From the holdings of the Department of Special Collections , Princeton University Library, Princeton, NJ

These documents are either in the public domain, or can only be used for educational and research purposes (Fair use) as per U.S. Copyright law (text below). By accessing this file, all users agree that their use falls in the public domain or within fair use as defined by the copyrightlaw. We do not charge any permission or usage fees for the publication of images of material inour collections, including those provided by Princeton University Library, via our website, catalog, or directly from staff.For more information regarding copyright, credit, and citation please review the information onthe Copyright, Credit and Citation Guidelines page of our website.
https://library.princeton.edu/special-collections/policies/copyright-credit-and-citation-guidelines. If you have any questions, including how to order higher-quality images from the collection, contact Special Collections Public Services via our Ask Us! Form. https://library.princeton.edu/special-collections/ask-us

Doctoral Dissertations, 2011-2026 | Public and International Affairs

2015

Little women: Essays on maternal nutrition, social hierarchy, and health in India

Coffey, Diane

Princeton, NJ : Princeton University

http://arks.princeton.edu/ark:/88435/dsp01m613n089v

U.S. Copyright law: The copyright law of the United States (Title 17, §108, United States Code) governs the making of photocopies or other reproductions of copyrighted material. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be used for any purpose other than private study, scholarship, or research. If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of fair use that user may be liable for copyright infringement. This institution reserves the right to refuse to accept a copying order if, in its judgment, fulfillment of the order would involve a violation of copyright law. https://www.copyright.gov/title17/title17.pdf

Little women:

Essays on maternal nutrition, social hierarchy, and health in India

Diane Coffey

A Dissertation

Presented to the Faculty

of Princeton University

in Candidacy for the Degree

of Doctor of Philosophy

Recommended for Acceptance

by the Woodrow Wilson School

of Public & International Affairs

Adviser: Angus Deaton

June 2015

© Copyright by Diane Coffey, 2015.

All rights reserved.

Abstract

This thesis is a collection of four papers on maternal health in India, its causes, its implications for population health, and the inadequacy of government response.

The first chapter introduces the dissertation and its themes. The second chapter defines the scope of maternal malnutrition in India: it provides, to my knowledge, the first estimates of pre-pregnancy underweight and weight gain during pregnancy. By applying reweighting techniques, it finds that 42.2% of pre-pregnant women are underweight, and that they gain only about 7 kilograms during pregnancy. This paper further documents the surprising fact that maternal nutrition is better in sub-Saharan Africa than it is in India.

The third chapter is co-authored with Reetika Khera and Dean Spears, and examines an important cause of poor maternal nutrition in India: low intrahousehold status of young women. It documents how differences in social status between women in joint rural households lead to differences in nutrition during pregnancy. These differences in maternal nutrition are in part responsible for differences in the heights of their children: the children of lower-ranking mothers in joint rural households are about a quarter of a standard deviation shorter than their cousins born to higher-ranking mothers.

The fourth chapter suggests population level health consequences of poor maternal nutrition in India. It documents a correlation between cohort height, a measure of health and human capital, and neonatal mortality in the cohort's year of birth, a measure of maternal health. These findings contribute what are, to my knowledge, the first evidence from within a developing country of associations between neonatal mortality and height.

The final chapter is a qualitative study of India's Janani Suraksha Yojana (JSY), a conditional cash transfer for women who give birth in health facilities, rather than at home. This qualitative study from a rural district in Uttar Pradesh sheds light on why the program has not improved health outcomes, including neonatal mortality. The program is narrowly focused on delivery, rather than on promoting health in pregnancy. Health

service providers are focused on capturing economic rents associated with the program, rather than on providing maternity care.

Acknowledgements

I am grateful to the many, many people who have given me the opportunity to write about the women and children you will in encounter in these pages. It is a privilege to have received my training at WWS and OPR, and a daily challenge to live up to the responsibility that this training implies.

First, I thank my teachers at Princeton. I couldn't have asked for a better team of advisors than Angus Deaton, Jeff Hammer and Sara McLanahan. If on some days in Sitapur, I wonder what good my research can do, I remember how much Angus has taught the world. Few people I know of say and write more that is true and important than Angus does. If one day I may approximate this, it will be because he has encouraged me to do so: sometimes explicitly as he challenges me to ask big questions; and sometimes implicitly, as I read and re-read what he has written, finding ever more wisdom. In Jeff, I have found a mentor, cheerleader, and friend. He has taught me so much about how the world works, and is always willing to support me in big and small ways. His unwavering confidence in my projects has been invaluable – often, I found myself struggling to do better work so that it would become what he already expected it would be. Sara has helped me to become a better writer and communicator, and has been especially supportive of my work with primary data. She mentored me for a general exam about demographic data collection, and gave me both the guidance and the confidence to do qualitative research. I deeply admire her generosity and commitment to her students.

I am grateful to many others at Princeton as well. Tom Espenshade introduced me to the field of demography and provided frequent feedback and encouragement on my work. Germán Rodriguez taught me Stata's tools of data analysis. Anne Case taught me Development Economics–twice–and has been an invaluable mentor, providing guidance in matters both professional and personal. Sam Schulhofer-Wohl taught me my very first statistics course. Doug Massey encouraged my interest in primary data collection by supervising my general exam and allowing me to learn from the Mexican Migration Project.

Marta Tienda and Betsy Armstrong provided valuable guidance as OPR DGS. The staff at OPR and WWS have supported me in so many ways; they make coming to the office fun. Thanks especially to Lillian Anderson, Wayne Appleton, Elana Broch, Jenn Curatola, Mary Lou Delaney, Joann Donatiello, Val Fitzpatrick, Lynne Johnson, Ann Lengyel, Joyce Lopuh, Karen McGuinness, Lil Morgan, Robin Pispecky, Eleidis Sierra, and Denise Zapecza. Friends in the program gave me valuable feedback on my work, and, very often, a place to stay, especially Ed Berchick, Kristin Bietsch, Mariana Campos, Angelina Grigoriyeva, Patrick Ishizuka, Ayesha Mahmud, Zitsi Mirakur, Laura Nolan, Takudzwa Sayi, Jonathan Tannen, Sal Thorkelson, Megan Todd, and Amy Winter. I am grateful to my demography cohort Elizabeth Sully, Lauren Gaydosh, and Jake Rugh for pushing me to work hard and making our initiation as demographers fun. Thanks to the "senior" students, Sofya Aptekar, Laura Blue, Elizabeth Marshall, and Dennis Feehan, who taught me the ropes at OPR. I am grateful for generous financial support from WWS and OPR.

Friends in India have made much of this work possible. I thank the Delhi School of Economics, where I have been visiting researcher, and especially Abhijit Banerji, Ashwini Deshpande, and Surjeet Singh. Reetika Khera, with whom chapter 3 is co-authored, helped us get started in India, and has often opened her home to us. I have learned much from her experience and deeply admire her commitment to the rural poor. Jean Drèze has provided frequent mentorship, and has often helped us find our way. His practical optimism in the face of many challenges provides both encouragement and hope. In Sitapur, I am grateful for the friendship and hospitality of M.R., Raana, and Saman Sharma, and for all that I have learned with the help of Baby Parveen Qurreshi. Chapter 5 would not have been possible without her excellent research assistance. Anita, Sujata, and Varsha have made my life in Sitapur better, and as *dalit* women in rural India, display the kind of grace in the face of adversity that I can only hope to emulate. I am grateful to the families in Sitapur who have been teaching me about their lives since early 2012. The children, who are now three, were newborns, or in some cases not yet newborns, when I first met them. They

and their mothers gave me the idea for chapter 2, helped me believe our results in chapter 3, and provided much needed distraction from the monotony of revising chapter 4. Their birth stories are told in chapter 5. I remember the five babies from this group who died, and their families.

I am grateful to the r.i.c.e. team, who have provided frequent feedback and encouragement since 2013. Avinash Kishore helped to start r.i.c.e., and I am privileged to get to work with Aashish Gupta, Payal Hathi, Sangita Vyas, Nikhil Srivastav and Dean Spears on a daily basis. I am excited for the work we will do together in the future.

I am also grateful to those who taught and encouraged me even before I began the PhD. I am lucky to have such loving parents, Bob and Lynn Coffey. My mom and dad are my first, and most constant supporters, even if I have sometimes chosen paths that make life more difficult for them. My brothers, Jeff and Kevin Coffey, are never more than a phone call away. At Villanova, I am particularly grateful to Jane Morris, whose belief in my potential as a scholar and a public servant opened many doors that would have been closed without her intervention. Ann Joyce Peters, Mary Alice Minogue, and Kathleen King taught me about the challenges, and the rewards, of working among the poor. This dissertation would not exist without my husband, Dean Spears. Almost eight years ago, he taught me what a standard error is. Now, he is my best friend and co-author in nearly everything, including on chapter 3 of this dissertation. He thought a PhD would be the right thing for me to do. I am so grateful that he started me on this path, and stayed with me every step of the way.

Some additional acknowledgements, for each chapter, are in order. For chapter 2, I thank Hoyt Bleakley, Anne Case, Robert Chase, Janet Currie, Angus Deaton, Thomas Espenshade, Dennis Feehan, Aashish Gupta, Jeffrey Hammer, Payal Hathi, Sara McLanahan, Franco Peracchi, Sangita Vyas, Charles Westoff, data specialists at ICF international and especially Dean Spears for helpful comments and discussions. I also thank participants at the Centre for Development Economics seminar at Delhi University, where this research

was presented, for helpful comments. Kenneth Wachter served as the *PNAS* editor for the paper; he and the reviewers provided helpful feedback to improve it.

For chapter 3, I appreciate comments and suggestions from Janet Currie, Angus Deaton, Jean Drèze, Josephine Duh, Andrew Foster, Michael Geruso, Jeffrey Hammer, Sara McLanahan, and Tom Vogl and information about the NFHS from Fred Arnold. I thank participants at the Center for Health and Well-being seminar at Princeton, the Centre for Development Economics seminar at Delhi University, and the Economic Demography Workshop at the 2013 Population Association of America meeting for their comments.

For chapter 4, I thank Angus Deaton, Jean Drèze, Aashish Gupta, Jeffrey Hammer, Laura Nolan, Germán Rodriguez, Dean Spears, Elizabeth Sully, Sangita Vyas for comments, as well as Office of Population Research librarians Elana Broch and Joann Donatiello, and librarians at the Institute for Economic Growth and the Delhi School of Economics, in New Delhi, India for help assembling the data for this project. The editors, John Komlos and Lawrence Haddad, and the reviewers at *Economics & Human Biology* helped improve the paper.

For chapter 5, I thank Elizabeth Armstrong, Veena Das, Josephine Duh, Jeffrey Hammer, Reetika Khera, and especially Elizabeth Chiarello, Sara McLanahan and Dean Spears for comments. The editor, Vivian Lin, and the reviewers at *Social Science & Medicine* did much to improve the paper.

For the women in Sitapur who taught me patiently, and who wanted to know how all this would lead to a *naukri*. And especially for Rihana and Ruksana.

Contents

Abstract iii

Acknowledgements v

List of Tables xiv

List of Figures xvi

1 Introduction: India's maternal health crisis **1**

1.1 India's high neonatal mortality indicates poor maternal health 1

1.2 Maternal health in India is worse than previously thought 2

1.3 Causes of poor maternal health 3

1.4 Consequences of poor maternal health 5

1.5 Government policies are doing little to solve the problem 6

1.6 First steps for improving maternal health in India 7

2 Pre-pregnancy body mass and weight gain during pregnancy in India & sub-Saharan Africa **10**

2.1 Introduction 10

2.2 Summary statistics 13

2.3 What fraction of pre-pregnant women are underweight? 13

2.4 Do Indian women compensate for low pre-pregnancy body mass with weight gain during pregnancy? 16

2.5 Discussion 19
2.6 Materials & methods 20
2.6.1 Data 20
2.6.2 Design weights 21
2.6.3 Estimation of pre-pregnancy indicators 21
2.6.4 Estimation of weight gain during pregnancy 23

3 Intergenerational effects of women's status: Evidence from child height in joint Indian households 38

3.1 Introduction 38
3.2 Background 42
3.2.1 Women's status in joint Indian households 42
3.2.2 Marriage does not match on groom's birth order 44
3.3 Empirical strategy and data 46
3.3.1 Demographic and Health Survey data 47
3.3.2 Identification and regression specification 47
3.3.3 Balance and summary statistics 48
3.4 First stage: Household rank and women's status 50
3.4.1 Reported status and decision-making 50
3.4.2 Evidence from a time use survey 51
3.5 Results: Effect of mother's rank on child height 52
3.5.1 Main result 53
3.5.2 Evidence from longitudinal data on household splits 55
3.6 Mechanism: Maternal net nutrition 57
3.6.1 No effect of rank on medical care 57
3.6.2 Effect of rank on mother's body mass 58
3.6.3 Effect of rank on very early life mortality 59

3.6.4 Effect of rank on birth weight in a district hospital 60
3.7 Conclusion 62
3.8 Appendix 63
3.8.1 Summary statistics about joint households 63
3.8.2 Further evidence on the height of adult brothers 63
3.8.3 Evidence from a regional difference in women's status 64

4 Early life mortality and height in Indian states 83
4.1 Introduction 83
4.2 Context 86
4.2.1 Early life determinants of height in developed countries 86
4.2.2 Early life determinants of height in developing countries 87
4.2.3 Causes of early life mortality in India 89
4.3 Data & modeling approach 91
4.3.1 Data sources & descriptive statistics 91
4.3.2 Modeling approach 95
4.4 Results 96
4.4.1 Neonatal mortality, postneonatal mortality & adult height 96
4.4.2 Pre-adult mortality & adult height 100
4.4.3 Neonatal mortality, postneonatal mortality & children's height . . . 101
4.5 Discussion 103
4.6 Conclusion 105

5 Costs and Consequences of a Cash Transfer for Hospital Births in a Rural District of Uttar Pradesh, India 118
5.1 Introduction 118
5.2 Setting & context 120
5.3 Methods 123

5.4 Results 126
5.5 Conclusion 134

Bibliography **139**

List of Tables

2.1 Summary statistics 29
2.2 Countries included in the sub-Saharan Africa sample 30
2.3 Estimates of pre-pregnancy BMI, fraction underweight and weight, and weight gain during pregnancy for India & sub-Saharan Africa 31
2.4 Sample means of covariates used to compute pre-pregnancy estimates . . . 33
2.5 Linear probability regressions predicting pregnancy, using covariates from the extended reweighting 35
2.6 Method one estimates of weight gain during pregnancy, which use early pregnancy as a counterfactual 36
2.7 Distribution of gestational ages in the Indian and sub-Saharan African samples 37

3.1 Balance of nuclear family, child, and pre-marriage characteristics 72
3.2 Intrahousehold rank predicts reported decision-making "say" within households 73
3.3 Main result: Effect of mother's rank on child's height-for-age 74
3.4 Effect of rank on child height only seen in joint, not split, households . . . 75
3.5 Mother's rank is not associated with early-life medical care 76
3.6 Effect of mother's rank on body mass index 77
3.7 Effect of mother's rank on early-life mortality 77
3.8 Fraction of rural households and children under five in three DHS surveys living in joint households 79

3.9 Comparison of joint rural households with two daughters-in-law and other households in rural India 80
3.10 Heights of adult brothers, in centimeters 81
3.11 No effect of mother's intrahousehold rank in south India 82
3.12 Rank among brothers is never mentioned in advertisements about grooms seeking brides 82

4.1 Causes of early life mortality in India from the 2010 Million Deaths Study 112
4.2 Neonatal, postneonatal mortality & adult height in India (state cohorts) . 113
4.3 Pre-adult mortality & adult height in India (state cohorts) 115
4.4 Neonatal mortality, postneonatal mortality & child height in India 117

5.1 Characteristics of and number of interviews with pregnant and recently delivered women 137
5.2 Number of interviews conducted with each type of birth worker 138
5.3 An estimate of the value of the JSY payment for poorer and less poor families 138

List of Figures

1.1 Neonatal mortality and GDP per capita in 181 countries, 2013 8

1.2 Fraction underweight by age among men and women in India, 2005 9

2.1 Underweight by age (among non-pregnant women) and pregnancy by age in India and sub-Saharan Africa 26

2.2 Estimated CDFs for pre-pregnant women and empirical CDFs for women at 3, 6, and 9+ months gestation 27

2.3 Three estimates of pre-pregnancy weight for India (left) and sub-Saharan Africa (right) 28

3.1 Structure of the joint Indian households we study 65

3.2 Differences in status unfold after marriage 66

3.3 Time spent outside the house of a normal day, by woman's rank 67

3.4 Height-for-age of children of higher and lower-ranking mothers 68

3.5 Height difference is present at all joint household birth orders 68

3.6 Children of lower-ranking mothers are shorter at all heights of parents . . . 69

3.7 Intrahousehold rank and birth weight in a district hospital 70

3.8 Intrahousehold rank and post partum BMI in a district hospital 71

3.9 Fraction of rural children under 5 in each Indian state, and the fraction of those children in our sample 78

4.1 State-wise average mortality rates from 1970-1983 107

4.2 National mortality rates from 1970-1983 108
4.3 Early life mortality measures in the NFHS 2 and the NFHS 3 109
4.4 Relationship between adult heights and infant mortality 110
4.5 State level variation in women's body mass correlates with neonatal mortality 111
5.1 The net value of the JSY payment 136

Chapter 1

Introduction: India's maternal health crisis

This dissertation deals with poor maternal health in India, what causes it, and how it shapes the health and well-being of the population. Chapter 2 shows that maternal nutrition in India is even worse than was previously thought. As illustrated in chapters 3 and 4, poor maternal health and nutrition have dire consequences for the health of Indian children, and for the well-being of the adults those children will grow up to be. Unfortunately, current government policies and programs on maternal health are both ill-conceived and ill-executed; chapter 5 sheds light on why one major program aimed at addressing maternal and infant health is failing. Here, I briefly introduce the themes of the dissertation and offer a few comments on useful directions for maternal health policy in India.

1.1 India's high neonatal mortality indicates poor maternal health

In recent years, in India, about three quarters of a million children die annually in the first month of life; neonatal deaths account for over 70% of infant deaths. Figure 1.1 shows that India's rate of neonatal mortality is substantially higher than what is predicted by its per capita GDP. It uses World Bank WDI 2013 data to plot the log of GDP per capita against

the neonatal mortality rate for 181 countries. The best linear fit of these data suggests that doubling GDP per capita is associated with a 6.3 per 1000 reduction in neonatal mortality. India's neonatal mortality rate in 2013 was 29.2, which is far higher than the rate that is predicted by its per capita GDP – 22.4. Indeed, the difference between India's predicted neonatal mortality rate and its actual neonatal mortality rate is about 90% of the total neonatal mortality rate for China in 2013, which was 7.7.

India's high rates of neonatal mortality are concerning not only because of the loss of life they represent, but because they suggest very poor maternal health and nutrition. Whereas postneonatal mortality rates often proxy for the disease environment (Bozzoli et al., 2009), neonatal mortality is often related to maternal health; chapter 4 discusses links between neonatal morality and maternal health in detail. The 2005 Million Deaths Study found that the leading cause of neonatal mortality in 2005 in India is low birth weight/prematurity (Million Death Collaborators, 2010), which is importantly related to poor maternal nutrition. Low birth weight babies who survive to adulthood grow up to be shorter, less cognitively able, and less economically productive than heavier babies.

Unfortunately, India has no definitive statistics on the fraction of newborns who are low birth weight. Many children are not weighed at birth, and the government has not set up a monitoring system to weigh a representative sample of infants. However, the NFHS 2005 found that even among those infants who were privileged enough to be weighed at birth, a very high fraction – 22% – were low birth weight. The figure for the population as a whole is likely to be much higher.

1.2 Maternal health in India is worse than previously thought

How does India fare on measures of maternal health and nutrition? Anemia, pre-pregnancy BMI and weight gain during pregnancy are three important indicators. Estimating anemia

is fairly straightforward. The NFHS 2005 collected data on hemoglobin levels of all Indian women, including pregnant women. It found that 55% of non-pregnant women and nearly 60% of pregnant women were anemic. This affects the physical development of their children and puts them at elevated risk of death from post-partum hemorrhage.

Estimating the fraction of women who begin pregnancy underweight is more complicated because it cannot be directly observed in a cross sectional survey. The NFHS 2005 found that 35.6% of all Indian women 15-49 have a body mass index score that is less 18.5. This is a very high fraction compared to other, poorer, countries; of 23 African countries with comparable data, only Eritrea has a higher fraction of underweight women than India (Deaton and Drèze, 2009). But, this 35.6% does not accurately represent the fraction of pre-pregnant women who are underweight. Chapter 2 finds that the fraction of pre-pregnant women who are underweight is actually substantially higher: by using reweighting techniques to adjust for selection into pregnancy, it finds that 42.2% of Indian women are underweight at the beginning of pregnancy. This is 7 percentage points higher than the fraction underweight in the population.

Not only are Indian women too thin when they begin pregnancy, they do not gain enough weight during pregnancy to compensate for low pre-pregnancy body mass. Chapter 2 estimates that women in India gain only about 7 kilograms, on average, during pregnancy. Although there are, to my knowledge, no national guidelines for weight gain during pregnancy in India, this level of weight gain is only about half of what the US Institute of Medicine recommends for American women (Yaktine and Rasmussen, 2009).

1.3 Causes of poor maternal health

Why are pre-pregnant women in India so poorly nourished? Figure 1.2 suggests a number of reasons for India's pre-pregnancy underweight problem. It plots the fraction of Indian men and women who are underweight at each age. It shows that young women, who are most

likely to be pregnant, are also the demographic group that is most likely to be underweight. In India, most marriages are patrilocal, which means that after marriage a woman goes to live in her husband's village or town, often in his parents' house. Prior research suggests that young, newly married women have very poor social status in their martial homes (Jeffery et al., 1988; Dyson and Moore, 1983): they are expected to be self-sacrificing, to do hard work, and to eat little.

Chapter 3 identifies an effect of women's social status on maternal health and by studying joint households in rural India. A woman's rank in a joint household is in part determined by whether she is married to the older or younger brother. This is a plausibly exogenous source of variation in women's status because women do not sort into marriages to older and younger brothers. Thus, the effect of social status on maternal health that we identify is unlikely to be confounded by other factors. We find that lower status women in a joint household are thinner than higher status women, that their children are more likely to die in the first month of life, and that their surviving children are shorter than children born to higher status women.

It is important to note that the low social status of young women is not the factor affecting their nutritional outcomes. All groups of Indian adults suffer from high rates of underweight: figure 1.2 shows that about 25% of middle-aged Indian men, who have the highest intrahousehold status, are underweight. In stark contrast, only 15% of women in sub-Saharan Africa are underweight. High rates of underweight among Indian adults are likely due, in part, to India's exceptionally poor disease environment. Poor sanitation transmits parasites and intestinal diseases that lead to low body weight (Duh and Spears, 2015). The 2011 census found that about 70% of rural households, and about 13% of urban households, do not own a toilet or latrine. The fraction of people practicing open defecation is probably much higher than this, as recent research shows that many people who own latrines do not use them (Coffey et al., 2014). Unfortunately, reducing open defecation in rural India will not be achieved by latrine construction alone: research shows that cultural

practices of purity and pollution associated with the caste system lead to rejection of the kinds of affordable latrines that are used in other countries (see Coffey et al.).

Disease likely contributes to high rates of underweight among all adults, and the low status of young women puts them at a special nutritional disadvantage because they get less quantity and quality of food than other members of the household. Low food intake is another reason for adult undernutrition; research shows that despite high rates of underweight, calorie consumption has actually been decreasing over time as people get richer (Deaton and Drèze, 2009). In light of the fact that many Indians could afford to eat more, and that it in many cases it would benefit their health and productivity (Schofield, 2014), more research is needed to understand why dietary intake is so low.

1.4 Consequences of poor maternal health

Poor maternal nutrition has serious consequences for India's health and human capital. Not only does it lead to low birth weight, which contributes to India's exceptionally high neonatal mortality, there is also accumulating evidence that poor maternal nutrition is an important reason why the Indian population is among the shortest in the world. Chapter 3 shows that differences in maternal nutrition between higher and lower ranked daughters-in-law in the same household leads to a difference in the heights of their children. Chapter 4 uses historical data on variation in neonatal mortality in India, which likely reflects variation in maternal nutrition, to predict the heights of Indian adults alive today. It is noteworthy that neonatal mortality does not predict adult height in Europe (Bozzoli et al., 2009), where maternal underweight is not a widespread problem.

The fact that Indian children and adults are so short is a sign that they are not achieving their cognitive potential, which likely has important effects on their economic productivity. Researchers now understand that the same early life health processes that stunt child height also affect their cognitive development: children who are stunted are less likely to be able

to read, and grow up to earn lower wages than taller people (Spears, 2012b; Vogl, 2011). Thus, stunting among Indian children and adults is not only a health issue, it is also an economic issue.

1.5 Government policies are doing little to solve the problem

Current government policies and programs do little to address widespread maternal nutrition deficits in India. The Indian government runs two national programs with the stated aim of improving maternal health - the Integrated Child Development Scheme (ICDS) and the Janani Suraksha Yojana (JSY). The ICDS is supposed to distribute free nutritious food to pregnant and breastfeeding women, young children, and adolescent girls. Although, on paper, the ICDS is a universal program, in practice, it reaches only a small fraction of pregnant women. The DLHS 2007, the latest national survey that collected data on ICDS coverage of pregnant women, found that less than 30% of pregnant women received any supplementary food during their last pregnancies. This figure masks considerable state-level variation in coverage; in Uttar Pradesh and Bihar, where about a quarter of pregnant women in India live, and where pregnant women are especially likely to be underweight, less than 10% got supplementary food during their last pregnancy.

The JSY, which pays a cash incentive to women who deliver in hospitals, rather than at home, has better coverage than the ICDS, but does not focus on improving maternal nutrition. Indeed, evaluations of JSY find that it has not improved neonatal mortality (Mazumdar et al., 2012). Chapter 5 examines why this is the case. In short, the JSY program does little to address to improve the extremely poor health care that women and infants receive at the time of delivery, and does not address poor nutrition during pregnancy, an important underlying cause of neonatal mortality.

1.6 First steps for improving maternal health in India

That poor maternal nutrition is related to social problems such as the low social status of young women in Indian households, and to larger public health problems such as widespread open defecation, make it a very difficult issue to address. However, the cost of taking a business-as-usual approach to poor health in pregnancy is high: India's abysmal maternal health leads to high rates of neonatal mortality and stunts the growth and cognitive development of the children who survive.

Given its consequences for human and economic development, the government should be doing much more to recognize and address this problem. An important first step is to measure it: a national monitoring system for maternal and infant health, that tracks a small, representative sample of women through pregnancy and delivery would be feasible and inexpensive. With a monitoring system in place, the government could experiment with several programs to see how maternal health responds to new efforts. Finally, the government should implement the universal maternity benefits program that is part of the 2013 National Food Security Act. Designed well, a maternity benefits program could help pregnant women and their families, and would be a good first step in making a much-needed commitment to maternal health in India.

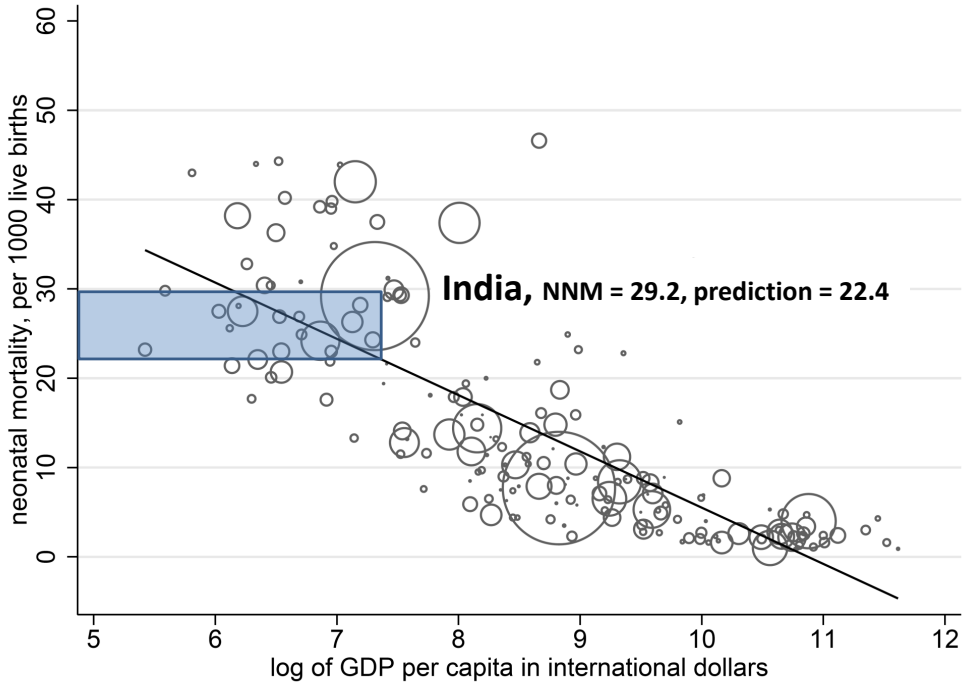


Figure 1.1: Neonatal mortality and GDP per capita in 181 countries, 2013

This figure plots neonatal mortality (NNM) against log of GDP per capita for 181 countries using World Bank World Development Indicators 2013 data. The size of each circle is proportional to the size of the population of the country in 2013. The line on the graph is the ordinary least squares "best-fit" regression line for these data. India's NNM exceeds what is predicted by log GDP per capita by almost 7 deaths per 1000 live births.

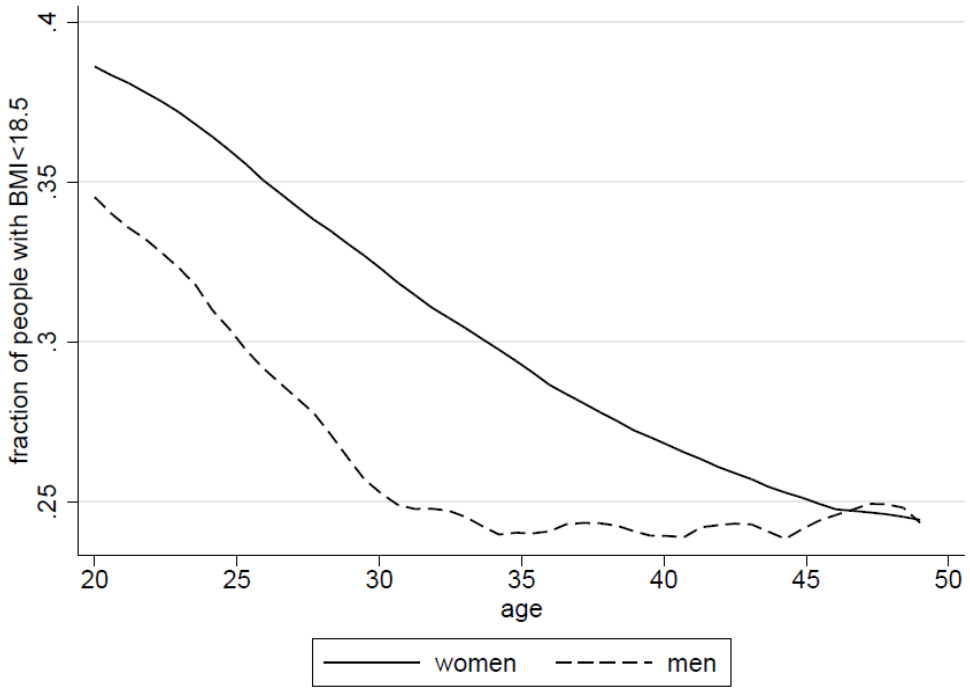


Figure 1.2: Fraction underweight by age among men and women in India, 2005

This figure uses local polynomial regression to plot the fraction of men and women who are underweight at each age in India using NFHS 2005 data.

Chapter 2

Pre-pregnancy body mass and weight gain during pregnancy in India & sub-Saharan Africa

[version of this chapter is published in *Proceedings of the National Academy of Sciences*, doi: 10.1073/pnas.1416964112]

2.1 Introduction

Children in India are significantly shorter and smaller than children in sub-Saharan Africa. Because Indian children are much richer, on average, than African children, scholars have described anthropometric differences between Indians and Africans as an "Asian enigma" (Bhutta, 2000; Nubé, 2009; Deaton, 2007; Underwood, 2002). Although there are likely many reasons why Indian children are shorter than African children (Coffey et al., 2013; Spears, 2013), and why Indian children are shorter than economic indicators predict, demographic and health surveys show that physical differences between Indian and African children begin very early in life, suggesting that the Asian enigma may in part reflect differences in maternal health. That Indian women have worse health during pregnancy than African women is also consistent with an anomalously high rate of neonatal mortality in India, as well as high rates of low birth weight, even among relatively privileged groups (WHO, 2004). Poor maternal health and nutrition among Indian women is of global sig-

nificance because India is home to one sixth of the world's population and one fifth of the world's births.

In recent decades, India has experienced rapid economic growth and significant reductions in poverty. Despite this economic success, however, measures of women's nutrition remain exceptionally poor. The latest Demographic and Health Survey (DHS), in 2005, showed that 35.5% of women aged 15-49 are underweight, suggesting that maternal health and nutrition are extremely also poor. India's high rate of underweight among women is worrisome in light of mounting evidence that nutrition during pregnancy is important not only for neonatal survival, but also for birth weight (Ludwig and Currie, 2010; Hytten and Leitch, 1971), which is associated with height and health in childhood and adulthood (Almond and Currie, 2011; Barker, 1995; Currie and Vogl, 2013; Adair, 2007), as well cognition and productivity (Behrman and Rosenzweig, 2004; Grantham-McGregor et al., 2007; Susser and Stein, 1994; Black et al., 2007).

Pre-pregnancy body mass and weight gain during pregnancy are useful measures of maternal nutrition. These factors interact to determine birth weight: on average, women with lower pre-pregnancy body mass need to gain more weight during pregnancy in order to deliver infants of the same birth weight as women who start pregnancy with higher body mass (Institute of Medicine, 1990; Yaktine and Rasmussen, 2009). The Institute of Medicine guidelines for women in the United States recommend higher weight gain during pregnancy for women with a pre-pregnancy body mass index (BMI), or ratio of weight in kilograms to height in meters squared, of less than 18.5 (Yaktine and Rasmussen, 2009).

What are average pre-pregnancy BMI and weight gain during pregnancy in India, and how do these figures compare to those in sub-Saharan Africa? These basic nutrition facts are unknown because no representative longitudinal monitoring systems exist for these regions. This paper's primary contribution is to produce the first representative estimates of pre-pregnancy BMI and weight gain during pregnancy for India and sub-Saharan Africa.

To estimate pre-pregnancy BMI, I adjust the BMIs of non-pregnant women for selection into pregnancy based on observable characteristics of pregnant women. I find that in India, 42.2% of pre-pregnant women are underweight; this figure is about 7 percentage points higher than the average fraction underweight among women 15 to 49 years old. These estimates constitute a significant contribution to the literature because they show that commonly cited figures for *average* women's nutrition in India (Bhutta, 2000; Bhutta et al., 2008; Black et al., 2008) significantly underestimate the fraction of *pre-pregnant* women who are underweight and overestimate average pre-pregnancy BMI. About half of the difference between the prevalence of women's underweight and the prevalence of pre-pregnancy underweight can be attributed to previously unquantified age patterns of fertility and undernutrition that are likely due to pronounced sex and age hierarchies in Indian households. Such hierarchies have been documented and studied by demographers, sociologists and anthropologists (Gupta, 1995; Jeffery et al., 1988; Dyson and Moore, 1983). In contrast, in the much poorer African sample, only 16.5% of pre-pregnant women are underweight.

Empirical distributions of the weights of pregnant women show that Indian women do not compensate for low pre-pregnancy body mass by gaining adequate weight during pregnancy. Indeed, on average, women in India *end* pregnancy weighing less than women in sub-Saharan Africa *begin* pregnancy.

Women in both India and sub-Saharan Africa gain only about 7 kilograms, on average, for a full term pregnancy. Two different methods confirm these results. Such a small weight gain is only about half of the minimum recommended gain for underweight women in the United States, for whom national guidelines recommend gaining between 12.5 and 18 kilograms during pregnancy. It is only about 60% of the minimum recommended gain for normal weight women, for whom the guidelines recommend gaining between 11.5 and 16 kilograms (Yaktine and Rasmussen, 2009).

2.2 Summary statistics

Table 2.1 shows that the 2005 Indian GDP per capita was twice the GDP per capita of sub-Saharan Africa, and the Indian population was 1.45 times as large (Heston et al., 2002). The 2005 poverty headcount ratio, using the World Bank's $1.25 per day poverty line, was lower in India than sub-Saharan Africa (World Bank, 2014). Further, the 2005 total fertility rate (TFR) in India was considerably lower than in sub-Saharan Africa; the Population Reference Bureau estimates an India TFR of 3.0, compared to 5.6 for sub-Saharan Africa (Population Reference Bureau, 2005).

Table 2.1 also provides information on the samples used for the analysis. The sample of African countries is restricted to those 29 countries with a DHS that measured women's weights between 2000 and 2010; these are listed in table 2.2. Sample countries from sub-Saharan Africa represent about 80% of the population of the region and are poorer than the region as a whole.

2.3 What fraction of pre-pregnant women are underweight?

It is common to cite the fraction of women who are underweight (BMI<18.5) as a proxy for pre-pregnancy undernutrition. However, if women who get pregnant are younger, less educated, or otherwise different from those who do not, and if these differences are correlated with body mass, then average BMI and fraction underweight among non-pregnant women of childbearing age in a representative cross section will give biased estimates of pre-pregnancy nutrition measures.

Are Indian women who become pregnant different from those who do not, in ways that correlate with nutrition? Figure 2.1 plots the fraction of non-pregnant women who are underweight at each age, as well as the fraction of women who are pregnant at each age.

The Indian data, in red, show a statistically significant ($P < 0.001$) negative relationship between age and the probability of being underweight: women in their early 20s are almost 15 percentage points more likely to be underweight than 40 year old women. The early 20s are also the time when Indian women are most likely to be pregnant, leading to a concentration of childbearing during a nutritionally vulnerable period. This finding coincides with a prior literature that suggests that young Indian women have particularly low social status early in their marriages (Jeffery et al., 1988). This has negative consequences for their own health and the health of their children (Gupta, 1995).

The Indian data contrast sharply with those for sub-Saharan Africa. The solid blue curve in figure 2.1 shows a quadratic relationship between age and underweight ($P < 0.001$) among African women. African women in their early 20s are about 25 percentage points less likely to be underweight than Indian women in the same age range. In sub-Saharan Africa, fertility levels, shown with dashed curves, are much higher and childbearing is spread out between the ages of about 17 and 35, rather than being concentrated in the early 20s.

To estimate pre-pregnancy BMI and fraction underweight, I construct a non-parametric reweighting function to compute what the BMIs of non-pregnant women would be if they had the same distribution of observable characteristics as pregnant women. Table 2.3 presents means and cluster bootstrapped confidence intervals resulting from statistical reweighting. For comparison, the first rows of panel A and B show average BMI and fraction underweight for non-pregnant women aged 15 to 49. The second rows of these panels show the results of reweighting by only the age structure of pregnant women, in years. Age reweighting makes a difference for India: BMI adjusted for the age profile of pregnancy is 0.7 points lower than that of the average woman, and the adjusted fraction underweight is 3.5 percentage points higher than the unadjusted fraction. Adjustment for the age pattern of pregnancy in sub-Saharan Africa shows that non-pregnant women with the same age distribution as pregnant women have similar average anthropometric outcomes as non-pregnant women.

The third rows of panels A and B of table 2.3 show the results of an extended statistical reweighting, which splits the sample of non-pregnant women in each region into mutually exclusive bins in order to account for differences between pregnant and non-pregnant women in age, education, urban/rural residence, the number of living children, the age of the youngest living child, whether she has at least one living son, and whether one or more of her children has died in the past five years. These factors were chosen for inclusion in the reweighting function because demographers have linked them to fertility (Martin, 1995; Bongaarts, 1987; Easterlin, 1971; Bongaarts et al., 1984; Das, 1987; Cohen et al., 1997; Preston, 1978), and they are also plausibly correlated with body mass. Summary statistics for these covariates, as well as linear probability regressions showing that they predict pregnancy are shown in tables 2.4 and 2.5.

The results of the extended reweighting of fraction underweight in panel B of table 2.3 show that 42.2% of pre-pregnant women in India are underweight, cluster bootstrapped 95% CI = [0.410, 0.432], compared with 16.5% in sub-Saharan Africa, cluster bootstrapped 95% CI = [0.157, 0.174]. The average pre-pregnant woman in India is about 7 percentage points more likely to be underweight than the average woman between the ages of 15 and 49. In sub-Saharan Africa, in contrast, the average fraction underweight and the fraction of pre-pregnant women who are underweight are very similar.

Only those non-pregnant women who are not using modern contraception at the time of the interview are used to compute the results of the extended reweighting. Because the Indian DHS collected data on contraceptive use histories, it is possible to check the assumption of a zero failure rate of contraception by statistically reweighting over the characteristics described above, as well as an indicator for whether non-pregnant women are using modern contraception. The results, shown in table 2.3, change very little, which is expected considering that only 4% of pregnant women in the Indian sample were using modern contraception in the month of conception. This specification is not shown for the African sample because only 9 of the 29 surveys collected contraceptive use histories.

In those countries where contraceptive use histories were collected, only 5% of pregnant women were using modern contraception in the month of conception.

The *Materials and methods* section provides further details about the reweighting functions used to generate the results in table 2.3.

2.4 Do Indian women compensate for low pre-pregnancy body mass with weight gain during pregnancy?

Prior research on weight gain during pregnancy in India studies small samples of women, which are not intended to be representative of the population (Yajnik et al., 2003; Agarwal et al., 1998; Hutter, 1994). In order to estimate average weight gain for full term pregnancies in the population, this paper uses two strategies: the first compares the weights of women in early pregnancy with those of women in late pregnancy, and the second compares the weights of non-pregnant women, adjusted for selection, with weights of women in late pregnancy.

Before turning to model-based estimates of weight gain during pregnancy, figure 2.2 plots distributions of weights of pregnant and pre-pregnant women in India and sub-Saharan Africa. Everywhere in the weight distribution, Indian women *end* pregnancy weighing less than African women do when they *begin* pregnancy. Each red or blue curve in figure 2.2 shows an empirical cumulative distribution (CDF) of weight in kilograms (above) or BMI (below) for women at 3, 6 or 9+ months of gestation. If, except for differences in gestational age, women who report early pregnancy are similar to those who report late pregnancy, then the horizontal distance between CDFs of the same color provides a visual description of weight gain during the second and third trimesters.

The black curves in figure 2.2 show estimated CDFs of pre-pregnancy weight and BMI, computed using the extended reweighting function on the sample of non-pregnant, non-contracepting women discussed in the previous section. For Indian women, the estimated

pre-pregnancy CDFs are very close to the empirical distributions for women at 3 months gestation. For African women, the CDFs of estimated pre-pregnancy weight and BMI are slightly to the left of the 3 month distributions. The larger gap between the pre-pregnancy distribution and the 3 month distribution for sub-Saharan Africa suggests that African women may gain more weight in the first trimester than Indian women. Figure 2.3 presents additional estimates of pre-pregnancy weight distributions that were calculated by modeling the association between body weight and gestational age, individual characteristics, and their interactions in cross sections of pregnant women.

Panel C of table 2.3 presents several estimates for mean pre-pregnancy weight, computed using the same methods described above for pre-pregnancy BMI and underweight. Panel D of table 2.3 shows estimated means and confidence intervals for weight gain during pregnancy for India and sub-Saharan Africa. The confidence intervals on weight gain for all four estimation strategies overlap within and across regions, demonstrating that despite very different pre-pregnancy BMIs, women in India and sub-Saharan Africa gain similar amounts of weight during pregnancy.

Estimates labeled "method one" are computed using OLS regressions of weight in kilograms on month of gestation for women three or more months pregnant. These regressions estimate average monthly weight gain. Linear modeling of these data is appropriate because weight gain during pregnancy is known to follow a linear pattern at these gestational ages (Thomson and Billewicz, 1957; Siega-Riz et al., 1994; Abrams and Selvin, 1995). Assuming that first trimester gain is 10% of second and third trimester gain Yaktine and Rasmussen (2009), average weight gain for a full term pregnancy is estimated as $1.1 \times 6 \times \hat{\beta}$, where $\hat{\beta}$ is the coefficient on month of gestation from the regression.

Table 2.3 presents two ways of estimating weight gain during pregnancy using OLS regression. The first row of panel D, labeled "method one, no controls," shows estimated weight gains using uncontrolled regressions of weight on month of gestation. The second row, labeled "method one, extended controls," shows estimated weight gains using coef-

ficients from regressions that control for factors related to selection into reported month of gestation, including age, years of schooling, number of living children, urban residence, and wealth quintile interacted with country. Dummy variables for the interaction of DHS sample region with month of interview are also included. Table 2.6 shows the regression table associated with the "method one" estimates from panel D of table 2.3, as well as weight gain estimates from additional regression specifications.

Estimates labeled "method two" in panel D of table 2.3 compute weight gain by comparing the weights of pregnant women who report 9+ months of gestation with the weights of non-pregnant women, adjusted for selection into pregnancy using the extended reweighting function used to compute pre-pregnancy BMI and fraction underweight. To account for the fact that women who report 9+ months of pregnancy will continue to gain weight until they deliver, these differences are adjusted upward by $\frac{1}{2}\hat{\beta}$, where $\hat{\beta}$ is average monthly gain estimated from the controlled regression described above. In panel D of table 2.3, the results labeled "method two, reweight with pregnant women" use the characteristics of pregnant women in the reweighting function; the results labeled "method two, reweight with women who delivered last year" use characteristics, from the time of conception, of women who delivered a live infant in the year prior to the survey. The results of these two strategies would differ if rates of terminated pregnancies (due either to miscarriage or abortion) or pre-term births are high, and if characteristics that correlate with terminated pregnancies and pre-term births also correlate with weight. However, table 2.3 shows that the results are similar.

The results in table 2.3 suggest that Indian and African women gain similar amounts of weight during pregnancy; the confidence intervals for all eight weight gain estimates overlap. Women in both regions gain only about 7 kilograms during pregnancy, which is far less than what is recommended for women in the United States with similar pre-pregnancy body mass. The estimation of these means and confidence intervals, as well as

the strengths and weaknesses of each approach, are discussed further in the *Materials and methods* section.

2.5 Discussion

This paper provides the first estimates of pre-pregnancy BMI, fraction underweight and weight gain during pregnancy for India, the country with the highest number of births in the world and serious challenges for population health, and for sub-Saharan Africa, a region which is significantly poorer.

By a novel application of reweighting estimation strategies, I find that 42.2% of pre-pregnant women in India are underweight, which is more than 25 percentage points higher than the comparable figure for sub-Saharan Africa. Women in both regions gain very little weight during pregnancy, but because of pre-pregnancy deficits, women in India *end* pregnancy weighing even less than women in sub-Saharan Africa *begin* it. Since pre-pregnancy BMI interacts with weight gain to produce birth weight, one would expect Indian infants to be born at significantly lower birth weights than African infants, a prediction which is supported by differences in anthropometric outcomes very early in life measured in the DHS. Because birth weight is a determinant of height, these differences in *in utero* nutrition may help explain "the Asian enigma" that Indians are shorter than Africans, despite their relatively better economic circumstances.

This study also found that in India, the prevalence of underweight among pre-pregnant women is higher than estimates for the average woman. About half of the gap between average underweight and pre-pregnancy underweight is explained by a previously unquantified relationship among age, the prevalence of underweight, and pregnancy, shown in figure 2.1.

These results suggest that further research is needed to understand why health during pregnancy in India is so poor and how it might be improved. Strong economic arguments

exist as to why India should invest in pregnancy to improve infant health (Behrman and Rosenzweig, 2004; Alderman and Behrman, 2006). However, to the extent that poor health during pregnancy is caused by low intra-household status among young women, which imposes a heavy burden of manual labor and restricts food intake (Jeffery et al., 1988), government intervention may prove extremely difficult. Indeed, prior literature on maternal health care has observed that the coincidence of childbearing with the restricted mobility and low intra-household status of young women limits their use of health services (Jeffery et al., 1988; Bloom et al., 2001).

Although certainly important, discrimination against young women is not the only reason why maternal health is so poor. Indeed, India's most recent DHS shows that the prevalence of underweight is 25% among men aged 40-50; these are the household members with the highest intra-household status. Exposure to infectious disease, poor sanitation, and poor diets all contribute to low body mass among both men and women. In the context of strong intra-household inequalities, investments in public goods that improve the disease environment similarly for everyone may be particularly useful.

2.6 Materials & methods

2.6.1 Data

This paper uses data from the Demographic and Health Surveys (DHS), which are publicly available from *www.dhsprogram.com.* For sub-Saharan Africa, I construct a dataset that includes all countries in which a survey collected data on women's weights and pregnancy duration between 2000 and 2010. If a country had more than one such DHS in this time window, the survey that took place closest to 2005 is chosen. A list of 29 countries and survey years included in the sub-Saharan Africa sample is presented in table 2.2. Anthropometry data are missing for 4.3% of pregnant women and 4.6% of non-pregnant women

in the India sample, and for 2.4% of pregnant women and 2.4% of non-pregnant women in sub-Saharan Africa sample; these observations are dropped from the analysis.

2.6.2 Design weights

Design weights are used to compute all results. For India, I use the women's sampling weights provided by the DHS. For sub-Saharan Africa, I construct a weight, s_{ic}, for each woman i in country c. $s_{ic} = \frac{pop_{c,2005}}{\Sigma_c pop_{c,2005}} \times \frac{w_i}{\Sigma_{i \in c} w_i}$, where $pop_{c,2005}$ is the population of country c in 2005 from the Penn World Tables Heston et al. (2002). w_i is the sampling weight for woman i within a given survey.

2.6.3 Estimation of pre-pregnancy indicators

This paper applies a non-parametric reweighting function similar to that described by DiNardo et al. (1996) and Geruso (2012). The reweighting function used to generate many of the results reported in table 2.3, Ψ, is defined as $\Psi(\mathbf{x}) = \frac{f(\mathbf{x}|P=1)}{f(\mathbf{x}|P=0)}$, where $\mathbf{x}$ is a single set of indicators for the intersections of categorical indicators assigned from observable characteristics that are correlated with pregnancy and body size. With the exception of education and urban residence, which are assigned for all women based on what is true at the time of survey, pregnant women are assigned characteristics based on what was true in the month of conception, and non-pregnant women are assigned characteristics based on what is true when they are surveyed. In panels A, B, and C of table 2.3, the results in the second row reweight only by age in years, and non-pregnant women who are using modern contraception are dropped from the reweighting procedure. The results of the extended reweighting likewise omit contracepting women, and include a larger set of characteristics in the reweighting function: dummy variables for age groups (15-19, 20-24, 25-30, 30-40, 40-50); education level (primary or less, some secondary or more); residence (urban, rural); age of the youngest child (no living children, youngest child is less than one year old,

youngest child is between one and two years old, youngest child is older than two years old); presence of a living son; number of living children (1, 2, 3, 4 or more); whether any of the woman's children died in the five years before the interview. Table 2.4 presents summary statistics for these covariates for pregnant and non-pregnant women. Table 2.5 shows linear probability regressions of an indicator for being 3 or more months pregnant on these covariates. The results in the last rows of panels A, B and C of table 2.3 include non-pregnant women who are using modern contraception and add to the extended reweighting function an indicator for the use of modern contraception at the time of conception.

The probability of reporting pregnancies of one or two months gestation is low relative to the probability of reporting pregnancies of other months of gestation. Table 2.7 shows the fraction of women reporting pregnancies of each gestational age. To avoid biasing the results due to selection into reporting of early pregnancies, only women reporting three months or more since their last menstrual period are included in the sample of pregnant women used to compute the reweighting function. Throughout the paper, month of gestation is calculated based on the respondent's reported time since her last menstrual period, which is asked of all respondents, and is rounded up or down to the nearest month if reported in weeks. Where data on time since last menstrual period is missing, the response to a question asked only of pregnant women ("How many months pregnant are you?") is used.

Mean pre-pregnancy BMI, $\overline{BMI}$, is $\frac{\Sigma_i BMI_i \times \Psi(\mathbf{x}_i)}{n_0}$ where i indexes non-pregnant women and n_0 is the number of non-pregnant women in the sample. For India, the results in panels A, B and C of table 2.3 for the age-only reweighting and the extended reweighting without contraceptive users drop less than 1% of the sample of pregnant women due to lack of support in the distribution of non-pregnant women. For the extended reweighting that includes contraceptive users, 2% of the sample of pregnant women are dropped prior to calculating the reweighting function. For sub-Saharan Africa, no pregnant women are dropped to compute the results of the age-only reweighting; for the extended reweighting, about a tenth of a percent of the sample of pregnant women is dropped.

To compute the bootstrapped confidence intervals reported in panels A, B and C of table 2.3, I re-sample clusters from the original data sources (DHS primary sampling units), stratifying within urban residence and state for the India sample and urban residence and country for the African sample.

2.6.4 Estimation of weight gain during pregnancy

Method one. Estimates labeled "method one" in panel D of table 2.3 present average weight gain for a full term pregnancy estimated as $1.1 \times 6 \times \hat{\beta}$, where $\hat{\beta}$ is the coefficient on month of gestation from an OLS regression of weight on month of gestation for women three or more months pregnant. This method for computing weight gain assumes that women in both regions gain an additional 10% of their second and third trimester weight gain in the first trimester. Table 2.6 presents estimates of weight gain in pregnancy computed using several different estimates of $\hat{\beta}$ from OLS regressions of the form:

$$weight_i = \alpha + \beta month_i + \Gamma C_i + \epsilon_i, \tag{2.1}$$

where $weight_i$ is the weight in kilograms of pregnant woman i. $month_i$ is month of gestation, calculated as described above. Controls, C_i, are added to the regression in stages to correct for possible selection into gestational age reporting, which could bias $\hat{\beta}$ negatively if disadvantaged women fail to report early pregnancies, or positively if disadvantaged women are more likely to miscarry or terminate the pregnancy. Column 3 of table 2.6 controls for age fixed effects, years of schooling fixed effects, number of living children fixed effects, an urban fixed effect, and dummy variables for the interaction of wealth quintile with country. Column 3 also adds controls for place interacted with month of interview. Places are countries in the Africa sample and states in the India sample. Columns 4 and 5 restrict the regression to women reporting 4-9 months and 3-8 months of pregnancy respectively, in order to test whether the results are sensitive to omitting the months that are most likely

affected by pregnancy underreporting and prematurity, respectively. The results are not sensitive to these re-specifications. 95% confidence intervals of weight gain for method one results in panel D of table 2.3 and in table 2.6 are calculated as $1.1 \times 6 \times (\hat{\beta} \pm 1.96 \times se_{\hat{\beta}})$.

Method two. It is useful to validate weight gain estimates from method one using a second method. Estimates produced using method one may overestimate weight gain during pregnancy if women gain less than 10% of second and third trimester gain in the first trimester. The black curve representing the distribution of weights among pre-pregnant women in India in figure 2.2 suggests that, for India, this may be true. However, if gestational ages are misreported, then the coefficients on gestational age would be attenuated, and method one would underestimate weight gain in pregnancy. Method two estimates average gain as the difference between average pre-pregnant weight computed using the non-parametric reweighting method described above for BMI and the average weight of women in late pregnancy. This method does not make assumptions about first trimester gain, nor does it potentially suffer from attenuation bias. However, method two will only produce unbiased estimates of weight gain in pregnancy insofar as the non-parametric reweighting accounts for all important endogeneity in selection into pregnancy. Figure 2.3, which plots the estimated pre-pregnancy weight distribution from the non-parametric reweighting of non-pregnant women against estimates of the distribution of pre-pregnant weight based on correcting the weights of individual pregnant women for gestational age, observable characteristics, and their interactions, provides evidence that the distributions resulting from the non-parametric reweighting are good estimates of the pre-pregnancy distributions.

Method two estimates average gain as $(\overline{W}_9 - \overline{W}_0) + \frac{1}{2}\hat{\beta}_1$, where $\overline{W}_9$ is the average weight of women reporting 9+ months of gestation; $\overline{W}_0$ is an estimate of pre-pregnancy weight from the non-parametric reweighting; and $\hat{\beta}$ is the average estimated monthly gain from the controlled regression described for method one. The inclusion of a half a month of linear weight gain assumes that pregnant women who report 9+ months since their last

menstrual period are, on average, at the midpoint of the final month of pregnancy. Average pre-pregnancy weight is computed using the extended reweighting function described above, dropping contraceptive users. The first row of "method two" results in panel D of table 2.3 reweights over characteristics of pregnant women; the second row of "method two" results reweights over characteristics, from the time of conception, of women who delivered a live birth in the year before the survey.

Sampling error contributes to the variance of both $\overline{W}_9$ and $\overline{W}_0$, and to the estimation of $\hat{\beta}$. Therefore, to calculate 95% confidence intervals for this estimate of weight gain, I bootstrap the entire calculation, stratifying within urban residence and state for the India sample and urban residence and country for the African sample. I cluster at the primary sampling unit level.

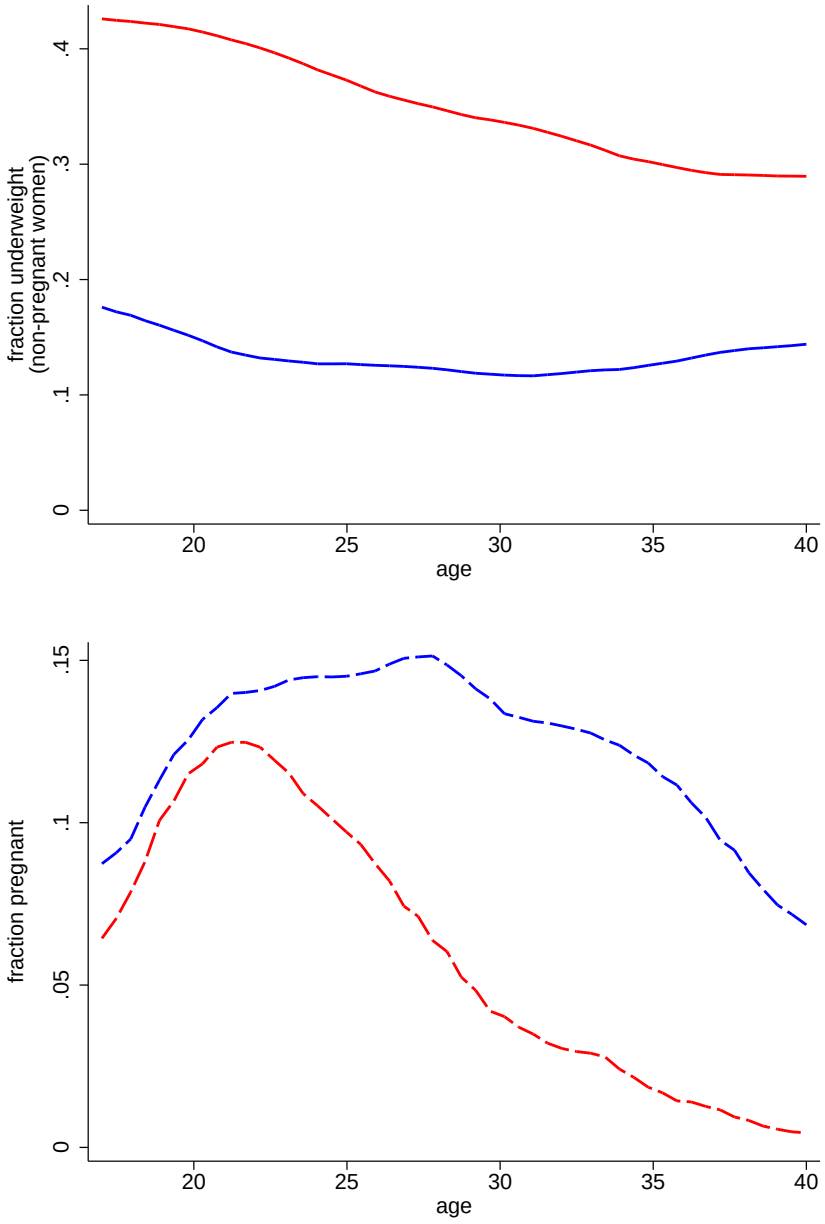


Figure 2.1: Underweight by age (among non-pregnant women) and pregnancy by age in India and sub-Saharan Africa

Epanechnikov kernel-weighted local polynomial regressions. Data from India are shown in red; data from sub-Saharan Africa are shown in blue. Underweight women have a BMI<18.5.

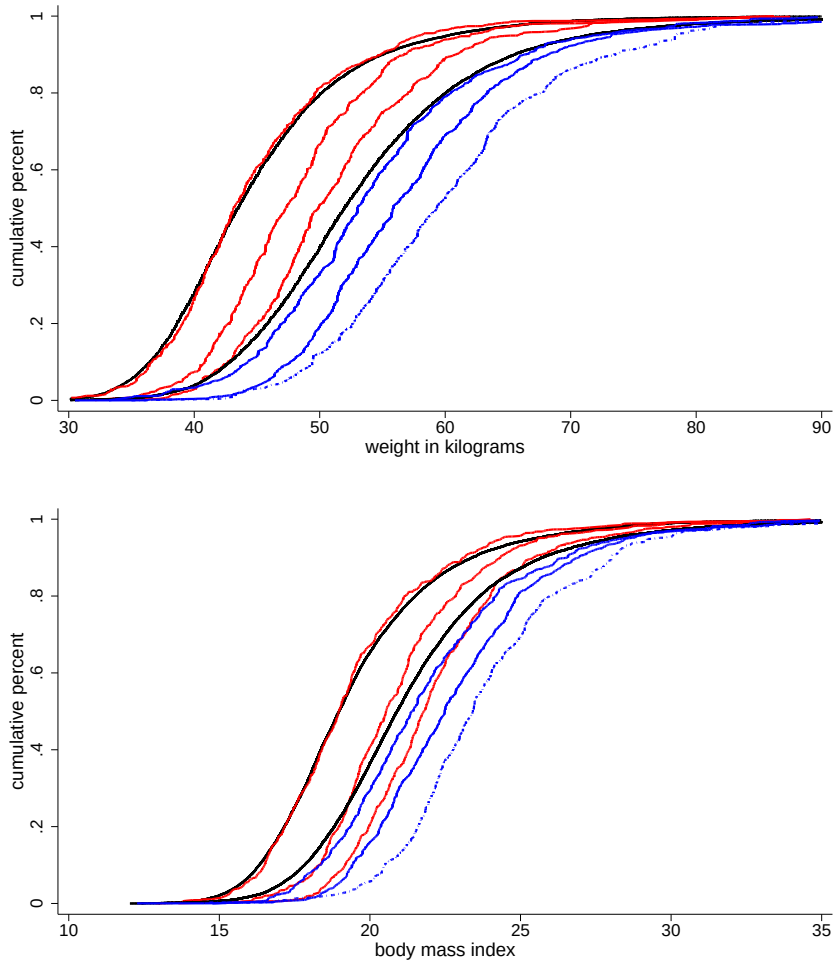


Figure 2.2: Estimated CDFs for pre-pregnant women and empirical CDFs for women at 3, 6, and 9+ months gestation

Estimated CDFs for pre-pregnant women are shown in **black** for in India (left) and sub-Saharan Africa (right). These are estimated using the extended reweighting function described in the *Materials and methods* section. Red curves represent empirical CDFs for Indian women at 3, 6, and 9+ months gestation (left to right). Blue curves present empirical CDFs for African women at 3, 6, and 9+ months gestation.

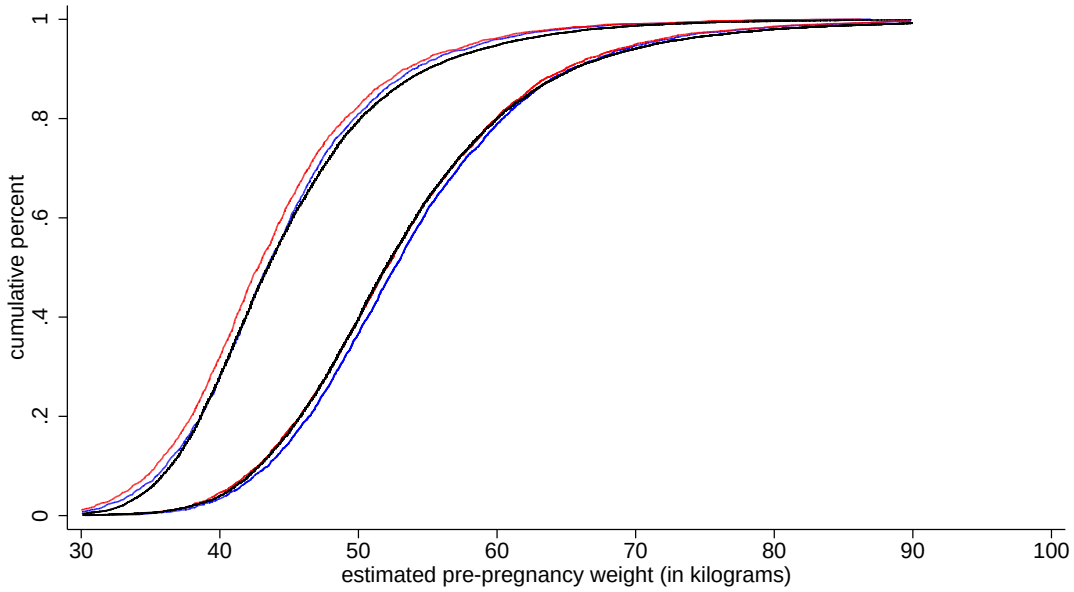


Figure 2.3: Three estimates of pre-pregnancy weight for India (left) and sub-Saharan Africa (right)

This figure shows six distributions of estimated pre-pregnancy weight. The three distributions for India are to the left of those for sub-Saharan Africa. The distributions in **black** are estimated using the extended non-parametric reweighting, which adjusts the body weights of non-pregnant women for selection into pregnancy. This method is described in the *Materials and methods* section. Distributions shown in red and blue are estimated from a cross-section of women who are 3+ months pregnant. I first regress body weight on month of gestation, and all the indicator variables used in the extended non-parametric reweighting, and their interactions with month of gestation. For each woman who has completed the first trimester, I compute the effect of gestational age on her body weight based on her own characteristics, month gestation and the interactions of these variables. To estimate an individual pre-pregnancy weight, I subtract from her body weight the product of her gestational age and her estimated effect. The blue distributions assume that no weight is gained in the first trimester, and the red distributions assume that 10% of an individual's estimated second and third trimester gain is gained in the first trimester.

Table 2.1: Summary statistics

	2005 population (in millions)[a]		2005 GDP per capita (in international dollars)[a]		poverty headcount ratio at $1.25 per day PPP[b]	
	region	sample	region	sample	region	sample
India	1,091	1,091	2,492	2,492	41.6%	41.6%
sub-Saharan Africa	752	597	1,480	990	52.8%	56.8%

	2005 total fertility rate[c]	number of countries		sample size women 15-49[d]	
	region	region	sample	non-pregnant, not contracepting	3+ months pregnant
India	3.0	1	1	69,543	5,055
sub-Saharan Africa	5.6	47	29	148,964	17,601

[a]Computations made using data from the Penn World Tables Heston et al. (2002), using real GDP per capita. [b]2005 World Development Indicators World Bank (2014) data are used. These estimates use purchasing power parity (PPP) figures from the 2005 International Comparison Program. The estimate for sub-Saharan Africa sample countries is computed using country-level poverty headcount ratio data from the years, between 2001 and 2007, that is closest to 2005. Data for Zimbabwe are missing. [c]Estimates are taken from the Population Reference Bureau (2005). [d]Sample sizes of women whose anthropometry was measured are shown.

Table 2.2: Countries included in the sub-Saharan Africa sample

country	**year of DHS survey**
Benin	2006
Burkina Faso	2003
Burundi	2010
Cameroon	2004
Chad	2004
Democratic Republic of Congo	2007
Ethiopia	2005
Gabon	2000
Ghana	2003
Guinea	2005
Kenya	2003
Lesotho	2004
Liberia	2007
Madagascar	2003
Malawi	2004
Mali	2006
Mozambique	2003
Namibia	2006
Niger	2006
Nigeria	2003
Rwanda	2005
São Tomé and Princípe	2008
Senegal	2005
Sierra Leone	2008
Swaziland	2006
Tanzania	2004
Uganda	2006
Zambia	2007
Zimbabwe	2005

Table 2.3: Estimates of pre-pregnancy BMI, fraction underweight and weight, and weight gain during pregnancy for India & sub-Saharan Africa

	India		sub-Saharan Africa	
	mean	95% CI	mean	95% CI
Panel A: Body mass index				
non-pregnant women, 15-49 years	20.47	[20.41, 20.53]	21.90	[21.82, 21.98]
pre-pregnant women, reweighted by age (CU dropped)	19.81	[19.73, 19.90]	21.75	[21.66, 21.84]
pre-pregnant women, extended reweighting (CU dropped)	19.54	[19.46, 19.62]	21.49	[21.39, 21.59]
pre-pregnant women, extended reweighting (CU included)	19.57	[19.50, 19.63]	.	.
Panel B: Fraction underweight ($BMI < 18.5$)				
non-pregnant women, 15-49 years	0.355	[0.349, 0.360]	0.152	[0.147, 0.158]
pre-pregnant women, reweighted by age (CU dropped)	0.390	[0.382, 0.399]	0.146	[0.140, 0.153]
pre-pregnant women, extended reweighting (CU dropped)	0.422	[0.410, 0.432]	0.165	[0.157, 0.174]
pre-pregnant women, extended reweighting (CU included)	0.418	[0.410, 0.432]	.	.

Table 1.3, continued

Panel C: Weight (in kilograms)				
non-pregnant women, 15-49 years	47.31	[47.17, 47.46]	54.58	[54.38, 54.81]
pre-pregnant women, reweighted by age (CU dropped)	45.81	[45.62, 46.02]	54.29	[54.05, 54.52]
pre-pregnant women, extended reweighting (CU dropped)	44.92	[44.71, 45.19]	53.45	[53.22, 53.74]
pre-pregnant women, extended reweighting (CU included)	45.04	[44.87, 45.21]	.	.
pre-pregnant women, extended reweighting, using women who delivered last year (CU dropped)	44.85	[44.69, 45.02]	53.08	[52.84, 53.33]
Panel D: Weight gain for a full term pregnancy (in kilograms)				
method 1, no controls	7.13	[6.48, 7.77]	6.47	[5.95, 6.99]
method 1, extended controls	7.00	[6.35, 7.64]	6.27	[5.88, 6.66]
method 2, reweight with pregnant women	6.88	[6.18, 7.69]	7.44	[6.32, 8.44]
method 2, reweight with women who delivered last year	6.95	[6.23, 7.76]	7.84	[6.73, 8.93]

CU stands for contraceptive users.

Table 2.4: Sample means of covariates used to compute pre-pregnancy estimates

	India		sub-Saharan Africa	
	women 3+ months pregnant[a]	non-pregnant, non-contracepting women[b]	women 3+ months pregnant[a]	non-pregnant, non-contracepting women[b]
age group				
15-19	0.228	0.326	0.176	0.245
20-24	0.434	0.221	0.271	0.184
25-29	0.225	0.139	0.253	0.159
30-39	0.106	0.179	0.255	0.232
40-49	0.007	0.136	0.045	0.180
education level				
primary or less	0.608	0.505	0.823	0.753
secondary or more	0.392	0.495	0.177	0.247
residence				
urban	0.240	0.310	0.234	0.298
rural	0.760	0.690	0.766	0.702
age of youngest child				
no living children	0.360	0.475	0.203	0.320
less than 12 months	0.090	0.115	0.055	0.082
between 12 & 23 months	0.240	0.077	0.286	0.058
24 months or more	0.310	0.332	0.460	0.540

Table 1.4, continued

	India		sub-Saharan Africa	
sex of children				
has a living son	0.408	0.402	0.626	0.560
number of living children				
none	0.360	0.475	0.203	0.320
one	0.287	0.157	0.204	0.140
two	0.162	0.135	0.178	0.121
three	0.092	0.088	0.134	0.109
four or more	0.099	0.146	0.282	0.311
child death				
any child death in last 5 years	0.095	0.039	0.182	0.112
n	5,055	69,543	17,061	148,964
fraction non-pregnant women contracepting at time of survey[c]	0.385		0.174	

[a]Sample means for women who are 3+ months pregnant are calculated based on what was true in the month of conception.
[b]Sample means for non-pregnant, non-contracepting women are calculated based on what was true at the time of the survey.
[c]Calculated for non-pregnant women whose weights and heights were measured.

Table 2.5: Linear probability regressions predicting pregnancy, using covariates from the extended reweighting

	India	**sub-Saharan Africa**
	pregnant	
age group		
15-19	.	.
20-24	0.053***	0.042***
	(0.003)	(0.003)
25-29	0.033***	0.040***
	(0.004)	(0.003)
30-39	-0.044***	-0.001
	(0.003)	(0.003)
40-49	-0.090***	-0.080***
	(0.004)	(0.003)
education level		
primary or less	0.027***	0.024***
	(0.002)	(0.002)
residence		
urban	-0.004*	-0.014***
	(0.002)	(0.002)
age of youngest child		
no living children	. .	.
less than 12 months	0.020***	-0.047***
	(0.005)	(0.003)
between 12 & 23 months	0.154***	0.223***
	(0.006)	(0.005)
24 months or more	0.093***	0.012***
	(0.005)	(0.004)
sex of children		
has a living son	-0.026***	0.001
	(0.004)	(0.003)
number of living children		
none	.	.
one	.	.
two	-0.024***	0.012***
	(0.004)	(0.003)
three	-0.024***	0.006
	(0.005)	(0.003)
four or more	-0.024***	0.010**
	(0.004)	(0.003)
child death		
any child death in last 5 years	0.065***	0.046***
	(0.007)	(0.003)
constant	0.033***	0.059***
	(0.002)	(0.002)
n	74,598	166,565

Standard errors are shown in parentheses. Two-sided p-values: † $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Women whose heights and weights were measured and who are 3+ months pregnant, or not pregnant and not contracepting, are included in the regression.

Table 2.6: Method one estimates of weight gain during pregnancy, which use early pregnancy as a counterfactual

	(1)	(2)	(3)	(4)	(5)
Panel A: India					
month gestation ($\hat{\beta}_1$)	1.08	1.06	1.06	0.99	1.08
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)
estimated gain (in kgs)	7.13	7.00	7.00	6.53	7.13
95% CI	(6.48, 7.77)	(6.35,7.64)	(6.35,7.64)	(5.76, 7.31)	(6.35, 7.90)
n	5,055	5,055	5,055	4,316	4,279
Panel B: sub-Saharan Africa					
month gestation ($\hat{\beta}_1$)	0.98	0.94	0.95	1.00	0.92
	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)
estimated gain (in kgs)	6.47	6.20	6.27	6.60	6.07
95% CI	(5.95, 6.99)	(5.82,6.59)	(5.88, 6.66)	(6.08, 7.12)	(5.55, 6.59)
n^a	17,601	17,333	17,333	15,149	15,244
age fixed effects		✓	✓	✓	✓
years of schooling fixed effects		✓	✓	✓	✓
number of children fixed effects		✓	✓	✓	✓
urban		✓	✓	✓	✓
wealth quintile × country		✓	✓	✓	✓
place × month fixed effects			✓	✓	✓
gestational months	3-9	3-9	3-9	4-9	3-8

All coefficients are significant at the 0.001 level. [a] Wealth quintiles are not provided for Gabon; these data are dropped from regressions in columns 2-5.

Table 2.7: Distribution of gestational ages in the Indian and sub-Saharan African samples

	India		**sub-Saharan Africa**	
	number of women	fraction of pregnant women	number of women	fraction of pregnant women
month of gestation				
1	107	0.019	509	0.026
2	495	0.088	1488	0.076
3	759	0.134	2197	0.112
4	729	0.129	2534	0.129
5	727	0.128	2736	0.139
6	693	0.123	2591	0.132
7	668	0.118	2627	0.134
8	695	0.123	2720	0.138
9+	785	0.139	2250	0.115

Design weights, described in the *Materials and methods* section, are used.

Chapter 3

Intergenerational effects of women's status: Evidence from child height in joint Indian households

[this chapter is co-authored with Reetika Khera & Dean Spears]

3.1 Introduction

Economists and social scientists have long debated the effects of inequality and social hierarchy on health. In particular, many economists have asked whether and how women's social status and empowerment shape the health and early-life human capital formation of their children (Thomas, 1990). This question is especially relevant for developing economies, where gender inequalities tend to be high, where women are often responsible for essentially all aspects of child care, and where low human capital is often a constraint on human development (Duflo, 2012; Jayachandran, 2015). Many development programs and policies are built on the assumption that socially empowering women will improve their children's outcomes (World Bank, 2001). Although effects of a women's status and empowerment on her children's health outcomes are plausible, and although estimating such an effect would be of clear importance, no prior paper in economics has identified such an effect.

Several challenges combine to make causal effects of a woman's status on her children's health and human capital difficult to identify and estimate. First, women of different social

status often differ in other relevant dimensions of human capital, personal resources, or household wealth (Strauss and Thomas, 1995). Second, women's status and empowerment are difficult to measure. Survey reported indicators of women's status used by economists, such as "say" in household decisions or experiences of violence, can suffer from considerable biases.[1] Finally, programs or events that influence women's status may also have other direct effects on child outcomes. For example, Jensen and Oster (2009) show an effect of cable TV in India on women's status and child education, but note that they cannot rule out direct effects of TV on children's education, through mechanisms other than women's status.[2] Despite these challenges, the importance of making well-identified estimates of effects of women's status on child health is clear both from its recurrence in the economic literature and from the emphasis that policy-makers place on the empowerment of women as a tool to improve child outcomes.

This paper overcomes these three identification challenges by exploiting a unique institutional feature of joint patrilocal households in India: women married to the older son are assigned higher social status than women married to the younger son.[3] Because this difference in mothers' status occurs within households, we can identify effects on children of an objectively measurable source of variation in mothers' status, while holding much about the environment to which children are exposed constant. Importantly, in this context, marriages do not sort mothers of different quality into different ranks; rather, status is assigned when a woman marries into a joint household. We empirically demonstrate this with evidence about such marriages and by showing that higher-ranking and lower-ranking

[1] In the 2005 Indian DHS, for example, whether a woman reports having experienced beating correlates positively with wealth. This suggests that it is difficult to measure women's status with survey questions because higher status women may be more likely to report a given level of maltreatment as a beating.

[2] Similarly, Thomas (1990) cannot separate a special effect of a mother's money from any social consequences it may entail. Miller (2008) shows an aggregate effect of women's suffrage on child health, but does not study effects of a mother's own status. Kishore and Spears (2014) find an effect of women in India having a son rather than a daughter on clean cooking fuel use, but cannot separate the mechanism of women's status from households' preference to invest in a son's health.

[3] Joint patrilocal households are ones in which adult sons live together with their parents, their wives, and their children.

mothers are similar before marriage on a range of characteristics related to health and human capital. Our analyses also show that differences in women's status and maternal nutrition emerge *after* marriage, and therefore only after exposure to this institution.

Using this strategy, we find that children of the lower-ranking mother are about a quarter of a height-for-age standard deviation shorter than their cousins born to the higher-ranking mother, within the same joint rural household. In support of this main result, we first verify "first-stage" institutional consequences of intrahousehold rank: women married to the younger son indeed have observably lower social status than women married to the older son. We show that lower-ranking daughters in law report less decision making power than their higher ranking counterparts and, in a time use survey, spend less time outside the home, a measure of autonomy among the women we study. We are also able to document a plausible and independently important mechanism for our effect: maternal nutrition. A mother's low intrahoushold rank – well-documented to be associated with restricted access to food and intense physical work requirements – lowers her body mass after marriage relative to higher-ranking mothers, decreases her babies' birth weight, and consequently increases neonatal mortality.

A central threat to the identification of our main result would be the possibility that differences in child outcomes are due to pre-marriage differences in the quality of mothers or fathers.[4] To address these concerns, we show a range of empirical evidence to demonstrate that pre-marriage differences in the quality of the mothers and fathers we study are not driving the differences in child height that we observe. We verify that the rank of the mothers of the children we study is "balanced" with respect to a wide range of observable characteristics that are fixed before marriage, in the spirit of a randomization balance table. Further we observe that the difference in heights of the children of higher and lower-ranking mothers is seen at all heights of their mothers and of their fathers. Lower-ranking mothers

[4]Perhaps, according to this concern, younger brothers systematically receive treatment that makes them less able to invest in the health of their children. Or, perhaps, lower quality mothers are systematically sorted into being lower-ranking daughters-in-law.

and their husbands are both, if anything, slightly taller and better educated, on average, than higher-ranking parents within the same household.

Similarly, we verify that the effect on child height that we identify only occurs among children exposed to the institutional forces of joint households. In a falsification test exploiting a separate data source that has longitudinally tracked households, we see that the effect of this measure of mother's status on child height is only found for children who are born into joint households; there is no difference in height between the children of adult brothers who live separately. This falsification test not only addresses concerns about the sorting of mothers into marriage to older and younger brothers, it also verifies that our results are not due to the possibility that households that are joint at the time of the survey are endogenously formed or selected in ways that drive the results.

We present further evidence that maternal nutrition is a mechanism for the effect of mother's social status; this evidence is important because it clarifies and emphasizes the causal chain linking status to child outcomes. We find that children of lower-ranking mothers are not disadvantaged in terms of natal and early-life medical care, but that lower-ranking mothers do have worse nutritional status than higher ranking mothers. A woman's body mass, which depends on her food consumption and energy expenditure, determines her ability to nourish her child *in utero* and while breastfeeding. Although lower-ranking mothers are no shorter than higher-ranking mothers, they have less body mass. Further, we find that children of lower-ranking mothers are more likely to die in their first month of life, when infant mortality is particularly dependent on birth weight and maternal nutrition, but are equally likely to die in their second to twelfth months of life. Finally, in newly collected data from a government hospital in a rural district of north India, we find that children of lower-ranked daughters-in-law weigh less at birth than children of higher-ranked daughters-in-law. Birth weight is highly dependent on maternal nutrition (Yaktine and Rasmussen, 2009), and is known to be a determinant of child height (Adair, 2007).

This paper contributes to several literatures in economics. First, we address a significant open empirical question by providing the first well-identified estimates of a causal effect of a women's social status on her own children's health. Second, by linking the difference we identify in height outcomes with maternal nutrition and birth weight, we contribute to the active literature on very early life origins of economic disadvantage (Aizer and Currie, 2014), and particularly to studies in economics on physical height as a measure of human capital (Case and Paxson, 2008; Steckel, 2009). Finally, we add to a growing literature that documents economically-relevant effects of social and household institutions, especially in developing economies (Jayachandran and Kuziemko, 2011; Vogl, 2013).

This paper is organized as follows. First, section 3.2 provides further background on the institutional features of joint households in rural India that we exploit. Then, section 3.3 presents our empirical strategy and data; section 3.3.3 verifies that children of higher and lower-ranking mothers are balanced on their mothers' and fathers' pre-marriage human capital and other properties. Section 3.4 presents evidence of an effect of intrahousehold rank on other measures of women's status, in the spirit of a first stage. Section 3.5 presents our main result: within the same household, children of the lower-ranking mother are shorter than their cousins. This difference is seen only when adult brothers' children live together in a joint household, not when nuclear families live separately. Section 3.6 presents evidence that maternal nutrition is one important mechanism through which women's status affects child height in this context. Section 3.7 concludes.

3.2 Background

3.2.1 Women's status in joint Indian households

Marriages in rural India are typically patrilocal; women move to their husbands' homes after marriage. The joint households that we study are ones in which the husband's parents and

his brothers live with him.[5] Figure 3.1 diagrams a simple case of a joint household in which two brothers live their parents, wives and children, the case that we study in this paper. Although the majority of young children in India live in nuclear families, joint households are nonetheless an important family structure: about 8% of rural children under five live in joint households like the ones depicted in figure 3.1. The absolute number of children living is such households is about seven million, which is about one-third of the total number of children under 5 in the United States. Table 3.8 presents data from India's Demographic and Health Surveys (DHS) on household type, and the distribution of children in household type.

How does joint family life generate within-household variation in women's status? Joint households are characterized by patriarchy and by age-hierarchy: women are subordinate to men and younger members are subordinate to older members. In her husband's home, a young woman typically behaves in ways that both reflect and reinforce her low social position; Mandelbaum (1988) describes how a newly married woman is expected to "be most diffident, shy, and self-effacing...[keeping] her gaze lowered, her voice still, her features covered, and her whole presence unobtrusive" (5).

The status of a woman who marries into the household is derived in part by her husband's birth order (Singh, 2005), and this is reflected in expectations for her behavior. The demands of propriety are typically even more oppressive for a daughter-in-law who is married to a younger brother than for one who is married to the other brother. Jeffery et al. (1988) point out that when a new daughter-in-law enters the joint household, the daughters-in-law who are already established in the household often "wield authority" over the new wife, "policing" her actions (30-31). Although relationships between the old-

[5]Another type of joint households, which we exclude from our analysis, is one in which brothers live together, without their parents. We exclude these households from our analysis because our identification strategy depends on households being economically integrated. Joint households in which both parents have died, or live elsewhere, do not have the joint responsibility of caring for parents, they are likely to be less economically integrated. In these households, household fixed effects are not as useful in controlling for the economic environment in which the children are raised.

est brother's wife with her husband's younger brothers are often casual and friendly, the younger brother's wife is expected to send signals of respect and deference to all adult members of the household (Mandelbaum, 1988). These differences between the lives of higher and lower ranked women in joint households have led Dyson and Moore (1983) to remark that "senior wives tend to dominate young in-marrying wives" (44).[6]

Not only does a woman's rank with in the joint household affect the amount of stress she experiences, it likely also influences her food intake. In joint households, it is also common for people to eat in the order of their social rank, with the household heads eating before their sons, who eat before the children, who eat before their mothers. Palriwala (1993) describes how, in the joint households she studied, "[t]he person who cooked and the youngest daughter in law, usually the same person, ate last. This acted against her...often there could be no vegetables or lentils left and she made do with a pepper paste and/or raabri. In a situation of deficit she went hungry when other household members did not have to " (60).[7]

3.2.2 Marriage does not match on groom's birth order

An important part of the institution that our identification exploits is the fact that marriage markets do not sort according to the groom's birth order. Research by anthropologists and demographers on joint family life suggests that status differences between higher and lower ranking daughters-in-law are salient in everyday life. Perhaps surprisingly to a non-Indian audience, however, whether the husband-to-be is an older or younger brother is not an important factor in marriage markets. The 2005 India Human Development Survey found

[6]Dyson and Moore (1983) point out that that gender hierarchies and intrahousehold rankings are more oppressive in north India than in south India. This implies that joint household hierarchies may not have the same effects on child health in south India. Table 3.11 tests whether the differences between the heights of children of higher and lower-ranking mothers that we observe in the main sample of children living in joint households are concentrated in the north; we find that that is indeed the case.

[7]The kinds of social relationships we describe here are more common in upper caste households, rather than Scheduled Caste and Scheduled Tribe households. Indeed, table 3.9 shows that the fraction of households which are joint is higher among of general caste and other backward caste households than among Scheduled Caste and Scheduled Tribe households.

that 95% of marriages in rural India are arranged (Banerji et al., 2013), meaning that the parents or extended family members of the bride and groom decide whether or not a couple will marry.[8] To these decision-makers – presumably unaware of the consequences for child height that this paper documents – a husband's birth order is unlikely to be considered, and at most merely a short-lived externality.

There is a large literature in economics that seeks to understand how marriages are arranged; in general, arranged marriages are highly constrained decisions, weighing many factors. The reasons for a marriage often have more to do with its economic and social implications for the extended families – that is, the people who make the decisions – than with externality effects on the daily life of the bride-to-be. For instance, Rosenzweig and Stark (1989) find that marriages to farther villages help families smooth consumption. Munshi and Rosenzweig (2006) discuss how marriage reinforces caste-based social networks that influence employment opportunities for men. In their research on dowry in South Asia, Anderson (2003) and Rao (1993) both discuss characteristics that influence brides' families perceptions of groom quality, including his caste, education, income, occupation, land holding, and city or village.

None of these papers – nor any other literature that we are aware of – discusses the birth order of the groom as a factor in Indian arranged marriage. In particular, this factor is absent from a related literature in economics which documents the tradeoffs that families are willing to make to marry their daughters according to the family's goals: within caste (Banerjee et al., 2009) and in the daughters' age order (Vogl, 2013). Banerjee et al. (2009) analyze data from bride and groom advertisements in Calcutta newspapers. Their summary statistics table lists 38 characteristics that they found in these advertisements; the birth order of the groom is not among them. We extended their analysis by conducting our own catalog of classified advertisements for groom in Uttar Pradesh; a table of char-

[8] Today, the bride and groom are sometimes consulted when a suitable match has been found, but they often play little role in marriage negotiations.

acteristics included in the advertisements is presented in the appendix to this paper, table 3.12. Although the distribution of characteristics mentioned in our advertisements is very similar to the advertisements reported by Banerjee et al. (2009), the birth order rank of the husbands was *never mentioned in a single advertisement.*

Our own qualitative research in rural Uttar Pradesh, a state where gender hierarchies are pronounced, suggests that the irrelevance of husband birth order to arranged marriage decisions may be because people see joint family life as temporary: joint families are believed to typically dissolve into nuclear families after the household heads pass away. Considering this, it is not surprising that the balance table in section 3.3.3 finds that higher-ranking and lower-ranking mother do not differ in properties established before marriage – such as education or physical height. Marriage decisions do not sort on husband's birth order.

3.3 Empirical strategy and data

Although it has often been hypothesized that constraints on women's status negatively impact the health and development of their children, such an effect has proven difficult to identify for two reasons. First, measures of women's status are often subjective and therefore subject to endogenous measurement error. Second, women of higher status – with more decision-making autonomy and a larger claim on resources – are often endogenously different in other ways that matter for child outcomes, such as education or wealth. As this section outlines, our empirical strategy overcomes both of these constraints on prior research. Exploiting the institutional properties of joint households in rural India outlined in section 3.2, we ask whether children of lower-ranking daughters-in-law are shorter, on average, than children of higher-ranking daughters-in-law within the same household.

3.3.1 Demographic and Health Survey data

Our primary dataset is India's 2005 round of the Demographic and Health Survey (DHS); this is the most recent DHS from India. These data are publicly available from *www.dhsprogram.com*. In each surveyed household, all women between the ages of 15 and 49 were interviewed.

Although the DHS is a nationally representative survey, we focus on a select sub-sample of children in the DHS, in support of our causal identification strategy. In order to include only those families which are most likely to share resources that influence children's health, such as money and food, we include in our sample only households that list a woman's father-in-law, or a woman's mother-in-law, as the head of household. For the main results, we study only children living in rural joint households with exactly two daughters-in-law, where both women have children under five years old.[9] The restriction of the data to children under five is necessary because the DHS only measures the heights of children under five years old. The restriction to households with two daughters-in-law eases interpretation of the results.[10]

3.3.2 Identification and regression specification

Our empirical strategy uses household fixed effects to compare cousins born to different mothers living in the same household. For a variety of outcomes we run regressions of the form:

$$outcome_{cmh} = \beta lower\ rank_{mh} + X_{cmh}\theta + A_{cmh}\lambda + \alpha_h + \varepsilon_{cmh}, \tag{3.1}$$

where c indexes individual children; m indexes the two mothers in each household we study; h indexes households, so α_h is a set of household fixed effects; and X_{cmh} is a set of controls

[9] Although our sample is a small fraction of Indian children, figure 3.9, in the appendix, shows that these households are distributed roughly proportionately across Indian states. Table 3.9, in the appendix, analyzes how our sample differs from the average household.

[10] Table 3.8 shows that in the DHS, 2005, 78% of joint households with more than one daughter-in-law had two daughters-in-law.

that will vary depending on the application. We include a full set of 120 child age-in-months by sex indicators A_{cmh} in our baseline specification. Standard errors are clustered by survey primary sampling unit (village).

Our independent variable of interest, *lower rank*, is an indicator with a value of 1 for the lower-ranking mother or her children and 0 for the higher-ranking mother or her children. We assign this indicator based on the ages of the two husbands; therefore, our measure of variation in women's status does not depend on self or subjective reports. In our main results, *outcome* will be a height-for-age z-score, scaled according to the 2006 WHO reference norms. In other regressions, we estimate the effect of *lower rank* on medical care and early-life mortality of children, and on properties of the children's mothers and fathers.

3.3.3 Balance and summary statistics

In this section we empirically verify the balance of the "treatment" of being the child of a low-ranking mother, in the standard sense of a verification that an instrument or random treatment assignment is not endogenously correlated with other observables. In particular, because we interpret our results as effects of intrahousehold social forces, it is important to verify that our results are not due to any differences *that would have been established before marriage* and formation of the joint household.

Table 3.1 shows that there is no difference in the pre-marriage human capital of the mothers or fathers of the children we study that is likely to explain our main result. The table is produced by estimating regression equation 3.1, with no further controls, in Panel A, and with cohort controls for mother's and child's year of birth in Panel B.[11]

[11]These cohort controls are included because lower-ranking mothers are younger, on average, than higher ranking mothers. Since the construction of the rank variable is based on husband's age, their husbands are always younger than the husbands of higher-ranking mothers. Because of these cohort effects, the fathers of the children of lower-ranking mothers are statistically significantly more likely to have been to school (an advantage that would bias away from our findings) in Panel A. This association is not statistically significant with controls for time trends in Panel B.

Our paper's main result is that the children of lower ranking mothers are shorter than their cousins on average; therefore, any evidence that pre-marriage human capital is worse for lower-ranking mothers or their husbands would threaten our identification. However, we find no such differences: intrahousehold rank is balanced in these important determinants of a child's early-life health. In fact, many of the point estimates on being born to a low ranking mother are *positive*, not negative. Although none of these differences are precisely estimated and each is of small magnitude, lower ranking mothers are slightly *taller*, on average, than higher ranking mothers; they were older when married; they are less likely to have been underage brides; they are more likely to have been to school; and they more likely to be literate.

We also find balanced characteristics, or small differences that would bias against our findings, among the fathers of the children we study. Table 3.1 shows that children born to the lower-ranking mother have a father who is slightly better educated than children born to the higher-ranking mother. There is no clear pattern of differences in the employment of the two adult brothers. Table 3.1 shows that the average child born to the lower-ranking mother has a father who is slightly and insignificantly taller;[12] however, men's height is from a small sample of 408 children and 313 fathers. Table 3.10 in the appendix uses larger samples of adult brothers, who may or may not have children under five, living in joint households to show that there is no difference in their heights that could be driving our results. Therefore, within joint households, the parents of the children we study are balanced in their height and human capital, and in terms of economic resources that fathers may in principle be able to direct to their own children.

[12]Note that, on average, there is be no heritable difference in genetic potential height between the two brothers.

3.4 First stage: Household rank and women's status

Before proceeding to our main results, in this section we show that intrahousehold rank is related to women's status. These results are comparable to "first stage" results verifying that an experimental treatment was implemented as intended, or that an instrumental variable is indeed related to the factor of interest. First, we use survey self-reported measures of decision making included within the DHS, which the DHS describes as measures of women's empowerment. Then, using the ITUS, we show a difference between the two daughters-in-law in time spent outside the home; in this cultural context, women's mobility outside the home is a measure of her social status (Rahman and Rao, 2004; Kabeer, 1999).

3.4.1 Reported status and decision-making

The DHS asks women who has final say on five decisions: the woman's own health care, making large purchases, making household purchases for daily needs, visits to family or relatives, and deciding what to do with money that her husband earns. We classify a woman as "having say" about that decision if she reports that she makes the decision herself or jointly with her husband. 51 percent of the children in our main sample have mothers who report having say on 1 or 0 of these decisions.

In our sample of children, using no household fixed effects or other controls, each additional decision on which a child's mother reports having say is linearly associated with the child being 0.102 height-for-age standard deviations taller [$s.e. = 0.032$; $t = 3.16$]. The identification challenge to which this paper responds is that this simple correlation includes confounding heterogeneity across mothers and households, in addition to any causal effect of women's status.

Table 3.2 reports estimates of equation 3.1, in which indicators for say in each decision are dependent variables. It also shows results of a regression in which the count of decisions in which a woman has say is the dependent variable. Women living in households with two

daughters-in-law comprise the sample for these regressions. Lower-ranking women report having say in 0.28 fewer decisions than higher-ranking women in the same households, on average. The coefficient is negative in each case, and statistically significantly negative in three cases that may be especially important for child nutrition: daily purchases such as food, spending money, and health. Panel A includes no controls beyond household fixed effects; Panel B adds a control for the ages of the individual women, to separate intrahousehold rank from the fact that the lower-ranking daughter-in-law is younger, which may have a direct effect on decision-making say.

It is important for our identification strategy that these differences in social status result from intrahousehold rank, rather than reflect fixed, individual properties of the women who become daughters-in-law of different rank. Figure 3.2 provides evidence for this; it plots the count of situations in which a woman reports having say at each duration of marriage, separately for higher and lower-ranking mothers of the children we study in section 3.5. The figure is centered vertically at zero because residuals are plotted after a regression of say on household fixed effects; this permits us to see how the say of the two mothers evolves relative to one another.

As the diverging lines show, reported say is initially similar between the two women early in marriage, and diverges over time. This may reflect a time-path of actual decision power, or of perceived or reported decision power after accumulating exposure to household institutions. Either way, what matters for our identification is that this trend appears not to reflect pre-existing differences in personality or preferences that women bring into marriage at different ranks.

3.4.2 Evidence from a time use survey

In the literature on women's status in India, women's mobility outside the home is a measure of her status and empowerment (Kabeer, 1999; Rahman and Rao, 2004). In this section, we use data from the India Time Use Survey (ITUS) to ask whether lower-ranking

daughters-in-law spend less time outside the home than higher-ranking daughters in law on a typical day.[13] As in our main analysis using the DHS, we restrict our analysis to the sample of households with exactly two daughters-in-law.

The ITUS, collected in 1998-9, interviewed the members of rural households in six states in India.[14] Each adult member was asked to report his or her activities on a typical day prior to the interview. In addition to reporting the activities in which he or she was engaged, respondents also reported how long he or she was doing the activity, and whether it took place inside or outside the home. We restrict our analysis to the 156 households for which time use for two daughters-in-law of the household head was recorded. For more information on the ITUS, see MOSPI (1999).

Figure 3.3 presents results: lower-ranking daughters-in-law spend an average of 27 minutes less time outside the home on a typical day [$p = 0.08$, clustered by household]. Although the small sample does not permit much further investigation, Panel A confirms that a difference is apparent at all ages, and is not therefore due to differences in the average age of the women. Panel B shows that the distribution of time outside the home for higher-raked women stochastically dominates the distribution for lower-ranked women [Kolmogorov-Smirnov $p = 0.07$]. This difference in time spent outside the home is therefore consistent with a first-stage effect of intrahousehold rank on women's status.

3.5 Results: Effect of mother's rank on child height

Compared to higher-ranking women, lower-ranking women have lower reported decision-making power and have less mobility outside the home, but neither they nor their husbands differ on pre-marriage characteristics. In this section, we turn to our main results. We

[13] The IHDS classifies days as "normal," "weekly variant" (such as Sunday), and "abnormal" (such as holidays); we follow other papers that use the ITUS (*e.g.* Barcellos *et al.*, 2012) in restricting our analysis to normal days.

[14] These are Harayana, Madhya Pradesh, Gujarat, Tamil Nadu, Orissa, and Meghalaya.

ask: after accounting for age differences, are children of lower-ranking mothers shorter, on average, than their cousins who born to higher-ranking mothers in the same household?

Figure 3.4 suggests that the answer is yes. This figure presents summary statistics using our main sample; however, it does not include household fixed effects. It plots height-for-age z-scores against age for children of higher and lower-ranking mothers and finds that, at all ages, there is a visible difference between the heights of children of higher-rankings mother and those of lower-ranking mothers. The presence of a difference at birth is consistent with *in utero* causes such as net maternal nutrition, which we will discuss in section 3.6. The rest of this section confirms the robustness of this result.

3.5.1 Main result

Table 3.3 presents results of our fixed effect regression equation 3.1, estimated using our main sample of children under five living in joint rural households with two daughters-in-law with children. The first column includes only household fixed effects and the indicator for a lower-ranking mother: in this specification, there is no evidence of an effect. This apparent result is an artifact of the construction of height-for-age scores and the fact that, in a population such as India's, where there is widespread stunting, height-for-age is well known to decline during first two years of life, as shown in figure 3.4. Because the average child of the lower-ranking mother is 8 months younger than the average child of the higher-ranking mother, this age gradient is an omitted variable that positively biases the coefficient in column 1. Starting in column 2, and in every subsequent regression, we include 120 age-in-months by sex indicators, which is the level of disaggregation at which the WHO height reference charts are defined.

Column 2 shows that the average child of the lower-ranking mother is about 0.25 height-for-age standard deviations shorter than the average child of the higher-ranking mother in the same household. Columns 3 through 5 add controls to verify that this result is not driven by other dimensions of possible difference between these children or their nuclear

families; all three sets of controls slightly increase the effect size, relative to the baseline specification in column 2.

Column 3 adds controls for demographic factors: an indicator for whether the child is first born to her mother, an indicator for whether the child is a single birth, the mother's age at the time of the child's birth, and the child's birth order in the joint household. The joint household birth order is the child's birth rank among all children, born to either mother. The average child of the lower-ranking mother is 0.432 positions later-ranking [$s.e. = 0.106$; $t = 4.06$]. This control exploits the fact that some children of the lower-ranking mother are born before some children of the higher-ranking mother, to verify that our result is not merely due to a bias in favor of earlier-born children (to whichever mother).[15]

Figure 3.5 further documents average height differences between children of the two mothers, at each joint household birth order. The vertical axis plots residuals after height-for-age is regressed on household fixed effects and age-in-months by sex indicators. Although the results are somewhat noisy for higher-order births – the last three birth orders shown account for only 25 percent of the births – there is a difference between the heights of children of higher and lower-ranked mothers at every birth order, which verifies that our result is not due to intrahousehold birth order.

Column 4 controls for properties of the child's mother: mother's height, indicator variables for years of education completed by the mother, and mother's age at marriage. Column 5 controls for properties of the child's father: indicator variables for the father's education in categories and years, father's category of occupation, and father's age. Balance table 3.1 verified that lower-ranking children are not disadvantaged in parents' pre-marriage characteristics (and perhaps slightly, imprecisely advantaged), so it is no surprise that the coefficient on mother's rank does not decrease. Our result is not due to differences in pre-marriage human capital or parenting ability among parents, unless such differences are uncorrelated with what we measure.

[15]Instead controlling for within-mother birth order produces very similar results.

Figure 3.6 provides further evidence that differences in parents' heights – which would have been determined in their childhood, before marriage – are not responsible for our results. Panel A uses our main sample of children to show a difference between children of the lower-ranking mother and of the higher ranking mother in average height at all mothers' heights. Panel B shows a difference across fathers' heights; this is important because it verifies that differences in early-life treatment of the fathers, who are brothers of different birth orders, is not the mechanism driving the results. The sample in panel B is smaller than the sample in panel A because the DHS only measured height for a randomly selected sub-set of men; panel B plots the heights of 408 children and 313 fathers. If, in this small sample, we add mother's height and father's height as controls to our baseline specification, we find that, conditional on these variables and the demographic controls, children of lower-ranked mothers are 0.351 standard deviations shorter [$s.e. = 0.239$; $p = 0.14$].

3.5.2 Evidence from longitudinal data on household splits

We interpret our main result to be due to differences in status *within* joint households, not differences in pre-marriage characteristics between parents. We have seen, in balance table 3.1, that there is little indication of differences between parents, and in figure 3.6 that there are differences in height between the children of high and low ranking mothers at all levels of heights of mothers and fathers. In this section, we exploit an additional data source to show that there is no difference in the average height of children of brothers who do not live together in a joint household. This analysis supports our main finding in two ways. First, it demonstrates that the difference in child height that we observe is not due to endogenous household formation; that is, it is not the case the older brothers with less healthy children differentially move out of joint households, or that younger brothers with more healthy children differentially move out of joint households. Second, it supports our argument that the difference in child height we observe arises due to status differences at work in joint households.

The 2005 India Human Development Survey (IHDS) longitudinally followed a sample of rural households from the Human Development Profile of India (HDPI), a survey conducted in the 1990s, including following parts of households that split.[16] The IHDS therefore allows nuclear households of adult brothers to be linked into an extended family. This means that we can compare height differences among cousins living within joint households with height differences among cousins living in split households, where two brothers have formed two households out of their nuclear families. If height differences among children were due to endogenous household formation, we would expect child height in the split sample to show an opposite effect of mother's rank as the one we find in the joint sample, rather than no effect.[17] However, we observe a height difference among children living in joint households, and no effect among children living in split households, suggesting that height differences are due to exposure to the social institutions of joint households.

Table 3.4 reports results from the IHDS 2005 data. Because reliable information on age in months is not available in the IHDS, instead of height-for-age z-scores we use the log of child height in centimeters as the dependent variable with controls for age in years, separately for girls and boys. In the IHDS data, among children under five, there is an effect on cousins' height of mother's social status in joint households (column 2), but not in split extended families (column 3), and this difference is statistically significant as an interaction (column 4). In columns 5 and 6, we replicate our main result with the DHS sample from table 3.3, to show that the results are quantitatively comparable to what is found in IHDS data when log of child height is used as the dependent variable in the DHS.

This result indicates that the effect of mother's rank on child height is due to intra-household processes. Additionally, the IHDS data provide evidence against the possibility

[16]The IHDS data are publicly available (Desai et al., 2008), and are described by Desai et al. (2009).

[17]If height differences among children were only due to individual differences between their fathers – perhaps their early-life health, human capital, or economic productivity – then we would expect to see effects on children living in split extended families; indeed, if joint households caused income differences between fathers to be pooled in joint consumption, then differences in child outcomes due to fathers' productivity might be *greater* in split families.

that Indian joint households endogenously split or stay together not due to economic or social factors, but as a *consequence* of child health. Further evidence for this claim is that of the 675 studied children living in split families, in all but 6 cases the household has not moved since before the child was born.

3.6 Mechanism: Maternal net nutrition

Children of higher-ranking mothers are taller than children of lower-ranking mothers, a result which is not due to differences among their parents from before marriage, nor to endogenous formation of households. This difference in child outcomes is accompanied with a difference in mother's status, apparent in her reported say in household decisions and time spent outside the home. In this section, we consider mechanisms for the height difference we observe. We do not find differences in use of prenatal or delivery care among higher and lower-ranking mothers, nor in immunization among their children. However, we do find several indicators that maternal net nutrition to which children are exposed *in utero* and during breastfeeding is different for children of higher and lower-ranking mothers. Effects of maternal net nutrition on child stunting are highly plausible in India; average maternal nutrition indicators are very poor, and maternal nutrition is known to impact birth weight, a leading indicator of child height (Ludwig and Currie, 2010; Adair, 2007).

3.6.1 No effect of rank on medical care

Table 3.5 runs household fixed effects regressions of the form of equation 3.1, to test whether children of lower-ranking mothers are shorter because they receive less medical care. We examine four binary dependent variables: having received any prenatal care during pregnancy, having been born in a facility rather than at home, having a government health card (used in part to track immunization), and having ever received any immunization.[18]

[18]We analyze whether the child has gotten any immunization rather than full immunization because health cards are used to determine whether a child is fully immunized. If she does not have a health card,

Panel A controls for household fixed effects without a time trend; in no case in Panel A is there evidence of an important disadvantage of children of lower-ranking mothers. Prenatal care and facility births both show an apparent *advantage* for children of lower-ranked mothers, but we note that lower-ranking births occur later, on average, and these services have become more commonly available and used over time. Panel B adds a fixed effect for the year of the child's birth and reduces the coefficients. However, even with the control for year of birth, children of lower-ranking mothers are more likely to be born in hospitals, rather than at home, which might bias against our results.

Panel C verifies that all four of these medical goods are normal goods, in the sense that they are more likely to be consumed by the richer children in our data.[19] It shows regressions of the four medical care outcomes on the DHS wealth index, which is constructed using household asset ownership, as well as other economic status variables such as housing type (see Filmer and Pritchett (2001)). We note this because if an important channel driving our results were differences in *economic* resources between the adult brothers' nuclear families, rather than effects of social rank, we might expect to see more consumption of medical care among higher-ranking children, which we do not. This observation provides further support that our main result is an effect of social institutions.

3.6.2 Effect of rank on mother's body mass

We propose that one important mechanism linking a mother's intrahousehold status to her children's height is her net nutrition. By "maternal net nutrition," we mean that what matters for child health outcomes is both the nutrition that mothers consume and the energy that is expended in work; lower-ranking mothers work hard and have less claim on

we do not know whether she has been fully immunized. However, the DHS does ask whether the child has received any immunizations.

[19]Poor people in rural India spend a relatively large amount of money on medical care and treatments (Banerjee and Duflo, 2007).

household food, as described in section 3.2. Maternal stress is a potential further channel through which intrahousehold rank may affect maternal net nutrition.

Although height is determined by a combination of a woman's genetic potential height and her *early-life* health and net nutrition, her weight is subject to more recent influences.[20] We have seen in balance table 3.1 that lower-ranking mothers are not shorter; this is consistent with similarity of lower-ranking and higher-ranking mothers before marriage. In this section, we ask whether higher-ranking mothers weigh more than lower-ranking mothers.

Table 3.6 reports household fixed effects regressions of the form of equation 3.1. The ideal dependent variables for this analysis would be a mother's BMI at the end of pregnancy and weight gain during pregnancy, because these are the variables that are most highly correlated with birth weight and subsequent child height. However, the DHS allows us to observe only her BMI at the time of the survey, so this is the dependent variable we use.

Columns 1 and 2 show that lower-ranking mothers have about one-third of a BMI point less body mass than higher-ranking mothers in the same household, on average. Columns 3 and 4 take seriously the possibility that this may be due to the two women being at different points in their childbearing or breastfeeding careers. However this result is essentially unchanged by flexibly controlling for the number of children the woman has had, as well as the age of her youngest child interacted with whether the child is breastfeeding. These interactions capture the amount of additional energy she requires to breastfeed. This effect of intrahousehold rank on maternal nutritional status that we identify is consistent with net maternal nutrition being a mechanism for the effect we document on child height.

3.6.3 Effect of rank on very early life mortality

If the differences we observe in child height have their origins in different maternal net nutrition, then we might also expect to see effects on very early life health and mortality.

[20] Thus, a diet can cause an adult to lose weight, but not to lose height.

Differences across places and times in average height can be partially accounted for by differences in infant mortality rates, because the same disease and poor net nutrition that causes infant death also stunts the growth of survivors (Bozzoli et al., 2009; Hatton, 2013). Infant mortality (IMR), or death in the first year of life, is divided into neonatal mortality (NNM), in the first month of life, and post-neonatal mortality (PNM), in the second through twelfth months of life. Although studies of height and early-life mortality in Europe have emphasized the importance of post-neonatal mortality, which is thought to in part reflect the infectious disease environment, chapter 3 shows that *neonatal* mortality is an important predictor of height in India, arguably due to extremely poor maternal nutrition.

Table 3.7 investigates whether mothers' intrahousehold rank is associated with early-life mortality, and decomposes IMR into NNM and PNM. Estimates use the same DHS data as our main analysis, but include all births in the 10 years before the survey to women living in joint rural households with two daughters-in-law.[21] Children of lower-ranking mothers are less likely to survive their first year of life, and essentially all of this effect is concentrated in neonatal mortality. Table 3.5 suggests that lower-ranking mothers do not receive worse medical care at birth. Therefore, these differences in neonatal death are consistent with differences in birth weight, caused by net maternal nutrition and health *in utero*, and resulting in childhood height differences.

3.6.4 Effect of rank on birth weight in a district hospital

The differences that we have documented in maternal BMI at the time of the survey and neonatal mortality are highly suggestive of differences in maternal nutrition between higher and lower-ranked mothers, leading to differences in the birth weights and heights of their children. Unfortunately, the Indian DHS does not reliably collect birth weight: only about a third of births in the data have a reported birth weight. Therefore, this section analyzes

[21] Infant mortality is observed for more children in the DHS than is height because it is survey-reported, not measured. Because of the long ten-year period under consideration, year fixed effects are included for the passage of time; younger women's children will be born in healthier later environments, on average.

original birth weight data collected by the authors between February 2013 to September 2014 in a government district maternity hospital in a largely rural district of Uttar Pradesh, a poor state in north India.

Six days a week, for a randomly selected subset of vaginal births in the previous 36 hours, we measured the birth weights of newborns and the heights and weights of their mothers. Of 2,376 observed births, 631 are to mothers in joint households of two daughters-in-law; we were able to collect anthropometric data on 549 of these births.[22] Note that because we observe births in the hospital, we are unable to use household fixed effects with this dataset.

Figure 3.7 presents results for birth weight, and 3.8 presents results for mothers' post-partum BMI. Lower-ranking mothers and their newborns both weigh less than higher-ranking mothers and their babies. These differences are not due to the mother's age nor to her number of prior births. Babies born to lower-ranking mothers weigh 84 grams less than babies born to higher-ranking mothers [$p = 0.051$], lower ranking mothers have 0.37 BMI points less body mass within 36 hours of delivery [$p = 0.086$], and themselves weigh 1.04 kilograms less, on average [$p = 0.085$]. It is noteworthy that, as in our main DHS sample, there is no difference in the mother's heights [-0.36 cm; $s.e. = 0.48$; $p = 0.45$].[23] Controlling for whether the mother already has a living boy child does not change the result; the children born to low-ranking mothers are still at a disadvantage of 75 grams [$p = 0.081$]. The results from these data further confirm that disadvantages in net maternal nutrition, especially during pregnancy, could partially explain the effects we document of intrahousehold social rank on child height.

[22]Some mothers refused data collection; 3.5 percent of births are recorded as dead at birth; 4.4 percent were recorded to have been born alive but died before our survey.

[23]Nor are there differences between higher and lower-ranking mothers in age at marriage [0.05 yrs; $s.e. = 0.88$; $p = 0.96$], or in the probability they have ever been to school [0.04 percentage points; $s.e. = 0.04$; $p = 0.36$], all of which would have been determined before marriage.

3.7 Conclusion

This paper addresses the question of whether women's social status affects children's health. Although many development practitioners assume that such a relationship exists, and although such a relationship is intuitive and plausible, omitted variables and measurement problems make it particularly difficult to find situations where we can be confident that mother's status has a causal effect on child health. This paper exploits the unique social institution of joint households in rural India, in which women married to the younger brother have lower social rank than women married to the older brother, but women are not sorted into these social roles based on motherhood quality.

The children of lower-ranking mothers are shorter, on average, compared with their cousins in the same household. We present evidence that this is an effect of intrahousehold social status: it only appears in joint households, not among children of brothers who live separately; first-stage-type effects on women's reported empowerment that emerge within the household environment. One important mechanism for this effect is maternal nutrition: although they are not shorter, lower-ranking mothers weigh less than higher-ranking mothers, including immediately after delivery; their children have lower birth weights; and their children are more likely to die in the first month of life, a period in which good maternal nutrition is particularly important for survival.

If our results have direct policy implications with regard to families we study, these may be to encourage polices that expand rural families' choice sets in ways that weaken traditional household hierarchies. Although well beyond the scope of this paper, such policies may include old-age pensions (Case and Deaton, 1998) or other forms of social support that allow older parents to support themselves without relying on the economic support that comes from the joint household structure. Cash transfers to women during pregnancy may give them greater bargaining power to improve maternal nutrition. More generally, these

results suggest future research into how the poor status of women in developing countries influences their nutrition during pregnancy and the early-life health of their infants.

3.8 Appendix

3.8.1 Summary statistics about joint households

Figure 3.9 plots the fraction of rural Indian children in each state against the fraction of children in our main sample (see table 3.1) in each state. It shows that states are roughly represented according to their population size in our main sample; the large, conservative northern state of Uttar Pradesh is slightly overrepresented.

Table 3.8 presents summary statistics about the fraction of rural households that are joint and about the fraction of rural children under five living in joint households for each of the three Indian DHS. Table 3.9 compares joint rural households with two daughters-in-law and other households in rural India. We find that these joint households are slightly better off than households that are not joint, and that the children in them are slightly taller, on average.

3.8.2 Further evidence on the height of adult brothers

Table 3.1, which verified the balance of nuclear family characteristics, and of pre-marriage characteristics of parents, for children of higher and lower-ranking mothers. It also found that younger brothers were were slightly taller than their older brothers, on average, in these joint rural households. However, this difference was not statistically significant, and was observed in a very small sub-sample because height was not measured for all men.

Table 3.10 extends this analysis to a larger sample of adult brothers in the DHS, 2005. The table presents simple regressions of height in centimeters on an indicator variable for being the older brother, along with either age linearly or as a set of year indicators and

with or without household fixed effects. Panel A uses a sample that includes all men living in joint households with two adult brothers, defined as two sons of the household head, whether or not they have children. In different specifications, males under 20 and under 22 are excluded to ensure that younger brothers do not appear shorter merely because they have not yet finished growing to their adult heights. Successive panels B and C restrict the sample to include only men with children, and then only with children under 5, to more closely match the sample in our main analysis. The observation that older brothers are shorter than younger brothers, on average, appears to be robust to all of these respecifications.

3.8.3 Evidence from a regional difference in women's status

India is a diverse country with well-studied regional differences. Intrahousehold institutions that rank daughters-in-law and create the unequal allocations of status, work, and nutrition that we document are weaker in the south of India than in the north (Dyson and Moore, 1983). Therefore, if our result is indeed due to such social institutions, it may be absent or diminished in the south of India.

Table 3.11 tests this prediction, returning to our main DHS sample from table 3.3. We operationalize the south of India as the states Andhra Pradesh, Karnataka, Goa, Kerala, and Tamil Nadu. In the south, there is no evidence of an effect of intrahousehold rank; although the coefficient in column 1 is imprecisely estimated in this small sub-sample, it is if anything of positive sign; the coefficient for the rest of India in column 2 is essentially unchanged from table 3.3. Column 4 suggests that this interaction may be statistically detectable, if differences in mothers' heights are used to improve estimates. This result is consistent with intrahousehold rank being important for child height because of women's status.

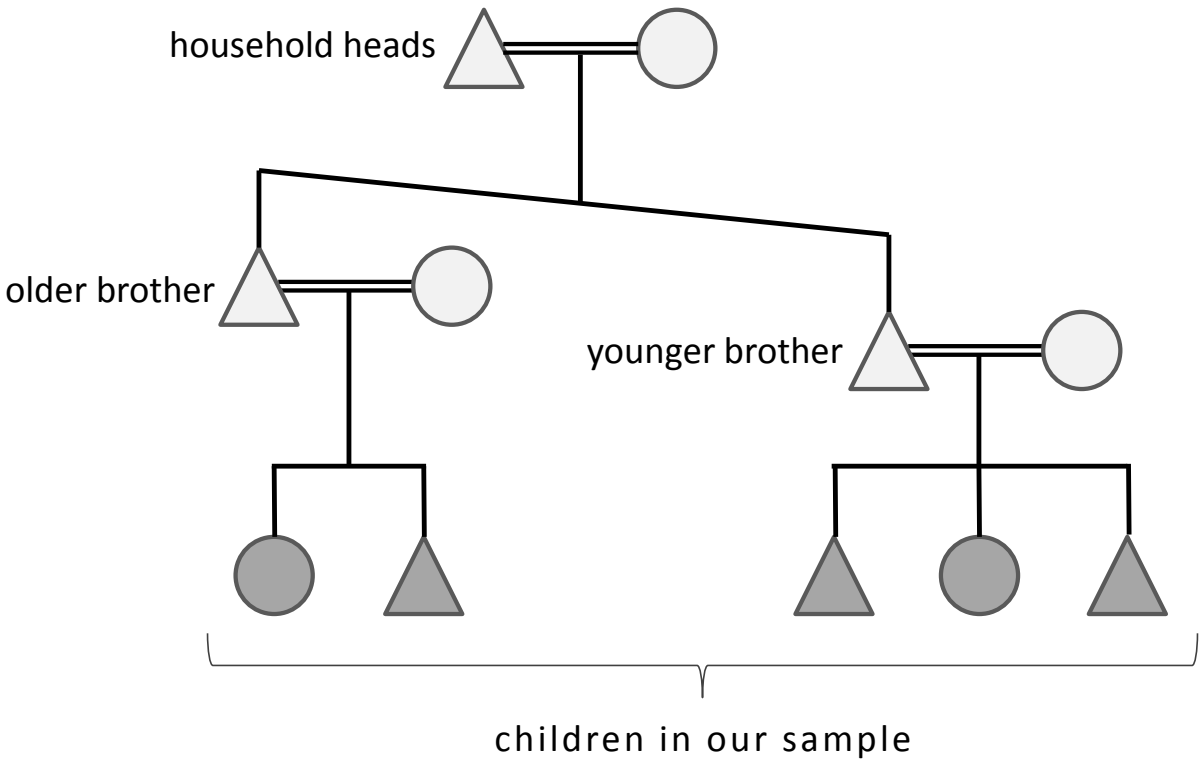


Figure 3.1: Structure of the joint Indian households we study

Males are represented as triangles and females as circles; marriage relationships are denoted as double lines. The slanted connection of the nuclear families reflects the difference in social rank that we study.

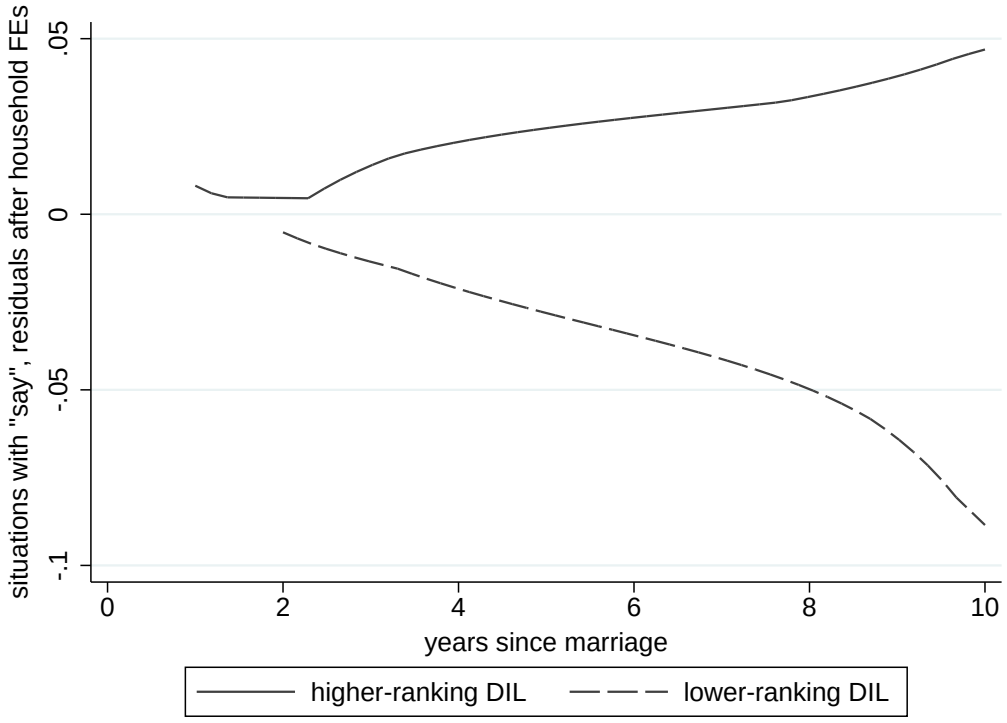
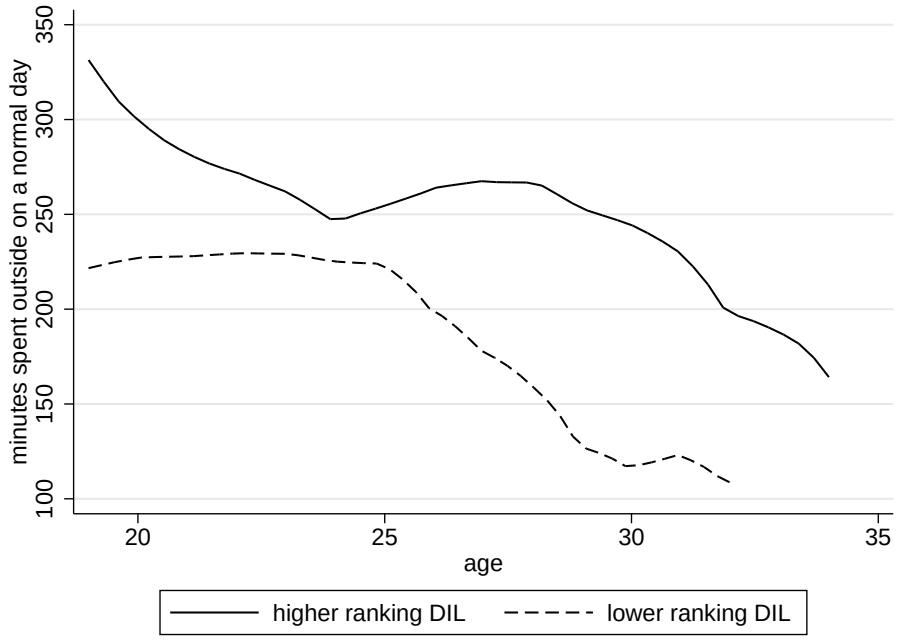


Figure 3.2: Differences in status unfold after marriage

India, 2005 DHS data. Observations are the mothers of the children in our main sample, in table 3.3. "Say" is the count of five situations in which the woman reports having say, either alone or jointly with her husband. Residuals are after a regression on household fixed effects. Local regression; bandwidth is three years.

(a) time spent outside on a normal day



(b) CDF of time spent outside on a normal day

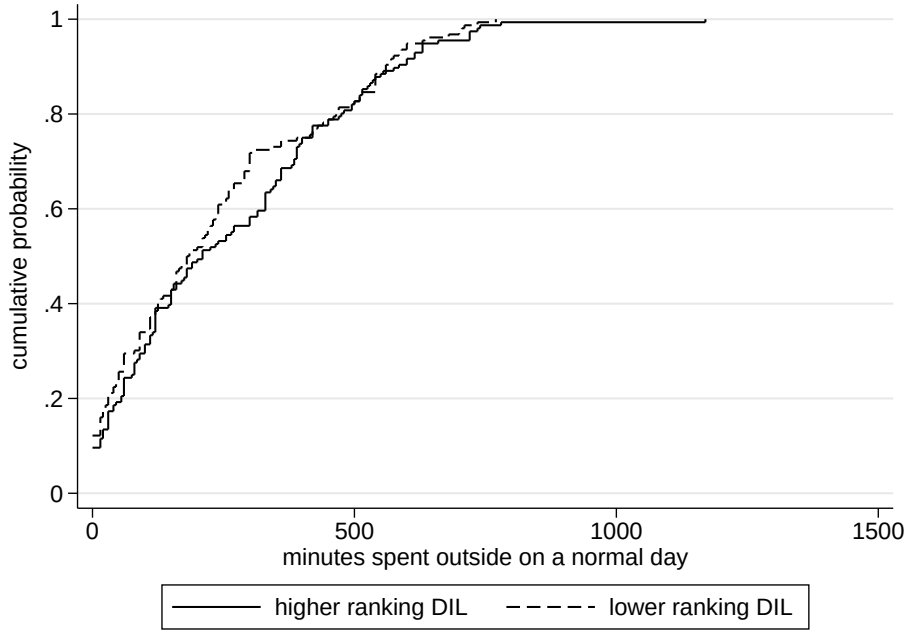


Figure 3.3: Time spent outside the house of a normal day, by woman's rank

India Time Use Survey (ITUS), 1993 data. DIL is daughter-in-law. Panel A plots minutes spent outside on a normal day by age using local polynomial regression with an epanechnikov kernel and a bandwidth of 1.75. Panel B is the cumulative distribution function of minutes spent outside on a normal day. n=312. We restrict the sample to daughters-in-law living in households with two daughters-in-law.

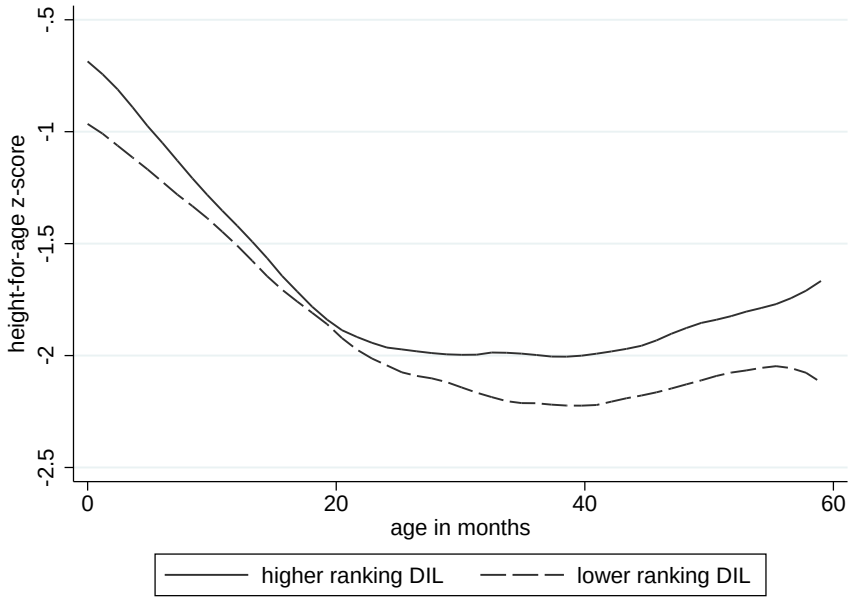


Figure 3.4: Height-for-age of children of higher and lower-ranking mothers

India, 2005 DHS data. WHO, 2006 reference norms. Local regression with an epanechnikov kernel and a bandwidth of 6 months. $n = 1078$, identical to main sample in table 3.3.

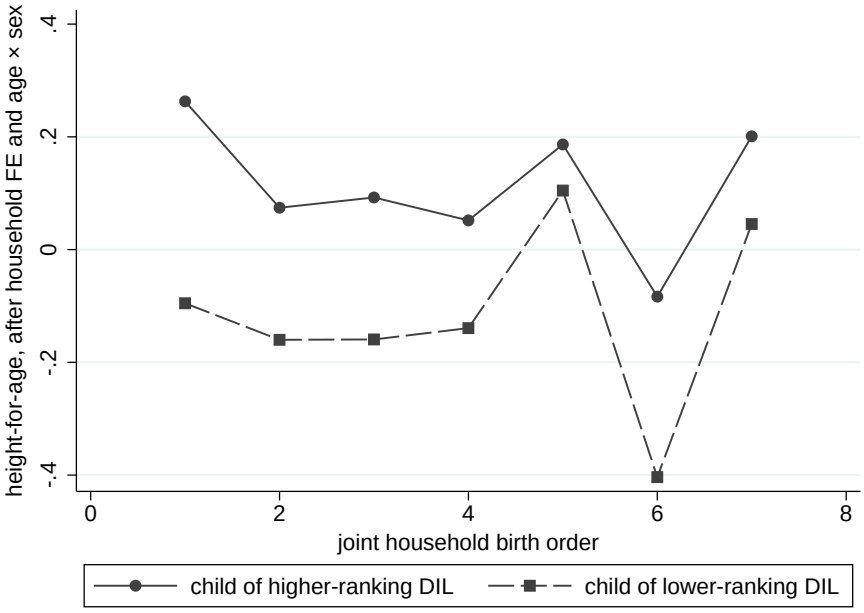
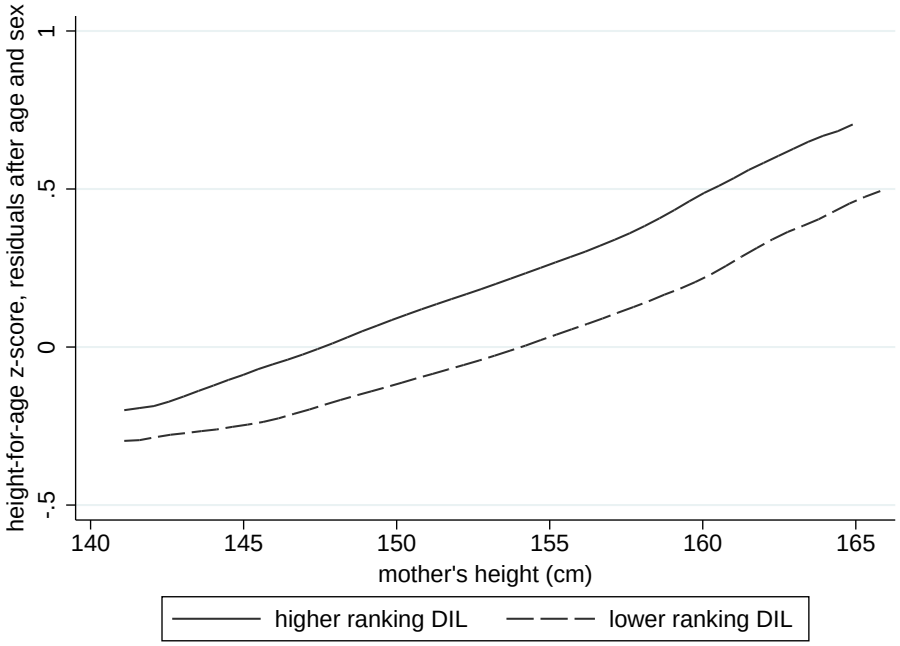


Figure 3.5: Height difference is present at all joint household birth orders

India, 2005 DHS data. Joint household birth order is rank among children of both mothers. $n = 1078$, identical to main sample in table 3.3.

(a) child height by mother's height



(b) child height by father's height

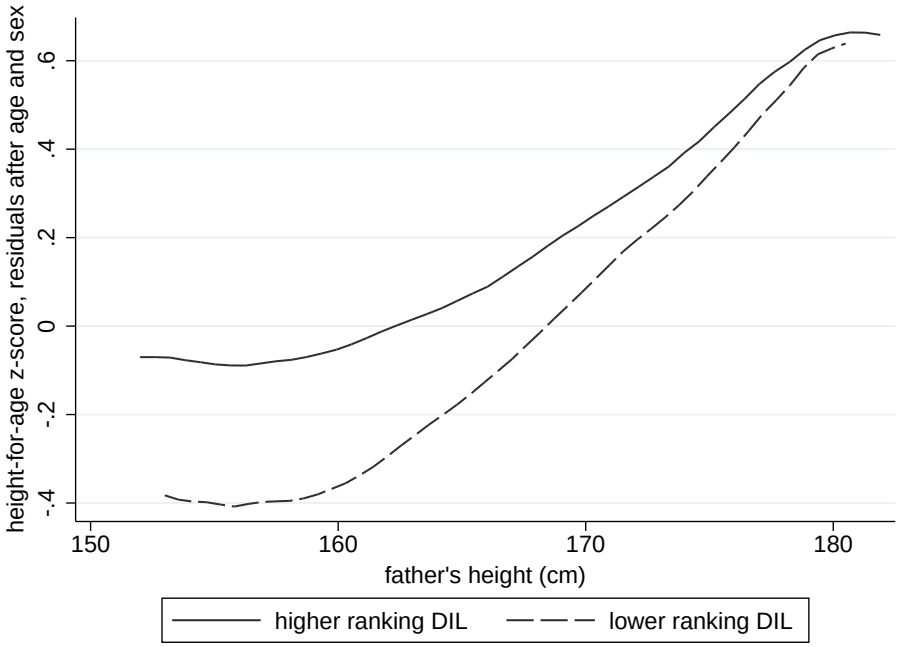
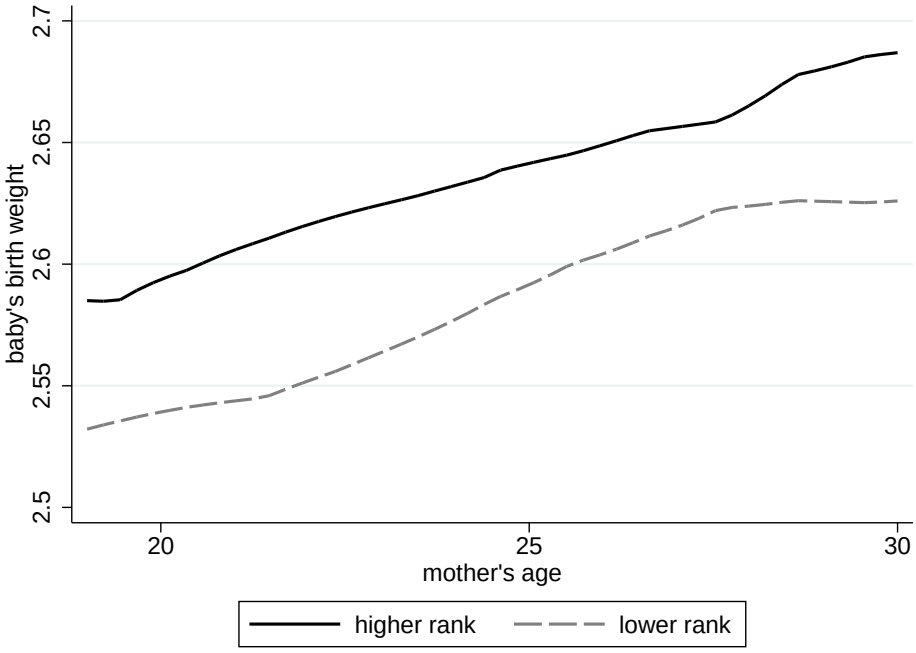


Figure 3.6: Children of lower-ranking mothers are shorter at all heights of parents

India, 2005 DHS data. Local polynomial regression with an epanechnikov kernel and a bandwidth of 5cm. In panel A, $n = 1078$, identical to main sample in table 3.3. In panel B, n =408, as the DHS only measured a sub-sample of men.

(a) birth weight, given age



(b) birth weight, given pregnancy count

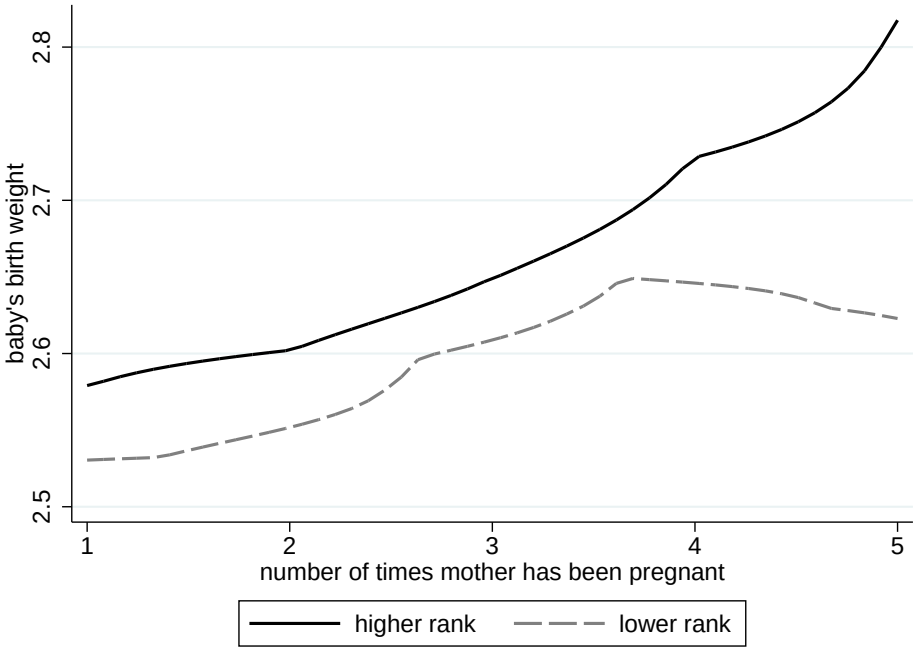
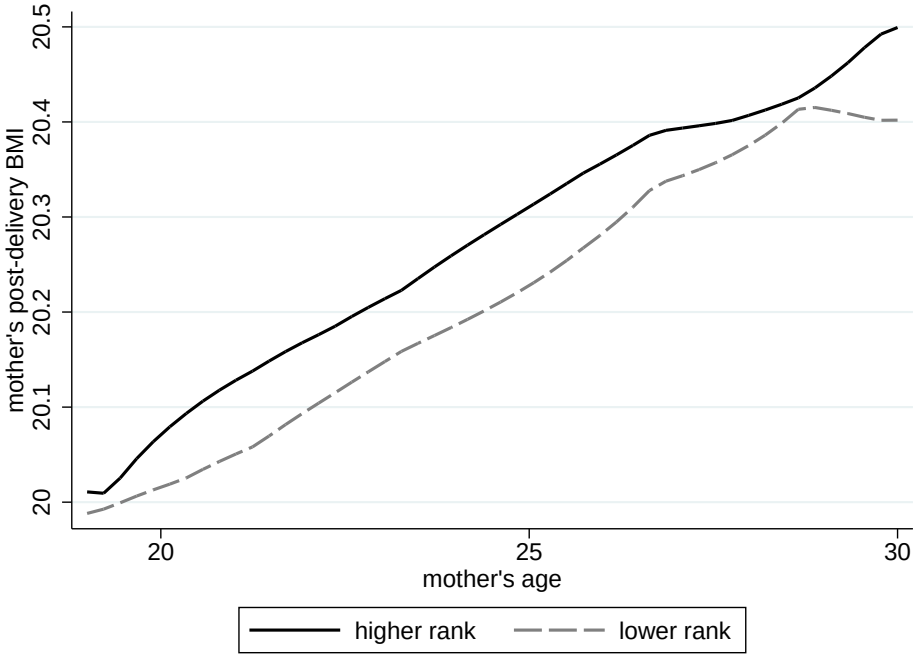


Figure 3.7: Intrahousehold rank and birth weight in a district hospital

Data are from the authors' original collection in a district maternity hospital in Uttar Pradesh. Birth weight was measured within 36 hours of birth. To match our main sample, data are restricted to women in households with exactly two daughters-in-law; note that because data are collected at the hospital, not in a household survey, household fixed effects cannot be used.

(a) mother's BMI, given age



(b) mother's BMI, given pregnancy count

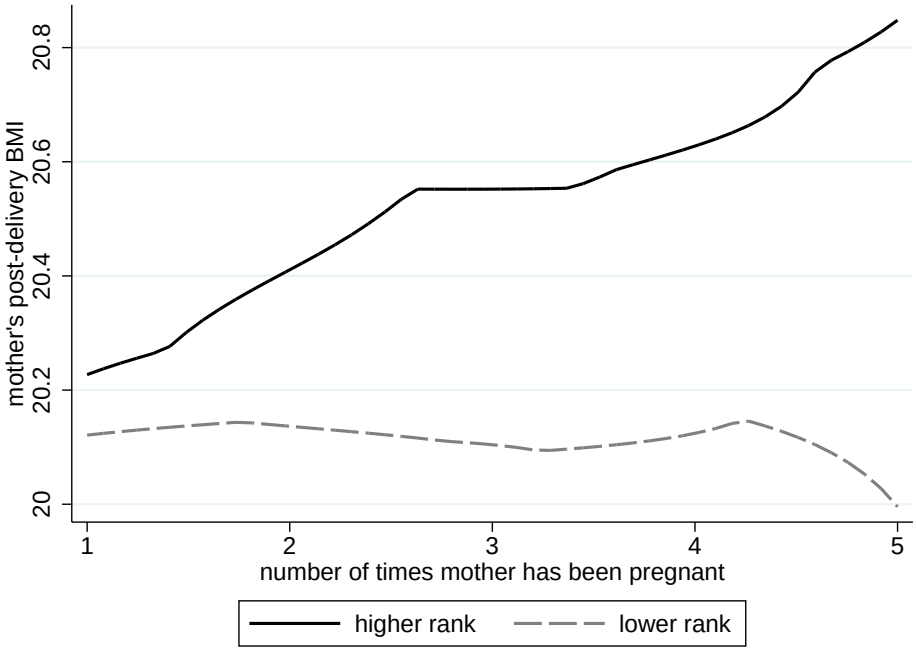


Figure 3.8: Intrahousehold rank and post partum BMI in a district hospital

Data are from the authors' original collection in a district maternity hospital in Uttar Pradesh. Post partum BMI was measured within 36 hours of birth. To match our main sample, data are restricted to women in households with exactly two daughters-in-law; note that because data are collected at the hospital, not in a household survey, household fixed effects cannot be used.

Table 3.1: Balance of nuclear family, child, and pre-marriage characteristics

		Panel A: no time controls			Panel B: with time controls			
	mean	$\hat{\beta}$ low rank	s.e.	t	$\hat{\beta}$ low rank	s.e.	t	n
mother's height (cm)	152.7	0.471	0.379	1.242	0.451	0.495	0.911	1,075
mother's height $< 145cm^{\dagger}$	0.084	-0.022	0.024	-0.909	-0.012	0.034	-0.341	1,075
mother's age at marriage	18.2	0.157	0.231	0.680	-0.241	0.305	-0.792	795
mother married before 18	0.447	-0.036	0.044	-0.818	0.043	0.047	0.930	795
mother no education	0.340	-0.023	0.023	-0.982	0.033	0.032	1.044	1,078
mother secondary education	0.498	0.049	0.026	1.866	0.033	0.037	0.883	1,078
mother literate	0.623	0.017	0.028	0.614	-0.013	0.036	-0.366	1,078
mother native Hindi speaker	0.604	-0.003	0.003	-1.342	0.000	0.004	-0.063	1,078
mother's desired children	2.385	-0.054	0.044	-1.222	0.045	0.057	0.781	1,061
husband's height* (cm)	165.8	0.778	0.561	1.387	1.181	0.961	1.230	408
husband no education	0.127	-0.043	0.020	-2.119	0.019	0.027	0.687	1,075
husband secondary education	0.766	0.033	0.026	1.291	-0.020	0.031	-0.661	1,075
husband years of school	8.31	0.185	0.230	0.806	-0.542	0.317	-1.712	1,064
husband absent for work	0.172	-0.006	0.025	-0.238	0.012	0.032	0.363	1,072
husband works h.h. land, if owned	0.822	0.067	0.054	1.257	0.099	0.067	1.479	353
husband does agricultural work	0.377	-0.023	0.026	-0.880	-0.007	0.038	-0.177	1,073
husband does white collar work	0.067	-0.014	0.013	-1.011	-0.005	0.023	-0.218	1,073
child female	0.458	0.000	0.000	0.522	0.000	0.000	-0.128	1,078
child month of birth	6.84	0.133	0.212	0.627	0.165	0.288	0.574	1,078
child summer birth	0.229	0.023	0.025	0.921	-0.004	0.035	-0.119	1,078

India, 2005 DHS data. Each coefficient $\hat{\beta}$ in Panel B is from a separate regression of the listed variable on an indicator for the lower-ranking mother and household fixed effects. To control for cohort differences and secular time trends, Panel B adds "time controls" for the century-month code month-of-birth of the mother and the child. Standard errors are clustered by survey PSUs. †The India DHS survey manual (2005) uses 145cm as a threshold for low height among adult Indian women. *By design, the DHS measured height only of a subset of adult men.

Table 3.2: Intrahousehold rank predicts reported decision-making "say" within households

dependent variable:	(1) sum	(2) own health	(3) large purchases	(4) daily purchases	(5) visits	(6) money
Panel A: Without control for woman's age						
lower ranking woman	-0.281*	-0.1000**	-0.0154	-0.0825*	-0.00906	-0.0737†
	(0.111)	(0.0363)	(0.0330)	(0.0344)	(0.0332)	(0.0382)
joint household fixed effects	✓	✓	✓	✓	✓	✓
n (daughters-in-law)	1395	1395	1395	1395	1395	1395
Panel B: With control for woman's age						
lower ranking woman	-0.298†	-0.0418	-0.0324	-0.140**	-0.0418	-0.0423
	(0.162)	(0.0542)	(0.0448)	(0.0487)	(0.0493)	(0.0544)
woman's age at the time of the survey	-0.00473	0.0157	-0.00461	-0.0155†	-0.00885	0.00846
	(0.0282)	(0.0107)	(0.00869)	(0.00907)	(0.0105)	(0.0116)
joint household fixed effects	✓	✓	✓	✓	✓	✓
n (daughters-in-law)	1395	1395	1395	1395	1395	1395

India, 2005 DHS data. Standard errors clustered at the PSU level are shown in parentheses. $\dagger p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. For each dependent variable, a woman is said to have "final say" if she says she has final say on her own, or jointly with another family member, most commonly her husband. The dependent variables are: (1) the number of decisions (out of five) in which a woman has final say; (2) a dummy variable for whether she has final say in decisions about her own health; (3) a dummy variable for whether she has final say about large household purchases; (4) a dummy variable for whether she has final say about daily purchases; (5) a dummy variable for whether she has final say about visits to her family/friends; (5) a dummy variable for whether she has final say about how to spend money earned by her husband.

Table 3.3: Main result: Effect of mother's rank on child's height-for-age

	(1)	(2)	(3)	(4)	(5)
dependent variable:	height-for-age z-score, WHO, 2006				
lower ranking mother	0.0144	-0.245*	-0.377**	-0.382**	-0.422**
	(0.108)	(0.102)	(0.133)	(0.136)	(0.159)
mother's age at birth			-0.0241	-0.0177	-0.0102
			(0.0233)	(0.0289)	(0.0391)
mother's height				0.0190	0.0241†
				(0.0143)	(0.0142)
joint household fixed effects	✓	✓	✓	✓	✓
age in months×sex controls		✓	✓	✓	✓
demographic controls			✓	✓	✓
mother specific controls				✓	✓
father specific controls					✓
n (children in joint households)	1078	1078	1078	1075	1069

India, 2005 DHS data. Standard errors clustered at the PSU level are shown in parentheses. $\dagger p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. Controls added by column: (2) age-in-months and sex dummies and their interactions; (3) a dummy for whether the child is first born to her mother, whether she is a single birth, her mother's age at the time of her birth, the child's birth order in the joint household; (4) mother's height, dummy variables for years of education completed by the mother, mother's age at marriage; (5) dummy variables for level of father's education, father's age at the time of the survey.

Table 3.4: Effect of rank on child height only seen in joint, not split, households

dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)
	ln(height in centimeters)					
data source:	IHDS	IHDS	IHDS	IHDS	DHS	DHS
households included:	joint & split	joint	split	joint & split	joint	joint
lower ranking mother	-0.0176*	-0.0368**	0.00228	-0.0345**	-0.0142**	-0.0220**
	(0.00863)	(0.0119)	(0.0127)	(0.0118)	(0.00475)	(0.00475)
lower ranking × is split				0.0370*		
				(0.0170)		
joint household fixed effects	✓	✓	✓	✓	✓	✓
age-in-years × sex	✓	✓	✓	✓	✓	✓
DHS demography controls						✓
n (children)	1,659	984	675	1,659	1,078	1,078

IHDS, 2005 & India DHS, 2005 data. Standard errors clustered at the PSU level are shown in parentheses. $\dagger p < 0.1$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. Columns 5 and 6 use the same sample as our main results in table 3.3. "Joint" households are as defined in our main sample; "split" households are cases where two adult brothers are married with children, but live separately and are recorded as separate households.

Table 3.5: Mother's rank is not associated with early-life medical care

dependent variable:	(1) prenatal care	(2) facility birth	(3) health card	(4) ever vaccinated
Panel A: No controls beyond household fixed effects				
lower rank	0.0588*	0.0697**	0.00366	-0.0117
	(0.0284)	(0.0250)	(0.0248)	(0.0124)
Panel B: Household and year of birth fixed effects				
lower rank	0.0410	0.0665*	-0.0111	-0.00384
	(0.0286)	(0.0261)	(0.0253)	(0.0126)
Panel C: Household wealth gradient in medical care, with state fixed effects				
household wealth index	0.105**	0.232**	0.113**	0.0383*
	(0.0228)	(0.0270)	(0.0322)	(0.0159)
n (births since 2001)	788	1,078	1,076	1,078
sample:	last birth	last 3 births	last 3 births	last 3 births

India, 2005 DHS data. Standard errors clustered at the PSU level are shown in parentheses. $\dagger p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. Each dependent variable is an indicator for the child (or mother in pregnancy) receiving care.

Table 3.6: Effect of mother's rank on body mass index

	(1)	(2)	(3)	(4)
dependent variable:	body mass index (BMI)			
lower ranking mother	-0.362*	-0.345†	-0.439†	-0.401†
	(0.142)	(0.177)	(0.233)	(0.237)
pregnant			1.503**	1.119*
			(0.551)	(0.509)
breast feeding			0.277	
			(0.372)	
age of youngest child			-0.00819	
			(0.0112)	
age of youngest child × breastfeeding				✓
mother's year of birth dummies			✓	✓
dummies for number of children ever born			✓	✓
household fixed effects		✓	✓	✓
n (daughters-in-law)	810	810	804	804

India, 2005 DHS data. Standard errors clustered at the PSU level are shown in parentheses. $\dagger p < 0.1$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. Age of youngest child × breastfeeding is a vector of indicator variables for the age of the woman's youngest child in months interacted with whether or not she is breastfeeding that child.

Table 3.7: Effect of mother's rank on early-life mortality

	(1)	(2)	(3)
dependent variable:	IMR	PNM	NNM
lower ranking mother	28.72†	4.791	26.43*
	(15.44)	(10.51)	(11.03)
girl	-12.08	-5.561	-10.04
	(12.72)	(8.981)	(9.804)
year of birth fixed effects	✓	✓	✓
constant	61.05	12.19	52.03
	(39.35)	(20.47)	(33.76)
n (live births in the last 10 years)	3,227	3,095	3,703

India, 2005 DHS data. The dependent variable is an indicator for child death, scaled to 0 or 1000 for comparability to published mortality rates. IMR = infant mortality rate (first 12 months); NNM = neonatal mortality rate (first month); PNM = post-neonatal mortality rate (months 2-12). Standard errors are clustered at the PSU level are shown in parentheses. $\dagger p < 0.1$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

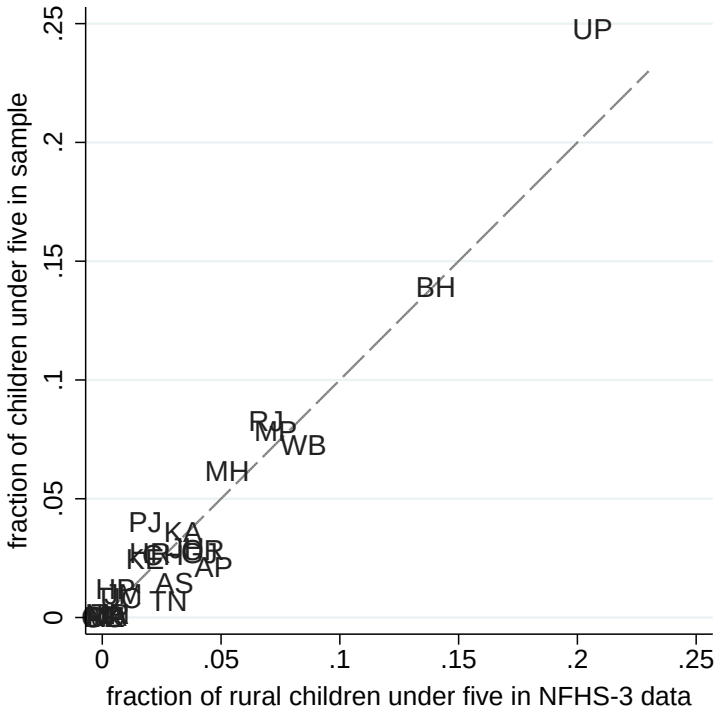


Figure 3.9: Fraction of rural children under 5 in each Indian state, and the fraction of those children in our sample

India, 2005 DHS data.

Table 3.8: Fraction of rural households and children under five in three DHS surveys living in joint households

	households			children under five		
	DHS 1993	DHS 1999	DHS 2005	DHS 1993	DHS 1999	DHS 2005
no daughters-in-law	0.771	0.788	0.812	0.664	0.645	0.678
one daughter-in-law	0.171	0.160	0.149	0.204	0.225	0.213
two daughters-in-law	0.045	0.040	0.031	0.091	0.092	0.082
more than two daughters-in-law	0.014	0.012	0.007	0.041	0.039	0.027

India, 1993, 1999 & 2005 data. Uses survey weights.

Table 3.9: Comparison of joint rural households with two daughters-in-law and other households in rural India

	(1) rural households with two daughters-in-law	(2) other households in rural India	(3) p-value (2) - (1) = 0*
Panel A: Characteristics of households			
household asset count (out of 19 assets)	6.9	4.5	0.00
household practices open defecation	0.66	0.74	0.00
household has electricity	0.63	0.56	0.00
household head is general caste	0.28	0.25	0.04
household head is other backward caste	0.50	0.42	0.00
household head is scheduled caste	0.16	0.22	0.00
household head is scheduled tribe	0.06	0.12	0.00
household head is Hindu	0.84	0.83	0.58
household head is Muslim	0.11	0.11	0.60
Panel B: Characteristics of children under five			
average height** of 0-11 month old children in the household	-0.99	-0.98	0.92
average age in months of 0-11 month old children in the household	5.76	5.88	0.50
average height of 12-23 month old children in the household	-1.87	-2.15	0.00
average age in months of 12-23 month old children in the household	17.20	17.41	0.28
average height of 24-59 month old children in the household	-2.09	-2.24	0.01
average age in months of 24-59 month old children in the household	40.66	41.60	0.02

India, 2005 DHS data. Uses survey weights. *F-statistic from a Wald test of a difference in means which uses survey weights. **Height-for-age z-score, WHO 2006.

Table 3.10: Heights of adult brothers, in centimeters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
included ages:	all ages	over 22	over 22	over 20	over 20	over 20	over 20
year of birth FEs	✓	✓		✓		✓	
household FEs						✓	✓
Panel A: Adult brothers living in joint households							
older brother	-0.248*	-0.393*	-0.416*	-0.429**	-0.444**	-0.208	-0.147
	(0.121)	(0.164)	(0.162)	(0.141)	(0.139)	(0.236)	(0.211)
age (linear)			-0.00815		-0.00950		-0.0371
			(0.0179)		(0.0153)		(0.0345)
n (adult men)	9,939	5,292	5,292	6,770	6,770	6,770	6,770
Panel B: Adult brothers living in joint households, with a child							
older brother	-0.538	-0.477	-0.537	-0.499	-0.524	-0.563	-0.425
	(0.365)	(0.369)	(0.362)	(0.367)	(0.359)	(0.675)	(0.658)
age (linear)			0.00799		0.0116		0.0331
			(0.0293)		(0.0285)		(0.0900)
n (adult men)	1,388	1,347	1,347	1,381	1,381	1,381	1,381
Panel C: Adult brothers living in joint households, with a child under 5							
older brother	-0.466	-0.383	-0.362	-0.415	-0.350	-1.017	-1.675
	(0.427)	(0.434)	(0.420)	(0.429)	(0.414)	(0.861)	(1.047)
age (linear)			-0.00665		0.000352		0.258
			(0.0423)		(0.0403)		(0.185)
n (adult men)	1,029	988	988	1,022	1,022	1,022	1,022

The dependent variable is height in centimeters. Data are from the men's recode of the India DHS, 2005. Standard errors clustered by survey PSU. Two-sided p-values: $\dagger p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 3.11: No effect of mother's intrahousehold rank in south India

	(1)	(2)	(3)	(4)
dependent variable:	height-for-age z-score, WHO 2006			
sample:	south only	non-south only	full sample	full sample
rank	0.113	-0.275*	-0.282**	-0.324**
	(0.280)	(0.108)	(0.107)	(0.109)
rank × south			0.457	0.593†
			(0.363)	(0.358)
interaction p-value			$p = 0.209$	$p = 0.098$
household FEs	✓	✓	✓	✓
age-in-months × sex	✓	✓	✓	✓
mother's height				✓
n	97	981	1,078	1,075

India, 2005 DHS data. Standard errors clustered at the PSU level are shown in parentheses. $\dagger p < 0.1$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. The sample is the same as our main sample in table 3.3. "South" is operationalized as Andhra Pradesh, Karnataka, Goa, Kerala, and Tamil Nadu.

Table 3.12: Rank among brothers is never mentioned in advertisements about grooms seeking brides

		Banerjee et al. (2009)
characteristic:	Uttar Pradesh	Table C4
rank among brothers	0	not discussed
number of brothers	0	not discussed
number of siblings	0	not discussed
age	1.00	0.98
religion	1.00	1.00
caste	1.00	0.97
education	0.93	0.78
height	0.91	0.90
type of job	0.88	0.61
income	0.44	0.22
appearance	0.28	
language	0.02	
n	148	8,038

We cataloged 148 advertisements, randomly selected from 5 newspapers in Uttar Pradesh, describing grooms seeking brides for arranged marriage.

Chapter 4

Early life mortality and height in Indian states

[a version of this chapter is published in *Economics & Human Biology*, doi:10.1016/j.ehb.2014.10.003]

4.1 Introduction

Economists have often used height as a measure of human development. Recent research has documented important relationships between height and survival, height and cognitive achievement, and height and productivity.[1] The importance of height as a measure of population health and well-being has led to the question: what determines height?

Several studies have used data from Europe to establish correlations between height and early life conditions, as captured by mortality levels in infancy (Schmidt et al., 1995; Crimmins and Finch, 2006; Bozzoli et al., 2009; Hatton, 2011, 2013). Postneonatal mortality (PNM), the number of infants per 1000 live births who die between the first and the twelfth months of life, emerges as a strong predictor of height. In these studies, postneonatal mortality is understood to proxy for the disease environment to which infants are exposed. Infants exposed to more disease early in life experience poor growth, leaving them stunted. In Bozzoli et al. (2009), neonatal mortality (NNM), which was largely determined by the

[1] See Jousilahti et al. (2000); Spears (2012b); Case and Paxson (2008) and Vogl (2011).

availability of advanced medical care for neonates, had no correlation with adult heights in European and American cohorts born from 1950-1980, controlling for other factors.

As in developed countries, height in developing countries is determined in large part by early life conditions, especially from conception to two years of age, but these conditions tend to be more varied, and more damaging than in developed countries. Also as in developed countries, the disease environment is likely an important determinant of height, but other factors, such as economic well-being and pre-natal nutrition may play a more important role in developing countries than in developed ones.

This paper examines correlates of height in India, a large developing country with one of the shortest populations in the world, and with significant differences in health outcomes across states (Deaton, 2008; Dréze and Sen, 1997). It finds that state level variation in mortality levels from a cohort's infancy predict both the heights of Indian adults born between 1970 and 1983, and the heights of Indian children born between 1995 and 2005. Consistent with prior literature on mortality and the disease environment, I find that state level variation in pre-adult mortality and postneonatal mortality correlate with adult height and child height, respectively. A novel finding of the paper is that, in contrast to in developed countries, neonatal mortality, or mortality between birth and one month of life, is a robust predictor of height in India. This is true both for adults born between 1970 and 1983, and for children born between 1995 and 2005.

The relationship between state level neonatal mortality and height is robust to controlling for postneonatal mortality, which proxies for the disease environment, as well as economic circumstances, measured by state domestic product, in the case of the adults, and household asset wealth, in the case of the children. Unlike in literature on the correlates of height from developed countries, but consistent with prior research on height in developing countries, I find that these measures of economic well-being indeed predict height (Steckel, 1983). Regressions of children's height on early life mortality rates also control for mother's

height, suggesting that there is not a spurious correlation between mortality in the state where a baby is born and her genetic height potential.

The finding that state level variation in neonatal mortality predicts Indians' heights raises the question: for what early life conditions that shape height does neonatal mortality proxy? I review the literature and existing cause of death data and propose that low birth weight, caused by poor pre-natal nutrition, could be driving the correlation between neonatal mortality and height. Vital statistics data suggest that low birth weight has long been, and continues to be, a leading cause of neonatal mortality in India. Indeed, UNICEF & WHO (2004) estimate that about a third of infants in India are born at a low birth weight, and that India is home to forty percent of the world's low birth weight babies. Although no representative state or national-level data on birth weight exist, the National Family Health Survey data reveal important differences in women's nutrition across Indian states.

These findings are important for researchers seeking to understand why, despite its high rates of economic growth, India continues to have one of the shortest populations in the world. Although Indians' heights are certainly determined by many factors,[2] these findings suggest that continuing neglect of women's health, and in particular pre-natal nutrition, will have continuing consequences for heights in India, and for all of the health and human development indicators that height reflects.

The paper proceeds as follow: section 4.2 provides contextual information on the early life determinants of height in developed and developing countries, as well as on causes of early life mortality in India. Section 4.3 presents the data sources and modeling strategy. Section 4.4 presents the results of three analyses: the first regresses the heights of adult cohorts born between 1970 and 1983 in different states of India on neonatal and postneonatal

[2]Spears (2013) finds that the Africa-India height gap can be statistically explained by Indians' early life exposure to poor sanitary conditions measured by open defecation, and Jayachandran and Pande (2013) focus on inequality among siblings of different sexes and birth orders. Osmani and Sen (2003) discuss the interactions of low birth weight and infection in producing child undernutrition.

mortality rates in their years of birth; the second regresses the heights of these adults on pre-adult mortality rates in their year of birth; and the third regresses the height-for-age z-scores of individual children from two rounds of India's Demographic and Health Survey on state-survey round level measures of neonatal and postneonatal mortality. Section 4.5 discusses the results, as well as the hypothesis that variation in neonatal mortality proxies for state level variation in maternal net nutrition. Section 4.6 concludes.

4.2 Context

4.2.1 Early life determinants of height in developed countries

In Europe, the relationships between height and the early life environment have been examined in the context of select groups, as well as at the population level. Schmidt et al. (1995) document a relationship between the adult heights of men who were conscripted in European armies and postneonatal mortality in the year of birth. Bozzoli et al. (2009) provide evidence for a similar relationship in the general populations of European countries and the United States for cohorts born between 1950 and 1980. They show that the relationship between adult height and postneonatal mortality is robust to a variety of controls, including neonatal mortality, log of GDP in the cohort's year and country of birth, and country and year fixed effects. Hatton (2011) finds a robust correlation between the heights of school children born between 1910 and 1950 in Britain and the infant mortality rates that prevailed when those children were between two and four years old.

All three of these papers posit that the mechanism linking height and early life mortality is the disease environment in early childhood. In Bozzoli et al. (2009), postneonatal deaths from pneumonia and diarrhea, diseases which are known to lead to stunting in childhood, correlate with adult heights, though death rates from pneumonia predict heights more strongly. None of the papers finds evidence of an effect of neonatal mortality on adult heights.

In these contexts, one would not expect adult height to be strongly influenced by factors determining neonatal mortality. Whereas in developing countries, temporal or regional differences in neonatal mortality might be due to variation in maternal nutritional deprivation during pregnancy, in developed countries, differences in the availability of life saving technology for premature infants would play a far more important role. Research on the relationship between maternal nutrition and infant outcomes in developed countries tends to focus on overweight and obese women, rather than on undernourished women.

Bozzoli et al. (2009) test for but do not find evidence of an effect of income on adult heights in Europe. The authors remind readers that their results do not rule out income or nutrition related constraints on adult heights for Western cohorts born pre-1950, nor do they rule out such a constraint on adult height in developing countries.

4.2.2 Early life determinants of height in developing countries

Silventoinen (2003) posits that the determinants of variation in height are different in developed and developing countries, and in particular, that compared to developed country settings, environmental variation (as opposed to genetic variation) in height is relatively large. This is because environmental insults to childhood growth are more severe in developing countries.[3]

Many factors determine heights in developing country and pre-industrial settings, and higher levels of development do not always lead to growth in physical stature (Komlos, 1998, 2003). However, at low levels of development, additional income may influence height through increasing calorie intake or the quality of the diet. Fogel (2004) discusses relationships between income, calorie availability and body size. In particular, Fogel proposes a "technophysio evolution" of body size corresponding with calorie availability, which in many contexts increases when income increases. The importance of shocks to income and

[3]Indeed, Spears (2013) shows that the correlation between mothers' heights and children's heights are lower in India and sub-Saharan Africa than in the United States.

nutrition as determinants of early life height and health have also been demonstrated in developing country settings (Maccini and Yang, 2009; Bhalotra, 2010).

Empirical evidence suggests that the early life disease environment influences height in impoverished settings. Akachi and Canning (2010) find that with the exception of sub-Saharan Africa, where the authors hypothesize that improvements in infant mortality have not been importantly due to reductions in morbidity, changes in adult heights correlate with changes in infant mortality rates in developing regions. Using data from three European populations in the 1800s, Crimmins and Finch (2006) find relationships between adult height and pre-adult mortality[4] measured when a cohort was a year old. Additionally, Spears (2013) suggests that sanitation coverage, a measure of the fecal pathogens to which a child is exposed, is a strong predictor of children's heights in modern developing countries.

Finally, pre-natal conditions may also contribute to stunting in situations of scarcity. There is substantial evidence that maternal nutrition promotes birth weight in developing countries (Kusin et al., 1993), and that birth weight is an important predictor of height (Binkin et al., 1988; Adair, 2007). A longitudinal study from Brazil finds that low birth weight is correlated with low pre-pregnancy weight (Barros et al., 1992). Kramer (1987) reviews the literature on birth weight, and concludes that, in addition to low pre-pregnancy weight, low weight gain during pregnancy additionally correlates with low birth weights in developing countries. Hytten (1979) discusses this relationship in the context of food supplements in pregnancy, which increase birth weights where women are undernourished.

Adair (2007) establishes links between birth size and adult height in a sample from the Philippines. Binkin et al. (1988) show that two causes of low birth weight–intrauterine growth retardation and prematurity–are both associated with low adult heights, though the relationship is stronger for intrauterine growth retarded infants than for premature

[4]The measures included ${}_5q_0$, ${}_5q_5$ and ${}_5q_{10}$. These are the probability of dying between the ages of 0 and 5, between 5 and 10, and 10 and 15 years old respectively.

infants.[5] Behrman and Rosenzweig (2004) show that differences in birth weight between identical twins predicts differences in height. Finally, Kusin et al. (1992) present experimental evidence from Indonesia that supplementation during pregnancy improves postnatal growth–that is, growth from age zero to age five. These findings are particularly important for India, where discrimination against women of child-bearing age, even in food consumption, is well documented (Jeffery et al., 1988; Das Gupta, 1995; Palriwala, 1993).

4.2.3 Causes of early life mortality in India

Cause of death data help identify those early life conditions that both kill children and stunt their growth, and those causes of death that are unlikely to also be, or to proxy for, major determinants of height. What are the leading causes of early life mortality in India?

Table 4.1 summarizes the results of the Million Deaths study, a national study of cause of death that was conducted in 2005 (Million Death Collaborators, 2010). Prematurity/low birth weight was the second leading cause of death at all ages and the leading cause of neonatal mortality, responsible for over a third of neonatal deaths. Neonatal infection was the second leading cause of neonatal death; according to Million Death Collaborators (2010), neonatal infection comprises neonatal pneumonia, septicemia and meningitis. Birth asphxia and trauma are the third cause of neonatal death. Together these three causes account for about 80% of neonatal death. Table 4.1 also shows cause of death for children between 1 and 59 months of life. The leading causes of child mortality are pneumonia and diarrheal diseases. A number of other infectious diseases comprise a large fraction of the remaining child mortality.

Among these causes of early life mortality, which reflect conditions that would also affect height? As outlined in section 4.2.2, there is clear evidence that low birth weight is importantly caused by poor pre-natal nutrition, which is prevalent in India, and which

[5] Villar and Belizán (1982) provide evidence that the relative contribution of intrauterine growth retardation to low birth weights is greater in developing countries than in developed ones.

also affects child and adult height. We would not expect birth asphyxia and trauma to cause stunting later in life. The extent to which the neonatal infections identified by the Million Deaths Study as important causes of death affect height is unclear. These infections are likely to be fast-acting, and are typically acquired before or during birth, or shortly thereafter (Duke, 2005).[6] While these early infections may have consequences for the heights of children who survive them, there is little evidence to suggest that they sap energy for growth in the way that postneonatal infections like respiratory and gastrointestinal infections do. In contrast, there is clear evidence that both respiratory and gastrointestinal infections impact height. Victora et al. (1990) and Bozzoli et al. (2009) find evidence that respiratory infections such as pneumonia stunt height, and Checkley et al. (2008) discuss the role of diarrheal disease in stunting.[7]

Because neonatal mortality is a particular focus on this paper, it would be useful to know whether the major causes of neonatal death in the 1970s and early 1980s were the same as in 2005, when the Million Deaths study was conducted. This is a difficult question to answer precisely due to lack of high quality cause of death data from this period. However, a cause of death study conducted by the Office of the Registrar General (ORG) in major Indian states in 1978 found that tetanus was the most common cause of neonatal mortality (Government of India, 1979). In contrast, the Million Deaths Study of 2010 found a death rate from neonatal tetanus of only 1.2 per 1000 live births. This suggests that the importance of neonatal tetanus has declined dramatically between the time in which the adults studied here were infants, and when the children studied here were infants.

Despite the importance of neonatal tetanus in determining the mortality rates for the adult cohorts I study, it is unlikely to have been an important cause of their stunting. In the

[6]Indeed, in a 1996-2003 trial of home based neonatal sepsis management in Maharastra, India, researchers found that over four fifths of deaths from neonatal sepsis occurred in the first week of life (Bang et al., 2005).

[7]More recently, research has focused on environmental enteropathy (Korpe and Petri, 2012; Humphrey, 2009; Spears, 2013), which although not a main cause of mortality, may be another important cause of stunting.

1970s and 80s, fatality from neonatal tetanus would have been extremely high. UNICEF (2011) reports that fatality rates from untreated neonatal tetanus can be as high as 100%, and Sokal et al. (1988) report on a study from Côte d'Ivoire estimates a fatality rate from neonatal tetanus of 90%. If nearly all children who suffered from tetanus died of it, it is unlikely to have been a major cause of stunting.

The 1978 ORG study suggests that low birth weight/prematurity was the second most important cause of neonatal death during the period in which the adults studied in this paper were infants (Government of India, 1979).[8] This cause of death likely reflects conditions of poor pre-natal nutrition that would have also played an important role in determining heights. The correlation between adult height and neonatal mortality that will be discussed in section 4.4 may reflect statewise variation in pre-natal nutrition when these adults were *in utero*, a hypothesis which will be discussed further in section 4.5.

4.3 Data & modeling approach

4.3.1 Data sources & descriptive statistics

Adult analyses

Mortality indicators. Mortality indicators from the 1970s and 1980s used for the analysis of adult heights come from the Sample Registration System (SRS), a vital statistics system run by the Office of the Registrar General at the Indian Ministry of Home Affairs. Trained SRS enumerators register vital events in sample localities in order to estimate demographic rates at the state and national levels. The SRS data cover the 17 major Indian states;[9] data

[8]Only "prematurity" was listed as a cause of death in this study, birth weight was not specifically mentioned. However, it is unlikely that this survey accounted for pregnancy length, or that women even knew the precise length of their pregnancies. Thus, any low birth weight infant who did not die from another obvious cause might have been said to have died from "prematurity."

[9]The SRS reports NNM, PNM, IMR, and other mortality rates for each year between 1970 and 1983 in the following states: Andhra Pradesh, Assam, Gujarat, Harayana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharastra, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh. There is no data for union territories in the SRS.

are available beginning in 1970. Data from the small northeastern states are missing from the SRS.[10] Bihar, Jammu & Kashmir and Punjab also have missing data: data from Bihar are missing from 1970-1980; data from Jammu & Kashmir are missing from 1970-1971; and data from Punjab are missing from 1970. Government of India (1968) and Bhat et al. (1984) provide detailed information about the SRS.

Height. Data on adult height are taken from two nationally representative surveys, the National Family Health Survey 2 (NFHS 2), which collected data on the heights of adult women in 1998-1999, and the National Family Health Survey 3 (NFHS 3), which collected data on the heights of adult men and women in 2004-2005. The analysis of adult heights includes only individuals aged 22 and older at the time that their heights were measured. The age of 22 was chosen because Deaton (2008) finds that men and women in India do not reach their adult heights until their early 20s. Since the SRS began measuring mortality in 1970, I have included in the sample women measured in the NFHS 2 and born between 1970 and 1977, as well as men and women measured in NFHS 3 and born between 1970 and 1983.

When matching the heights of individuals measured in NFHS 3 to the SRS data, it is necessary to account for the fact that some state boundaries changed between 1970 and 2005. NFHS 3 height from both Uttarkhand and Uttar Pradesh are matched with SRS data for Uttar Pradesh. Similarly, Bihar and Jharkhand, and for Chattisgarh and Madhya Pradesh.

Control variables. For the analysis using adult heights, controls for state level income from the 1970s and 1980s come from the Economic & Political Weekly (EPW) Research Foundation, which produced an annual series of net domestic product by state, at 1970

[10]These states are: Sikkim, which had previously been a British protectorate and was founded in 1975; Tripura, Meghalaya and Manipur, all of which were founded in 1972; Arunchal Pradesh, which was formed as a union territory out of Assam in 1972, and became state in 1987. An early report on the SRS from the Office of the Registrar General suggests that data from the region that became the union territory of Arunchal Pradesh were not included in the Assam estimates from 1970-1972. Together, these omitted states made up less than 1% of the population of India in the 2011 census.

prices, for the period from 1970-1983. The EPW Research Foundation (2009) explains that net state domestic product is "the totality of commodities and services produced during a given period of time within the geographical boundary of the state in monetary terms counted without duplication" (175). State net domestic product per capita does not include, for example, remittance income from migrants working outside the state. The EPW series has complete information on Indian states during the time period of interest.

The analyses using data on the heights of adults additionally control for whether the state is in the north, as well as for survey round and year of birth.

Summary statistics. Figure 4.1 presents summary statistics that reveal large variation at the state level in early life mortality rates during the period from 1970 to 1983, but figure 4.2 shows that there was much less variation in mortality rates over time during this period. Figure 4.1 shows the average neonatal and postneonatal mortality rates in each state from the period of 1970-1983, and figure 4.2 shows the national time trends for neonatal and postneonatal mortality. National neonatal mortality changed very little, from 75 deaths per thousand to about 70. Decline in postneonatal mortality, from about 65 to about 38, was responsible for much of the national decline in infant mortality.[11]

Child analyses

Mortality indicators. In the child level analysis, I compute neonatal and postneonatal mortality from the National Family Health Surveys (NFHS) at the state-survey round levels. I use children born in the three years before the survey in order to compute these measures. A child, whether dead or alive at the time of the survey, is included in the computation of neonatal mortality only if at least a month has passed since his birth. Likewise, a child is used in the computation of postneonatal mortality only if at least a

[11]Deaton (2006) points out that child mortality (a large fraction of which is infant mortality) was much higher in India than in neighboring China during this period, and that the decline in child mortality was much slower.

year has passed since his birth. I scale the fraction of children who died by 1000 to allow for a simple interpretation of the coefficients.

Height. Height-for-age z-scores of children under three years of age are the dependent variable. z-scores provide a measure of the heights of children relative to a healthy population. These scores were computed based on the WHO 2006 growth reference standards (De Onis, 2006).[12] For children in NFHS 3, scores are provided in the published data; for children in the NFHS 2, scores were computed based on child sex, age and height in centimeters using WHO Anthro software (WHO, 2011).

Control variables. All specifications include a vector of controls for the age-in-months of the child. Controls for economic well-being include a vector of dummy variables for ownership of household assets, including whether or not the child's household owns a radio, a TV, a fridge, a bicycle, a motorcycle, a car, whether the household has electricity, and the household's drinking water source. A control for mother's height, a measure of the child's genetic potential, is also included.

Summary statistics. Figure 4.3 presents summary statistics of the state level neonatal and postneonatal mortality rates used in the child level analysis. The Indian states shown in figure 4.3 are ordered by their neonatal mortality rates form the NFHS 2, which range from approximately 13 in Kerala, to over 50 in Madhya Pradesh. When using the NFHS 3 data for this figure, and for all the following analyses, I merge data for the states that split between 1998 and 2005 into the state that existed in 1998. Therefore, Jharkhand and Bihar are represented by Bihar, Chattisgarh and Madhya Pradesh are represented by Madhya Pradesh, and Uttarkhand and Uttar Pradesh are represented by Uttar Pradesh.

[12]For more on using the WHO 2006 charts in the Indian context, see Tarozzi (2008).

4.3.2 Modeling approach

Stunting and selection

Research that correlates early childhood mortality rates with height often interprets mortality rates as a measure of the force or burden of disease in a population. However, the effect of disease burdens in childhood on heights may not always be monotonic. Preston et al. (1998), Bozzoli et al. (2009) and Hatton (2011) recognize that high disease burdens could cause both selection and stunting of survivors. Where there is selection, healthier (taller) members of a cohort survive childhood; where there is stunting, adult heights are lower than their genetic potential because energy is spent fighting disease rather than growing during formative years. Thus selection and stunting could produce offsetting effects on height. Bozzoli et al. (2009) develop a model of the joint effects of selection and stunting on population heights. They predict that, at a given high level of infant mortality, the selection effect may dominate stunting such that the adults of a cohort which experienced a very high disease burden in infancy may be taller than a cohort which experienced a slightly lower disease burden. Although they derive this result theoretically, clear evidence for the existence of a "turning point" is lacking.[13]

In the Indian data, however, there is no evidence of a "selection effect." Figure 4.4 shows a scatter plot (separately for men and women) of the relationship between the infant mortality rate to which a state cohort born between 1970 and 1983 was exposed in its year of birth, and the average height of the adults in that state cohort. Although there is a negative relationship between infant mortality and height, figure 4.4 shows no visible

[13]There is a notable exception to this statement, though the infant mortality rates required to produce a "turning point" are outside the range of most modern human experience. Gørgens et al. (2012) find that the adult heights of people who were children during the Great Chinese Famine (1959-1961), during which mortality rates were estimated to be about 200 per 1000 (Ashton et al., 1984), are no different than the heights of cohorts born just before or just after the famine. The heights of their children, however, are taller than the children of cohorts born just before, or just after the famine. The authors interpret this as evidence that those who survived the famine were selected on the basis of their health, that is, that they had the genetic potential to be tall. However, this genetic potential was not realized due to famine conditions in infancy and childhood, which stunted them.

reversal, or flattening out, of the stunting effect at high levels of infant mortality. If a quadratic function is nonetheless fitted to the data in figure 4.4, the coefficient on the quadratic term, though positive, is not statistically significant. The turning points would be at 262 for men and 212 for women. These numbers are not beyond the realm of human experience, but they are far extrapolations of the relationships in these data. Finally, Alderman et al. (2011) assess the magnitude of the bias in Indian children's heights that might be due to selection, and find that the effect is likely small. Therefore, this paper models the relationships between heights and mortality using only linear terms throughout.

Men and women

The heights of Indian men and women should be modeled separately for several reasons. First, sex ratios differ substantially across time and place (Bhat, 2003). Second, it is likely that somewhat different processes determine the heights of men and women. Sex discrimination in the allocation of nutrition and health in early childhood has been well-documented (see Behrman (1988), Borooah (2004) and Pande (2003)). These differences in early life conditions could lead different determinants of height to be more important for one sex than the other. Indeed, Deaton (2008) shows that there have been different trends in men's and women's heights in India from the 1960s to 2005: men have grown at about three times the rate of women. Finally, Barcellos et al. (2014) show that compared to children in other developing countries, boys in rural India have an advantage in height relative to girls.

4.4 Results

4.4.1 Neonatal mortality, postneonatal mortality & adult height

I use ordinary least squares (OLS) regression to estimate the association between early life mortality and the mean heights of adult cohorts. The variation exploited in this analysis

comes primarily from large variation in mortality across states. While other papers that have looked at the relationship between measures of early life conditions and adult height have done so during a period of declining infant mortality, and have found effects of mortality on adult height controlling for year, for region, or both, the meager declines in infant mortality in India during the periods under study mean that the conclusions presented here are based almost entirely on variation in mortality across the states. Thus, the relationships are not robust to including state fixed effects. The relationship between adult height and neonatal mortality is robust to controls for state net domestic product per capita and a fixed effect for being a northern state.

Table 4.2 presents the results of twelve regressions of similar form. Panel A presents the results for women and panel B presents the results for men. Column 1 shows the results of regressions of height on neonatal mortality, and column 2 regresses adult height on postneonatal mortality. Columns 3 through 6 introduce controls to demonstrate the robustness of the association between adult height and neonatal mortality.

The regression equation which corresponds to column 6 of panel A of table 4.2 is:

$$\begin{aligned} mean\,height_{rys} &= \beta_0 + \beta_1 NNM_{ys} + \beta_2 PNM_{ys} + \beta_3 ln(SDP)_{ys} + \\ &\quad \beta_4 north_s + \alpha_y + \phi_r + \epsilon_{rys}, \end{aligned} \tag{4.1}$$

where $mean\,height_{rys}$ is the mean height of the cohort of women measured in survey round r, born in year y and residing in state s at the time they were surveyed. Since the NFHS does not have information on the state of birth, all of the specifications assume that the state of residence at the time of the survey is the state of birth. The assumption is likely unproblematic for the analysis; Munshi and Rosenzweig (2009) point out that India has very low rates of mobility compared to other developing countries. Though women are more mobile than men due to migration for marriage, cultural and linguistic differences across states make inter-state marriage relatively rare. Moreover, Tripathi and Srivastra (2011)

cite a figure from the 2001 census identifying 41 million Indians as inter-state migrants. This is less than 4% of the 2001 population.

NNM_{ys} is the neonatal mortality rate in state s in year y, and PNM_{ys} is the post-neonatal mortality rate. $ln(SDP)_{ys}$ is the log of the net state domestic product per capita for state s in year y. $north_{ys}$ is a dummy variable that controls for possible spurious correlation between neonatal mortality and region.[14] Deaton (2008) finds that in northern states the difference between men's and women's heights is greater than in southern states. α_y is a fixed effect for year of birth.

ϕ_r is a fixed effect for survey round, which is equal to one if the height data for cohort ys was taken from the NFHS 3. Deaton and Drèze (2009) have documented a systematic difference in the heights of women between the two rounds of the survey; the same cohorts are about 0.5 centimeters taller when measured in NFHS 3. The fixed effect for survey round is only used in regressions in which the dependent variable is women's heights because men's heights were not measured in NFHS 2.

Standard errors were clustered at the state level. However, due to concern about the small number of clusters (there are 17 states), wild-cluster bootstrap t p-values, as suggested by Cameron et al. (2008), are additionally shown for the coefficients on NNM_{ys} in each of the regressions. These regression results are unweighted, but weighting by the number of observations that were used to calculate the mean of heights does not change any of the main conclusions.

Column 1 of table 4.2 shows the results of a regression of adult height on neonatal mortality in the year of birth. The coefficient on neonatal mortality is negative and statistically significant. Column 2 of table 4.2 shows the results of a regression of adult height on postneonatal mortality. The coefficient on postneonatal mortality is negative, but not

[14]The following states are coded as northern states: Jammu & Kashmir, Himachal Pradesh, Punjab, Harayana, Rajasthan, Uttar Pradesh, Bihar, Assam, West Bengal, Orissa, Madhya Pradesh and Gujarat. Not included among the northern states are Maharastra, Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.

statistically significant for either men or women. Columns 3-6 of table 4.2 show regressions that include both neonatal and postneonatal mortality, and controls for income, region, year of birth and survey round. Again, it is neonatal mortality that has a robust and statistically significant association with adult heights.

The magnitudes of the coefficients on neonatal mortality in columns 3-6 are similar for men and women; they are about -0.04. This suggests that a 20 per thousand reduction in neonatal mortality is associated with a 0.8 centimeter difference in the mean heights of state cohorts.

These findings differ from the findings of papers using developed country data on adult heights and early life mortality in two ways. First, this paper finds that *neonatal mortality* is a strong predictor of adults heights. Second, it finds that net domestic product is a significant predictor of adult height, even controlling for postneonatal mortality. The coefficient on state net domestic product per capita in column 6 suggests that a 10 percent difference in state net domestic product per capita is associated with a 0.17 centimeter difference in average women's heights, and a 0.27 centimeter difference in average men's heights. This suggests that the difference in the rates of change of men's and women's heights in India, documented by Deaton (2008), might be in part explained by an associate between material resources and men's heights that is different from the association between material resources and women's heights.

The lack of a statistically significant relationship between adult heights and postneonatal mortality in these data is puzzling, and raises a potential issue of data quality, since it is likely that the early life disease environment likely mattered for determining heights in this context. Therefore, it is probably not appropriate to interpret this lack of relationship as evidence that the disease environment in early life did not affect adult heights in this context. Indeed, Bozzoli et al. (2009) have suggested that postneonatal mortality may be an incomplete measure of the disease environment in poor country settings. They suggest using measures of pre-adult mortality, which provide more complete information on the

disease environment because they measure mortality between the ages of 0 and 15 in the cohort's year of birth. The following section presents the relationship between pre-adult mortality and adult height. There are indeed statistically significant relationship between pre-adult mortality and adult height.

4.4.2 Pre-adult mortality & adult height

Table 4.3 reports the results of OLS regressions of adult heights of state cohorts born in India between 1970 and 1983 on levels of pre-adult mortality to which they were exposed in their first year of life. Each panel of columns 1 and 2 of table 4.3 presents the results of six regressions. The coefficients reported for each of the ${}_nm_x$ in column 1 of panel A are the $\hat{\beta}_1$ from regressions of the form:

$$meanheight_{ysr} = \beta_0 + \beta_1({}_nm_x)_{ys} + \phi_r + \epsilon_{ysr}. \tag{4.2}$$

The coefficients in column 2 are generated using the same procedure, but controls are added for log of net state domestic product per capita, northern region, and year fixed effects. Standard errors, clustered at the state level, are shown in parentheses. Each of the mortality rates has a statistically significant effect on adult heights in both the uncontrolled and the controlled regressions.[15]

Columns 3-6 of table 4.3 present the results of regressions that include the three mortality rates in the same regression. Due to multicollinearity of the three ${}_nm_x$ measures, one would not expect the individual coefficients on the ${}_nm_x$ measures to remain statistically significant in this analysis, and they do not. However, the coefficients on the ${}_nm_x$ measures are of the anticipated sign and the p values of F tests for the joint significance of ${}_5m_0$, ${}_5m_5$ and ${}_5m_{10}$ show that the variables are jointly significant for all of the regressions.

[15]That the magnitude of the coefficients on ${}_5m_{10}$ is so much greater than those on ${}_5m_0$ is likely due, in large part, to a mechanical relationship resulting from the fact that values for ${}_5m_0$ are about 20 times the size of values of ${}_5m_{10}$.

It is noteworthy that, using data from the 1800s in Europe, Crimmins and Finch (2006) present the results of regressions similar to those in column 3 of table 4.3. They use the probability of dying, ${}_nq_x$, rather than mortality rates, ${}_nm_x$. When the ${}_nm_x$ values in this analysis are converted to ${}_nq_x$ values, assuming a constant death rate in the age interval, the magnitudes of the coefficients on the regressors in column 3 are consistent with the magnitudes of the coefficients estimated by Crimmins and Finch (2006).

This analysis finds that each of the measures of pre-adult mortality individually correlates with mean adult height for both men and women, and the rates are jointly significant in regressions containing all three rates. If pre-adult mortality is indeed measuring variation in the disease environment, then these regressions suggest that the disease environment was an important determining factor of adult heights in India.

4.4.3 Neonatal mortality, postneonatal mortality & children's height

Height is largely set quite early in life (Schmidt et al., 1995), so relationships between child height and early life mortality can be used to explore the likely determinants of the heights of the next generation of Indian adults. In this section, I take an approach similar to the one used above, and present the results of regressions of child height-for-age z-scores on state level measures of early life mortality. I find that neonatal mortality correlates with the heights for children much as it did with the heights of adults born two to three decades earlier.

Data from the NFHS 2 and 3 allow regressions of an individual child's height on neonatal and postneonatal mortality rates in the state where she was born, as well as controls for possibly confounding variables, such as the child's household socioeconomic status and her mother's height, which is a measure of the child's genetic potential. Table 4.4 presents the results of regressions of individual children's height-for-age z-scores, on state-survey round

level neonatal mortality, postneonatal mortality and controls. It presents results separately for girls and boys. The coefficients in column 5 of table 4.4 were computed using OLS regressions of the following form:

$$\begin{aligned} hfa_{ihsr} &= \beta_0 + \beta_1 NNM_{sr} + \beta_2 PNM_{sr} + E_{hsr}\Lambda \\ &\quad + \beta_4 mother's\ \ height_{ihsr} + A_{ihsr}\Gamma + \epsilon_{ihsr}, \end{aligned} \tag{4.3}$$

where hfa_{ihsr} is the height-for-age z-score of child i in household h in state s in survey round r. NNM_{sr} is the state and survey round specific neonatal mortality among children born in the three years before the survey. PNM_{sr} is the state and survey round specific postneonatal mortality among children born in the three years before the survey. E_{hsr} is a vector of household-level controls for economic well-being; these have been described in section 4.3. $mother's\ \ height_{ihsr}$ is the height in centimeters of the child's mother. A_{ihsr} is a vector of age-in-months indicators, and ϵ_{ihsr} is a child specific error term. All standard errors are clustered at the state round level; there are 52 state rounds.

Because the magnitudes of the coefficients are similar for girls and boys, I discuss only the coefficients in panel A of table 4.4, which gives results for girls. Indeed, none of the coefficients in panel B, for boys, is statistically significantly different from the corresponding coefficient in the girls table. This is perhaps surprising considering that the coefficients on state net domestic product were different for men and women in the adult regressions. If pre-natal nutrition is the main mechanism leading to both neonatal mortality and stunted heights, it makes sense that the coefficients on neonatal mortality would be similar; because parents would not have known the sex of the child before birth, they would not have been able to make differential investments in pregnancy. However, if parents are both able, and chose to better protect their male children from a bad disease environment, we might expect the coefficient on postneonatal mortality to be steeper for girls than for boys. That the coefficients on postneonatal mortality are similar for both boys and girls suggests that

parents are either not able to modify the disease environment differentially, or are choosing not to do so.

Columns 1 and 2 show an association between state level neonatal and postneonatal mortality, respectively, and children's height. In column 3, when both NNM and PNM are included in the same regression, the magnitude of the coefficient on each of these predictors is smaller than when the predictor is entered individually, but both predictors have statistically significant coefficients. The magnitudes of the coefficients change little when controls for household level socioeconomic variables and mother's height are added.

The interquartile range for neonatal mortality in these data is 22 to 43 per 1000 and the interquartile range for postneonatal mortality is 11 to 23 per 1000. Therefore, both mortality measures have an interquartile range of about 20 per 1000. The coefficients on both NNM and PNM are approximately -0.01. This implies that a difference of 20 per 1000 of either neonatal or postneonatal mortality is associated with a difference about -0.2 standard deviations in average child height. For a three year old girl, 0.2 standard deviations is about three quarters of a centimeter. It is noteworthy that this height difference is very close to the effect size found for adult cohorts exposed to a similar difference in neonatal mortality regimes.[16]

4.5 Discussion

The correlations between height and postneonatal mortality and pre-adult mortality documented here likely reflect relationships between height and infectious diseases that both stunt growth and cause early death. However, prior papers have not found relationships between height and neonatal mortality. In these data, what are the early life conditions that stunt growth for which neonatal mortality likely proxies?

[16]Waterlow (2011) finds that much of absolute height deficit among adults in developing countries is set by the time they are five years old.

One factor that is likely to be be important is poor pre-natal nutrition, which has been, and continues to be, a widespread constraint on children's health in India (Ramalingaswami et al., 1996; Bhutta et al., 2004). Pre-pregnancy body mass index (BMI) and weight gain during pregnancy are useful indicators of pre-natal nutrition that are predictive of birth weight (Yaktine and Rasmussen, 2009). Because India has no national monitoring system for maternal health, there are no data on these indicators. However, the BMI for women of child-bearing age can be used as a proxy for pre-pregnancy BMI. Deaton and Drèze (2009) analyze National Nutrition Monitoring Bureau (NNMB) data from 1975 to 1990, and find that about half of Indian women in the states covered by these data had BMI scores below 18.5, the WHO cutoff for underweight during this period. Improvements in pre-pregnancy body mass between the 1970s and 2005 seem to have been modest; the NFHS 3 found that more than a third of Indian women between the ages of 15 and 49 were underweight. Although there is no nationally representative data on weight gain during pregnancy, the World Health Organization (1995)'s review of studies from India found that women in those studies gained an average of only seven kilograms during pregnancy.

If poor pre-natal nutrition is indeed an important mechanism driving the relationship between neonatal mortality and height in these state level regressions, we would expect state level measures of pre-natal nutrition to correlate with the state level measures of neonatal mortality that are used in this paper. Figure 4.5 plots the neonatal mortality numbers used in section 4.4.3 against state level estimates of pre-pregnancy body mass. To estimate pre-pregnancy body mass, I use the average BMI of non-pregnant women aged 18-30 in each state; these ages represent the 10th and 90th percentiles of age among pregnant women both the NFHS 2 and the NFHS 3. Figure 4.5 shows a strong negative relationship between state level neonatal mortality and state level BMI of women of child bearing age; the correlation coefficient associated with these data is about -0.6. A similar plot of postneonatal mortality against women's body mass produces a much lower correlation, of only about -0.3. Although the data are not presented here, Gopalan (1985) reports that

there was important spatial variation in indicators of women's nutrition in India during the 1970s and 1980s, which correlated with child outcomes, including neonatal mortality (see also Visaria (1985)).

Of course, the interpretation that is being advanced here, that neonatal mortality proxies for poor pre-natal nutrition in the relationship between height and neonatal mortality, does not rule out that a high burden neonatal infection may also influence heights. However, large literatures link neonatal mortality to poor pre-natal nutrition, poor pre-natal nutrition to low birth weight and low birth weight to height, whereas such a literature does not exist for neonatal infection and height. More research would be needed to fully characterize the relative importance of these two factors.

4.6 Conclusion

Using data from state cohorts born between 1970 and 1983 and from children in two rounds of the more recent NFHS surveys, this article has documented a negative relationships between height and measures of early life mortality in India. These findings contribute to the literature the first evidence from within a developing country of the associations between neonatal mortality and height. This finding is novel, since other authors who have looked at the relationships between early life mortality and height have not found an association between neonatal mortality and height. This literature has, however, used data from Europe and the United States in the 20th century, where there was little nutritional deprivation among mothers.

As in developed countries, this paper finds relationships between pre-adult mortality and the heights of adult cohorts, and between postneonatal mortality and children's height in the NFHS surveys, which suggests that variation in the disease environment predicts heights in India. Unlike in developed countries, however, aggregate income in early childhood, as measured by net state domestic product per capita in the year of birth, predicts adult

heights in India. Unfortunately, this analysis cannot distinguish which mechanisms lead from income to adult height, nor why the coefficient for men is larger than the coefficient for women. Future research in this area should focus on exploring possible mechanisms, and determining whether they are the same for men and women.

Finally, it is likely that relationships between state level neonatal mortality and population heights at least in part reflect important state level variation in pre-natal nutrition. The extent to which poor pre-natal nutrition may have population-wide and lasting effects on the heights of Indians has not previously been well documented. Such an analysis is important not only for understanding the relationship between height and early life mortality, but also for public policy. If poor pre-natal nutrition not only affects infants' chances of survival, but also stunts their heights, and therefore compromises their later life health and human capital accumulation, the welfare impacts of poor pre-natal nutrition in India may be importantly under-appreciated.

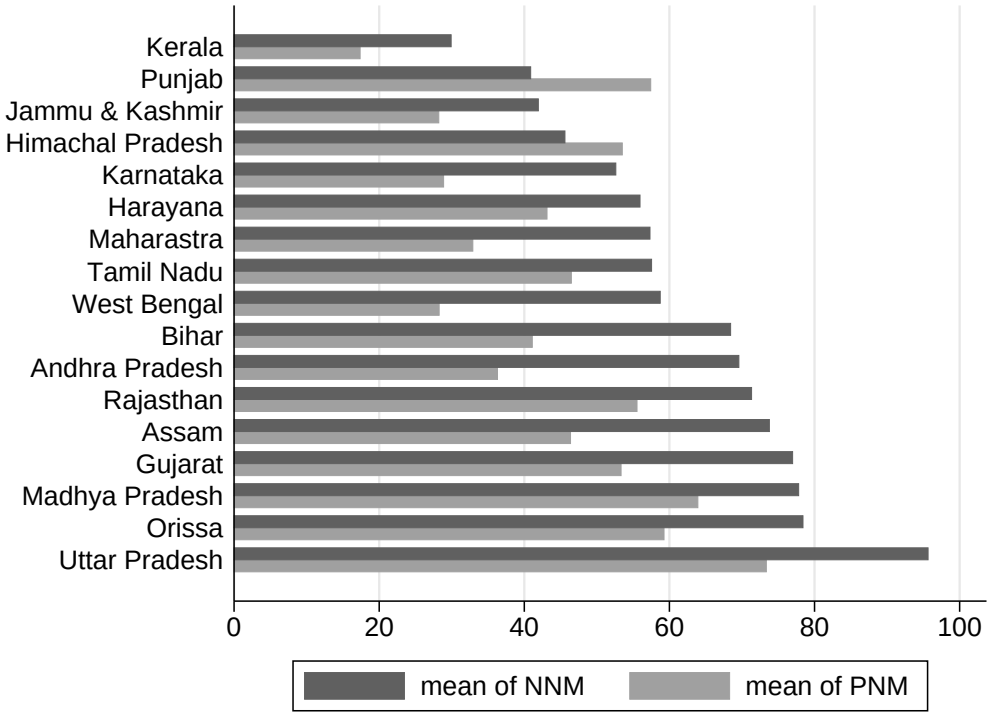


Figure 4.1: State-wise average mortality rates from 1970-1983

Data are from the Sample Registration System. State-wise means of neonatal mortality (NNM) and postneonatal mortality (PNM) are shown for the period from 1970-1983 for the states included in this analysis. A few states are missing values for 1970 and 1971 and Bihar and West Bengal only have PNMs for 1981-1983.

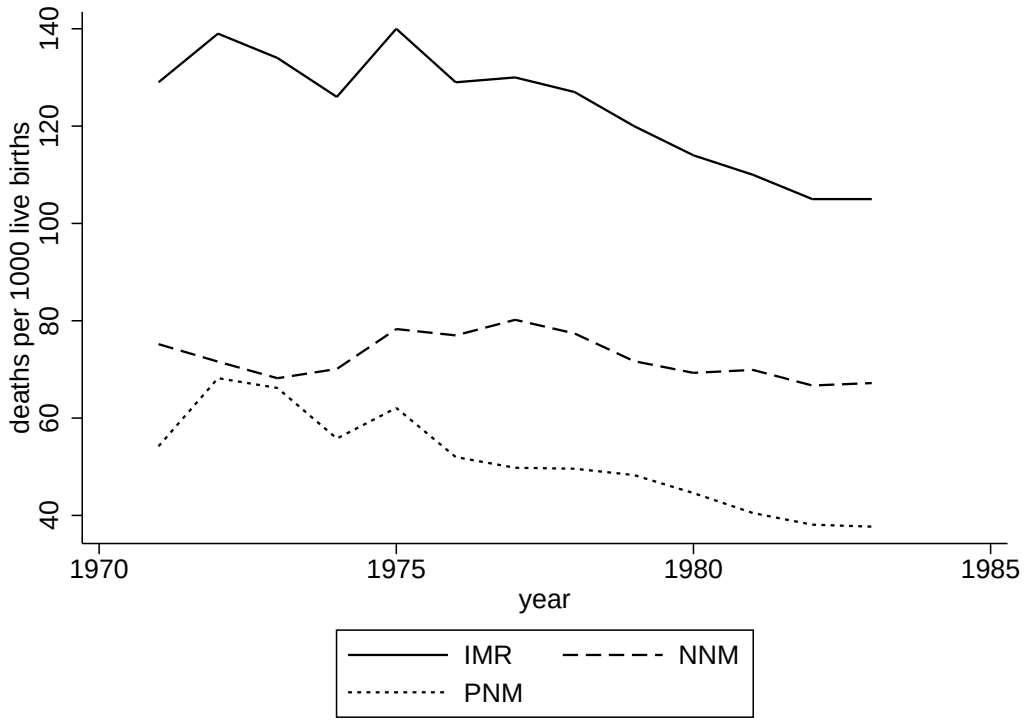


Figure 4.2: National mortality rates from 1970-1983

Data are from the Sample Registration System. National time trends are shown for neonatal mortality (NNM), postneonatal mortality (PNM), and infant mortality (IMR), for the period from 1970-1983 for the states included in this analysis. A few states are missing values for 1970 and 1971 and Bihar and West Bengal only have PNMs for 1981-1983.

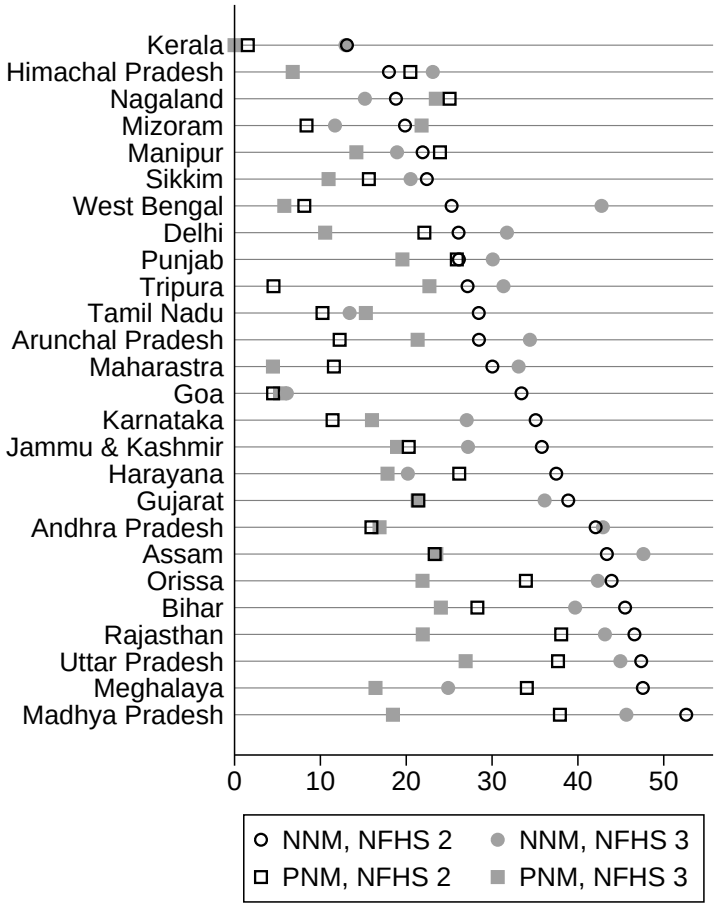


Figure 4.3: Early life mortality measures in the NFHS 2 and the NFHS 3

Neonatal and postneonatal morality are given at the state-survey round level, based on the fraction of children born in the three years before the survey who died. A child, whether dead or alive at the time of the survey, is used in the computation of neonatal mortality only if at least a month has passed since his birth. Likewise, a child is used in the computation of postneonatal mortality only if at least a year has passed since his birth. The fraction of children who died is scaled by 1000.

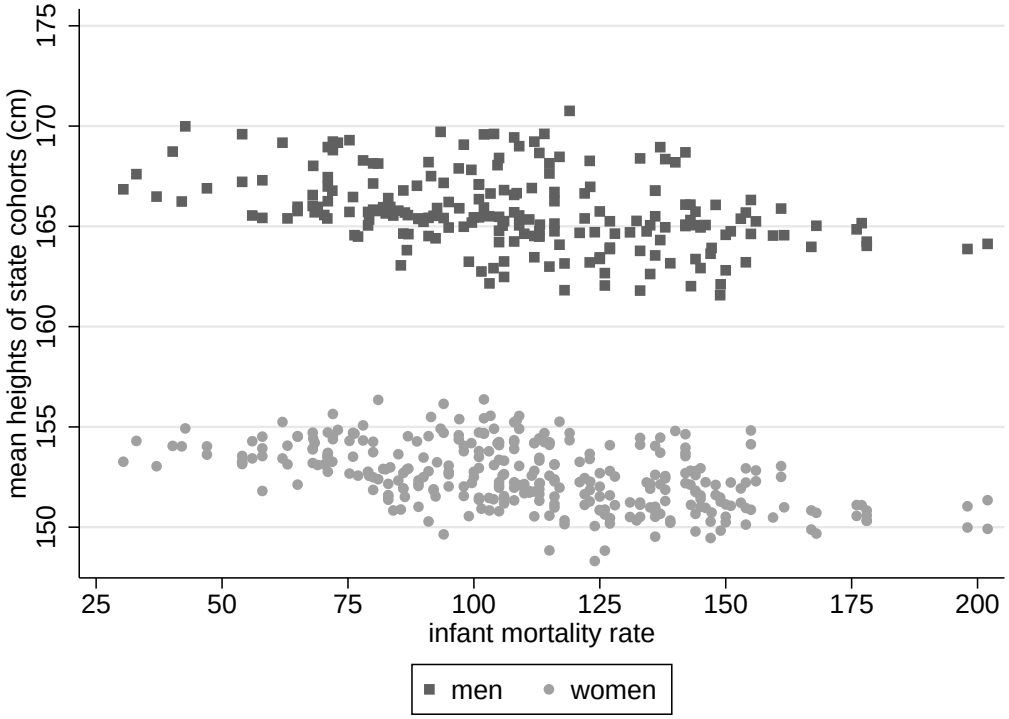


Figure 4.4: Relationship between adult heights and infant mortality

Observations are state cohorts born 1970-1983. The slope of a fitted line for women is -0.022 and the p-value is <0.001, using homoskedastic standard errors. The slope of the fitted line for men is -0.023 and the p-value is <0.001.

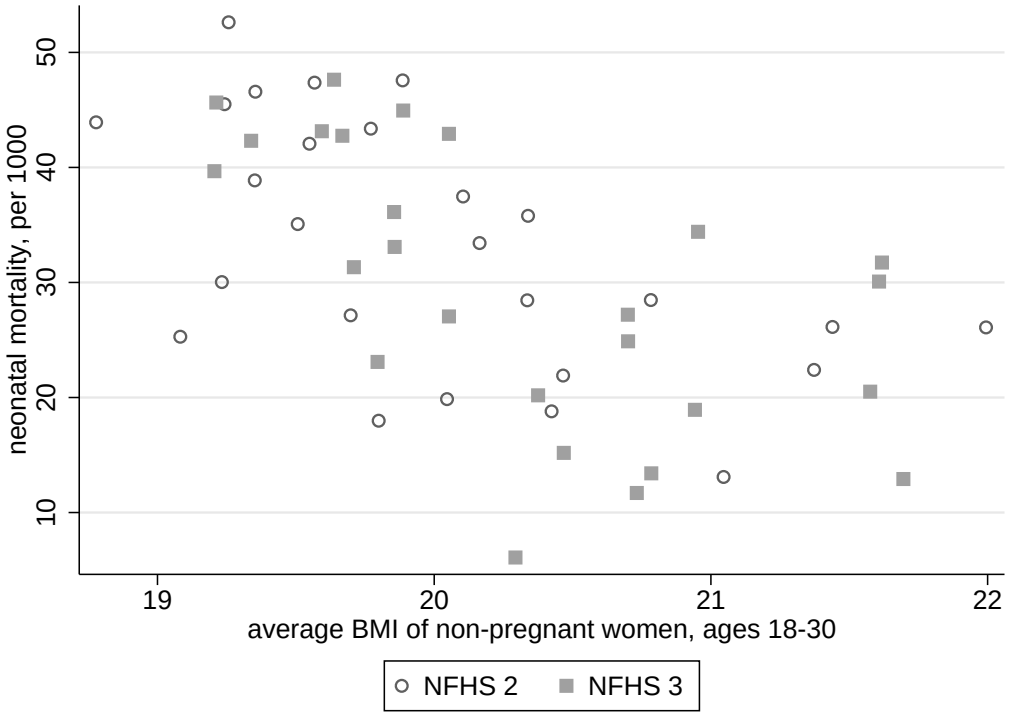


Figure 4.5: State level variation in women's body mass correlates with neonatal mortality

Observations are states in the NFHS 2 and the NFHS 3. The horizontal axis plots the average body mass index score of non-pregnant women age 18 to 30; these ages are the 10th and 90th percentile ages among pregnant women in both the NFHS 2 and the NFHS 3. The vertical axis plots neonatal mortality, the fraction of infants born in the three years before the survey who died in the first month of life.

Table 4.1: Causes of early life mortality in India from the 2010 Million Deaths Study

mortality from 0-1 months	
cause of death	mortality rate per thousand live births (all India 2005)
prematurity and low birth weight	12.0
neonatal infections	9.9
birth asphyxia and birth trauma	7.0
other non-communicable diseases	1.8
congenital anomalies	1.2
tetanus	1.2
injuries	0.2
other causes	2.4
all causes	36.9

mortality from 1-59 months	
cause of death	mortality rate per thousand live births (all India 2005)
pneumonia	13.5
diarrhoeal diseases	11.1
measles	3.3
other non-communicable diseases	3.2
injuries	2.9
malaria	2.0
meningitis/encephalitis	1.9
nutritional diseases	1.5
acute bacterial sepsis and severe infections	1.4
other infectious diseases	1.2
other causes	6.9
all causes	48.9

Source: Million Death Collaborators (2010). Causes of neonatal and child mortality in India: A nationally representative mortality survey. *The Lancet* 376, 1853-1860.

Table 4.2: Neonatal, postneonatal mortality & adult height in India (state cohorts)

	(1)	(2)	(3)	(4)	(5)	(6)
	height in centimeters					
Panel A: women (pooled sample of NFHS 2 & 3)						
NNM	-0.046***		-0.047***	-0.036***	-0.037***	-0.036***
	(0.008)		(0.008)	(0.009)	(0.008)	(0.008)
	$p = 0.000$		$p = 0.000$	$p = 0.002$	$p = 0.000$	$p = 0.000$
PNM		-0.017	0.002	0.003	-0.000	-0.003
		(0.013)	(0.006)	(0.008)	(0.010)	(0.012)
ln(NSDPPC)				1.826*	1.698*	1.764*
				(0.720)	(0.744)	(0.803)
northern state					0.296	0.351
					(0.446)	(0.460)
NFHS 3	0.588***	0.525**	0.603***	0.541***	0.524***	0.583***
	(0.111)	(0.139)	(0.101)	(0.117)	(0.123)	(0.117)
YOB fixed effect	no	no	no	no	no	yes
constant	155.000***	153.000***	155.000***	142.500***	143.300***	142.600***
	(0.466)	(0.686)	(0.554)	(4.768)	(4.935)	(5.191)
R^2	0.369	0.083	0.370	0.455	0.460	0.483
n (state cohorts)	322	322	322	322	322	322

Table 3.2, continued

	(1)	(2)	(3)	(4)	(5)	(6)
	height in centimeters					
	Panel B: men (NFHS 3 only)					
NNM	-0.050***		-0.054***	-0.037**	-0.039**	-0.039**
	(0.011)		(0.011)	(0.011)	(0.011)	(0.011)
	$p = 0.000$		$p = 0.001$	$p = 0.009$	$p = 0.010$	$p = 0.007$
PNM		-0.015	0.009	0.012	0.008	0.004
		(0.015)	(0.009)	(0.009)	(0.012)	(0.013)
ln(NSDPPC)				2.958**	2.795**	2.784**
				(0.788)	(0.834)	(0.875)
northern state					0.375	0.480
					(0.541)	(0.537)
YOB fixed effects	no	no	no	no	no	yes
constant	168.800***	166.400***	168.700***	148.300***	149.300***	148.800***
	(0.677)	(0.683)	(0.625)	(5.442)	(5.742)	(5.833)
R^2	0.257	0.023	0.264	0.431	0.436	0.475
n (state cohorts)	209	209	209	209	209	209

Notes: OLS regression model. Standard errors are clustered at the state level and shown in parentheses. Due to the small number of clusters (17), I have also computed wild bootstrap t two-sided p-values for neonatal mortality (see Cameron et al. (2008)); these are listed below clustered standard errors.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
NNM is neonatal mortality; PNM is postneonatal mortality; YOB fixed effects are year of birth fixed effects; ln(NSDPPC) is the natural log of net state domestic product per capita.

Table 4.3: Pre-adult mortality & adult height in India (state cohorts)

	(1)	(2)	(3)	(4)	(5)	(6)
columns 1 - 6: Height in centimeters is dependent variable. For 1 & 2, see notes on the next page.						
Panel A: women, pooled sample of NFHS 2 & 3						
${}_5m_0$	-0.044***	-0.034†	-0.017	-0.013	-0.015	-0.018
	(0.011)	(0.017)	(0.016)	(0.015)	(0.018)	(0.019)
${}_5m_5$	-0.525***	-0.396**	-0.295*	-0.163	-0.155	-0.199
	(0.101)	(0.123)	(0.128)	(0.097)	(0.109)	(0.131)
${}_5m_{10}$	-0.890***	-0.637*	-0.345†	-0.292	-0.298	-0.347 †
	(0.210)	(0.225)	(0.178)	(0.183)	(0.186)	(0.183)
ln(net state domestic		✓		1.739†	1.685†	1.609†
product per capita)				(0.852)	(0.896)	(0.875)
northern state		✓			0.132	0.213
					(0.483)	(0.468)
indicator for NFHS 3	✓	✓	0.340*	0.361**	0.356*	0.583***
			(0.121)	(0.122)	(0.123)	(0.117)
year fixed effects	no	yes	no	no	no	yes
constant	✓	✓	154.9***	142.8***	143.2***	143.7***
			(0.585)	(5.740)	(6.035)	(5.778)
R^2	-	-	0.330	0.400	0.400	0.450
n (state cohorts)	321	321	321	321	321	321
p value of F test for joint significance of ${}_5m_0$, ${}_5m_5$, ${}_5m_{10}$			$p = 0.000$	$p = 0.011$	$p = 0.012$	$p = 0.002$

Table 3.3, continued

	(1)	(2)	(3)	(4)	(5)	(6)
columns 1 - 6: Height in centimeters is dependent variable. For 1 & 2, see notes below.						
Panel B: men, NFHS 3						
${}_0m_5$	-0.042**	-0.024	-0.007	-0.000	-0.003	-0.007
	(0.0126)	(0.021)	(-0.490)	(-0.010)	(-0.170)	(-0.470)
${}_5m_5$	-0.536**	-0.330†	-0.344†	-0.103	-0.093	-0.153
	(0.156)	(0.175)	(-1.750)	(-0.810)	(-0.700)	(-1.090)
${}_5m_{10}$	-0.950**	-0.632*	-0.403	-0.327	-0.333	-0.432†
	(0.284)	(0.264)	(-1.620)	(-1.490)	(-1.480)	(-2.030)
ln(net state domestic		✓		3.132**	3.066**	2.873**
product per capita)				(3.270)	(3.020)	(3.010)
northern state		✓			0.166	0.302
					(0.280)	(0.560)
year fixed effects	no	yes	no	no	no	yes
constant	✓	✓	168.100***	146.400***	146.800***	148.000***
			(247.370)	(21.480)	(20.510)	(22.240)
R^2	-	-	0.200	0.360	0.360	0.430
n (state cohorts)	208	208	208	208	208	208
p value of F test for joint significance of ${}_5m_0$, ${}_5m_5$, ${}_5m_{10}$			$p = 0.009$	$p = 0.210$	$p = 0.247$	$p = 0.066$

The values reported in Columns 1 are coefficients and clustered standard errors for three different regressions of average height in centimeters on each ${}_nm_x$ measure separately.
Column 2 repeats these same three regressions with controls.
Columns 3-6 report coefficients from single regressions.
Standard errors for all regressions are clustered at the state level and shown in parentheses.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.4: Neonatal mortality, postneonatal mortality & child height in India

	(1)	(2)	(3)	(4)	(5)
	height for age z-scores				
Panel A: girls					
NNM	-0.025***		-0.019***	-0.013***	-0.012**
	(0.003)		(0.003)	(0.003)	(0.004)
PNM		-0.026***	-0.011**	-0.009*	-0.009*
		(0.004)	(0.004)	(0.004)	(0.004)
NFHS 3	0.324***	0.251**	0.274***	0.258***	0.245***
	(0.064)	(0.082)	(0.060)	(0.057)	(0.060)
mother's height					0.045***
					(0.002)
asset variables				✓	✓
n (children under three)	24504	24504	24504	24503	24416
Panel B: boys					
NNM	-0.021***		-0.015***	-0.008*	-0.008†
	(0.002)		(0.003)	(0.004)	(0.004)
PNM		-0.023***	-0.011**	-0.009*	-0.010*
		(0.003)	(0.003)	(0.004)	(0.005)
NFHS 3	0.307***	0.238**	0.258***	0.202***	0.184**
	(0.060)	(0.071)	(0.055)	(0.057)	(0.058)
mother's height					0.045***
					(0.003)
F-test on assets				✓	✓
n (children under 3)	26401	26401	26401	26396	26316

OLS regression model. Standard errors are clustered at the state-round level. Children under three from the NFHS 2 & 3 are included in the regression. The dependent variable is height for age z-scores computed using the WHO 2006 standards. Indicators for age-in-months are included in each specification. Assets indicators are for whether or not the child's household owns a radio, TV, fridge, bicycle, motorcycle, car, whether or not it has electricity, and the type of drinking water the child's house uses (17 options). In all cases, asset variables are jointly statistically significant. *NNM* is the fraction of children born in the individual's state in the three years before the survey who died in the first month of life. *PNM* is the fraction of children born in the individual's state in the three years before the survey who died between the second and twelfth months of life. $\dagger p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Chapter 5

Costs and Consequences of a Cash Transfer for Hospital Births in a Rural District of Uttar Pradesh, India

[a version of this chapter is published in *Social Science & Medicine*, doi:10.1016/j.socscimed.2014.05.035]

5.1 Introduction

Despite its recent economic development, India faces important challenges to improving maternal and infant health (Bhutta et al., 2004; Claeson et al., 2000). India's vital registration system found that the national maternal mortality rate was 178 deaths per 100,000 births in 2010-2012, and 292 in Uttar Pradesh, the country's most populous state, and the state in which the field work for this study was carried out (Government of India, 2013). Neonatal mortality is also very high: 35 per 1000 live births nationally in 2008, and 50 per 1000 live births in Uttar Pradesh in 2011 (Annual Health Survey, 2011).

In order to reduce maternal and neonatal mortality, the Indian government introduced the Janani Suraksha Yojana (JSY), a "safe motherhood program," in 2005. JSY provides cash transfers to women who give birth in government and accredited private health facilities rather than at home, and in some circumstances, payments to village health workers

to accompany pregnant women to health facilities for delivery. In 2009-2010, according to administrative data compiled by Accountability Initiative (2012), India's JSY program cost about $300 million that year, and had over 10 million beneficiaries, making it the largest conditional cash transfer in the world by number of beneficiaries (Lim et al., 2010). The Government of India allocated 11 percent of the budget of the National Rural Health Mission, an initiative of rural health sector reform, to JSY.

JSY's strategy of encouraging hospital births takes a different approach than previous efforts from India to make home birth safer, such as training birth attendants and promoting good neonatal care practices (Stephens, 1992; Kumar et al., 2008). JSY is part of a larger group of recent programs in South Asia that subsidize hospital deliveries, including a voucher scheme in Bangladesh (Ahmed and Khan, 2011; Nguyen et al., 2012) and the Safe Delivery Incentive Program in Nepal (Ensor et al., 2009; Witter et al., 2011; Powell-Jackson and Hanson, 2012). A related program is Rwanda's "Pay for Performance," in which health centers were paid by the visit and service. Basinga et al. (2011) found that this program increased hospital deliveries without improving some aspects of quality of care, such as prenatal visits.

Surveys have found high rates of participation in JSY (United Nations Population Fund, 2008; Khan et al., 2010; Sidney et al., 2012) and there are now several quantitative impact evaluations of the program. These studies find that JSY increases hospital delivery but does not improve health outcomes. Dongre (2010) finds that finds that Indian states that got higher intensity JSY programs improved rates of hospital delivery faster than states that got lower intensity programs. Mazumdar et al. (2012) find that JSY has failed to improve neonatal mortality. Lim et al. (2010) use three identification strategies to look for an effect of JSY on neonatal mortality. The first two strategies, a matching analysis and a "with-versus-without" analysis, are methodologically weak because they fail to account for selection of women into the program. The third strategy is a district level difference-in-differences analysis which compares the change in neonatal mortality in districts that

got JSY with the change in neonatal mortality in districts that did not get the program. This strategy is methodologically strongest, and does not find an effect of JSY on neonatal mortality. Lim et al. (2010) also use this strategy to look for an effect of JSY on maternal mortality and do not find one.

Qualitative studies are needed to understand the puzzle of why JSY increases hospital births without improving health outcomes. The few qualitative studies that exist are implementation studies that focus on the administrative details of the program (Malini et al., 2008; Scott and Shanker, 2010). The main contributions of this study are to address the question of why JSY does not improve health outcomes, and to provide a clear picture of the value of the program to beneficiaries. The findings suggest that JSY does not improve maternal and infant health because the program does nothing to restructure the incentives of service providers in a dysfunctional health system (see Das and Hammer (2007) and Banerjee et al. (2008)). Service providers are focused on capturing the economic rents from JSY, and provide an extremely poor quality of care.

Even if the conditionality of a cash transfer program does not improve outcomes, it might still be worthwhile if it transfers money to families in poverty in a time of need. For instance, Case (2002) describes the South African pension, a relatively large unconditional transfer that is used by families to invest in health improvements. This paper, which provides a detailed accounting of the costs of home and hospital births, finds that the value of JSY transfers to beneficiaries is small. It also finds that women who deliver at the hospital have emotionally and psychologically taxing experiences that should be included when considering the value of the program.

5.2 Setting & context

JSY uses pre-program rates of institutional delivery to distinguish between "low-performing" and "high-performing" states, and considers Uttar Pradesh, the state

where this study took place, to be "low-performing." JSY transfers to beneficiaries are higher in low-performing states than high-performing ones, and, other than delivery in an approved institution, there are no eligibility requirements (see Dongre (2010) for more details). Although at the national level, the program allows women who deliver in accredited private facilities to receive JSY transfers; in Uttar Pradesh, JSY transfers are only made to women who deliver in public facilities (Khan et al., 2010). The program does not make transfers for women who deliver at home.

Three villages from a poor, populous, rural district in Uttar Pradesh were studied as a part of this project. The district has high early life mortality; neonatal mortality was almost 15% higher than the Uttar Pradesh average in 2011 (Annual Health Survey, 2011). The villages were selected from three Gram Panchayats (local government administrative units) for their caste and class diversity. All are located within 10 kilometers of the district capital town. Only one of the villages has any households with electricity, and many families live in houses made of mud and cow dung rather than bricks and cement. The choice to study only three villages was made in order to permit the researcher to make repeated visits to the same participants. This longitudinal approach increased the depth of information gathered by allowing the author to gain access to, and the trust of, pregnant and recently delivered women, a group who, in rural Uttar Pradesh, is often sheltered from outsiders.

The villages chosen for the study are arguably among the places where JSY is most likely to affect the fraction of deliveries that take place in health facilities. The fraction of facility-based deliveries in the district before JSY was implemented was quite low; the District Level Health Survey (DLHS) 2002 indicates that less than 20 percent of women who gave birth in the district between 2001 and 2002 did so in a health facility, and the DLHS 2008, which was done as the JSY program was being launched in the district, found that 21.4 percent of last births since 2004 took place in a health facility. These figures indicate the large potential for behavior change in response to JSY.

Birth histories suggest that JSY had an effect on the delivery location of the 20 women who participated in the study; details about the participants are given below. Most of the women in the study had given birth or been pregnant prior to their most recent birth. Only 27% of their prior births took place in a health facility rather than at home. Of births that took place before 2008, the year that ASHAs were assigned to the three villages and the de facto start of JSY in those villages, only 13% took place at the hospital. Table 5.1 shows that in contrast to the high rates of home birth prior to JSY, only three of the 20 births studied for this project in 2012 took place at home.

Qualitative evidence also supports the idea that, in this sample of women, the JSY cash incentive motivated hospital deliveries. In later interviews, participants spoke openly about this; an upper caste woman, who had delivered her youngest daughter in the government maternity hospital after three home births, said, "people are running after those 1400 rupees." One of the women who gave birth at home regretted that her labor progressed too quickly to go to the hospital. Her mother-in-law was annoyed that they would not receive the 1400 rupee payment and said that the village health worker – called an Accredited Social Health Activist (ASHA) – was upset with them for not leaving early enough for the hospital. To put the value of the intended transfer into context, the Planning Commission of the Government of India reported the average monthly per capita expenditure for rural Uttar Pradesh in 2011-2012 to be 1073 rupees (Planning Commission, 2013).

In addition to low pre-program rates of hospital delivery, there are several other reasons why women from the study villages may be more likely to change their behavior as a result of the JSY program than women in other parts of India. First, villages' proximity to the government maternity hospital means that pregnant women rarely have to pay for transportation to the hospital. Women in the study villages were able to get to the hospital in carts pulled by bicycles, on family members' motorcycles, or in cycle rickshaws. In contrast, a survey done by the UNFPA found that women in Uttar Pradesh who delivered in health facilities paid on average 294 rupees, or about $6, in transportation costs to reach the

facility (UNFPA, 2008). Second, the hospital studied, unlike smaller public health facilities that give JSY transfers, is a women's hospital which serves only gynecology patients, and is open 24 hours a day, 7 days a week. Smaller facilities have high rates health worker absence (Chaudhury et al., 2006). The hospital studied is better equipped and staffed than smaller facilities in the area; for instance, some staff are qualified to perform cesarean sections. The hospital reported to the author that over 13,000 deliveries, or more than 35 per day, were performed in 2011, which was more than a three-fold increase over the administrative figure reported for 2006. The third reason why women from the study villages were particularly likely to respond to JSY is that all three villages have been assigned government village health workers, or ASHAs, who are paid to bring women to the hospital for delivery. The presence of an ASHA is important to the functioning of the program because it gives village level actors an incentive to implement the program, a feature which has been important to the implementation of other government health programs as well (see Spears (2012a) on the Total Sanitation Campaign).

5.3 Methods

Participants and data collection. Data for this study come from semi-structured interviews with pregnant and recently delivered women, interviews with government health workers, and observations in villages and at a government maternity hospital. The interview data were collected from January to March, 2012 and from July to August, 2012. Interviews with the women were facilitated by the research assistant and conducted in Hindi and the local dialect. Interviews with government health workers were conducted by the author in Hindi. Detailed field notes were taken about each interview, as well as about each observation.

In each village, a census of women who were at least seven months pregnant at the time of listing, or who had delivered in the two months prior to the listing was taken. Twenty-

one women were listed as eligible for the study, but three did not agree to participate. During the course of the study, two additional women joined; one woman came to her parents' home in a study village in late February and delivered in March, and another who was not identified at the time of listing approached the researcher because she was recently delivered and wanted to participate.

Twenty pregnant and recently delivered women participated in 114 semi-structured interviews. Table 5.1 presents information about each participant's birth history, age, years of education, caste, relative economic status, and the number of interviews in which she participated. The number of interviews per participant ranged from 2 to 8, and depended on the woman's availability; some women returned to their natal villages for holidays during the study period, limiting the number of interviews that could be conducted. Although the author addressed questions to a specific woman in each interview, in practice, the interviewee's female relatives often joined the interviews.

Individual in-depth interviews were also carried out with government-employed birth workers; these are summarized in table 5.2. Three ASHAs, who were hired by the government as part of the JSY program in 2008 to work in the study villages, were interviewed in their homes. On paper, ASHAs have many responsibilities, both in their villages and at health facilities. In practice, the ASHAs did the tasks for which they were paid, including accompanying women to the hospital for delivery and for sterilization, and those that were directly supervised by the Auxiliary Nurse Mid-Wife (ANM), a higher ranking government health worker, including calling children to be vaccinated when the ANM visited the village. In principle, it is the ANM's job to monitor the implementation of the program by holding monthly meetings with the ASHAs. Two of the three ASHAs were observed working with the ANM in the village, and two were observed carrying out their work at the government maternity hospital.

Between January 2012 and November, 2013, the author visited the government maternity hospital over twenty times to accompany or visit beneficiaries, to interview doctors,

nurses, and administrators, and to observe the JSY program. The author presented herself as a doctoral candidate researching maternal and infant health, and in the hospital's busy atmosphere, dense with women, infants, and their many attendants, she attracted little attention, particularly after the first couple of visits.

Research strategy and data analysis. This project relied on a grounded theory approach. Grounded theory is a methodology in which data collection and analysis proceed iteratively so that analysis informs later stages of data collection and theories emerge from the data (Corbin and Strauss, 1998; Charmaz, 1983). The project also made extensive use of observation, using the strategies described in Patton (1987), who describes how observation allows researchers to gather information on sensitive topics that respondents avoid in interviews, and how it complements and contextualizes the selective perceptions of interviewees. In this project, observation helped the author see beyond the "official government transcript" about the program, which is quite different from how it operates in this context.

In the first stage of data collection, the author developed questions about the JSY program based on initial interviews and observations. This led to a second stage of data collection, in which semi-structured questionnaires were used; these were especially useful for the accounting analysis presented in table 5.3. The author also observed ASHAs' visits to women in villages, hospital births and the collection of JSY payments at the hospital. Data analysis involved the development of codes and categories that allowed the author to recognize patterns in the data. Memos and diagrams, or notes based on these codes and categories, were used to draw comparisons between experiences of birth and birth work before and after the program. Such analyses allowed the author to identify gaps in the data; these gaps were filled by a third set of interviews and observations. The final analysis attempted to place the experiences of these particular beneficiaries and birth workers in the broader context of maternal and infant health in rural India.

Ethical approval. The study was granted ethical approval by the Internal Review Board at the author's university.

5.4 Results

This section presents the finding that JSY does not improve maternal and infant health because service providers are focused on capturing the economic rents from JSY, and provide an extremely poor quality of care. It also presents detailed accounting of the costs of home and hospital births to show that the net value of JSY transfers to beneficiaries is small. Finally, it documents the emotional and psychological costs to participants of delivering at the hospital.

Government birth workers seek to capture economic rents created by JSY. Government birth workers in the study site have financially benefited from JSY. The three ASHAs who participated in the study are part of a larger group of over 13,600 ASHAs in Uttar Pradesh, whose positions were created between 2005 and 2010 by the National Rural Health Mission (mhf). Rather than receiving a salary, ASHAs are supposed to be paid conditional on performing a variety of village-based health activities. In practice, however, they were rarely paid for activities other than accompanying women to the hospital for delivery. Like JSY payments to beneficiaries, JSY payments to ASHAs are less than the advertised amount. Two of the three ASHAs in the study villages said that one sixth of the JSY payment from every birth is regularly retained by higher ranking health officials.

ASHAs supplement their incomes in several ways. They accept payments from the families of women who they accompany to the hospital. ASHAs earn extra money by offering the services of an ASHA to women who come to the hospital without one. ASHAs can facilitate higher JSY payments for urban women, who, according to the rules of the program, are supposed to receive 1000 rupees instead of 1400. The position of ASHA is seen as a lucrative one compared to other work villagers might do; evidence of this is that

ASHAs' husbands often chose to supervise and facilitate the work of their wives. In doing so, they reduce the cost of transportation to the hospital for their wives (men can drive motorcycles or bicycles, women would have to take a rickshaw), and abide by the socially conservative norms of the society, which frown upon women going to public places, such as the hospital, without a male escort. But, they pay the opportunity cost of their own time.

Hospital staff gain from the JSY program. Although under the table payment for service was common at the government maternity hospital prior to JSY, the hospital staff now use ASHAs to facilitate payments from patients' families. Before delivery, ASHAs advise families to save or borrow an appropriate amount of money to bring to the hospital. After delivery, ASHAs locate the woman's husband or relatives in the public area of the hospital, and bring them news of the baby, and staff members' request for payment. ASHAs feel compelled to cooperate with this system, both because of their low rank in the health bureaucracy, and because paperwork from nurses facilitates the collection of their own compensation. One ASHA explained that she could not protest her role a rent collector. If she did, she said, "the nurses would write 'no ASHA' on the birth certificate."

In addition to being able to collect payments more easily, hospital staff are receiving payments from more patients than before JSY was implemented. The number of deliveries reported by the maternity hospital more than tripled between 2006 (about 4,100 reported deliveries) and 2011 (about 13,300 reported deliveries). The latter number is likely inflated; the hospital may want to show the state government that it is implementing JSY well, and may over-report the number of patients in order to collect extra JSY payments. However, the participants' birth histories suggest that many deliveries that would otherwise have occurred at home now occur at the district maternity hospital. According to the head doctor of the hospital, very few additional staff joined during this period.

Further evidence of JSY's financial benefit to staff was the presence of a young nurse, who was not an official employee of the hospital, in the delivery room. After completing her internship for nursing school at the district maternity hospital, and proving herself to be a

hard worker, she was informally allowed to continue working without a salary. Although her outside option was a job in a private clinic paying approximately 10,000 rupees a month, she worked at the hospital for several months, supporting herself on side payments, some fraction of which she paid to higher ranking nurses.

The quality of hospital care is extremely poor. Jeffery and Jeffery (2010)'s claim that "[e]ncouraging institutional deliveries without rectifying...serious shortcomings in the modes of operation within government services is a seriously flawed approach" (1717) was supported by the over 20 separate observations that this author made at the hospital. In the crucial moments for survival after birth, babies are routinely left in delivery pans, covered by cloth, and unmonitored, while most of the staff sits outside the delivery room. Often, newborns do not receive basic immunizations before leaving the hospital, and are rarely breastfed after birth despite widespread knowledge of its benefits among hospital staff.

As described in Banerji et al. (2013), who study maternal mortality in Bihar and Jharkhand, basic emergency maternal care is rarely provided. Women whose deliveries are complicated or dangerous are routinely told to leave hospital, and to seek care in a larger one, more than two hours away. One of the 20 participants in the study, who was severely anemic, was turned out of the hospital after the birth of her daughter, without a blood transfusion, and in serious condition. Although her daughter died before she left the hospital, the staff nonetheless charged her family for delivering the infant. This participant was more fortunate than other women in need of blood transfusions who came to the hospital during the study period; others died in the hospital or after being sent to other facilities.

The value of the JSY transfer is small, and is smaller for less poor than for poorer women. Does the JSY program make an effective wealth transfer to families at a time when they are likely to be spending money on women and infants? In this setting, although JSY does make a net transfer to the families of women who deliver in the government maternity hospital, the amount of that transfer is far less than the amount

advertised by the program. Figure 5.1 summarizes the accounting exercise that is described in this section, averaging over all of the families of women in the study. The left bar, labeled "credit," depicts the JSY payment that women who give birth in health facilities receive from the government, and the savings their families experience by not having a home birth. The next column, labeled debit, depicts how much of the transfer is used on participation in the JSY program. It clearly shows why the actual value of the transfer is far lower than advertised amount.

Studies of childbirth in Uttar Pradesh have documented that women from different socioeconomic backgrounds have different experiences of childbirth (Jeffery et al., 1988; Pinto, 2013). Wealthier, higher caste women tend to incur higher costs at the time of a birth than poorer, low caste women, and they tend to observe more post-partum restrictions on movement and work. In many ways, hospital births motivated by JSY payments look more alike for women of different social classes than home births. However, the JSY assistance constituted a larger net transfer to poor families than to less poor families because the latter pay less for services at the time of birth. Families were split into the categories or "poor" and "less poor" based on their observed characteristics of their economic status, including quality of dwelling, quality of food, assets, quality of children's schooling, etc. Table 5.3 shows the goods and services that poor and less poor families purchased at the time of the last child's birth in the government maternity hospital. It estimates the actual value of the JSY transfer by considering both expenses incurred in choosing a hospital birth and the savings from not choosing a home birth.

Although advertised as free, hospital births are not, in practice, free. Although prominently displayed signs in the government maternity hospital declare that the services and medicines are provided free of cost to the patient, in practice, they are not. Nurses send ASHAs to buy supplies, including intramuscular injections of oxytocin and epidosin to speed delivery (see Jeffery et al. (2007)), cotton used to absorb blood after birth, and occasionally medicines from medical shops outside the hospital. Patients also

pay for official papers and for tests done at the hospital. Because many recently delivered women want to return home more quickly than the government guidelines mandate after birth, ASHAs retrieve their discharge papers.

Women recognize the work that the ASHAs do on their behalf and see ASHAs as their advocates at the hospital. Tasks regularly undertaken by the three ASHAs in the study include arranging tetanus toxoid injections with the Auxiliary Nurse Midwife, coming to a woman's house to check on her close to the time of delivery, escorting her to the hospital, dealing with the demands of hospital staff, and arranging paperwork. While women are eager to speak, somewhat angrily, about payments to hospital staff, they are more hesitant to talk about payments to ASHAs. In later interviews, though, nearly all disclosed that their families had paid 100 or 200 rupees to the ASHA, depending on their means.

It is noteworthy that the largest single expense associated with a hospital delivery is the under the table fees paid to the hospital staff. Families from the study villages paid between 500 and 700 rupees to hospital staff on duty when they were admitted or when their babies were born. Relatively better off families paid more for deliveries, as did families who had boys rather than girls. The higher payments by families who have boy babies can be understood in the context of Indian son-preference (Arnold et al., 1998; Dasgupta, 1987): families whose babies are boys are happier about the birth, more thankful to hospital staff, and therefore willing to make higher payments.

Although district officials and hospital administrators publicly claim that women do not pay for delivery at the district maternity hospital, ASHAs know better than to make such promises to pregnant women. One ASHA explained how she convinces families to bring pregnant women to the hospital: "I tell them, maybe there are seven or eight hundred rupees of spending at the hospital, but you are getting two or three hundred more than that." Her statement reflects the reality that the program transfers much less than the advertised 1400 rupees to beneficiaries; indeed, her estimate of the transfer is actually quite close to difference between the payment and the total expenses listed in table 5.3.

A final cost associated with participating in the program is the opportunity cost of retrieving the check for the JSY payment and cashing it at a bank. Husbands miss a day of work to accompany their wives and infants to retrieve the payment. Many of the husbands work as day laborers or rickshaw pullers. The loss of wages for table 5.3 was calculated based on reported daily wages, and adjusted down to reflect that husbands do not find work every day.

Delivery at the hospital saves on some home birth expenses, but not all. A calculation of the transfer should take into account that families would have incurred different expenses if the birth had taken place at home. Women described how, after home births, a family member is sent to buy a clean blade from the shop, and to summon the low caste birth worker, who will cut the umbilical cord, clean up the room where the birth took place, and dispose of the blood and placenta. In the 5 to 10 days following a birth, this low caste birth worker comes to the woman's house to massage and bathe the mother. (See Pinto (2013) for a more complete description of this work.) Table 5.3 gives the approximate cost of this service.

Following home births, most families hire a *dhobi*, or washerman, because the cloths on which a woman bleeds during childbirth are considered ritually dirty. Regular washing by the household's women will not get them clean; they should be cleaned by someone from the *dhobi* caste. However, in the case of a hospital birth, many lower caste families did not hire a dhobi, explaining that "all of the dirtiness happened there." For both Hindu and Muslim higher caste families, though, delivering in the hospital does not change the calculus of whether or not to hire a *dhobi* after a birth. As the mother-in-law of a high caste Muslim family explained, "even if we throw the cloths [used in the hospital] out, we still have to call the *dhobi*, so that other people see this."

The two types of families saved approximately the same amount of money, about 250 rupees, by delivering in the hospital rather than at home. Adding the savings and the JSY

payment, and subtracting the expenses yields a net transfer of about 400 rupees from the JSY program for less poor families and about 700 rupees for poorer families.

Giving birth at the hospital is emotionally and psychologically taxing. The previous section documented that the actual value of the JSY transfer is less than the advertised transfer. The non-monetary costs of hospital births are more difficult to quantify. Both groups of women-those who are relatively poor in their villages and those who are relatively better off-are subject to demeaning treatment at the government maternity hospital.

The following is an excerpt from field notes taken during a interview with Lilam, a poor, low caste young woman, and her female relatives:

> Interviewer: "How was it in the hospital?"
> Lilam looked up, narrowed her eyes, pursed her lips, and looked back down at the pot she was scrubbing with sand. She did not respond.
> Interviewer: "So you did not have an OK time in the hospital?"
> Lilam: "No."
> She did not look up from the pot she was scrubbing.
> Interviewer: "Why not?"
> When Lilam looked up, she gave the impression she might be about to cry. She started to respond, hesitated, and then looked back down at her work.
> Interviewer: "Was it because of the pain, or the money, or something else?"
> Lilam: "There will be pain [when someone gives birth], it was because of the money."
> Lilam went on to explain that her husband fought with the staff to try to avoid paying them the money he had scrambled to borrow from neighbors before they left for the hospital. Eventually, he paid 480 rupees so that she could be admitted.
> Interviewer: "So what would happen if you said that you weren't going to pay?"
> Lilam's mother-in-law: "If you don't pay, they don't look at you, or admit you, or cut the cord. If you don't pay, they turn you out."
> Lilam's female relative: "The hospital was built to help people, but if you don't pay, they run you off."

During the exchange with her female relatives, Lilam was quiet, seemingly grateful that her female relatives had joined the interview. She did not seem to want to talk much about the demeaning and vulnerable situation that the hospital staff had put her in: without their

cooperation, she would not be eligible for the JSY transfer, but without a large, upfront payment, they would not permit her to deliver there.

Ramila, an upper caste woman, had delivered three children at home before giving birth in the hospital. She described how stressful an experience the hospital delivery had been, particularly because the nurses seemed to be in such a hurry for her to deliver. She said: "the nurses at the hospital don't want it [labor] to take any time at all, they want everything to happen quickly!" The medical details Ramila gave of the birth seem to support this analysis. She was given labor-inducing intramuscular injections and an episiotomy, despite having delivered three children without episiotomies, and despite the hospital's policy (stated by the head doctor) of doing episiotomies only for first births. Ramila, who did not consent to the episiotomy, explained why, she believed, it had been done: "if it takes even a little bit of time, then the nurses go straight to the operation."

While it is possible that there was a valid medical reason for the episiotomy, it is significant that Ramila was not aware of it. It is noteworthy that the birth of Ramila's baby happened only a few minutes before the nurses changed shifts, suggesting that the nurse who attended Ramila may have been in a hurry to collect payment for Ramila's delivery, rather than forfeiting it to the next nurse on duty. Reflecting on whether she would give birth at the hospital again, Ramila said that "going to the hospital is completely useless...we should have our pains at home." Other high caste women and their mothers-in-law echoed this sentiment. Upon being asked whether the costs of going to the hospital outweighed the benefit of the JSY payment, Najma's mother-in-law, high caste Muslim woman, answered emphatically, "It is only good [to give birth] at home!"

The treatment described by these two women is consistent with observations made at the hospital – women were yelled at, slapped by hospital staff, and badgered for higher payments, and episiotomies were routinely performed without permission and stitched without local anesthesia. It is similarly consistent with treatment of patients described by Jeffery and Jeffery (2010), who write about "staff who embezzle government funds, extort money

illegally and treat patients in distress in discriminatory, demeaning and punitive ways" (1717). Although it is beyond the scope of this study to explore the following hypothesis in detail, it is important to mention that the JSY program may actually exacerbate poor treatment at the hospital. Overcrowding may lead to more short-tempered behavior on the part of the nurses. Additionally, higher willingness to pay on the part of patients, caused by the future JSY payment, may lead to their greater tolerance for corruption and rough treatment.

These data highlight two important patterns about the non-monetary costs of births at the hospital. The first is that both groups of women seem to experience high psychological costs of hospital births. The second is that better-off women are more likely express the idea that going to the hospital was, in the end, not worth the costs. Perhaps this is because they and their families are less accustomed to demeaning treatment, and it may also be because the value of the transfer they receive is less in both absolute and relative terms than the transfer received by poorer people.

5.5 Conclusion

This study has addressed the question of why the JSY program, which motivates many women to go to the hospital for birth, does not improve health outcomes. It finds that service providers, who are focused on capturing the rents from JSY, provide an extremely poor quality of care. This study also examined the value of the program to beneficiaries, since, even if the conditionality of a cash transfer program does not improve outcomes, it might still be worthwhile to transfer money to families in poverty in a time of need. Indeed, some scholars believe that JSY is accomplishing that. In a recent article for the popular press, Glassman and Birdsall (2013) praise JSY, saying that the increase in facility-based births is evidence that "the best way to let poor people have more money is give it to them."

However, this study's accounting of the costs of hospital delivery suggests that, in this instance, the program did not importantly transfer wealth to the families at the time of birth. In the study site, the value of the transfer received by poorer women is greater than that received by less poor women, but both groups receive far less than the 1400 rupees promised by the JSY program. It is important to note that in most other rural places, the value of the transfer would be even lower than it was in the study site because of the costs of transportation to the health facility. This study also documents the psychological and emotional costs of delivering at the hospital, which arise from the maltreatment of women and their families by hospital staff. These costs need to be considered in the broader discussion of JSY's costs and benefits.

The findings on quality of care, the low value of the transfer and mistreatment at the hospital raise the question: why do families participate in the program? Although it is beyond the scope of this study to address this question in detail, social pressure used by ASHAs and the fact that pregnant women, who have low intra-household rank, often do not decide where they will give birth are potentially important reasons. However, there are open questions about whether families, after having had an initial experience with JSY, will continue to opt for facility-based deliveries, and whether hospital staff may be motivated to charge smaller under the table fees to maintain interest in hospital delivery.

Ultimately, the JSY program does nothing to restructure health worker incentives to improve the quality of care provided to mothers and infants, nor does it provide a substantial transfer of resources to families at a time when they might otherwise be investing in women and infants. In other words, when mothers are paid to be physically present in facilities, health service providers in contexts such as this one seek to capture rents from the program, but have little incentive to improve health outcomes. These findings suggest the need for a substantial rethinking of the JSY program with careful attention to incentivizing health outcomes.

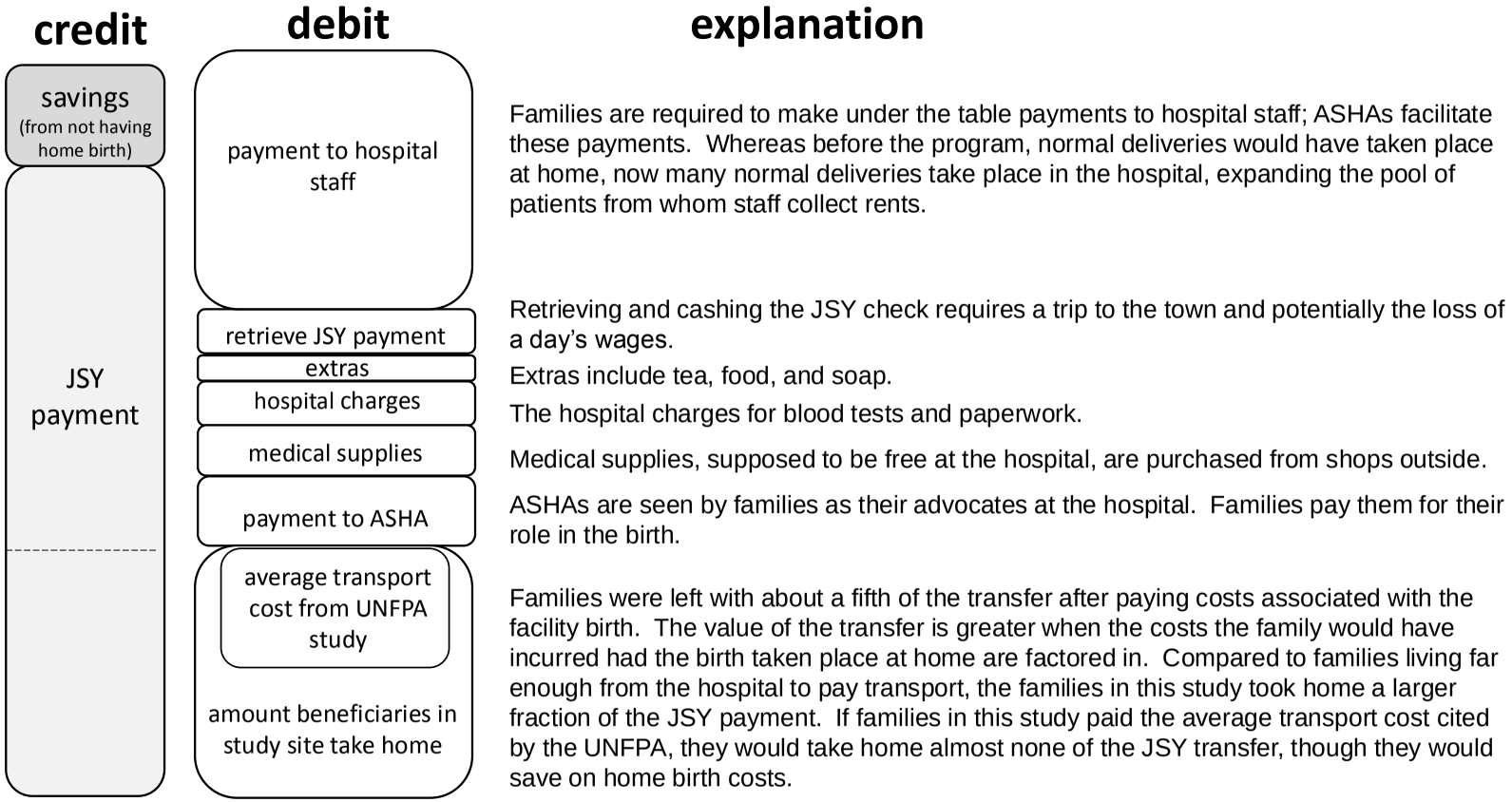


Figure 5.1: The net value of the JSY payment

Table 5.1: Characteristics of and number of interviews with pregnant and recently delivered women

village ID	woman ID	number of interviews	birth order of studied birth	location of studied birth	prior home births	prior hospital births	age	years of education	caste	economic status
1	1	8	4	hospital	1	2	32	0	lower	poor
1	2	7	3	hospital	1	1	24	10	higher	less poor
1	3	2	2	hospital	0	1	24	10	higher	less poor
1	4	4	5	hospital	4	0	19	0	lower	poor
1	5	6	2	hospital	0	1	18	0	lower	poor
2	6	8	3	home	1	1	24	8	higher	less poor
2	7	8	2	home	0	1	33	0	higher	poor
2	8	4	4	hospital	3	0	25	0	lower	poor
2	9	7	8	home	7	0	33	0	lower	poor
2	10	6	2	hospital	1	0	23	8	lower	poor
2	11	3	3	hospital	1	1	23	0	higher	less poor
2	12	5	1	hospital	0	0	18	10	higher	less poor
2	13	5	2	hospital	0	1	24	5	lower	poor
2	14	2	1	hospital	0	0	19	5	higher	less poor
3	15	7	1	hospital	0	0	21	5	lower	poor
3	16	7	4	hospital	2	1	28	0	lower	poor
3	17	6	5	hospital	4	0	31	7	higher	less poor
3	18	6	4	hospital	2	1	30	2	lower	less poor
3	19	6	3	hospital	1	1	23	0	lower	poor
3	20	7	2	hospital	1	0	20	8	higher	less poor

Table 5.2: Number of interviews conducted with each type of birth worker

birth worker ID	role	number of interviews
1	ASHA	3
2	ASHA	3
3	ASHA	3
4	nurse	1
5	nurse	2
6	doctor	2
7	doctor	3
8	JSY administrator	1

Table 5.3: An estimate of the value of the JSY payment for poorer and less poor families

	Less poor families	Poorer families
expense		
transport to hospital	-20	-20
fees paid to nurses and *ayas*	-650	-500
supplies from the medical store (including injections, medications and cotton to absorb postpartum blood)	-110	-110
soap and/or oil at the hospital	-10	0
chai and snacks in the hospital	-50	-50
admission paper	-1	-1
blood and urine tests	-50	-50
charges for birth certificate and discharge papers	-50	-50
payment to ASHA	-200	-100
opportunity cost of husband's time to retrieve and cash the check	-110	-75
total expenses	-1251	-956
savings		
savings on cord cutting	21	11
savings on cost of blade to cut cord	1	1
savings on postpartum massage	220	175
savings on employing a *dhobi*	0	50
total savings	242	237
JSY payment	1400	1400
value of JSY payment	391	681

Bibliography

Abrams, Barbara and Steve Selvin. 1995. "Maternal weight gain pattern and birth weight." *Obstetrics & Gynecology*, 86(2): 163–169.

Accountability Initiative. 2012. "National Rural Health Mission: GoI, 2011–2012." *Technical report, Budget brief.*

Adair, Linda S. 2007. "Size at birth and growth trajectories to young adulthood." *American Journal of Human Biology*, 19(3): 327–337.

Agarwal, DK, KN Agarwal, K Satya, and S Agarwal. 1998. "Weight gain during pregnancy: A key factor in perinatal and infant mortality." *Indian pediatrics*, 35: 733–744.

Ahmed, Shakil and M Mahmud Khan. 2011. "Is demand-side financing equity enhancing? Lessons from a maternal health voucher scheme in Bangladesh." *Social Science & Medicine*, 72(10): 1704–1710.

Aizer, Anna and Janet Currie. 2014. "The intergenerational transmission of inequality: Maternal disadvantage and health at birth." *Science*, 344(6186): 856–861.

Akachi, Yoko and David Canning. 2010. "Health trends in Sub-Saharan Africa: Conflicting evidence from infant mortality rates and adult heights." *Economics & Human Biology*, 8(2): 273–288.

Alderman, Harold and Jere R Behrman. 2006. "Reducing the incidence of low birth weight in low-income countries has substantial economic benefits." *The World Bank Research Observer*, 21(1): 25–48.

Alderman, Harold, Michael Lokshin, and Sergiy Radyakin. 2011. "Tall claims: Mortality selection and the height of children in India." *Economics & Human Biology*, 9(4): 393–406.

Almond, Douglas and Janet Currie. 2011. "Killing me softly: The fetal origins hypothesis." *The Journal of Economic Perspectives*, 25(3): 153.

Anderson, Siwan. 2003. "Why dowry payments declined with modernization in Europe but are rising in India." *Journal of Political Economy*, 111(2): 269–310.

Annual Health Survey. 2011. "Annual Health Survey: Uttar Pradesh." Tehnical report, Government of India.

Arnold, Fred, Minja Kim Choe, and TK Roy. 1998. "Son preference, the family-building process and child mortality in India." *Population Studies*, 52(3): 301–315.

Ashton, Basil, Kenneth Hill, Alan Piazza, and Robin Zeitz. 1984. "Famine in China, 1958-1961." *Population & Development Review*, 10(4): 613–645.

Banerjee, Abhijit V and Esther Duflo. 2007. "The Economic Lives of the Poor." *Journal of Economic Perspectives*, 21(1): 141.

Banerjee, Abhijit V, Esther Duflo, and Rachel Glennerster. 2008. "Putting a Band-Aid on a corpse: Incentives for nurses in the Indian public health care system." *Journal of the European Economic Association*, 6(2-3): 487–500.

Banerjee, Abhijit, Esther Duflo, Maitreesh Ghatak, and Jeanne Lafortune. 2009. "Marry for what: Caste and mate selection in modern India." *National Bureau of Economic Research*(14958).

Banerji, Manjistha, Steven Martin, and Sonalde Desai. 2013. "Are the Young and the Educated More Likely to Have "Love" than Arranged Marriage? A Study of Autonomy in Partner Choice in India." *India Human Development Study Working Paper*(8).

Bang, Abhay, Rani Bang, Barbara Stoll, Sanjay Baitule, Hanimi Reddy, and Mahesh Deshmukh. 2005. "Is Home-Based Diagnosis and Treatment of Neonatal Sepsis Feasible and Effective? Seven Years of Intervention in the Gadchiroli Field Trial (1996 to 2003)." *Journal of Perinatology*, 25: S62–S71.

Barcellos, Silvia, Leandro Carvalho, and Adriana Lleras-Muney. 2014. "Child gender and parental investments in India: Are boys and girls treated differently?" *American Economic Journal: Applied*, 6(1): 157–89.

Barker, DJP. 1995. "The fetal and infant origins of disease." *European Journal of Clinical Investigation*, 25(7): 457–463.

Barros, Fernando, Sharon Huttly, Cesar Victora, Betty Kirkwood, and J. Patrick Vaughan. 1992. "Comparison of the causes and consequences of prematurity and intrauterine growth retardation: A longitudinal study in southern Brazil." *Pediatrics*, 90(2): 238–244.

Basinga, Paulin, Paul J Gertler, Agnes Binagwaho, Agnes LB Soucat, Jennifer Sturdy, and Christel MJ Vermeersch. 2011. "Effect on maternal and child health services in Rwanda of payment to primary health-care providers for performance: An impact evaluation." *The Lancet*, 377(9775): 1421–1428.

Behrman, Jere. 1988. "Intrahousehold allocation of nutrients in rural India: Are boys favored? Do parents exhibit inequality aversion?" *Oxford Economic Papers*, 30(1): 32–54.

Behrman, Jere R and Mark R Rosenzweig. 2004. "Returns to birthweight." *Review of Economics and Statistics*, 86(2): 586–601.

Bhalotra, Sonia. 2010. "Fatal fluctuations? Cyclicality in infant mortality in India." *Journal of Development Economics*, 93(1): 7–19.

Bhat, P.N. Mari. 2003. "On the Trail of 'Missing' Indian Females: II: Illusion and Reality." *Economic and Political Weekly*, 37(52): 5244–5263.

Bhat, P.N. Mari, Samuel Preston, and Tim Dyson. 1984. "Vital Rates in India, 1961-1981." Report 24, Committee on Population and Demography.

Bhutta, Zulfiqar A. 2000. "Why has so little changed in maternal and child health in South Asia?" *British Medical Journal*, 321(7264): 809–812.

Bhutta, Zulfiqar A, Tahmeed Ahmed, Robert E Black, Simon Cousens, Kathryn Dewey, Elsa Giugliani, Batool A Haider, Betty Kirkwood, Saul S Morris, HPS Sachdev et al.. 2008. "What works? Interventions for maternal and child undernutrition and survival." *The Lancet*, 371(9610): 417–440.

Bhutta, Zulfiqar A, Indu Gupta, Harendra de'Silva, Dharma Manandhar, Shally Awasthi, SM Hossain, and MA Salam. 2004. "Maternal and child health: Is South Asia ready for change?" *British Medical Journal*, 328(7443): 816–819.

Binkin, Nancy J., Ray Yip, Lee Fleshood, and Frederick Trowbridge. 1988. "Birth weight and childhood growth." *Pediatrics*, 82: 828–834.

Black, Robert E, Lindsay H Allen, Zulfiqar A Bhutta, Laura E Caulfield, Mercedes De Onis, Majid Ezzati, Colin Mathers, Juan Rivera et al.. 2008. "Maternal and child undernutrition: Global and regional exposures and health consequences." *The Lancet*, 371(9608): 243–260.

Black, Sandra E, Paul J Devereux, and Kjell Salvanes. 2007. "From the cradle to the labor market? The effect of birth weight on adult outcomes.." *Quarterly Journal of Economics*, 122: 409–439.

Bloom, Shelah S, David Wypij, and Monica Das Gupta. 2001. "Dimensions of women's autonomy and the influence on maternal health care utilization in a north Indian city." *Demography*, 38(1): 67–78.

Bongaarts, John. 1987. "The proximate determinants of fertility." *Technology in Society*, 9(3): 243–260.

Bongaarts, John, Odile Frank, and Ron Lesthaeghe. 1984. "The proximate determinants of fertility in sub-Saharan Africa." *Population & Development Review*: 511–537.

Borooah, Vani K.. 2004. "Gender bias among children in India in their diet and immunisation against disease." *Social Science & Medicine*, 58(9): 1719–1731.

Bozzoli, Carlos, Angus Deaton, and Climent Quintana-Domeque. 2009. "Adult Height and Childhood Disease." *Demography*, 46(4): 647–669.

Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller. 2008. "Bootstrap-based improvements for inference with clustered errors." *The Review of Economics and Statistics*, 90(3): 414–427.

Case, Anne. 2002. "Health, income and economic development." in B. Pleskovic and N. Stern eds. *Proceedings of the Annual World Bank Conference on Development Economics, 2001/2002*: 221–41.

Case, Anne and Angus Deaton. 1998. "Large cash transfers to the elderly in South Africa." *The Economic Journal*, 108(450): 1330–1361.

Case, Anne and Christina Paxson. 2008. "Stature and Status: Height, Ability, and Labor Market Outcomes." *Journal of Political Economy*, 116(3): 499–532.

Charmaz, K.. 1983. "The grounded theory method: An explication and interpretation." in R. Emerson ed. *Contemporary field research: A collection of readings*: Waveland Press: 109–126.

Chaudhury, Nazmul, Jeffrey Hammer, Michael Kremer, Karthik Muralidharan, and F Halsey Rogers. 2006. "Missing in action: Teacher and health worker absence in developing countries." *The Journal of Economic Perspectives*, 20(1): 91–116.

Checkley, William, Gillian Buckley, Robert Gilman, Ana Assis, Richard Guerrant, Saul Morris, Kare Mølbak, Palle Valentiner-Branth, Claudio Lanata, and Robert Black. 2008. "Multi-country analysis of the effects of diarrhoea on childhood stunting." *International Journal of Epidemiology*, 37: 816–830.

Claeson, Mariam, Eduard R Bos, Tazim Mawji, and Indra Pathmanathan. 2000. "Reducing child mortality in India in the new millennium." *Bulletin of the World Health Organization*, 78(10): 1192–1199.

Coffey, Diane, Angus Deaton, Jean Drèze, Dean Spears, and Alessandro Tarozzi. 2013. "Stunting among children: Facts and implications." *Economic & Political Weekly*, 48(34): 68–70.

Coffey, Diane, Aashish Gupta, Payal Hathi, Nidhi Khurana, Dean Spears, Nikhil Srivastav, and Sangita Vyas. 2014. "Revealed preference for open defecation." *Economic & Political Weekly*, 49(38): 43.

Coffey, Diane, Aashish Gupta, Payal Hathi, Dean Spears, Nikhil Srivastav, and Sangita Vyas."Culture and the health transition: Understanding sanitation behavior in rural north India." *r.i.c.e. working paper* `www.riceinstitute.org`.

Cohen, Barney, Mark R Montgomery et al.. 1997. *From Death to Birth: Mortality Decline and Reproductive Change*: National Academies Press.

Corbin, Juliet and Anselm Strauss. 1998. *Basics of qualitative research: Techniques and procedures for developing grounded theory*: Sage publications.

Crimmins, Eileen and Caleb Finch. 2006. "Infection, inflammation, height and longevity." *Proceedings of the National Academy of the Sciences*, 103(2): 498–503.

Currie, Janet and Tom Vogl. 2013. "Early-life health and adult circumstance in developing countries." *Annual Review of Economics*, 5: 1–36.

Das, Narayan. 1987. "Sex preference and fertility behavior: A study of recent Indian data." *Demography*, 24(4): 517–530.

Das, Jishnu and Jeffrey Hammer. 2007. "Money for nothing: The dire straits of medical practice in Delhi, India." *Journal of Development Economics*, 83(1): 1–36.

Das Gupta, Monica. 1995. "Perspectives on Women's Autonomy and Health Outcomes." *American Anthropologist*, 97(3): 481–491.

Dasgupta, Monica. 1987. "Selective discrimination against female children in rural Punjab, India." *Population & Development Review*, 13: 77–100.

De Onis, Mercedes. 2006. "WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development."Technical report, Geneva: World Health Organization.

Deaton, Angus. 2006. "Global patterns of income and health: Facts, interpretations, and policies." WIDER Annual Lecture 10, UNU World Institute for Development Economics Research.

——— 2007. "Height, health, and development." *Proceedings of the National Academy of Sciences*, 104(33): 13232–13237.

——— 2008. "Height, Health & Inequality: The Distribution of Adult Heights in India." *AEA Papers and Proceedings*, 98(2): 468–474.

Deaton, Angus and Jean Drèze. 2009. "Nutrition in India: Facts and Interpretations." *Economic & Political Weekely*, XLIV(7): 42–65.

Desai, Sonalde, Amaresh Dubey, B Joshi, Mitali Sen, Abusaleh Shariff, and Reeve Vanneman. 2008. "India Human Development Survey (IHDS) [Computer file]. ICPSR22626ev1. University of Maryland and National Council of Applied Economic Research, New Delhi [producers], 2007." *Ann Arbor, MI: Inter-university Consortium for Political and Social Research.[distributor].*

Desai, Sonalde, Amaresh Dubey, Brij Lal Joshi, Mitali Sen, Abusaleh Shariff, and Reeve Vanneman. 2009. "India Human Development Survey: Design and Data quality." *IHDS technical paper*, 1.

DiNardo, John, Nicole M Fortin, and Thomas Lemieux. 1996. "Labor market institutions and the distribution of wages, 1973-1992: A semiparametric approach." *Econometrica*, 64: 1001–1044.

Dongre, Ambrish. 2010. "Effect of Monetary Incentives on Institutional Deliveries: Evidence from India." *working paper*.

Dréze, Jean and Amartya Sen. 1997. *Indian development: Selected regional perspectives*: Oxford University Press.

Duflo, Esther. 2012. "Women Empowerment and Economic Development." *Journal of Economic Literature*, 50(4): 1051–79.

Duh, Josephin and Dean Spears. 2015. "Health and hunger: Disease, energy needs and the Indian calorie consumption puzzle." *Economic Journal*.

Duke, T.. 2005. "Neonatal pneumonia in developing countries." *Archives of Disease in Childhood–Fetal Neonatal Edition*, 90: F211F219.

Dyson, Tim and Mick Moore. 1983. "On kinship structure, female autonomy, and demographic behavior in India." *Population & Development Review*, 9: 35–60.

Easterlin, Richard A. 1971. "Does human fertility adjust to the environment?" *The American Economic Review*: 399–407.

Ensor, Tim, Susan Clapham, and Devi Prasad Prasai. 2009. "What drives health policy formulation: Insights from the Nepal maternity incentive scheme?" *Health Policy*, 90(2): 247–253.

EPW Research Foundation. 2009. "Domestic Product of States of India : 1960-61 to 2006-07, 2nd updated edition."Technical report.

Filmer, Deon and Lant H Pritchett. 2001. "Estimating wealth effects without expenditure dataor tears: An application to educational enrollments in states of India." *Demography*, 38(1): 115–132.

Fogel, Robert. 2004. *The Escape from Hunger and Premature Death, 1700–2100: Europe, America, and the Third World*: Cambridge University Press.

Geruso, Michael. 2012. "Black-White Disparities in Life Expectancy: How Much Can the Standard SES Variables Explain?" *Demography*, 49(2): 553–574.

Glassman, Amanda and Nancy Birdsall. 2013. "Can India defeat poverty?." Foreign Policy blog `http://www.foreignpolicy.com/articles/2013/01/08/can_india_defeat_poverty`.

Gopalan, C.. 1985. "The Mother and Child in India." *Economic and Political Weekly*, 20(4): 159–166.

Gørgens, Tue, Xin Meng, and Rhema Vaithianathan. 2012. "Stunting and selection effects of famine: A case study of the Great Chinese Famine." *Journal of Development Economics*, 97: 99–111.

Government of India. 1968. *Vital Statistics of India for 1963-4: Based on Civil Registration System*, 134: Office of the Registrar General.

——— 1979. *Survey on Infant and Child Mortality, 1979*: Office of the Registrar General.

——— 2013. "Special Bulletin on Maternal Morality in India: 2010-2012."Technical report, Sample Registration System, Office of the Registrar General.

Grantham-McGregor, Sally, Yin Bun Cheung, Santiago Cueto, Paul Glewwe, Linda Richter, Barbara Strupp et al.. 2007. "Developmental potential in the first 5 years for children in developing countries." *The Lancet*, 369(9555): 60–70.

Gupta, Monica Das. 1995. "Life course perspectives on women's autonomy and health outcomes." *American Anthropologist*, 97(3): 481–491.

Hatton, Timothy. 2011. "Infant mortality and the health of survivors: Britain, 1910-50." *The Economic History Review*, 64(3): 951–972.

——— 2013. "How have Europeans grown so tall?" *Oxford Economic Papers*, 66: 349–372.

Heston, Alan, Robert Summers, and Bettina Aten. 2002. "Penn World Table." *Center for International Comparisons at the University of Pennsylvania*.

Humphrey, Jean. 2009. "Child undernutrition, tropical enteropathy, toilets, and handwashing." *The Lancet*, 374: 1032–1035.

Hutter, Inge. 1994. *Being pregnant in rural south India: Nutrition of women and well-being of children*: Purdue University Press.

Hytten, Frank. 1979. "Nutrition in pregnancy." *Postgraduate Medical Journal*, 55: 2934–2939.

Hytten, Frank and Isabella Leitch. 1971. *The physiology of human pregnancy*: Blackwell Scientific Publications, Oxford.

Institute of Medicine. 1990. *Nutrition during pregnancy: part I, Weight gain*: Natl Academy Press.

Jayachandran, Seema. 2015. "The Roots of Gender Inequality in Developing Countries." *Annual Review of Economics*, 7.

Jayachandran, Seema and Ilyana Kuziemko. 2011. "Why do mothers breastfeed girls less than boys?: Evidence and implications for child health in India." *Quarterly Journal of Economics*, 126(3): 1485–1538.

Jayachandran, Seema and Rohini Pande. 2013. "Why are Indian children shorter than African children?" working paper, Northwestern University.

Jeffery, Patricia and Roger Jeffery. 2010. "Only when the boat has started sinking: A maternal death in rural north India." *Social Science & Medicine*, 71(10): 1711–1718.

Jeffery, Patricia, Abhijit Das, Jashodhara Dasgupta, and Roger Jeffery. 2007. "Unmonitored intrapartum oxytocin use in home deliveries: Evidence from Uttar Pradesh, India." *Reproductive Health Matters*, 15(30): 172–178.

Jeffery, Patricia, Roger Jeffery, and Andrew Lyon. 1988. *Labour Pains and Labour Power: Women and Childbearing in India*: Zed Book Ltd.

Jensen, Robert and Emily Oster. 2009. "The power of TV: Cable television and women's status in India." *The Quarterly Journal of Economics*, 124(3): 1057–1094.

Jousilahti, P., J. Tuomilehto, E. Vartiainen, J. Eriksson, and P. Puska. 2000. "Relation of adult height to cause-specific and total mortality: A prospective follow-up study of 31,199 middle-aged men and women in Finland." *American Journal of Epidemiology*, 151: 11121120.

Kabeer, Naila. 1999. "Resources, agency, achievements: Reflections on the measurement of women's empowerment." *Development and Change*, 30: 435–464.

Khan, ME, Avishek Hazra, and Isha Bhatnagar. 2010. "Impact of Janani Suraksha Yojana on selected family health behaviors in rural Uttar Pradesh." *Journal of Family Welfare*, 56: 9–22.

Kishore, Avinash and Dean Spears. 2014. "Having a son promotes clean cooking fuel use in urban India: Women's status and son preference." *Economic Development and Cultural Change*, 62(4): 673–699.

Komlos, John. 1998. "Shrinking in a growing economy? The mystery of physical stature during the industrial revolution." *Journal of Economic History*, 58: 779–802.

——— 2003. "Access to food and the biological standard of living: Perspectives on the nutritional status of native Americans." *The American Economic Review*, 93(1): 252–255.

Korpe, Poonam and William Petri. 2012. "Environmental enteropathy: Critical implications of a poorly understood condition." *Trends in Molecular Medicine*, 18(6): 328–336.

Kramer, Michael S.. 1987. "Intrauterine Growth and Gestational Duration Determinants." *Pediatrics*, 80(4): 502–511.

Kumar, Vishwajeet, Saroj Mohanty, Aarti Kumar, Rajendra Misra, Mathuram Santosham, Shally Awasthi, Abdullah Baqui, Pramod Singh, Vivek Singh, Ramesh Ahuja et al.. 2008. "Effect of community-based behaviour change management on neonatal mortality in Shivgarh, Uttar Pradesh, India: A cluster-randomised controlled trial." *The Lancet*, 372(9644): 1151–1162.

Kusin, Jane, Sri Kardjati, and U.H. Renqvist. 1993. "Chronic undernutrition in pregnancy and lactation." *Proceedings of the Nutrition Society*, 52: 19–28.

Kusin, Jane, Sri Kardjati, Joop Houtkooper, and U.H. Renqvist. 1992. "Energy supplementation during pregnancy and postnatal growth." *The Lancet*, 340(8820): 623–626.

Lim, Stephen S, Lalit Dandona, Joseph A Hoisington, Spencer L James, Margaret C Hogan, and Emmanuela Gakidou. 2010. "India's Janani Suraksha Yojana, a conditional cash transfer programme to increase births in health facilities: An impact evaluation." *The Lancet*, 375(9730): 2009–2023.

Ludwig, David S and Janet Currie. 2010. "The association between pregnancy weight gain and birthweight: A within-family comparison." *The Lancet*, 376(9745): 984–990.

Maccini, Sharon and Dean Yang. 2009. "Under the weather: Health, schooling, and economic consequences of early-life rainfall." *The American Economic Review*: 1006–1026.

Malini, S, RM Tripathi, P Khattar, KS Nair, YL Tekhre, N Dhar, and D Nandan. 2008. "A rapid appraisal on functioning of Janani Suraksha Yojana in south Orissa." *Health Population Perspectives Issues*, 31: 126–31.

Mandelbaum, David. 1988. *Women's seclusion and men's honor*: University of Arizona Press.

Martin, Teresa Castro. 1995. "Women's education and fertility: Results from 26 Demographic and Health Surveys." *Studies in family planning*: 187–202.

Mazumdar, Sumit, AJ Mills, and Timothy Powell-Jackson. 2012. "Financial incentives in health: New evidence from India's Janani Suraksha Yojana." *working paper*.

"National Rural Health Mission."

Miller, Grant. 2008. "Women's suffrage, political responsiveness, and child survival in American history." *The Quarterly Journal of Economics*, 123(3): 1287.

Million Death Collaborators. 2010. "Causes of neonatal and child mortality in India: A nationally representative mortality survey." *The Lancet*, 376: 1853–1860.

MOSPI. 1999. "Time Use Survey: Summary of findings." Ministry of statistics and programme implementation, Government of India. `http://mospi.nic.in/Mospi_New/site/inner.aspx?status=3&menu_id=91`.

Munshi, Kaivan and Mark Rosenzweig. 2006. "Traditional institutions meet the modern world: Caste, gender, and schooling choice in a globalizing economy." *American Economic Review*, 96(4): 1225–1252.

——— 2009. "Why is mobility in India so low?: Social insurance, inequality, and growth." *NBER Working Paper*(14850).

Nguyen, Ha TH, Laurel Hatt, Mursaleena Islam, Nancy L Sloan, Jamil Chowdhury, Jean-Olivier Schmidt, Atia Hossain, and Hong Wang. 2012. "Encouraging maternal health service utilization: An evaluation of the Bangladesh voucher program." *Social Science & Medicine*, 74(7): 989–996.

Nubé, Maarten. 2009. "The Asian enigma: Predisposition for low adult BMI among people of South Asian descent." *Public health nutrition*, 12(04): 507–516.

Osmani, Siddiq and Amartya Sen. 2003. "The hidden penalties of gender inequality: Fetal origins of ill-health." *Economics & Human Biology*, 1(1): 105–121.

Palriwala, Rajni. 1993. "Economics and patriliny: Consumption and authority within the household." *Social Scientist*, 21(9/11): 47–73.

Pande, Rohini. 2003. "Selective gender differences in childhood nutrition and immunization in rural India: The role of siblings." *Demography*, 40(3): 395–418.

Patton, Michael Quinn. 1987. *How to use qualitative methods in evaluation*: Sage.

Pinto, Sarah. 2013. *Where there is no midwife: Birth and loss in rural India*: Berghahn Books.

Planning Commission. 2013. "Press note on poverty estimates."Technical report, Government of India.

Population Reference Bureau. 2005. "2005 World Population Datasheet." *Washington, DC*.

Powell-Jackson, Timothy and Kara Hanson. 2012. "Financial incentives for maternal health: Impact of a national programme in Nepal." *Journal of Health Economics*, 31(1): 271–284.

Preston, Samuel H. 1978. *The effects of infant and child mortality on fertility*: Academic Press, Inc.

Preston, S., M. Hill, and G. Drevenstedt. 1998. "Childhood conditions that predict survival to advanced ages among African Americans." *Social Science and Medicine*, 47: 1231–1236.

Rahman, Lupin and Vijayendra Rao. 2004. "The determinants of gender equity in India: Examining Dyson and Moore's thesis with new data." *Population & Development Review*, 30(2): 239–268.

Ramalingaswami, Vulimiri, Urban Jonsson, and Jon Rohde. 1996. "Commentary: The Asian enigma." The Progress of Nations, United Nations Childrens Fund.

Rao, Vijayendra. 1993. "The rising price of husbands: A hedonic analysis of dowry increases in rural India." *Journal of Political Economy*: 666–677.

Rosenzweig, Mark R and Oded Stark. 1989. "Consumption smoothing, migration, and marriage: Evidence from rural India." *The Journal of Political Economy*: 905–926.

Schmidt, I.M., M.H. Jorgensen, and K.F. Michaelsen. 1995. "Height of conscripts in Europe: Is postneonatal mortality a predictor?" *Annals of Human Biology*, 22(1): 57–67.

Schofield, Heather. 2014. "The economic costs of low caloric intake: Evidence from India." *working paper*.

Scott, Kerry and Shobhit Shanker. 2010. "Tying their hands? Institutional obstacles to the success of the ASHA community health worker programme in rural north India." *AIDS care*, 22(S2): 1606–1612.

Sidney, Kristi, Vishal Diwan, Ziad El-Khatib, and Ayesha de Costa. 2012. "India's JSY cash transfer program for maternal health: Who participates and who doesn't – a report from Ujjain district." *Reproductive health*, 9(1).

Siega-Riz, Anna Maria, Linda S Adair, and Calvin J Hobel. 1994. "Institute of Medicine maternal weight gain recommendations and pregnancy outcome in a predominantly Hispanic population." *Obstetrics & Gynecology*, 84(4, Part 1): 565–573.

Silventoinen, Karri. 2003. "Determinants of variation in adult body height." *Journal of Biosocial Sciences*, 35: 263–285.

Singh, J.P.. 2005. "The contemporary Indian family." in Bert Adams and Jan Trost eds. *Handbook of World Families*: Sage, Chap. 6: 129–166.

Sokal, D. C., G. Imboua-Bogui, G. Soga, C. Emmou, and T. S. Jones. 1988. "Mortality from neonatal tetanus in rural Côte d'Ivoire." *Bulletin of the World Health Organization*, 66(1): 69–76.

Spears, Dean. 2012a. "Effects of rural sanitation on infant mortality and human capital: Evidence from India's Total Sanitation Campaign." *r.i.c.e. working paper* `www.riceinstitute.org`.

——— 2012b. "Height and cognitive achievement among Indian children." *Economics & Human Biology*, 10: 210–219.

——— 2013. "How much international variation in child height can sanitation explain?" *World Bank policy research working paper*(6351).

Steckel, Richard H. 1983. "Height and per capita income." *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, 16(1): 1–7.

Steckel, Richard. 2009. "Heights and human welfare: Recent developments and new directions." *Explorations in Economic History*, 46: 1–23.

Stephens, Carolyn. 1992. "Training urban traditional birth attendants: Balancing international policy and local reality: Preliminary evidence from the slums of India on the attitudes and practice of clients and practitioners." *Social Science & Medicine*, 35(6): 811–817.

Strauss, John and Duncan Thomas. 1995. "Human resources: Empirical modeling of household and family decisions." *Handbook of development economics*, 3: 1883–2023.

Susser, Mervyn and Zena Stein. 1994. "Timing in prenatal nutrition: A reprise of the Dutch Famine Study." *Nutrition reviews*, 52(3): 84–94.

Tarozzi, Alessandro. 2008. "Growth reference charts and the nutritional status of Indian children." *Economics & Human Biology*, 6: 455–468.

Thomas, Duncan. 1990. "Intra-household resource allocation: An inferential approach." *Journal of Human Resources*: 635–664.

Thomson, AM and WZ Billewicz. 1957. "Clinical significance of weight trends during pregnancy." *British Medical Journal*, 1(5013): 243–247.

Tripathi, Amarnath and Shraddha Srivastra. 2011. "Interstate migration and changing food preferences in India." *Ecology of Food and Nutrition*, 50(5): 410–428.

Underwood, Barbara A. 2002. "Health and nutrition in women, infants, and children: Overview of the global situation and the Asian enigma." *Nutrition reviews*, 60(s5): S7–S13.

UNICEF & WHO. 2004. *Low birthweight: Country, regional and global estimates*: UNICEF.

UNICEF. 2011. "Elimination of maternal and neonatal tetanus." `http://www.unicef.org/health/index_43509.html`.

United Nations Population Fund. 2008. "Concurrent assessment of Janani Suraksha Yojana (JSY) in selected states: Bihar, Madhya Pradesh, Orissa, Rajasthan and Uttar Pradesh."Technical report, UNFPA.

Victora, Cesar, Fernando Barros, Betty Kirkwood, and J. Patrick Vaughan. 1990. "Pneumonia, diarrhea, and growth in the first 4 years of life: A longitudinal study of 5914 urban Brazilian children." *American Journal of Clinical Nutrition*, 52(39): 1–6.

Villar, José and José Belizán. 1982. "The relative contribution of prematurity and fetal growth retardation to low birthweight in developing and developed societies." *American Journal of Obstetrics and Gynecology*, 143: 793–798.

Visaria, Leela. 1985. "Infant Mortality in India: Level, Trends and Determinants." *Economic & Political Weekly*, 20(32): 1352–1359.

Vogl, Tom. 2011. "Height, Skills, and Labor Market Outcomes in Mexico." working paper, Harvard University.

——— 2013. "Marriage institutions and sibling competition: Evidence from South Asia." *Quarterly Journal of Economics*, 128(3): 1017.

Waterlow, J.C.. 2011. "Reflections on stunting." in Charles Pasternak ed. *Access not Excess*: Smith–Gordon.

WHO, Unicef &. 2004. *Low Birthweight: Country, regional and global estimates*: UNICEF.

WHO. 2011. "WHO Anthro for personal computers, version 3.2.2." `http://www.who.int/childgrowth/software/en/`.

Witter, Sophie, Sunil Khadka, Hom Nath, and Suresh Tiwari. 2011. "The national free delivery policy in Nepal: Early evidence of its effects on health facilities." *Health Policy and Planning*, 26(2): ii84–ii91.

World Bank. 2001. *Engendering development: Through gender equality in rights, resources and voice*: World Development Report.

——— 2014. "World Development Indicators 1960-2013.." *World Bank, Washington, DC*.

World Health Organization. 1995. "Maternal anthropometry and birth outcomes: A WHO collaborative study." *Bulletin of the World Health Organization*, supplement to volume 73.

Yajnik, CS, CHD Fall, KJ Coyaji, SS Hirve, S Rao, DJP Barker, C Joglekar, and S Kellingray. 2003. "Neonatal anthropometry: The thin–fat Indian baby. The Pune maternal nutrition study." *International Journal of Obesity*, 27(2): 173–180.

Yaktine, Ann L and Kathleen M Rasmussen. 2009. *Weight Gain During Pregnancy: Reexamining the Guidelines*: National Academies Press.