0.00500	0.000565	0.00608		
	(0.00735)	(0.00762)	(0.0113)	(0.0116)		
Sales	0.00902	0.00830	0.00627	0.00402		
	(0.00655)	(0.00638)	(0.00981)	(0.00968)		
Agricultural Self-Employment	-0.0107	-0.00472	0.0142	0.0273*		
	(0.00852)	(0.00897)	(0.0148)	(0.0155)		
Services	0.000677	0.00120	-0.00133	-0.000750		
	(0.00604)	(0.00592)	(0.00936)	(0.00932)		
Low birth weight (binary)		-0.0185***		-0.0440***	-0.0126	-0.00904
		(0.00675)		(0.0110)	(0.0300)	(0.0497)
Missing birth weight (binary)		-0.00951**		-0.0215***	-0.0158	-0.0157
		(0.00450)		(0.00690)	(0.0138)	(0.0229)
Multiple Birth (binary)		-0.00495		-0.0363	-0.0594	-0.128
		(0.0159)		(0.0226)	(0.0553)	(0.0915)
Family size (number of children)		-0.00717***		-0.0113***		
		(0.00170)		(0.00250)		
Mother's age at birth		0.00145		-0.00342	0.0110	0.0311**
		(0.00211)		(0.00320)	(0.00769)	(0.0127)
Mother's age at birth, squared		-1.47e-05		7.79e-05	-0.000161	-0.000534**
		(3.75e-05)		(5.67e-05)	(0.000141)	(0.000234)

Mother's BMI		0.00296***		0.00697***		
		(0.000326)		(0.000536)		
Household identification number					-2.99e-06	-1.14e-06
					(2.67e-06)	(4.43e-06)
Mother's identification number					0.00229	-0.00370
					(0.00353)	(0.00585)
Constant					-0.0852	-0.127
					(0.106)	(0.176)
Observations	14,656	14,656	14,656	14,656	1,257	1,257
R-squared					0.024	0.042

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 11: LINEAR REGRESSION OUTPUTS FOR INITIATION

VARIABLES	(7) hw_P	(8) hw_P
Breastfeeding initiation was instantaneous	-0.799*	-2.108
	(0.485)	(1.666)
Male (Binary)	-0.985**	-1.900
	(0.446)	(1.525)
Age of child (in months)	-0.0994***	-0.289***
	(0.0133)	(0.0415)
Urban (binary)	-0.502	
	(0.618)	
Wealth index (in quintiles)	0.236	
	(0.295)	
Ethnicity: Black/Afro-Cuban Descent	-5.216***	
	(0.879)	
Ethnicity: Other	-4.710***	
	(0.673)	
Maternal education (in years)	0.718***	
	(0.0694)	
Maternal Employment		
Not working	-0.381	
	(0.883)	
Sales	0.514	
	(0.770)	
Agricultural Self-Employment	1.626	
	(1.090)	
Services	-0.428	
	(0.740)	
Low birth weight (binary)		-2.289
		(3.640)
Missing birth weight (binary)		-0.834
		(1.677)
Multiple Birth (binary)		-12.21*

		(6.705)
Family size (number of children)		0.128
		(0.933)
Mother's age at birth		-0.00404
		(0.0172)
Mother's age at birth, squared		-0.000548*
		(0.000324)
Mother's BMI		-0.861**
		(0.428)
Constant	53.55***	66.44***
	(1.247)	(12.87)
Observations	14,656	1,257
R-squared	0.018	0.046

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 12: PROBIT & LINEAR PROBABILITY MODEL REGRESSION OUTPUTS FOR DURATION

					Fixed Effects Model	Fixed Effects Model
VARIABLES	(9) P(Obese)	(10) P(Obese)	(11) P(Heavy)	(12) P(Heavy)	(13) P(Obese)	(14) P(Heavy)
Child was breastfed for at least six months	-0.0265***	-0.0249***	-0.0737***	-0.0721***	-0.0269*	-0.0667***
	(0.00529)	(0.00516)	(0.00813)	(0.00808)	(0.0139)	(0.0230)
Male (Binary)	-0.00879**	-0.00937**	-0.0201***	-0.0218***	0.00787	-0.0182
	(0.00374)	(0.00364)	(0.00572)	(0.00565)	(0.0125)	(0.0207)
Age of child (in months)	-0.000893***	-0.000863***	-0.00132***	-0.00134***	-0.000955**	-0.00259***
	(0.000113)	(0.000111)	(0.000172)	(0.000173)	(0.000375)	(0.000620)
Urban (binary)	-0.0109**	-0.0109**	-0.0104	-0.0104		
	(0.00553)	(0.00538)	(0.00809)	(0.00800)		
Wealth index (in quintiles)	0.00831***	0.00673***	0.00730*	0.00448		
	(0.00244)	(0.00240)	(0.00375)	(0.00376)		
Ethnicity: Black/Afro-Cuban Descent	-0.0143**	-0.0152**	-0.0247**	-0.0269***		
	(0.00631)	(0.00599)	(0.0102)	(0.00996)		
Ethnicity: Other	-0.0161**	-0.0187***	-0.0259***	-0.0319***		
	(0.00628)	(0.00624)	(0.00909)	(0.00914)		
Maternal education (in years)	0.00303***	0.00186***	0.00551***	0.00389***		
	(0.000588)	(0.000629)	(0.000895)	(0.000975)		
	0.00184	0.00546	0.00184	0.00769		
Maternal Employment						

Not working						
	(0.00735)	(0.00763)	(0.0113)	(0.0117)		
Sales	0.00990	0.00928	0.00881	0.00685		
	(0.00656)	(0.00640)	(0.00984)	(0.00973)		
Agricultural Self-Employment	-0.0103	-0.00422	0.0161	0.0295*		
	(0.00853)	(0.00900)	(0.0149)	(0.0156)		
Services	0.00134	0.00197	0.000689	0.00160		
	(0.00602)	(0.00591)	(0.00935)	(0.00932)		
Low birth weight (binary)		-0.0183***		-0.0433***	-0.0142	-0.00787
		(0.00671)		(0.0110)	(0.0299)	(0.0494)
Missing birth weight (binary)		-0.00929**		-0.0207***	-0.0158	-0.0164
		(0.00449)		(0.00688)	(0.0138)	(0.0228)
Multiple Birth (binary)		-0.00809		-0.0440**	-0.0689	-0.141
		(0.0151)		(0.0213)	(0.0551)	(0.0911)
Family size (number of children)		-0.00735***		-0.0120***		
		(0.00169)		(0.00249)		
Mother's age at birth		0.00138		-0.00367	0.0105	0.0305**
		(0.00210)		(0.00318)	(0.00768)	(0.0127)
Mother's age at birth, squared		-1.22e-05		8.64e-05	-0.000153	-0.000528**
		(3.73e-05)		(5.65e-05)	(0.000141)	(0.000233)
Mother's BMI		0.00288***		0.00678***		
		(0.000324)		(0.000534)		
Household identification number					-2.97e-06	-1.05e-06
					(2.67e-06)	(4.41e-06)
Mother's identification number					0.00233	-0.00356
					(0.00352)	(0.00583)
Constant					-0.0689	-0.117
					(0.105)	(0.174)
Observations	14,656	14,656	14,656	14,656	1,257	1,257
R-squared					0.027	0.048

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 13: LINEAR REGRESSION OUTPUT FOR DURATION

VARIABLE	(15) hw_P	(16) hw_P	(17) hw_P
Child was breastfed for at least 6 months	-7.309***	-7.133***	-6.810***
	(0.566)	(0.560)	(1.677)
Male (Binary)	-0.965**	-1.111**	-1.984
	(0.444)	(0.437)	(1.516)
Age of child (in months)	-0.0584***	-0.0644***	-0.211***
	(0.0136)	(0.0136)	(0.0453)
Urban (binary)	-0.565	-0.664	
	(0.614)	(0.606)	
Wealth index (in quintiles)	0.0973	-0.0865	
	(0.294)	(0.294)	
Ethnicity: Black/Afro-Cuban Descent	-5.225***	-5.480***	
	(0.873)	(0.861)	
Ethnicity: Other	-5.067***	-5.560***	
	(0.669)	(0.664)	
Maternal education (in years)	0.707***	0.594***	
	(0.0690)	(0.0753)	
Maternal Employment			
Not working	-0.227	0.118	
	(0.878)	(0.885)	
Sales	0.729	0.337	
	(0.766)	(0.759)	
Agricultural Self-Employment	1.881*	2.867***	
	(1.084)	(1.074)	
Services	-0.238	-0.250	
	(0.736)	(0.731)	
Low birth weight (binary)		-6.870***	-2.141
		(1.014)	(3.608)
Missing birth weight (binary)		-1.863***	-0.908
		(0.543)	(1.667)
Multiple Birth (binary)		-1.182	-13.45**
		(1.927)	(6.657)
Family size (number of children)		-0.902***	
		(0.184)	
Mother's age at birth		-0.474*	0.0727
		(0.246)	(0.927)
Mother's age at birth, squared		0.00873**	-0.00347
		(0.00438)	(0.0170)
Mother's BMI		0.829***	
		(0.0452)	
Household identification number			-0.000539*
			(0.000323)
respondent			-0.847**
			(0.426)
Constant	58.07***	48.24***	67.32***
	(1.247)	(3.569)	(12.70)
Observations	14,656	14,656	1,257
R-squared	0.029	0.057	0.058

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VII. DISCUSSION

Overall, these results suggest that the WHO recommendation for at least six months of breastfeeding is indeed protective against child obesity. Breastfeeding duration was associated with significantly negative effects on child weight-for-height percentiles as well as the likelihood of both obesity and overweight. Beginning breastfeeding immediately after birth was not significantly associated with either obesity or higher weight outcomes in general, but immediate initiation generally had a negative correlation with weight gain. These results suggest that the policymakers in Bogotá were indeed doing something that would help contribute to reducing the risk of overweight among children in the city, since breastfeeding does seem to impart positive effects on child weight outcomes. The rest of Colombia could consider implementing similar initiatives to encourage breastfeeding, since it is a relatively inexpensive action for the government that has beneficial consequences for the population at large.

Other developing countries that are combating child health problems, particularly regarding nutrition, could also consider policies targeting breastfeeding as a way to reduce obesity in children. By heading off early weight gain, there will hopefully be beneficial effects on adolescent and adult obesity as well. Of course, there are many other factors that collectively determine weight outcomes later in life, but breastfeeding is one concrete and simple solution that is easy to implement but carries major benefits.

While this paper provides encouraging results about the benefits of breastfeeding for preventing child overweight, there are many ways it could have been improved. First, I was able to measure breastfeeding duration, but it would have been helpful to have more detailed information regarding the exclusivity of the breastfeeding–i.e. whether or not the child was

also being fed other foods or liquids, and if so, how much. There was one question in the survey that asked about what the child had consumed in the past 24 hours, but it would have been helpful to have more comprehensive information than that. Since I wanted to look at longer-term effects of breastfeeding behaviors, I did not incorporate this variable into my analysis. Separating infant feeding patterns between breastfeeding and non-breastfeeding is also an oversimplification. It would be beneficial to conduct a more detailed study about the types of milk substitutes that infants and children are consuming, and to assess the impact of the range of options that are offered.

Another factor that would have been helpful to include would have been the role of bottle feeding, since this is something that has been the subject of research in the past, specifically as regards to child feeding behaviors. The only data contained in the survey about bottle feeding asked if the child had ever been fed with a bottle–again, this simple binary variable seemed to lack comprehensiveness for my purposes of establishing longer-term relationships, so I also left it out of my final analysis. Further research on the matter of breastfeeding and child weight gain should look more closely at specific feeding patterns to determine the role that bottle feeding plays in infant and child overweight. It would also be good to examine the interactions of bottle-feeding and exclusive breastfeeding with breastfeeding initiation and duration. The latter two were the ones that I had data for, but a more comprehensive analysis of all the aspects of infant feeding would be conducive to a more thorough understanding of the matter.

The way I went about assembling my sample could have also introduced bias into the results. While my initial sample was fairly representative of the population, I had to drop a substantial number of observations before arriving at my final sample. This may have swayed

the results by creating biases that I was unable to explicitly correct for in my regressions. This is especially true of the sibling pairs sample, which only included children with siblings. This helped to provide robust results, but it also means the data pertaining to single children were lost. Since I also dropped all observations that were missing data on my variables were interest, I lost more information. There may have also been omitted variable bias in my regressions, despite the use of the sibling pairs samples.

Despite these shortcomings, this paper contributes to the existing literature by providing a study of breastfeeding in a Latin American country where there was a protective effect against overweight and obesity, which contradicts earlier findings in Brazil. Only two countries is not enough, however - a similar type of analysis should be conducted on other countries as well in order to provide a solid base of information for potential health policy. It is possible other countries will display results like Brazil's, where breastfeeding imparts no protective effect against overweight. Alternatively, the results from this paper might be repeated elsewhere, with breastfeeding being a factor significantly associated with a lower risk of overweight.

Regardless of the findings from other countries, it is also not enough to stop at breastfeeding. Breastfeeding is clearly an important factor in child weight, but it is not the sole determinant of child overweight. More research needs to be done about dietary intake in childhood and adolescence. The relationship between child nutrition and later weight outcomes is one that deserves more thorough exploration through more years of childhood. Obtaining data to conduct such a study would be challenging, since there is only a small amount of consumption data in Latin America. However, those constructing future surveys or data sets would do well to include data about what children are eating.

Before implementing any major policy changes about breastfeeding, however, it would be good to conduct research about what influences a mother's decision to breastfeed. Studying past policies and their effectiveness would also be beneficial. Latin America is currently undergoing a period of economic development, with Brazil at the forefront of an economic boom. Increased globalization is likely to alter perceptions and behaviors, and breastfeeding could be seen as an old-fashioned behavior. More than that, increased urbanization usually brings more employment opportunities, which could also make it more difficult for mothers to breastfeed. These are all issues that governments who wish to encourage breastfeeding for its benefits to child health should consider.

VIII. CONCLUSION

Child obesity and overweight are major health concerns across the globe, but it remains a vastly understudied phenomenon in many developing countries. Latin America is one area in particular that merits more attention in the literature because overweight is quickly becoming a health issue there as well. Breastfeeding is an important factor in determining child health outcomes, and an added benefit of breastfeeding is a potential to protect against overweight. There are many potential policies that could help to prevent obesity through the promotion of breastfeeding, but before any policy changes take place it is important to determine the exact effect that breastfeeding has on weight gain.

While there are numerous studies that examine this phenomenon in developed countries, especially in Europe and the U.S., the body of research about the relationship between breastfeeding and overweight in developing countries remains dismally small. There is a need for more studies using data from developing countries, like those of Latin America, since covariates may interact differently with breastfeeding and obesity in a different context. Indeed, many of the control variables in my regressions behaved differently in this study from how they usually influence weight outcomes. Maternal education, for instance, is usually associated with lower rates of child obesity in the U.S., but in developing countries it is the more-educated mothers who are likely to have obese children.

In this paper, breastfeeding duration had a significant effect in reducing the risk of overweight and obesity, and also contributed to lower weight-for-height percentiles in children up to the age of five. Breastfeeding initiation was less significant, but still had a fairly consistent negative relationship with weight gain. This implies that policies designed to encourage breastfeeding could indeed have beneficial effects by reducing the likelihood of

overweight and obesity. It should be noted that the findings from this paper were only of correlation, and not causation. However, since the methodology included fixed-effects models that controlled for many potential confounders, the results obtained are very robust.

This paper contributes to the existing body of literature by providing a very up-to-date study of the interaction of breastfeeding and child overweight in Latin America using new data for a country where this issue has not been covered extensively. However, this study was also not without its limits–the construction of the samples could have led to biases in the results. Further research is necessary before drawing any comprehensive conclusions about the overall relationship between breastfeeding and obesity, but this is an encouraging start.

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