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Three Essays on Maternal and Child Health

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

by

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Dedication

To,

Raag Bhimpalasi (राग भीमपलासी)

… for energizing countless afternoons

Table of Contents

List of Tables

List of Figures

Abstract

THREE ESSAYS ON MATERNAL AND CHILD HEALTH

By Mandar V. Bodas, Ph. D., MHA, BAMS

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

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This dissertation is a collection of three separate essays on the health of women and children. In the first essay, I along with my co-authors, analyzed the impact of two large, national-level health policies (the Janani Suraksha Yojana (JSY) and the National Rural Health Mission (NRHM)) on maternal health outcomes (proportion of institutional deliveries) in India. We used data from the India Human Development Survey (IHDS) and found that the JSY and the NRHM had a greater impact on institutional deliveries in high-focus states. We also found that the conditions of the public health facilities, did not change after the implementation of the JSY and the NRHM. Finally, we found that adequacy of health facilities was not associated with the likelihood of mothers in high-focus states having an institutional delivery. In the second

essay, I examined whether a key social determinant of health in South Asia- gender inequality, is associated with physical health outcomes among Indian women. I found that the gender inequality expressed as the gendered household practice of seclusion was negatively associated with body weight of Indian women. Further, I found that participation in all household decisions by women of the household was generally not associated with body weight outcomes. The association between gendered household practices and women's body weight outcomes was generally similar among rural and urban Indian women. In the final essay, I examined whether perinatal food environments (FE), maternal gestational weight gain (GWG) and early childhood weight (ECW) outcomes are associated. I used data on mother-children dyads from the Early Childhood Longitudinal Study – Birth cohort (ECLS-B), Area Resource Files (ARF) and Current Business Practices (CBP). I found that maternal GWG was associated with ECW outcomes. I also found that measures of food environment were associated with ECW outcomes. Specifically, I found that having an additional full-service restaurant per one thousand population in the maternal perinatal county of residence was associated with lower BMI among children at age two years. Finally, I found that GWG did not mediate the association between food environment and ECW outcomes.

Chapter 1: Strategies That Work But Facilities That Do Not: An Assessment of the National Rural Health Mission (NRHM) and the Janani Suraksha Yojana (JSY) of India

Introduction

More than 98% of global maternal deaths occur in developing countries and nearly 16% of them in India. [1] Raising the rates of institutional deliveries (the proportion of deliveries that occur at a health facility) is a crucial step towards reducing maternal mortality in India and in other developing countries.[2] In 2005, India implemented a combination of interventions to improve the proportion of institutional deliveries and other health outcomes [3]: the Janani Suraksha Yojana (JSY) and the National Rural Health Mission (NRHM). The JSY, one of largest cash transfer programs in the world, attempted to reduce financial barriers to accessing health care by offering cash benefits conditional on having an institutional delivery. The NRHM was aimed at strengthening the existing health infrastructure by improving quality of public health services. Both policies were directed at rural India where less than 32 % of deliveries were institutional prior to the policy enactment compared to urban areas where about 70 % of deliveries were institutional.[3] Under each of the policies, Indian policymakers strategically paid more attention to a group of Indian states. Prior to policy implementation, certain states had considerably lower levels of institutional deliveries compared to other parts of India.[3] These states accounted for up to 62% of maternal deaths in India and about 12% of the global burden of maternal deaths.[4] Greater policy attention was provided via an early roll-out of interventions and more generous incentives offered in certain states along with giving these states more flexibility to spend the funds allocated under the schemes.[5] Policymakers hoped that targeting such regions with high maternal mortality would reduce regional disparities in the proportion of institutional deliveries. Thus, specific regions of India were ‘targeted’ to improve the proportion of institutional deliveries with the aim to reduce the burden of maternal deaths.

The purpose of this study is to evaluate the impact of the ‘targeting’ strategy under the JSY and the NRHM on institutional deliveries. This is in contrast to the available literature which broadly falls into two groups. First, a group of studies evaluated national-level changes in India’s maternal health indicators after JSY & NRHM implementations.[6-8] While valuable, the inference from these studies does not provide a direct comparison of health outcomes in the targeted and the non-targeted ones (referred to as ‘high-focus states’ and non-high-focus states from here onwards in this study). Secondly, pre-post assessments of institutional deliveries within specific regions of India are available in some other studies.[4,9] These studies are useful in understanding how a particular region performed after the implementation of the policies. However, they do not provide information about the success of the ‘targeting’ strategy, which is an important limitation of the current literature. To ascertain whether the ‘targeting’ was effective, a comparative analysis of states after the joint implementation of the JSY and the NRHM is essential but is not yet available. Our primary aim is to fill this gap in literature and provide Indian policymakers evidence on whether to incorporate the ‘targeting’ in future maternal health interventions.

As a secondary goal of the study, we wish to contribute to the literature focusing on the mechanisms that can influence pregnant mothers’ choice of place of delivery in India and in other developing countries. The mechanism we explore in this study is the role of the local-level health facilities. There are two main reasons for evaluating this particular issue. First, the major reason why pregnant mothers in developing countries deliver at home is the poor quality of health services available at the local health facilities.[10-13] This is particularly relevant in rural India where delivery services are often provided by only the public health facilities, which are often poorly staffed and have inadequate infrastructure.[5,14] Secondly, evidence from the Indian Planning Commission[5], independent studies[15] and the NRHM's own Common Review Mission (CRM) reports[16] indicates that despite implementing the JSY and the NRHM, there was little or no change in the conditions of rural public health facilities. Yet, the proportion of institutional deliveries in rural India increased by up to 150% from their level in 2006 after the execution of the JSY and the NRHM.[7] It is unclear why a higher proportion of rural Indian mothers chose to deliver at facilities after the policy implementation while the facilities continued to remain in poor conditions. These two issues prompt us to ask: after the JSY and NRHM implementation, did the conditions of local level health facilities play any role in mother's decisions of selecting a place for child delivery? We hypothesize that the increase in institutional deliveries could be partially explained by the incentives offered under the JSY and by a more active role played by local-level health workers. Through this secondary goal we hope to draw policymakers' attention to the alarmingly poor condition of rural public health infrastructure in India.

To address our study aims, in this study we first assess the impact of the targeting strategy under the JSY and the NRHM on the likelihood of rural Indian mothers having an institutional delivery using nationally-representative data from two rounds (2005 and 2012) of household surveys in the India Human Development Survey (IHDS) [17]. Next, we use information from a separate survey within the IHDS that was conducted on the local-level health facilities accessed by the mothers in our main analytical sample. We exploit the differences in the policy attention received by the high-focus states to employ difference-in-differences (DID) analysis methods to understand whether institutional deliveries in high-focus states grew at a faster rate compared to other states. Further, in a novel contribution, we analyze the conditions of local level health facilities and create an indicator for the 'adequacy' of health facility's conditions. This unique measure was developed using information from the IHDS surveys and enabled us to conduct a 'before and after' comparison of medical facilities in high-focus and other states. Finally, we evaluate whether health facility adequacy is associated with the probability of having institutional deliveries by mothers living in high-focus states. We also conduct supplementary analyses on the role of community health workers to examine issues relevant to the study aims. Specifically, we analyze whether health workers were more active and whether more mothers received cash support for having an institutional delivery in high-focus states.

Research Questions

This study evaluates the following research questions:

1. Did the strategy of 'targeting' under the JSY and the NRHM translate into higher improvement in the proportion of institutional deliveries in the high-focus (targeted) states compared to non-targeted parts of the country?
2. Did the policy interventions under the NRHM produce improvements in the conditions of public health facilities in rural India?
3. Was the improvement in the proportion of institutional deliveries associated with the conditions of the public health facilities in high-focus states?

Study hypotheses

We now summarize the study hypotheses articulating the complex relationship between policy interventions, observed change in institutional deliveries and finally, the role of the JSY and the NRHM in generating changes in the proportion of institutional deliveries.

Hypothesis 1: Institutional deliveries in 'high-focus' states increased at a higher rate compared to that in in non-high focus states.

High-focus states received greater policy attention via an early roll-out of interventions, more generous incentives and higher flexibility to spend the funds allocated under the schemes.[3] For example, criterion for receiving cash incentives for having an institutional delivery under the JSY scheme were more generous for pregnant mothers living in high-focus states compared to other states. Implementation of both the policies began relatively early in high-focus states compared to other parts of the country. The overall funds available to high-focus states under the NRHM were considerably higher compared to other states. Based on these factors, we hypothesize that the high-focus states will show better improvements in the proportion of institutional deliveries.

Hypothesis 2: Despite the implementation of the NRHM, conditions of the public health facilities in high-focus states did not show major improvements.

Several issues with the implementation of the JSY and the NRHM have been documented in high-focus states including corruption and leaking of government funds.[18] These issues provide strong reasons to be cautious about whether the conditions of the Indian public health facilities improved as a result of increased funding. We expect that the public health facilities, specifically those in the high-focus states, will not improve significantly in terms of their infrastructural conditions.

Hypothesis 3: Observed change in institutional deliveries in the high-focus states will not be associated with the conditions of the local public health facility.

Finally, we posit that the improvements in institutional deliveries probably occurred due to reasons other than improvements in the conditions of local-level health facilities. There are two reasons to propose this hypothesis. First, in high-focus states, mothers and health workers (called Accredited Social Health Activists (ASHAs)) were quite generously incentivized compared to other parts of the country.[3]Secondly, the numerous hurdles involved in the implementation of the JSY and NHRM (example, such as 'leakages' of resources through corruption[18]) show that creating structural changes in developing country health systems are extremely difficult to achieve. It is likely that the child-birth related behavior of mothers (in terms of having an institutional delivery) in high-focus states altered more in response to the monetary incentives and personal urging of health workers.

Background

In the early 2000's, India lagged behind several developing countries with respect to improvements in maternal mortality, in large part due to lower rates of institutional deliveries. [19] For example, countries such as Brazil and South Africa had Maternal Mortality Rates (MMR) of 6 and 85 per 100,000 live births in the year 2000 compared to India's MMR of 374 per 100,000 live births.[19] Having an institutional delivery provides mothers attention from trained medical personnel and is known to significantly reduce pregnancy-related deaths.[1] To address this and other issues affecting the Indian health sector, the Indian government launched the NRHM in April 2005.[3] The overall mission of the policy was to provide affordable and quality health care to the rural Indian population. The NRHM was a massive undertaking unlike several previous healthcare programs in India in terms of financial allocation.[3]

The NRHM

The three strategic components of the NRHM were: improving existing health facilities, building new facilities as needed and introduce innovations in the healthcare work force. This was a so-called 'supply-side'[20] intervention, focused on the supply of health services to the population. The first step under this strategy was assessing the how many facilities were required based on the population they would serve. Population norms were established for operationalizing public health facilities **(Table 1)**. In the Indian health system, the types of facilities range from the smallest unit, a Sub-Center (SC) which served a population of 5,000 to a District Hospital (DH) that served the population of an entire district (generally about one and a half million). Facility-specific service quality standards were introduced under the NRHM.

Another key component of the NRHM was its strategic targeting of eighteen states (Eight states from the northern and the western regions of the country (Bihar, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand, Rajasthan, Orissa, and Uttaranchal), eight northeastern states, Jammu and Kashmir and Himachal Pradesh) mainly concentrated in the north central region of India **(Figure 1)**. These 'high-focus' states, performed poorly in terms of health outcomes (for example they had higher Maternal Mortality Rates[4]) and also had poor health infrastructure compared to the rest of the country. High focus states were paid extra attention in a variety of methods. For example, high-focus states could spend up to 33% of the allocated funds (called as Mission Flexipool funds) exclusively on health infrastructure while other states could spend only up to 25% of the funds on infrastructure.

Finally, to revitalize the Indian health workforce, the NRHM proposed the recruitment of Accredited Social Health Activists (ASHAs. The word 'Asha' means 'hope' in Hindi). Global experience suggests that locally recruited female health workers with minimal training can improve healthcare utilization.[21] Based on this evidence, women between the ages of 25-40 years, preferably having completed 10 years of education were selected from the village to "act as the interface between the community and the public health system". ASHAs were provided basic induction training and were equipped with a drug kit containing over the counter medicines.

The JSY

The Janani Surakasha Yojana (JSY) was a demand side intervention launched under the NRHM to improve the utilization of maternal health services including institutional deliveries. Cash incentives were offered to mothers conditional on giving birth at an accredited public or private health facility.[22] The JSY continues to operate currently with minor alterations and is one of the largest conditional cash transfer (CCT) schemes in the world. Since its inception, more than 105 million women have benefited from incentives under the program and more than Rs.104 billion ($ 1.3 billion) have been distributed under the scheme since its launch. [23]

It was mandatory for all states in India to implement the JSY.[3,12,15] Women's eligibility and incentive amounts offered varied considerably across state groups. For example, in high-focus states, all pregnant women were eligible irrespective of socioeconomic status, age, or parity. In rural areas of high focus states, pregnant women were offered more money (Rs.1400 (about USD ($) 21)) compared to women in urban areas of these states (Rs.1000 ($15)). In non-high-focus states, cash incentives were considerably smaller and only available to women who met certain eligibility requirements (example disadvantaged caste and/or low income). Assistance to eligible pregnant women in rural and urban areas of these states was Rs.700 ($10.30) and Rs.600 ($9) respectively. Further, only in high-focus states, health workers (ASHAs) were offered incentives for institutional delivery along with pregnant mothers. In rural areas of high focus states, ASHAs were offered Rs.600 ($9) and in urban areas of these states, ASHAs were offered Rs.200 ($3).

Implementation issues

After its launch the JSY achieved near-universal coverage.[22] In contrast, the rollout of the NRHM experienced numerous hurdles and was not implemented uniformly across all regions of the country. In 2012, Indian national auditors uncovered an enormous NRHM scandal in Uttar Pradesh, the largest and the most populous state in India and also a high-focus states.[18] Local bureaucrats and politicians pocketed vast sums of money allocated to the state under the scheme (to the tune of U.S. $ 1.6 billion). Auditors found that projects to build new public health facilities and to repair the existing ones in Uttar Pradesh existed only on paper. In other high-focus states, the funds allocated to state governments could not be effectively used because the public health system was understaffed and did not have the right mechanisms (such as skilled staff) in place to utilize the funds. This is understandable since achieving change in the fundamental aspects of a large, complex health system is an arduous process. Indeed, the CRM reports confirm that the health facilities in high-focus states did not improve significantly even after the implementation of the NRHM.[16,24]

Interestingly, despite the problems in implementation, India's maternal health outcomes and specifically, the proportion of institutional deliveries in rural areas improved over the time period of the JSY and the NRHM implementation.[6,9] This change could perhaps be partly assigned to the successful implementation of the financial incentives under the JSY. In addition, prior literature has not taken into account the lack of improvements in health facilities while evaluating either the JSY or NRHM. Due to this oversight the possible causal role of the local-level health facilities in changing the likelihood of a mother having an institutional delivery remains unclear.

Review of Literature on the Relationships between the JSY, NRHM and Maternal Health Outcomes

Existing studies suggest that the JSY and NHRM led to improvements in India's national-level maternal health outcomes. For example, in a review of the policies Nagarajan et al (2015) found that the JSY and the NRHM led to reduction in Infant Mortality Rates (IMR), reduction in Maternal Mortality Rates (MMR) and an increase in institutional deliveries.[7] These studies do not directly compare the high-focus and other states in their analysis and as a result, their results are not helpful to understand whether the policy provision of 'targeting' of certain states was useful. Next, some studies provide regional-level assessments of the JSY and the NRHM.[9,25] For example, Devadasan et al (2008) review the JSY and the NRHM implementation in four states of Maharashtra, Chattisgarh, Orissa and Karnataka.[9] Coffey (2014) focus on the consequences of JSY implementation within a single district in the state of Uttar Pradesh.[8] Vellakal (2017) assessed the impact of the NRHM only in the high-focus states.[6] Such studies have not explored the possible role of local level health facilities in increasing the rate of institutional deliveries in India and more evidence is required on the topic.[5-7,15,26,27]

To my knowledge, only a few studies have attempted to evaluate the causal impact of the JSY on maternal health outcomes.[4,22,28] For instance, Lim et al. (2010) analyzed the impact of the JSY on a host of maternal health outcomes such as institutional births, cash incentive receipts, receipt of antenatal care and finally, neonatal care. The authors used data from the District Level Health Survey–2 and 3 (2004 and 2008) and employed three identification strategies: individual-level matching, a modified before and after design, and a two-period district level difference-in-difference approach.[22] They concluded that the JSY raised the utilization of maternal health care and reduced neonatal mortality. There were important limitations of this study by Lim (2010). The results of the difference-in-difference analysis in Lim (2010) were not conclusive, lacked statistical power and perhaps were given less importance.[28] In contrast, Powell-Jackson et al. (2015) used the same data set and employed a difference-in-differences strategy that controlled for observables at the district level.[28] The authors found that the financial incentives under the JSY were associated with an increase in the use of maternal health services. However, the authors suggest that substitution away from the private sector, rather than improvements in the local health facilities, accounted for a sizeable proportion of the effect.

Both Lim (2010) and Powell-Jackson (2015) use data collected between December 2007 and December 2008. Early implementation of the JSY was prioritized to districts with poorer outcomes.[29] Financial allocations to states under the JSY increased substantially after this period. For example, the largest state in India, Uttar Pradesh, received only Rs. 130 million ($ 2 million) in the financial year 2007-08 (period between April 2007 to March 2008) which substantially increased to Rs. 2.6 billion ($ 40 million) in financial year 2008-09 (an increase of 1,900%).[23] While early effects of the JSY could have been captured in the data used by Lim and Powell-Jackson, large, significant effects of the JSY program could be expected after the year 2009. Since both Lim (2010) and Powell-Jackson (2015) use data that was mostly collected prior to 2009, their results do not represent the full impact of the JSY and are not generalizable beyond the period of its initial implementation.[46]

Randive et al. (2013), evaluated the JSY using data from the Sample Registration Survey (SRS) between the years 2005 and 2010.[4] They found a significant rise in institutional births in this period. Their main analysis evaluated the impact of a change in the proportion of institutional births on MMR and found no significant effects. Unlike other national-level studies, Randive (2013) focused only on nine states and their results do not provide a national-level comparison between high-focus and other states.

Gaps in literature

As seen in the review of literature on the JSY and the NRHM, no direct comparisons of high-focus and other states in terms of the impact on the proportion of institutional deliveries are available. Further, studies have not explored the causal role of the local-level health facilities in increasing the proportion of institutional deliveries in India. Further, studies often used household survey data, which provided information of mothers' childbirth decisions but were not able to provide any information about the conditions of the local health facilities accessed by mothers in the sample. Addressing these gaps in research is important. Policymakers in India wish to determine whether the targeting and other strategies under the JSY and the NRHM were effective in meaningfully improving the health of the Indian population.[27,30]

Study Contribution

To the best of our knowledge, ours is the first study to directly compare the performance of the JSY and the NRHM in the high-focus and that in other states. Inference from this analysis will provide evidence on whether the 'targeting' strategy was successful. Further, ours is the one of the few studies to use data on public health facilities obtained from non-governmental sources. This is a major improvement over the current evidence since information from governmental sources is known to be unreliable.[5] Finally, we explore an overlooked aspect of the health systems in developing countries – the worrying state of public health infrastructure. Developing countries are moving towards a regime of universal health insurance coverage for their population without regard to where and how health services are provided.[31] The issue of public health infrastructure in developing countries such as India needs attention now more than ever.

Conceptual Framework

In order to analyze the impact of the JSY and the NRHM, we adopt the Anderson Healthcare Utilization model[32] to create a conceptual framework for maternal health service use by rural women in India shown in **Figure 2.** The Andersen Model has been used in a number of different settings to study a variety of health outcomes,[33] including maternal health behaviors in developing countries.[34]

As seen in the model, multiple factors classified into environmental and population characteristics affect outcome measures for health services use (defined as having an institutional birth). The design and organization of the health care system represent the environmental factors which impact health outcomes. According to the constitution of India, the responsibility of providing healthcare to the population lies with individual states.[35] As a result, health care services are organized at the state level. Medical and paramedical professionals working in the public health systems are state government employees. Rules on practice restrictions for physicians and medical education policies also differ markedly among Indian states. As a result, the state of residence is an important proxy of the status of the health system accessed by a rural Indian woman. Next, the population characteristics under this model are categorized into predisposing characteristics, enabling resources and need factors. Predisposing characteristics are a set of individual-, household- and community-level factors which affect the likelihood of a health service being used; for this study it is having an institutional delivery. These include the age of the woman, education of the woman, education of the husband, religion and caste, all of which have been shown to affect use of maternal health services in rural India.[13,14] Finally, response to cash incentives conditional on using health services will depend on the income of the household. Therefore income is also considered as a predisposing factor. The enabling resources are a set of characteristics independent of individual characteristics which can affect the use of health services. Service utilization will be affected by supply of health facilities that have adequate infrastructure and which provide guaranteed availability of maternal health services (such as prenatal care and childbirth). Also, incentivizing the use of health services through cash transfers can be considered as an enabling factor. In summary, we analyze how environmental factors affect the relationship between enabling factors and maternal health outcomes in India.

Data and Methods

Data source

This study uses data from the first and second waves of the India Human Development Surveys (IHDS).[17] The IHDS was conducted by researchers from the University of Maryland, USA and the National Council of Applied Economic Research (NCAER), New Delhi, India. The IHDS-I (2004-05) is a multi-topic cross-sectional, nationally representative household survey designed to collect information on the economic and social conditions at the household and individual level. The IHDS-I covered the non-institutionalized population living in private households in India.

The sample for the IHDS was drawn using stratified random sampling. Villages and urban blocks (comprising of 150-200 households) formed the primary sampling unit (PSU) from which the households were selected. An in-person interview was conducted with the head of each household. The Household questionnaire collected information about the demographic characteristics of household members, sources of income, expenditure patterns and other information pertaining to the household. The Education, Health and Learning Tests questionnaire collected information on education of children and marriage practices of the household. A section of this questionnaire was answered only by ever married women aged 15-49 years and it collected information on women's marital history, fertility preferences, birth history, pre-natal and ante-natal care.

Additionally, separate interviews were conducted to collect information about the economic conditions of the village and health facilities most often used by the villagers. Data collection for IHDS-I began in November 2004 and ended in September 2005. The IHDS-I sample consisted of 41,554 households including 13,900 rural households which were interviewed during 1993-94 in a previous survey by the NCAER.[17] Robustness checks and comparisons of the IHDS-I rural sample with other data sets from India confirm that the new households added to the IHDS-I rural sample provided a nationally representative sample.[36] IHDS-I was conducted in all states and union territories of India.

Of the 612 districts in India in 2001, 382 were included in IHDS-I. The sample was spread across 1,503 villages and 971 urban blocks. IHDS II (2011– 2012) followed the same sampling and interview procedures as IHDS-I. IHDS-II re-interviewed about 85% of the households interviewed during the baseline survey. In urban blocks and rural areas of northeastern Indian states where 5 or more IHDS-I households were lost to attrition, the interviewers were asked to notify NCAER monitors of this loss. Once the loss was verified via physical check, a replacement household was randomly selected in the same neighborhood to refresh the sample. This led to 2,134 new households being included in the IHDS-II sample.[37]

Data collection for IHDS-II began in November 2011 and was almost completed by October 2012. The final sample size for IHDS-II was 42,152 households. These households were spread across 33 states and union territories, 384 districts, 1420 villages and 1042 urban blocks in India. Both IHDS data sets are publicly available through the Inter-University Consortium for Political and Social Research (ICPSR). Information about IHDS data collection procedures, funding and quality assurance about its data is available elsewhere.[17]

Data structure

The IHDS data is hierarchical in nature owing to its multi-stage sampling design. Households are nested in villages, villages are nested in districts and districts are nested in states. The state represents the highest level of geographical categorization. Data at the individual-level (age, sex, education etc.), the household-level (income, expenditure, family size etc.) and at village-level (health facilities, schools, roads etc.) are organized into separate files. Linkages are possible across data files using unique identifiers. Thus, it is possible to link a particular health facility within a village to individuals from a household living in that village. Numerous types of weights are available for analyzing the IHDS data, including weights for households and individuals, and truncated weights for statistical routines that require integer weights. IHDS recommends the use of appropriate individual survey weights for individual cross sectional analyses. Following this advice, we use individual weights from each IHDS survey in the current analysis.

IHDS and NRHM implementation timeline

The timeline of IHDS surveys make them an ideal source of data to evaluate the effects of the NRHM on maternal healthcare utilization. As mentioned earlier, data collection for IHDS-I was conducted between November 2004 and September 2005. Fertility and birth history of ever married women in the five-year period prior to the interview was collected in IHDS-I. Analysis of this period provides details on the pre-NRHM period in India. The NRHM was announced in

2005 and was implemented nation-wide from 2006 onwards. Information on fertility and birth history of ever married women during this period (2006-2011) was collected during IHDS-II (which was conducted between November 2011 and October 2012). Thus, there is no overlap between the data collected during two rounds of IHDS. As explained earlier, the effect of and the JSY and the NRHM should be expected in the latter period of implementation. Since IHDS-II collects data over the entire implementation period of NRHM, it is a valuable resource for evaluating NRHM's impact. **Figure 3** graphically explains NRHM implementation and IHDS survey timelines.

Sample derivation

In IHDS-I, household interviews were conducted with 33,510 ever-married women aged 15–49 years while 39,523 ever-married women aged 15–49 were interviewed in IHDS-II. The sample for the current study is restricted to women who gave birth within five years before the survey interview. This yielded an initial analytical sample of about 11,942 women from IHDS-I and 16,561 women in IHDS-II. The larger number of observations in IHDS-II is due to the method of replacing IHDS-I households lost to follow-up during IHDS-II.

The sample for the first set of analyses is limited to women living in rural areas. We exclude urban women from the analysis for two main reasons. First, health services are organized quite differently in rural India compared to urban India.[38] for example, there is greater availability of multiple types of specialist and non-specialist care in urban areas.[32] Due to better public and medical transport, even poor women from urban India can travel long distances in case of obstetric emergencies. For these reasons, urban women may often seek out care in facilities other than the ones closest where they live whereas rural women rarely have such choices. Second, neither IHDS-I nor IHDS-II collected information about neighborhood health facilities for households located in urban areas. After applying all the relevant exclusions, the final analytical sample of about 7,843 women from IHDS-I and about 8,102 women from IHDS-II was obtained. The sample derivation procedure for this analysis is described in **Figure 4**.

Next, a village-level health facility analysis was conducted. The sample of this analysis was restricted to those villages which satisfied the following conditions: 1) the sample for the first analysis was obtained from the village and 2) the village was surveyed in both rounds of the IHDS. There are two reasons for imposing the above conditions 1) to ensure that the data from village-level surveys provides information about the context of the health services available to pregnant mothers and 2) to ensure that the same set of villages was reviewed before and after the implementation of JSY and the NRHM. A total of 1,291 villages were part of this analysis.

Dependent Variables

The primary *dependent variable* was the place of delivery of last birth for each woman in the sample (i.e. institutional delivery). Women in IHDS samples were asked the question "At what kind of a place did you deliver your last child?" Women who answered either "Government hospital or clinic" or "Private nursing home" to the survey question were coded as 1 while those who answered as "home" to the survey question were coded as 0.

For the village-level analysis, type and adequacy of health facilities were used as the outcome variables. The construction of the adequacy variable is described in detail in the next section.

Independent Variables

State of residence

The main *independent variable* is an indicator for maternal residence in a high-focus state. It was categorized as living in a high-focus state (1) or not living in a high-focus state (0). (Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand, Orissa, Uttarakhand, Jammu and Kashmir, Himachal Pradesh, Assam, Manipur, Sikkim, Meghalaya, Mizoram, Arunachal Pradesh, Nagaland and Tripura) were classified as high-focus states. The rest of the states and union territories were classified as non-high-focus states.

Adequacy of Health Facilities

The other *independent variable* was an indicator for the 'adequacy' of the public health facility in the village of a pregnant woman's residence. As stated earlier, the goal of this analysis is to assess whether the conditions of local-level health facilities play a role in determining whether a mother has an institutional delivery. Adequacy in the current study is defined as the availability of basic infrastructure (electricity, piped water and toilets) and of health services (prenatal and birthing services) at a public health facility. There are two primary reasons for including only public health facilities to construct this variable. First, while IHDS reviewers surveyed a public and a private health facility in each village from which households were sampled, the public health facility was often the sole health services provider in the village.[37] Secondly, in rural India birthing services at private health facilities are far more expensive compared to those at a public health facility.[14] Services of a private provider during childbirth are often out of financial reach of most poor families. A pregnant woman in rural India is more likely to go to a public health facility for childbirth rather than a private one.[39] Thus, while not perfect, the conditions at a public health facility in a village are still a good indicator of the adequacy of maternal health care available to the women in the IHDS sample.

Detailed information on the conditions found in public health facilities was in the IHDS Medical Facilities file. The Medical Facilities file includes basic infrastructure data, such as availability of electricity, availability of piped drinking water and availability of a toilet in the facility. Collectively, these infrastructural factors formed the first measure of health facility adequacy. Second measure of facility adequacy was the availability of prenatal care and childbirth services. The final measure for defining adequacy was the number of hours for which the outpatient department (OPD) is open at the facility. If a facility in a particular village satisfied *all* the infrastructural and service requirements, then the *village* was categorized as having an adequate health facility (the *adequacy* variable was coded as 1, zero otherwise). This analysis was performed for each round of the IHDS.

As described earlier, under the NRHM, health facilities were classified into various categories based on the population served by each category (Table 1). The criterion for determining the adequacy of a health facility was adjusted for each of these categories. For example, different set of criterion were used to determine the adequacy of a Primary Health Center (PHC, which was designed to serve a population of 30,000) and that of a District Hospital (which serves a much larger population). The details of the adequacy criterion used for each type of facility are included in **Table 2.** There were some villages for which information on measures used to determine health facility adequacy was missing. Observations from such villages were excluded from analysis.

Caution must be exercised not to confuse the 'adequacy' of health facilities with the traditional notions about the 'quality' of services provided at a public health facility. Quality of services provided at health facilities is often measured using certain metrics or standards described by accreditation agencies.[40] For example, the IPHS standards mentioned earlier, provide details about the quality metrics for each type of public health facility in India.[3,5] Measurement of such metrics requires regular assessment of health facilities.[40] However, the IHDS survey information was collected in a single visit to the facility with no follow-up. Further, information was obtained only about the overall functioning of the facility but not on the 'standard' 'quality measures' such as mortality rates, infection rates, waiting times and medical errors etc.[40] Therefore, no conclusions about the quality of health services provided at public health facilities can be made based on the IHDS data. It is possible that the overall quality might differ between two facilities which are both defined as 'adequate'. Nevertheless, it can be argued that such differences are unlikely to influence mother's decision to select a health facility for giving birth. In the study sample, more than 40 % of the women had no education. (See **Table 4**) Their perception of the quality of health services provided at a public health facility may not depend on complicated information on formal 'quality outcomes'.[13] Instead, mother's decision may most likely depend on basic indicators of infrastructural adequacy. Consequently, a conscious choice was made to use the term 'adequacy' rather than 'quality' of health facilities.

Based on our measure of adequacy, we generated a variable indicating whether a village has adequate health services was generated. Thus, if a village had an adequate health facility then the adequacy variable was coded as 1 or was coded as 0 otherwise. This variable was merged with the household level data on health outcomes. Sensitivity analyses related to the definition of the adequacy variable along with other infrastructure aspects of public health facilities were conducted. The details of this analysis is available in **Appendix A**.

Control Variables

Personal, spousal and household characteristics and the adequacy of maternal health services available to women in the sample at the village level was included as controls in analysis. Definitions of these and other control variables are described further in **Table 3**. Education of the mother and her husband were classified into 4 categories: No education, Primary education (1 to 4 years of schooling), secondary education (5 to 10 years of school) and higher secondary or more (10 or more years of education). Mother's religion was categorized as Hindu, Muslim or Other religion. Caste was categorized as Forward, Other Backward Caste (OBC), Scheduled Caste (SC), Scheduled Tribes (ST) or others. The religion and caste categories used here are commonly used when analyzing population from India. Finally, an indicator for whether a mother had 3 or more prenatal visits was used as a control in some models.

Identification strategy

In order to examine the impact of NRHM and the JSY in the first set of analyses, we employed a difference-in-difference approach.[41] The difference-in-difference (DD) estimation method is often used to determine the effect of a policy that was implemented in two different groups.[42] Key assumption for DD estimation models is the so-called 'parallel trends assumption'.[41] Under this assumption, in the absence of policy, the two groups would have undergone similar changes in the outcomes of interest during the period under review. In other words, this assumption states that the trend in the difference in the outcomes of the two groups prior to implementation would have remained the same if the policy was not implemented. Extending this to the current study, we argue that without the greater policy attention received under the NRHM and the JSY, the high focus states would have continued to lag behind other states in the post-period. It is worthwhile to note that the high-focus states collectively lagged behind other states in terms health outcomes even after implementing the JSY and the NRHM. As noted earlier, substantial change in the health systems of developing countries occurs over a longer period of time than the relatively short span of the JSY & NRHM implementation.

Nevertheless, the main advantage of using the DD method is that it controls for secular time trends which occur in the two groups. The baseline information comes from IHDS-I. IHDS-I was conducted in 2004-05 and collected information in the period starting from year 2000 to 2005. Since the JSY and the NRHM were implemented after 2006, we do not expect any effect of the program on outcomes prior to this period. It can be argued that a mother's decisions about the place for delivery was exogenous to selection of the state of mother's residence as a 'high-focus' state under the JSY and the NRHM. It is possible that there is low endogeneity in the model.

As described in the conceptual framework, multiple individual-and household-level characteristics can affect maternal health service use. We control for a set of characteristics using data from the household and eligible women surveys.

Model Specification

The first objective of this study was to estimate whether the effect of combination of the JSY and the NRHM programs on institutional birth and prenatal care utilization differed between the high focus and the non-high focus states. We specify the following difference-in-difference model -

$$Y_{it} = \alpha_0 + \beta_1(Post_t) + \beta_2(HighFocus_i) + \beta_3(HighFocus_i * Post_t) + \lambda X_{it} + \varepsilon_{it} \qquad (1)$$

where Y_{it} is an outcome variable measuring the likelihood of either having an institutional birth by woman *i* at time *t*. $HighFocus_i$ is an indicator which takes the value one if the i^{th} woman lives in one of the high-focus states under the JSY and the NRHM and zero otherwise. $Post_t$ is an indicator which takes the value one if time period *t*, when the child was born, is after the implementation of the JSY and NRHM (2005 to 2011) and zero otherwise. X_{it} is a vector representing characteristics of the i^{th} woman in period *t*. λ is a vector of coefficients corresponding to such characteristics. ε_{it} is the random error term. The coefficient β_3 on the interaction of $HighFocus_i$ and $Post_t$ is the DD parameter of interest.

The second objective of this study is to determine whether the adequacy of the public health facilities was associated with a change in the proportion of institutional deliveries. The analysis for this particular objective is in two parts. First, we conduct village-level analysis of public health facilities. This analysis was done to evaluate whether there were significant improvements in public health facilities at the village-level in the post-period compared to pre-period. We then focus on only the post-period and conduct a multilevel logit regression analysis to determine effect of local-level health facilities on the likelihood of having an institutional delivery by adding an indicator for adequacy in model (1). We focus on the outcomes in high-focus states during the post-period for multiple reasons. First, high-focus states contributed more than 10% of global and more than half of India's maternal mortality.[3] Second, these states also have health facilities that are in very poor conditions and remained in poor conditions after implementing the JSY and the NRHM.[3] Taken together, the paradox of a simultaneous increase in proportion of institutional deliveries and a continuation in the poor conditions of public health facilities is far more pronounced in high-focus states compared to other parts of India. We aim to address this paradox by analyzing the determinants of maternal choice of place for childbirth under the second study objective.

Statistical analyses

We begin by describing the characteristics of the sample for the first set of analyses. We then conduct bivariate analyses to test statistically significant differences between mothers from the high-focus states and those from other states. Next, we use logistic regressions to model the likelihood of having an institutional birth by pregnant women. Finally, we perform checks for the model specification and conduct sensitivity analyses.

For ease of interpretation, we report the results as odds ratios. P-values and confidence intervals are used to determine the statistical significance of results. The alpha was determined at the traditional level of 0.05. All analyses were conducted using sample individual weights made available in the IHDS data. Standard errors were adjusted to account for the complex survey design of the IHDS-I and IHDS-II. All statistical analyses were performed using Stata 14.[43]

Supplementary analyses

In addition to the analyses mentioned above, we also conduct additional analyses to better understand the causal mechanisms of why more women had institutional deliveries in the period after the implementation of the JSY and the NRHM. Under this analysis, we use the information in the IHDS about the experiences of mothers during child birth. Specifically, we analyze the information on ASHAs, what proportion of mothers received governmental support for child birth and who urged mothers to have an institutional delivery. This analysis will provide clues about the factors other than the conditions of the public health facilities that might have influenced mothers' decisions regarding child birth. It should be noted however that the sample for this analysis is smaller than the main analytical sample.

Results

Sample characteristics

The characteristics of the study sample are described in Panel A of **Table 4**. As mentioned earlier, the sample is restricted to rural ever-married women between the ages of 15 to 49 years who had at least one childbirth in the five year period prior to the survey interview.

Thus, for IHDS-I, the period under analysis is from the year 2000 to 2005 while from IHDS-II that period is from 2006 to 2011. In Column (1), we report the averages and standard deviations for the births in the full sample in the period before implementing the JSY and the NRHM (referred as the pre-period from here onwards) while in Column (2) we report the same in the post-implementation period (referred as the post-period from here onwards). Nearly 34 % of births in the pre-period took place in an institution, which increased to about 64 % in the post-period. In Columns (3) to (6), we compare the high-focus and the non-high-focus states in the pre- and post-period. In the pre-period, the proportion of mothers who had an institutional birth in high-focus states was 19.4 % while the same was 57.5 % in non-high-focus states. During the post-period in the high-focus states, proportion of mothers having institutional births care increased considerably (55.8 and 59.7 % respectively, Column (5)). The same was also observed in non-high-focus states (78.1 % and 78.4 % respectively, Column (6)).

Panel B of Table 4 reports the characteristics of women and their spouse including age, education, religion, caste and the household asset index (calculated by IHDS). On average, women that had a childbirth in the pre-period were younger. Since 83% of the households from IHDS-I were re-contacted during IHDS-II, this possibly indicates the aging of the sample. More than half of the women in the sample reported having no education in the pre-period (55.3 % Column (1)) which reduced to about 40% in the post-period Column (2). In both periods, about 83% of the sample was Hindu and about 13% was Muslim (Columns (1) and (2)). This is quite similar to the estimates from the recent Census of India, in which Hindus and Muslims were reported to be 80.5% and 13.4 % of India's population respectively.[44] The distribution of the sample in various caste categories remained stable in both periods. The household asset index increased by about 3 points in the post-period compared to the pre-period. This is possibly due to the rapid economic growth seen in India and also due to a rural employment guarantee scheme implemented during the study period. In addition, number of previous births for the women in the sample is also reported. The number of births per woman in the sample is lower than the total fertility rate of India because IHDS collected data about births that occurred only in the last five years. Finally, the adequacy of public health facilities available to women in their village/neighborhood is reported in Panel B. The construction of the adequacy variable was discussed earlier. The proportion of mothers with access to adequate health facilities did not change significantly in the post-period. Compared to non-high-focus states, in the pre-period, mothers from high-focus states were older, less educated and reported having lower number of household assets (Columns (3) and (4)). This trend was also seen in the post-period (Columns (5) and (6)).

Comparison between state groups

Table 5 reports the impact of the JSY and NRHM programs on the study outcomes. Each fully adjusted regression controls for maternal characteristics (age and education), the characteristics of her spouse (age and education), household assets, number of previous births, religion and caste. In a separate set of analyses, measures of the mothers receiving tree or more prenatal care visits was included (results not shown). However, the measure of prenatal care was not included in the main analysis due to high proportion of missing information (15% of the sample). The standard errors were adjusted for complex survey design using survey weights. In column (1) results from regressions that used Stata survey analytical methods (using the *svy: subpopulation* commands in Stata) are displayed. In column (2), results are shown for the same survey model repeated with the addition of state-level effects (coefficients for individual states not shown for brevity). Finally, results from same model using multi-level analytical method (using the *melogit* Stata command) are displayed in column (3). Each of these alternative analytical approaches for the difference-in-difference analyses helped strengthen the identification and served as a sensitivity check for the specification of the main model.

Overall, women were more likely to have an institutional birth after implementing the JSY and NRHM programs (Odds Ratio (OR) 2.04, Confidence Interval (CI) 1.69 – 2.4) (Column 1). The coefficient on the interaction of High Focus and Post Period reports the effect of the JSY and the NRHM in the high focus states. The estimate is positive and highly statistically significant (OR 2.34, CI 1.84 – 2.97). The interaction term is significant at the traditional alpha level ($p<0.05$), indicating that the policy did not affect high focus and non-high focus states equally. Thus we reject the null hypothesis that the proportion of institutional births in high-focus and other states improved at a similar rate. Further, the positive value for the coefficient of the interaction terms indicates that the effect of the programs in high focus states was significantly greater compared to other states. Other factors significantly associated with having an institutional birth include: mother's age, education, religion and caste. Results from alternative approaches showed results similar to the main specification (Columns 2 and 3).

Village-level analysis of public health facilities in the sample

In this set of analysis, we compared the distribution, type and adequacy of public health facilities and also tracked the changes in these factors across the two IHDS surveys. As mentioned earlier, this analysis was done at the village-level. The distribution of various types of facilities is summarized in **Table 6**. Based on the size of the population that they serve, public health facilities in India are categorized into - 1) a District Hospital (DH), 2) Primary Health Center (PHC), 3) Community Health Center (CHC) and 4) a Sub-center (SC). Panel A describes the period before NRHM & JSY implementation (2000-2005, referred to as pre-period).

Columns 1 & 2 describe the overall sample. Details about villages from non-high focus states are summarized in columns 3 & 4. Finally, the condition of villages in high-focus states is described in columns 5 & 6. Overall, 1,291 villages were part of the sample. The analysis is restricted to those villages which appeared in both surveys.

In the pre-period, PHCs were present in 47.95% of villages in the overall sample, followed by SCs (17.66%), CHCs (9.99%) & DHs (8.37%). Compared to high-focus states, non-high focus states had a higher proportion of villages with PHCs & DHs. In contrast, more villages in high-focus states had CHCs & SCs. Information on public health facilities from about 10.53 % of villages was missing in the overall sample, slightly higher in the non-high focus states compared to high-focus states. In the post period, the trends in distribution were somewhat similar except for the proportion of DHs. Higher proportion of villages in high-focus states had DHs.

After ascertaining the adequacy of health facilities using criterion described earlier in the article, each village was coded as either having an adequate health facility or having an inadequate health facility. The result of this analysis is summarized in **Table 7**. The panels and columns are similar to **Table 6**. In the pre-period, about 14.18% villages had an adequate public health facility. The proportion of villages that had an adequate facility was much higher in non-high focus states compared to high focus states (19.41 vs 9.05%). Similar trends were observed in the post period - the proportion of villages with an adequate health facility in the overall sample was about 15.34%. High-focus states continued to have far lower proportion of villages with an adequate public health facility compared to non-high focus states (11.04 vs 19.72%).

Finally, **Table 8** reports results about the adequacy of health facilities stratified by the type of facility in each village. Panel A again describes the pre-period and Panel B the post-period. The panels are further divided to present information about high-focus and non-high-focus states separately. In this table each column represents a different type of facility. The first column represents villages with no public health facility (all of them were categorized as being 'inadequate'). Columns 2 to 5 represent SCs, CHCs, PHCs and DHs respectively. Finally, Column 6 represents the overall adequacy. In the pre-period, lower proportion of villages in high-focus states had adequate public health facility across all types of health facilities; for example, 26.60% of villages that had a PHC in non-high focus states had an adequate health facility compared to 8.99% of the same in high-focus states (Column 4). This trend continued in the post-period. It is interesting to note that far higher proportion of villages with CHCs and SCs in non-high focus states had adequate public health facilities during the post period (Panel B, Columns 2 & 3), though the opposite was observed for PHCs & DHs.

Role of health facility adequacy

To determine the role of the local-level health facilities in determining maternal choice of having an institutional delivery, we fitted a logistic model for an indicator of having an institutional delivery with adequacy of public health facilities in the village as the main predictor along with other covariates. The analysis was restricted to mothers from high-focus states in the post-period. Overall, 5,250 mothers from 625 villages in 11 states were part of the analysis. The results are summarized in **Table 9**. As in **Table 5**, in column (2), results are shown for the same survey model repeated with the addition of state-level effects (coefficients for individual states not shown for brevity). Finally, results from same model using multi-level analytical method (using the *melogit* Stata command) are displayed in column (3). Results show that the adequacy of the public health facility was not significantly associated with the likelihood of having an institutional birth (OR 1.057, CI 0.717 – 1.558). Results from alternative approaches showed results similar to the main specification (Columns 2 and 3).

Supplementary analysis on ASHAs and on governmental support for delivery

In order to better understand the causal mechanisms of the change in childbirth-related behaviors of mothers in India after the implementation of NRHM, we performed a series of sub-analyses using data from the post-NRHM period (IHDS 2012). The analysis compares high-focus and non-high-focus states. The results are presented in **Tables 10 to 13.**

Table 10 presents the results of an analysis of reproductive age women in the IHDS household sample who were asked the question – "Who motivated you to go to a health facility for delivery?" The sample was limited to those women that delivered a child within the last five years (*N*= 9,922). Women could choose to answer from a set of multiple options and it is possible that a woman could report to have been urged by more than one category of personnel. For example a woman can report that both a Doctor and a nurse urged her to deliver at a facility. Figures in columns for high-focus and other states do not add up to a hundred. Compared to non-high-focus states, more women from high-focus reported that the ASHA in from their village urged them to deliver at a health facility (14.92% vs 30.53%, Row 1). However, compared to high-focus states higher proportion of medical or paramedical personnel (such as Doctors and Nurses/ANMs) seem to have motivated women in non-high-focus states (Rows 3 to 7). The results possibly indicate that due to monetary incentives offered to them, the ASHAs in high-focus states were more active in motivating pregnant mothers to deliver at health facilities. In contrast, doctors and nurses being more active in other states may indicate that the staff at health facilities was more active.

Results from **Table 11 and 12** provide further support to this conclusion. Both tables present results from village-level analyses. In other words, the figures represent proportion of villages in the IHDS 2012 sample (*N*=1490). Along with a household survey; in IHDS 2012 a knowledgeable person in the village was asked questions about the ASHAs working in the village. Table 10 summarizes whether villages had any ASHA working in them. Slightly higher proportion of villages from high-focus states seem to have an active ASHA worker (91.37% vs 94.68%). Table 11 summarizes information about the distance from the village to the ASHA workers' home. When compared using chi-2 tests, there does not appear to be a significant difference between high-focus and other states in terms of the distance of an ASHA from the village. Considered together, these results highlight two important issues – 1) both groups of states had similar presence of ASHAs and 2) the distance of ASHAs from villages in each group of states was similar. As seen in Table 9, ASHA's in high-focus states were reported to be more active in motivating mothers to have an institutional delivery, but it was not due to either 1) higher proportion of villages in high-focus states having an ASHA or 2) the ASHAs in high-focus states living closer to the villages.

Finally, **Table 13** uses data from the household survey again (*N*= 9,922) and presents results for another survey question – 'Did you receive any money from the government for hospital delivery?' The sample was limited to those women that delivered at a health facility (*N*= 9,922). Substantially higher proportion of women in high-focus states reported to have received money for an institutional delivery. Recall that the overall proportion of women that has an institutional delivery in high-focus states was lower than that in non-high-focus states. This possibly indicates that the early rollout of the JSY in high-focus states ensured that when they had an institutional delivery, more women in high-focus states received governmental support.

Discussion

In this study, we analyzed the impact of two large, national-level health policies (the JSY and the NRHM) on maternal health outcomes (proportion of institutional deliveries) in India. The main aims of the study were to understand whether the policy of targeting high focus states under the JSY and the NRHM was effective in increasing the rate of institutional deliveries, to assess whether the local health infrastructure improved after implementing the JSY-NRHM policies and finally to ascertain whether the conditions of the local health facilities were associated with the likelihood of having an institutional birth. We used nationally representative household survey data along with information from a survey of medical facilities accessed by the households from the India Human Development Survey (IHDS). We found that the JSY and the NRHM had a greater impact on institutional deliveries in high-focus states. We also found that the conditions of the public health facilities, defined in terms of facility adequacy, did not change after the implementation of the JSY and the NRHM. Finally, we found that adequacy of health facilities was not associated with the likelihood of mothers in high-focus states having an institutional delivery. Additional analyses showed that the higher increase in the proportion of institutional deliveries in high-focus states could have been due to more mothers in such states receiving monetary support for delivering at a health facility and also due to ASHAs (health workers) being more active in encouraging mothers to have an institutional delivery.

Results from the first set of analyses showed that effect of the JSY and the NRHM varied greatly between the high-focus and other states. The impact of these policies on the proportion of institutional deliveries was significantly higher in the high-focus states. We can reject the null hypothesis that the policymakers' strategy of 'targeting' lead to similar improvements in the proportion of institutional births in high-focus states compared to other states. In the second set of analysis conducted at the village-level, we uncovered key differences in the conditions of public health facilities in high-focus and of those in other states. Main takeaways from this analysis are: 1) distribution of health facilities was different in villages from high-focus states compared to villages in non-high focus states in each period 2) adequacy of public health facilities was much higher in villages from non-high focus states, both in pre- and post-periods 3) considerable proportion of villages in non-high focus states that had a public health facility catering to a smaller population (an SC or a CHC) shifted to having an adequate health facility during the post-period but the same was not seen in villages from the high-focus states. In summary, it is clear that the adequacy of the local level public health facilities changed little after the implementation of the JSY and the NRHM. In other words, conditions of the local-level public health facilities in high-focus states did not improve. This was consistent with the second hypothesis of the study. Finally, findings from the final set of analysis show that after adjusting for covariates, the likelihood of having an institutional delivery did not differ based on the adequacy of the public health facility in the village. In other words, having access to an adequate health facility within the village did not affect the likelihood of a mother having an institutional delivery. These findings allow us to reject the null hypothesis which posited that the conditions of the local-level health facilities were associated with the changes in the study outcome.

The main results of this study are consistent with available literature.[4,6,22,28] Similar to prior work, we found substantial rise in both - the proportion of institutional births after the implementation of the JSY and the NRJM. This is an encouraging sign not only for India but also for maternal health worldwide. The various methods through which policymakers' provided more attention to high-focus states could help explain the relatively rapid progress made by these states. However, the village-level analysis showed that public health facilities in India still struggle to provide high-quality care to pregnant mothers. Even after several years of implementing the NRHM, public health facilities in the high-focus states remained in poor conditions. This was also noted by reports commissioned by the government of India as well as the Common Review Mission reports produced by the NRHM staff.[16,24]

In a new contribution to the literature, this study combined information from households sampled in a large survey along with data from a survey of medical facilities accessed by the same households. Under this method, we first created a measure for the adequacy of health facilities and then assessed whether this measure was associated with maternal health outcomes. We believe this aligned with one of the study objectives to assess health behaviors while being mindful of the health services available. Unlike some previous studies, the data used for this study was compiled by non-government sources. In some reports, the reliability of data collected by the government has been questioned.[5] The use of the non-governmental data in the study is a significant improvement from prior literature.[5] Next, to the best of our knowledge, the village-level analysis of public health facilities is the first of its kind. Quite often, before and after implementing major health reforms, health facilities from a randomly drawn sample of Indian villages are assessed. While such evaluations are valuable, they do not allow for a comparison of the same locations over a period of time. Leveraging the unique information from the IHDS, we were able to compare a set of villages from all parts of India before and after the JSY and NRHM implementation. The concept of defining health facility adequacy at the village-level to provide a context of health services available to households is a unique contribution of this study.

There are several limitations of the current study. First, the definition of 'adequacy' of health facilities is not an exact measure of the quality of services provided by these facilities. The categorization of facilities into being either 'adequate' or 'not adequate' was somewhat subjective. However, as we argued in the methods section, complete information about the 'quality' of services at public health facilities available to mothers in the IHDS sample was not available. Also, despite its subjective nature, we believe that creating and analyzing such a measure is useful in current and future policy analysis. Second, the sample sizes in the current study are perhaps small for the size of the Indian population. Large-scale, nationally representative household surveys conducted by non-government sources in India are rare. The creators IHDS mentions that they attempted to construct a nationally representative survey and we believe the sample for the current study was representative of at least the states from which it was derived. Third, there could a recall bias in mothers' responses regarding the place of delivery for their last child birth. We could not estimate this bias and whether this bias was different for mothers from high-focus and from other states. Finally, an inherent limitation in using the DD estimation method as described by Bertrand, Duflo and others[41,45] is that a correlation bias can occur when using data from successive rounds of a survey. Due to limitations of the available IHDS data we could not implement strategies in Bertrand and Duflo.

Despite its limitations the study extends current knowledge on the policy provisions that can help improve maternal health in India and other developing countries. Indian policymakers should continue to target certain states to improve health outcomes of the nation. They should also monitor the conditions of local-level health facilities more closely.

The results of this study are also relevant to the current health policy environment in India. Recently released Indian National Health Policy discussed the introduction of large-scale public health insurance schemes.[30] This is shift away from earlier periods, where provisioning of health services was the main focus of government health policy. Public health insurance schemes incentivize the use of private health facilities which are then reimbursed by the government for the service provision. Such schemes have been operational in several states.[46] They have run into issues such as rendering of unnecessary services by private health providers who performed surgeries when there was no clinical need for the same.[47] Public health insurance certainly prevents the poor in India from potential bankruptcy due to major illnesses. But they do not remedy the issues of low availability and poor quality of health services in rural India. Further, public health insurance schemes are susceptible to fraud and misuse without proper oversight as seen else where such as the Medicare and Medicaid programs in the United States.[48,49] A strong network of public health facilities is a major asset of the Indian health system. Yet, the same network can become a burden if neglected in health policies. In future, policymakers in India should not shun their responsibility of providing high quality health services to the people of India.

Figures and tables

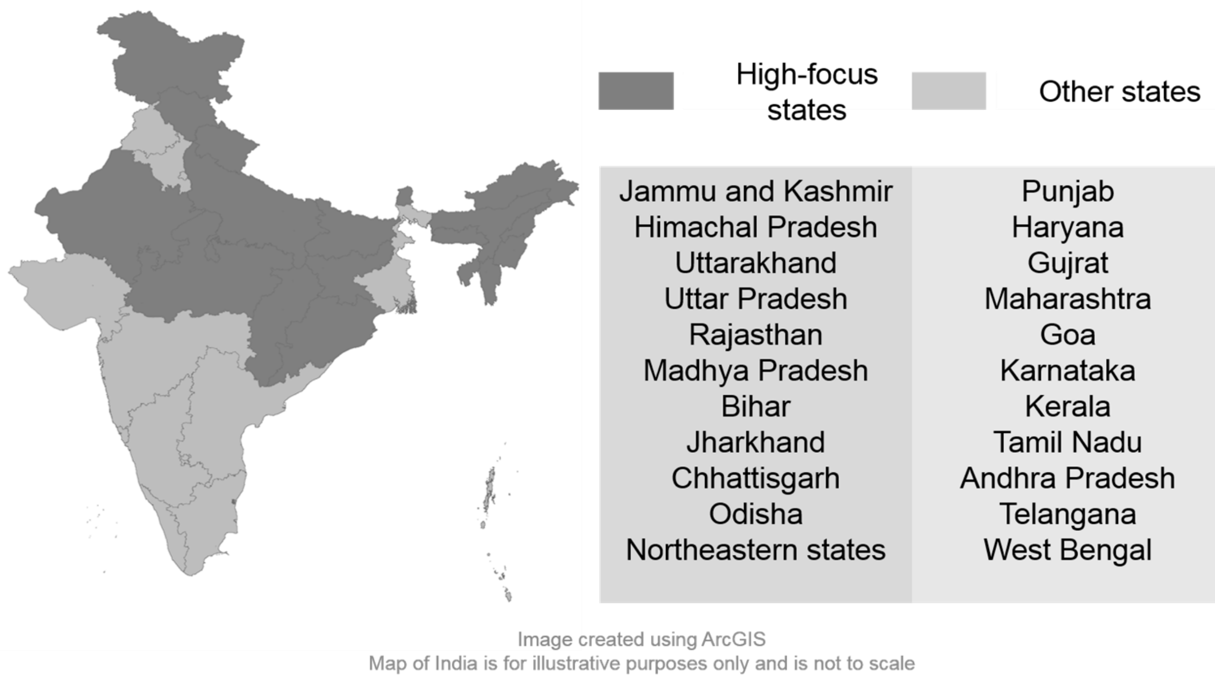


Figure 1: Targeting of states under the JSY and the NRHM

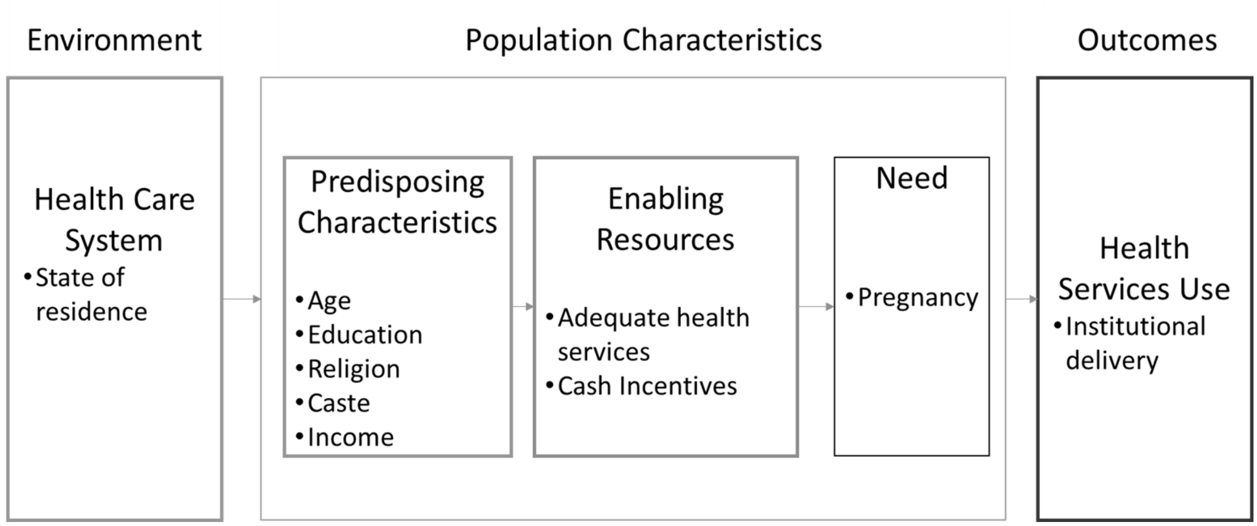


Figure 2: Conceptual framework

Table 1: Facility Norms under the NRHM

	Type of facility	Number of persons served
1	Sub-center (SC)	5,000
2	Primary Health Center (PHC)	30,000
3	Community Health Center (CHC)	120,000
4	District Hospital (DH)	One in each district (about 1.5 million)

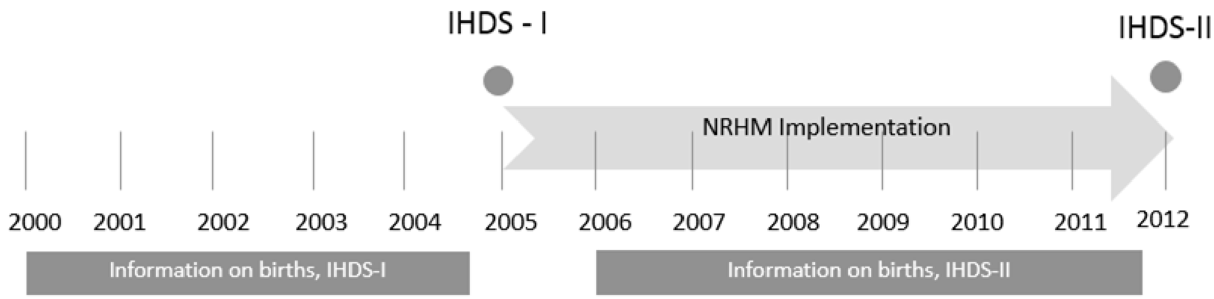


Figure 3: Timeline of the IHDS surveys and NRHM implementation

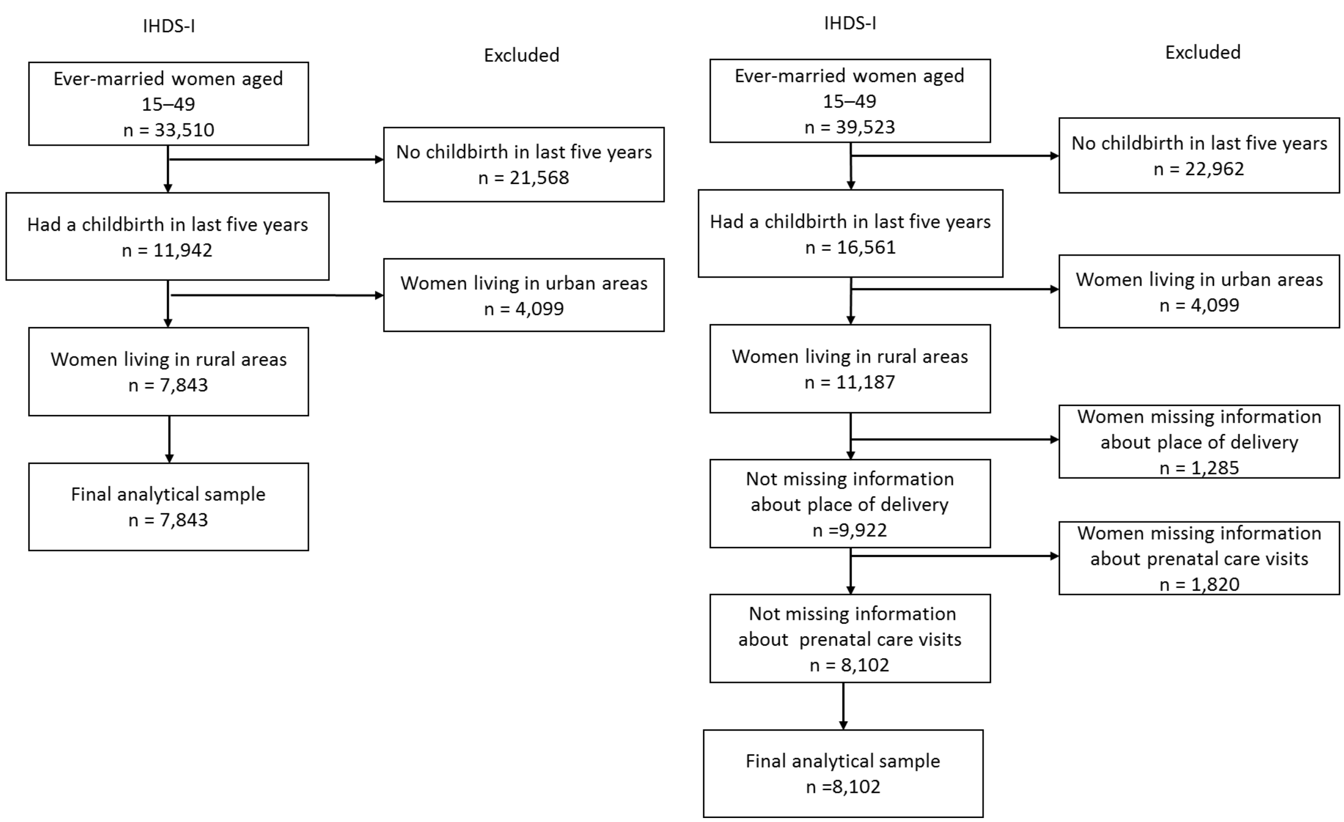


Figure 4: Sample Derivation

Table 2: Criterion for Determining Adequacy of a Public Health Facility

	Type of facility	Topic	Criterion for adequacy
1.	District hospital	Electricity	21 to 24 hours per day
		Piped water	Present
		Toilet within the facility	Present
		Number of OPD hours per week	35
		Prenatal services	Provided
		Childbirth services	Provided
2.	Primary Health Center	Electricity	18 to 24 hours per day
		Piped water	Present
		Toilet within the facility	Present
		Number of OPD hours per week	28
		Prenatal services	Provided
		Childbirth services	Provided
3.	Community Health Center	Electricity	15 to 24 hours per day
		Piped water	Present
		Toilet within the facility	Present
		Number of OPD hours per week	21
		Prenatal services	Provided
		Childbirth services	Provided
4.	Sub-center/other	Electricity	15 to 24 hours per day
		Piped water	Present
		Toilet within the facility	Present
		Number of OPD hours per week	21

Table 3: Variable Definitions

Variable	Type	No. of categories	Definitions/Categories	Notes	IHDS file
Outcomes/Dependent Variables					
Health Service Utilization					
Place of delivery for last birth (Institutional Delivery)	Categorical	2	Answer to the survey question: 'What kind of a place did you deliver your last child?' Coded = 0 if place of last delivery for last birth was home Coded = 1 if place of last delivery for last birth was not home	In the first round of IHDS in 2005, this variable was a part of the 'Household file' In second round, a separate file was created for eligible women's survey. However, the survey question remained the same.	Household File IHDS 2005 Eligible women's File IHDS 2011
Independent Variables					
Health System Factors					

Residence in high-focus state	Categorical	2	coded = 0 if the state of residence was not one of the 'high focus ' states under the NRHM coded = 1 if the state of residence was one of the 'high focus ' states under the NRHM	Based on state of residence of the respondent/household, which could be one of the 28 states of India. High focus states were[22]: Jammu and Kashmir, Himachal Pradesh, eight Empowered Action Group states and Northeastern states Other states were non high focus states In addition, there are observations from 7 Union territories (small areas directly under the rule of the central government) which were coded as 'non-high-focus'. No new states were created during the period under the analysis. The proportion of households migrating away from their state of residence in the first round is less than 1 percent.	Household File IHDS 2005 Household File IHDS 2011
Predisposing factors					
Individual-level Characteristics					
Age	Categorical	4	15-19 years, 20-29 years, 30 - 39 years and 40 - 49 years	This age classification is consistent with other studies on maternal health	Individual File IHDS 2005 Individual

					File IHDS 2011
Parity	Continuous	NA	Number of children previously born	Most mothers in the sample had not given birth prior to IHDS-I	Household File IHDS 2005 Household File IHDS 2011
Education: respondent woman	Categorical	4	No education, primary school, secondary school and higher secondary or higher	Very small proportion of women had education higher than secondary school and will be grouped together	Individual File IHDS 2005 Individual File IHDS 2011
Education: husband	Categorical	4	No education, primary school, secondary school and higher secondary or higher	Categories selected to stay consistent with above	Individual File IHDS 2005 Individual File IHDS 2011
Adequate prenatal care	Categorical	2	Answer to the survey question: 'How many times did you receive antenatal check-ups during the last pregnancy?' Coded = 0 if a woman had less than three check-ups Coded = 1 if 3 or more check-ups	In the first round of IHDS in 2005, this variable was a part of the 'Household file' In second round, a separate file was created for eligible women's survey. However, the survey question remained the same. The 'adequacy' was defined under the Janani Suraksha Yojana (JSY) of the NRHM as having a minimum of three antenatal check-ups[22]	Household File IHDS 2005 Eligible women's File IHDS 2011

Religion	Categorical	3	Hindu, Muslim or other	Hinduism and Islam are the two major religions of India. The proportion of women from other religions was relatively small in the sample.	Individual File IHDS 2005 Individual File IHDS 2011
Caste	Categorical	5	Upper, Other Backward classes, Scheduled castes, Scheduled tribes, others	This classification is consistent with categorization of castes in the Indian census	Individual File IHDS 2005 Individual File IHDS 2011
Household-level characteristics					
Income	Categorical	5	Poorest, poor, middle, richer and richest quintile	IHDS collects data on aggregate household income. Based on that information a household is classified into one of the five income categories.	Household File IHDS 2005 Household File IHDS 2011
Enabling Factors					
Village-level characteristics					
Health facility adequacy	Categorical	2	coded = 0 if the health facility in the village of a mother's residence is not of adequate quality coded = 1 if the health facility in the village of a mother's residence is of adequate quality	Adequate quality of a health facility is defined as having electricity seven days a week, operating in a building with concrete walls, having access to piped water, having a toilet in the facility These criterion are borrowed from the IPHS standards for public health facilities in India	Medical facilities file 2005 Medical facilities file 2011

Table 4: Characteristics of women from the IHDS sample

	1	2	3	4	5	6
	Full Pre	Full Post	High Focus Pre	Non High Focus Pre	High Focus Post	Non High Focus Post
Panel A (%)						
Institutional Birth	0.337	0.636	0.194	0.575	0.558	0.781
	(0.012)	(0.011)	(0.0108)	(0.0173)	(0.0143)	(0.0141)
Adequate Prenatal care	0.439	0.674	0.272	0.716	0.597	0.784
	(0.014)	(0.011)	(0.013)	(0.017)	(0.016)	(0.013)
Panel B (%)						
Adequate Public Health Facility	0.127	0.117	0.058	0.252	0.068	0.204
	(0.012)	(0.011)	(0.010)	(0.025)	(0.010)	(0.023)
High Focus state	0.625	0.649				
	(0.018)	(0.018)				
Mother's Age 15 to 19 years	0.045	0.028	0.0320	0.0654	0.0244	0.0344
	(0.004)	(0.004)	(0.00398)	(0.00669)	(0.00497)	(0.00463)
Mother's Age 20 to 29 years	0.613	0.599	0.565	0.694	0.551	0.688
	(0.009)	(0.008)	(0.0124)	(0.0118)	(0.00990)	(0.00984)
Mother's Age 30 to 39 years	0.296	0.317	0.340	0.221	0.349	0.256
	(0.008)	(0.007)	(0.0108)	(0.0107)	(0.00852)	(0.00959)
Mother's Age 40 to 49 years	0.046	0.056	0.0628	0.0191	0.0749	0.0219
	(0.004)	(0.004)	(0.00529)	(0.00302)	(0.00576)	(0.00302)
Number of Prior Births	0.442	0.650	0.488	0.364	0.724	0.512
	(0.012)	(0.014)	(0.0156)	(0.0143)	(0.0186)	(0.0160)
Mother's Education none	0.553	0.401	0.643	0.404	0.489	0.236
	(0.011)	(0.012)	(0.0131)	(0.0164)	(0.0146)	(0.0120)
Mother's Education primary	0.070	0.066	0.0547	0.0944	0.0522	0.0922
	(0.005)	(0.004)	(0.00521)	(0.00851)	(0.00480)	(0.00842)
Mother's Education secondary	0.323	0.422	0.270	0.413	0.370	0.518
	(0.010)	(0.010)	(0.0118)	(0.0150)	(0.0133)	(0.0135)

Mother's Education higher	0.054	0.111	0.0331	0.0881	0.0880	0.154
	(0.004)	(0.005)	(0.00374)	(0.00842)	(0.00635)	(0.00973)
Husband's Education none	0.267	0.216	0.300	0.212	0.234	0.184
	(0.010)	(0.009)	(0.0132)	(0.0127)	(0.0119)	(0.0121)
Husband's Education primary	0.092	0.082	0.0771	0.117	0.0718	0.102
	(0.005)	(0.005)	(0.00573)	(0.0104)	(0.00547)	(0.00959)
Husband's Education secondary	0.455	0.500	0.453	0.459	0.500	0.498
	(0.009)	(0.010)	(0.0126)	(0.0125)	(0.0139)	(0.0143)
Husband's Education higher	0.186	0.202	0.170	0.212	0.194	0.217
	(0.008)	(0.007)	(0.00963)	(0.0123)	(0.00989)	(0.0109)
Hindu	0.826	0.829	0.828	0.823	0.847	0.796
	(0.011)	(0.011)	(0.0152)	(0.0163)	(0.0140)	(0.0174)
Muslim	0.123	0.132	0.134	0.105	0.131	0.133
	(0.010)	(0.010)	(0.0138)	(0.0152)	(0.0132)	(0.0170)
Other religion	0.051	0.039	0.0377	0.0721	0.0217	0.0709
	(0.006)	(0.005)	(0.00781)	(0.00834)	(0.00587)	(0.00784)
Caste upper	0.036	0.036	0.0499	0.0136	0.0471	0.0166
	(0.004)	(0.004)	(0.00628)	(0.00269)	(0.00586)	(0.00351)
Caste OBC	0.426	0.421	0.478	0.340	0.458	0.350
	(0.014)	(0.015)	(0.0186)	(0.0183)	(0.0192)	(0.0184)
Caste SC	0.254	0.250	0.240	0.277	0.235	0.276
	(0.011)	(0.011)	(0.0142)	(0.0180)	(0.0138)	(0.0167)
Caste ST	0.105	0.108	0.109	0.0978	0.118	0.0905
	(0.009)	(0.010)	(0.0123)	(0.0140)	(0.0128)	(0.0141)
Caste other	0.178	0.184	0.123	0.271	0.140	0.266
	(0.010)	(0.010)	(0.0107)	(0.0192)	(0.0119)	(0.0175)
Household Assets	8.553	11.975	7.627	10.10	10.51	14.68
	(0.116)	-0.172	(0.132)	(0.188)	(0.198)	(0.239)

Source: India Human Development Survey, 2005 and 2011.
Analysis restricted to ever-married women between the ages of 15 to 49 years, who had a birth in the five years prior to the interview and did not have data missing on covariates
Standard errors in parentheses.
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes

Table 5: Logistic regression results of difference in differences analysis for the probability of having an institutional delivery

	1	2	3
	Model 1	Model 2	Model 3
Observations	17833	17833	17833
Survey weights	Yes	Yes	No
State Fixed Effects	No	Yes	NA
Multilevel model	No	No	Yes
Post Period	2.041***	2.513***	2.567***
	(1.694 - 2.460)	(2.057 - 3.069)	(1.836 - 3.590)
High Focus	0.233***	0.0312***	0.293***
	(0.193 - 0.281)	(0.00341 - 0.285)	(0.117 - 0.736)
Post Period*High Focus	2.341***	2.077***	1.980***
	(1.842 - 2.976)	(1.616 - 2.670)	(1.269 - 3.090)
Mother's Age 20 to 29 years	0.705**	0.649**	0.688**
	(0.514 - 0.968)	(0.465 - 0.907)	(0.513 - 0.923)
Mother's Age 30 to 39 years	0.462***	0.412***	0.472***
	(0.334 - 0.639)	(0.293 - 0.578)	(0.338 - 0.660)
Mother's Age 40 to 99 years	0.445***	0.394***	0.403***
	(0.304 - 0.653)	(0.265 - 0.587)	(0.280 - 0.580)
Number of Prior births	0.919**	0.954	0.916*
	(0.854 - 0.988)	(0.888 - 1.026)	(0.827 - 1.014)
Mother's Education primary	1.187	1.149	1.110
	(0.955 - 1.475)	(0.918 - 1.438)	(0.948 - 1.300)

Mother's Education secondary	1.694***	1.627***	1.562***
	(1.459 - 1.967)	(1.393 - 1.901)	(1.364 - 1.789)
Mother's Education higher	3.447***	3.061***	3.157***
	(2.611 - 4.551)	(2.295 - 4.084)	(2.619 - 3.805)
Husband's Education primary	0.886	0.911	0.967
	(0.735 - 1.068)	(0.754 - 1.102)	(0.834 - 1.121)
Husband's Education secondary	1.034	1.056	1.162**
	(0.892 - 1.198)	(0.908 - 1.227)	(1.021 - 1.323)
Husband's Education higher	1.117	1.209*	1.349***
	(0.905 - 1.380)	(0.974 - 1.500)	(1.172 - 1.553)
Muslim	0.610***	0.580***	0.675***
	(0.485 - 0.766)	(0.464 - 0.726)	(0.503 - 0.905)
Other religion	0.991	1.102	0.966
	(0.733 - 1.338)	(0.772 - 1.573)	(0.768 - 1.216)
Caste OBC	1.491**	1.307	1.076
	(1.029 - 2.161)	(0.905 - 1.888)	(0.869 - 1.333)
Caste SC	1.392*	1.293	1.076
	(0.949 - 2.043)	(0.885 - 1.890)	(0.850 - 1.363)
Caste ST	0.887	0.722	0.606***
	(0.583 - 1.349)	(0.473 - 1.100)	(0.484 - 0.760)
Caste other	1.705***	1.517**	1.204
	(1.143 - 2.546)	(1.014 - 2.270)	(0.944 - 1.536)
Household Assets	1.063***	1.061***	1.067***

	(1.049 - 1.078)	(1.045 - 1.077)	(1.055 - 1.080)

Source: India Human Development Survey, 2005 and 2011.
Analysis restricted to ever-married women between the ages of 15 to 49 years, who had a birth in the five years prior to the interview and did not have data missing on covariates
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes
Coefficients represent odds ratios
Confidence intervals in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Distribution of facilities among villages in the study sample

		1	2	3	4	5	6
		Overall		Non-high focus		High focus	
		n	%	n	%	n	%
Panel A: Pre period							
No facility		71	5.50	22	3.44	49	7.52
SC		228	17.66	94	14.71	134	20.55
CHC		129	9.99	35	5.48	94	14.42
PHC		619	47.95	352	55.09	267	40.95
DH		108	8.37	54	8.45	54	8.28
	N	1,291	100.00	639	100.00	652	100.00
Panel B: Post period							
No facility		71	5.50	40	6.26	31	4.75
SC		294	22.77	170	26.60	124	19.02
CHC		192	14.87	57	8.92	135	20.71
PHC		483	37.41	262	41.00	221	33.90
DH		148	11.46	46	7.20	102	15.64
	N	1,291	100.00	639	100.00	652	100.00

Notes: Analysis is at village level.
Villages that did not have any public health facility were categorized as 'No facility'
DH - District Hospital
PHC - Primary Health Center
CHC - Community Health Center
SC - Sub-Center
*Percentages do not add up to 100 due to missingness of data

Table 7: Adequacy of health facilities

	1	2	3	4	5	6
	Overall		Non-high focus		High focus	
	n	%	n	%	n	%
Panel A: Pre period						
Does not have adequate public health facility	972	75.29	433	67.76	539	82.67
Has adequate public health facility	183	14.18	124	19.41	59	9.05
N	1,291		639		652	
Panel B: Post period						
Does not have adequate public health facility	990	76.68	449	70.27	541	82.98
Has adequate public health facility	198	15.34	126	19.72	72	11.04
N	1,291		639		652	

Notes: Analysis is at village level.
Villages that did not have any public health facility were categorized as 'No facility'
DH - District Hospital
PHC - Primary Health Center
CHC - Community Health Center
SC - Sub-Center
*Percentages do not add up to 100 due to missingness of data

Table 8: Adequacy of health facilities by type in high focus and non-high focus states

	1	2	3	4	5	6
Panel A: Pre period						
	Non High-Focus states					
	No Health facility	SC	CHC	PHC	DH	Overall
Adequate public health facility (%)	0.00	7.45	37.14	26.70	18.52	19.41
	High focus states					
Adequate public health facility (%)	0.00	2.99	26.60	8.99	11.11	9.05
Panel B: Post period						
	Non High-Focus states					
	No Health facility	SC	CHC	PHC	DH	Overall
Adequate public health facility (%)	0.00	22.94	42.11	20.99	17.39	19.72
	High focus states					
Adequate public health facility (%)	0.00	3.23	22.22	9.50	16.67	5.98

Notes: Analysis is at village level.
Villages that did not have any public health facility were categorized as 'No facility'
DH - District Hospital
PHC - Primary Health Center
CHC - Community Health Center
SC - Sub-Center
*Percentages do not add up to 100 due to missingness of data

Table 9: Logistic regression results for the likelihood of having an institutional delivery

	1	2	3
	Model 1	Model 2	Model 3
Observations	5,250	5,250	5,250
Survey weights	Yes	Yes	No
State Fixed Effects	No	Yes	NA
Multilevel model	No	No	Yes
Adequacy	1.057	0.944	0.975
	(0.717 - 1.558)	(0.651 - 1.369)	(0.592 - 1.607)
Mother's Age 20 to 29 years	0.603	0.529	0.64
	(0.267 - 1.361)	(0.239 - 1.169)	(0.293 - 1.398)
Mother's Age 30 to 39 years	0.364**	0.321***	0.376**
	(0.163 - 0.815)	(0.147 - 0.704)	(0.151 - 0.937)
Mother's Age 40 or more	0.315***	0.282***	0.306***
	(0.140 - 0.711)	(0.128 - 0.622)	(0.135 - 0.695)
Number of Prior births	1.059	1.089*	1.025
	(0.959 - 1.168)	(0.985 - 1.205)	(0.890 - 1.180)
Mother's Education primary	0.928	0.924	1.025
	(0.641 - 1.344)	(0.623 - 1.371)	(0.690 - 1.523)
Mother's Education secondary	1.398***	1.482***	1.343***
	(1.099 - 1.777)	(1.158 - 1.896)	(1.116 - 1.615)
Mother's Education higher	2.541***	2.903***	2.826***
	(1.654 - 3.902)	(1.848 - 4.562)	(2.217 - 3.601)
Husband's Education primary	0.89	0.915	0.975
	(0.632 - 1.252)	(0.647 - 1.295)	(0.684 - 1.389)
Husband's Education secondary	0.973	1.018	1.066
	(0.770 - 1.229)	(0.806 - 1.286)	(0.947 - 1.202)
Husband's Education higher	1.044	1.157	1.407**
	(0.750 - 1.454)	(0.822 - 1.627)	(1.071 - 1.850)
Muslim	0.638***	0.606***	0.654***
	(0.454 - 0.896)	(0.427 - 0.858)	(0.517 - 0.828)
Other religion	1.335	1.491	1.547*
	(0.450 - 3.964)	(0.601 - 3.697)	(0.937 - 2.556)
Caste OBC	1.227	1.26	1.369
	(0.736 - 2.048)	(0.733 - 2.167)	(0.916 - 2.044)
Caste SC	1.17	1.24	1.185
	(0.681 - 2.010)	(0.711 - 2.161)	(0.810 - 1.733)
Caste ST	0.881	0.836	0.776

	(0.487 - 1.594)	(0.463 - 1.512)	(0.483 - 1.245)
Caste other	1.561	1.446	1.226
	(0.835 - 2.919)	(0.755 - 2.770)	(0.870 - 1.728)
Household Assets	1.046***	1.042***	1.046***
	(1.024 - 1.069)	(1.018 - 1.067)	(1.027 - 1.065)

Source: India Human Development Survey, 2005 and 2011.
Analysis restricted to ever-married women living in high-focus states between the ages of 15 to 49 years, who had a birth in the five years prior to IHDS-II and did not have data missing on covariates
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes
Coefficients represent odds ratios
Confidence intervals in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10: Who urged health facility for delivery?

	Non-high focus states (%)	***High focus states (%)***
ASHA	**14.92**	**30.53**
Doctor	65.92	30.49
Nurse/ANM	53.38	30.51
Health worker	24.83	7.09
Anganwadi (an Indian govenment. program)	24.18	13.83
NGO worker	3.02	0.33
Husband	88.11	84.77
Family	81.96	79.48
Friends	26.55	14.28
Self	51.58	61.46
Others	9.22	4.47

Table 11: Presence of an ASHA in the village

	Non-high focus states (%)	***High focus states (%)***
Has an ASHA	91.37	94.68
Does not have an ASHA	8.63	5.32

Table 12: Distance of ASHA's residence from the village

	Non-high focus states (%)	*High focus states (%)*
Within village (less than 1 km)	91.32	91.05
1 to 5 kilometers	5.14	5.61
More than 5 kilometers	3.54	3.34

Table 13: Received money from government for last delivery

	Non-high focus states (%)	***High focus states (%)***
Did not receive	81.36	63.81
Received	**18.64**	**36.19**

Appendix A: Sensitivity analyses for the adequacy of health facilities

As described earlier, a measure of the ‘adequacy’ of public health facilities was created in this study. To the best of our knowledge, such a variable has not been used in prior literature. In the measures section, we explained the rationale of creating this variable, the interpretation of the indicator of adequacy and finally the use of the variable in the analysis. In addition, we performed a series of additional sensitivity analyses to test our assumptions and methods of creating the measure of adequacy. In this section, we describe the steps of the sensitivity analysis, its results and also interpret whether the output supports our assumptions in creating the adequacy variable.

First, we separately analyzed the infrastructure and service provision measures that were used to categorize adequacy. The results are summarized in Table 13. In columns 1 and 2, we compare high-focus and non-high-focus states during the period before implementing the JSY and the NRHM. While in columns 3 and 4 we present the same comparison in the period after implementing the JSY and the NRHM. The results show that for all measures of infrastructure, non-high-focus states performed better than high-focus states. Specifically, public health facilities in non-high-focus states had greater availability of electricity (14.16 hours/day in non-high-focus vs 10.16 hours/day in high-focus states), number of employees (8.89 vs 8.40), the facility of toilets (63.35 vs 46.00%) and availability of piped drinking water (55.43 vs 29.01%). Public health facilities in the non-high-focus states also had higher overall availability of gynecological services (66.0 vs 53.66), prenatal services (63.20 vs 55.50%) and birthing services (50.00 vs 45.00%). By and large, such trends were also seen in the period after implementing the JSY and the NRHM. It must be noted however that high-focus states made considerable improvements in the provision of services. For example, availability of gynecological services in the period before implementing the JSY and the NRHM was about 12% higher in the facilities of non-high-focus states; but it was almost completely eliminated in the period after the JSY and NRHM implementation. In summary this analysis shows that in both periods, high-focus states lagged behind other states in terms of individual measures of defining the adequacy of a public health facility.

In the next step of the sensitivity analysis, we tested construction of the adequacy variable. Specifically, we recalculated the adequacy of public health facilities using two criterion that were different from the one used for the main analysis. Recall that the infrastructure and service provision criterion for each type of health facility were dissimilar (Table 1b). Public health facilities in Indian are of varying types and they differ in terms of the number of people they serve and in terms of the service provision expectations from each. The District Hospitals (DH) (generally the largest component of the Indian rural public health system) had relatively ‘strictest’ criterion to be considered ‘adequate’ while the Sub-Centers (SCs) had the ‘least strict’ criterion for them to be considered adequate. Under this sensitivity analysis, the criterion used for measuring the adequacy of DH was applied to all other types of facilities (Primary Health Clinics (PHCs), Community Health Centers (CHCs) and Sub-Centers (SCs)). The aim was to enforce the ‘strictest’ criterion for all types of facilities and assess the changes in the overall ‘adequacy’. Next, we conceptually reversed this process and applied the adequacy criterion for SCs to all other types of facilities. Thus, the ‘least strict’ criterion for categorizing ‘adequacy’ (used for SCs) was applied to all other types of facilities. The results are presented in Tables 14. In the period before implementing the JSY and the NRHM, the overall adequacy decreased from 14.18 % to about 7.36 % when the strictest definition of adequacy was used for categorization (Panel A). In contrast, when the least strict definition of adequacy was used, the overall adequacy increased to 18.20% (Panel A). Thus, the re-categorization provided variation for the adequacy of health facilities. To avoid repetition, we use the following terms from here onwards– least strict adequacy (LSA), adequacy and more strict adequacy (MSA).

Finally, we reanalyzed models that included a measure of adequacy, using the LSA and the MSA variables to check whether the results altered. Tables 15 shows results of this analysis. Neither LSA nor MSA were associated with the likelihood of having an institutional birth in high focus states after the implementation of the JSY and the NRHM. Changing the criterion of ascertaining adequacy did not alter the results of the analysis.

Table 14: Survey of Medical Facilities in Rural India, India Human Development Survey, 2004-2012

	2004-05		2011-12	
	Non-High Focus states	High Focus States	Non-High Focus States	High Focus States
N	~1260	~1290	~1270	~1259
Infrastructure				
Hours of electricity per day (Mean)#	14.16	10.16***	13.88	9.49***
Number of employees (Mean)#	8.89	8.40	8.96	10.11
Has toilet (%)*	63.35	46.00***	61.42	54.20***
Has piped drinking water (%)*	55.43	29.01***	54.57	32.51***
Number of hours operational per week (Mean)#	68.27	55.83***	48.47	49.05
Services Offered				
Gynecological (%)*	66.00	53.66***	47.76	47.1
Prenatal (%)*	63.20	55.50***	55.52	45.67***
Birthing (%)*	50.00	45.00	38.76	38.36

Source: India Human Development Survey 2004-05, 2011-12
Restricted to rural facilities from villages that were part of both rounds of the survey and supplied sample for the main study analyses
*chi-square tests to compare between high-focus and non-high-focus states
#student's t-test to compare between high-focus and non-high-focus states

Table 15: Sensitivity analysis of the definition of adequacy of public health facilities

	1	2	3
	Overall	Non-high focus	High focus
	%	%	%
Panel A: Pre period			
Most strict definition of Adequacy (MSA)	7.36	8.76	5.98
Original definition of Adequacy	14.18	19.41	9.05
Least strict definition of Adequacy (LSA)	18.20	25.82	10.74
Panel B: Post period			
Most strict definition of Adequacy (MSA)	6.51	6.57	6.44
Original definition of Adequacy	15.34	19.72	11.04
Least strict definition of Adequacy (LSA)	21.92	28.79	15.18

Notes: Analysis is at village level.
Villages that did not have any public health facility were categorized as 'No facility'
DH - District Hospital
PHC - Primary Health Center
CHC - Community Health Center
SC - Sub-Center

Table 16: Logistic regression results for the likelihood of having an institutional delivery

	1	2	3
	Model 1	Model 2	Model 3
Observations	5,250	5,250	5,250
Survey weights	Yes	Yes	Yes
Most strict definition of Adequacy (MSA)	1.162		
	(0.687 - 1.965)		
Original definition of Adequacy		1.057	
		(0.717 - 1.558)	
Least strict definition of Adequacy (LSA)			1.17
			(0.849 - 1.612)
Mother's Age 20 to 29 years	0.602	0.603	0.598
	(0.267 - 1.359)	(0.267 - 1.361)	(0.265 - 1.352)
Mother's Age 30 to 39 years	0.364**	0.364**	0.362**
	(0.163 - 0.814)	(0.163 - 0.815)	(0.162 - 0.811)
Mother's Age 40 or more	0.315***	0.315***	0.314***
	(0.140 - 0.711)	(0.140 - 0.711)	(0.139 - 0.709)
Number of Prior births	1.059	1.059	1.06
	(0.959 - 1.169)	(0.959 - 1.168)	(0.961 - 1.170)
Mother's Education primary	0.926	0.928	0.927
	(0.639 - 1.342)	(0.641 - 1.344)	(0.641 - 1.342)
Mother's Education secondary	1.397***	1.398***	1.401***
	(1.099 - 1.777)	(1.099 - 1.777)	(1.102 - 1.781)
Mother's Education higher	2.542***	2.541***	2.546***
	(1.658 - 3.896)	(1.654 - 3.902)	(1.662 - 3.901)
Husband's Education primary	0.888	0.89	0.887
	(0.631 - 1.251)	(0.632 - 1.252)	(0.629 - 1.249)
Husband's Education secondary	0.972	0.973	0.976
	(0.770 - 1.227)	(0.770 - 1.229)	(0.773 - 1.232)
Husband's Education higher	1.043	1.044	1.048
	(0.749 - 1.451)	(0.750 - 1.454)	(0.753 - 1.459)
Muslim	0.638***	0.638***	0.639***
	(0.455 - 0.895)	(0.454 - 0.896)	(0.456 - 0.897)
Other religion	1.34	1.335	1.349
	(0.451 - 3.979)	(0.450 - 3.964)	(0.454 - 4.004)
Caste OBC	1.225	1.227	1.233
	(0.735 - 2.043)	(0.736 - 2.048)	(0.738 - 2.058)
Caste SC	1.167	1.17	1.172
	(0.680 - 2.006)	(0.681 - 2.010)	(0.681 - 2.015)
Caste ST	0.875	0.881	0.88

	(0.484 - 1.584)	(0.487 - 1.594)	(0.486 - 1.593)
Caste other	1.559	1.561	1.563
	(0.834 - 2.913)	(0.835 - 2.919)	(0.836 - 2.923)
Household Assets	1.046***	1.046***	1.045***
	(1.023 - 1.069)	(1.024 - 1.069)	(1.022 - 1.068)

Source: India Human Development Survey, 2005 and 2011.
Analysis restricted to ever-married women living in high-focus states between the ages of 15 to 49 years, who had a birth in the five years prior to IHDS-II and did not have data missing on covariates
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes
Coefficients represent odds ratios
Confidence intervals in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 2: Sick of inequality? Exploring the association between Indian women's body weight and gender inequality

Introduction

Women struggling to maintain a healthy body weight is a critical issue in developing countries, where the disease burden is shifting towards higher prevalence of lifestyle diseases at the population-level.[50] Unhealthy body weight among women has both individual- and societal-level implications.[50] Having a suboptimal weight is associated with increasing an individual's risk of lifestyle diseases such as diabetes, hypertension and heart diseases.[51] Among childbearing women, body weight may also influence the health and wellbeing of their offspring.[52] For example, underweight and obese mothers both tend to have poor perinatal outcomes such as low-birthweight, pregnancy complications and early delivery.[53-55] Children born with such complications are more likely to develop lifestyle diseases such as hypertension and diabetes in later life.[56,57] Addressing such population health issues in developing countries requires identifying the determinants of unhealthy body weight among women.[50]

In this study, I investigate an underexplored potential determinant of women's body weight in India – gender inequality. Gender inequality is defined as treating a specific population of the society disadvantageously based on gender.[58] For example, women are sometimes paid lower wages compared to men of equal qualifications performing similar duties.[59] Prior research has shown that gender inequality (for example, women not participating in household decisions) is associated with several health-related outcomes such as mortality, fertility rates and healthcare utilization.[60,61] Economist Amartya Sen has noted that 'gender inequality directly involves matters of life and death' in the South Asian subcontinent.[60] While research has generally focused on the link between gender inequality and economic outcomes, Indian policymakers are increasingly interested in the role of gender inequality as a determinant of women's health.[30] However, to my knowledge, no existing studies have assessed whether gender inequality is a determinant of Indian women's body weight. This is an important oversight, given recent national-level evidence of a simultaneous high prevalence of underweight in rural Indian women along with a rise of obesity among urban women.[62,63] India's future health depends in part on evaluating the social determinants of unhealthy body weight among its women.

Gender inequality manifests in a complex manner in South Asian societies in general and Indian society in particular. Global comparisons indicate that India is a poor performer on the Gender Inequality Index (GII), one of the United Nations (UN) Human Development Indicators (HDIs).[64] More specifically, Indian society is generally patriarchal despite its so-called 'westernization' in recent decades. Patriarchal thought influences a range of social behaviors[65] such as family structures, division of household duties and household family relationships.[60] Further, women in certain Indian household follow customs such as 'veiling' where they completely or partially cover their faces in the presence of elders or strangers.[66] Such family arrangements, traditions and customs are together referred to as 'household practices'.[67-69] It is clear that the preference to males over females overtly influences household practices in India. In summary, gender inequality is reflected in the 'gendering' of household practices in India.

These gendered household practices might affect Indian women's weight-related outcomes in numerous ways. While gender-based inequality is known to influence women's weight through social pressures to be thin in the West,[70] the ways in which gender inequality affects Indian women's health can be significantly different. For example, limited access to food is common in some segments of Indian society. In this context, gendered practices can create gender-based inequalities in intra household food allocation.[71] For example, evidence suggests that South Asian women often receive inadequate nutrition due to their lower status within the household.[72,73] Assigning a subordinate status to women is another way gendered practices may influence women's healthy weight. Subordinate status might reduce women's 'bargaining power' in the household dynamic.[66,74] Lower bargaining power may mean that women have less of a say in what foods are prepared and served, which can then affect women's nutritional intake. The third way gendered practices may influence weight outcomes is by engendering a sense of ostracization among Indian women, whereby they do not feel in control of their own health and destiny.[75,76] The resulting psychological stress can make Indian women neglect their own health, nutrition and consequently their body weight.[76] Finally, gendered household practices may cause a division of household duties, wherein women are not permitted to engage in wage work or have access to cash. This creates a sense of dependency on the patriarchs of the household [77] and also means that women are not able to purchase additional food out of the home. Taken together, it is plausible to hypothesize an association between Indian women's body weight and gendered household practices.

However, the association between gendered household practices and body weight may not be similar for all subgroups of Indian women. Urbanization can disrupt this relationship in several ways. [74,77,78] First, family sizes in urban India are generally smaller.[44] Smaller family sizes can help women counter the effects of patriarchy and provide them greater bargaining power in the household.[74] This might reduce the household food allocation inequality in, thereby increasing the quantity of the food consumed by women. Second, urbanization provides women more opportunities to participate in wage work.[79-82] Along with enhancing women's self-confidence and the sense of 'being in control' of their life,[75,76] wage work can provide women access to cash which may provide them more choice over food selection. Finally, urban environments have much higher food availability compared to rural areas.[83] Urban women can take advantage of higher food availability and of access to cash through wage work to supplement the food available at home. Thus, urban and rural women may differ in several ways in terms of the ability to counter the effect of gender inequality on their body weight. Yet, few studies have evaluated such rural-urban differences in the association between gender inequality and weight outcomes.

Background

Household practices as the expression of gender inequality

Indian society consists of myriad diverse linguistic, religious and caste sub-groups. [44] Maintaining relationships with other members of one's social group by asserting the collective group identity [84] can reap great rewards for Indian households. Gendered household practices are an important mechanism for asserting and maintaining group identity.[85-87] Consequently, a typical Indian household follows prevalent social norms and household practices of its caste. In India, women are considered the 'keepers of family status and of caste purity'.[88] As a result, many household practices are applicable to Indian women but not to Indian men.[68,89] For example, only women in some Indian households participate in veiling **Figure** 5.[84,90,91] Due to veiling, women are 'covered away' from the rest of the society or in other words, they are secluded. Therefore, veiling practices are jointly referred to as 'seclusion' in this study. Interestingly, no customs akin to seclusion exist for Indian men. Along with seclusion, there are numerous other examples of gendered household practices. Dowry is a common practice in many Indian communities.[92] In some Indian households, men and women do not have meals together.[68] Women are often prohibited from going out of the house alone in some families.[93]

Interpreting gendered household practices

One possibility is that the household practices mentioned here are simply an indicator of 'normative culture' and nothing more. It can be argued that gendered household practices represent not just the prevailing culture but also women's unequal status in the household. Sociologists suggest that gendered household practices continue to frame women as the 'symbolic repository of group identity'.[89,94,95] In other words, it reinforces the historically interpreted role of women in the Indian society. For example, seclusion is considered to be a context-sensitive interaction ritual that indicates women's unequal status in Indian households.[90] Seclusion is aptly interpreted by Andrist (2010) - *"while practicing purdah does not in itself seclude women, except in a symbolic sense, it denotes a complex of behaviors, which collectively preclude women from interacting with men as equals."* [66] The practice of seclusion unequivocally represents gender inequality and has been used in many sociological studies to denote the same.[68,96]

Recent social trends in India

Reassuringly, the Indian society is addressing the issue of gender inequality in several ways. Some examples include outlawing the practice of dowry during weddings to prevent dowry-related harassment of women,[97] establishing female quotas in corporate board rooms[98] and more than doubling the already generous paid maternity leave available at workplaces.[99] Half of all the seats in local elections (generally conducted at the village level) are reserved for women.[98] These measures were introduced to reduce gender inequality in India and expand women's role both within the household and outside of it. The current study aims to support such efforts by providing new evidence on the direct impact of gender inequality on women's health.

It is important to note however that the benefits of these societal changes are not distributed equally among Indian women. On average, urban Indian women have a much higher education and rates of employment compared to rural women.[44] Rural Indian women often deal with restrictions of the caste system during marriage and face the threat of violence if they do not adhere to these restrictions.[100,101] In contrast, while urban Indian women are subjected to similar restrictions based on caste and religion, they still enjoy greater freedom in terms age of marriage and choice of partners.[68] Considering such issues, it is important to assess whether urban and rural women differ in terms of how they are affected by and cope with gender inequality.

After providing the context of gendered household practices in India and their origins in gender inequality, I now describe the literature that broadly evaluates the role of gender inequality in India and in other developing countries.

Review of Literature on Gender Inequality and Health Outcomes

Studies in numerous settings have evaluated the effects of gender inequality on diverse health and behavioral outcomes. [58,61,102,103] Only a handful of studies have considered the effect of gender inequalities on women's health. As mentioned earlier, gender inequality is the differential treatment of certain members of a society because of their gender.[58] In most studies on the topic, the concept of gender equality is operationalized by including an indicator for women's decision-making freedom within the household. An analysis of fertility data collected in 54 countries by Abadian (1996) showed that increased gender equality is associated with improvements in important population level measures such as lower Total Fertility Rates (TFR) and lower Infant Mortality Rates (IMR).[103] Similarly, large review of literature by Upadhyay et al (2014) recorded positive associations between greater gender equality and fertility outcomes such as lower unintended pregnancies and higher intervals between pregnancies.[61] Al Riyami (2004), in their study on Oman, showed that contraception use was higher among women that enjoyed greater equality in the household.[102] Higher contraception use enables appropriate spacing between children and positively influences the health of women.[102] Thus, reduced gender inequality is generally associated with a positive impact on women's health.

Researchers have also evaluated the impact of greater gender equality in the Asian continent. In a comparison of four Asian countries, Ghuman (2003) found that decreased gender inequality is associated with better infant and child mortality outcomes.[104] Similarly, Adhikari (2011) found that infant mortality was significantly lower among Nepalese women that enjoyed greater equality in the household.[105] In another study from Nepal, Matsumura (2001) found lesser household gender inequality was associated with higher uptake of prenatal care.[106] An analysis of India's National Family Health Survey (NFHS) 200-06 by Mistry (2009) showed that a reduction in household inequality increased use of pregnancy care in India.[93] The negative effects of gender equality may continue beyond childbirth. In a study by Shroff (2006) that used data from a southern Indian state showed that gender inequality was an independent predictor of early childhood stunting.[107] Osmani and Sen (2012) also report that gender inequality can have direct penalties in terms of its effect on women's health and hidden penalties in the form of its intergenerational impact on children's health.[50]

Fewer researchers have examined specific gendered household practices, such as the practice of seclusion on socioeconomic and health outcomes of Indian women in particular. Desai et al (2010) showed that practice of seclusion is associated with lower age of marriage among Indian women.[68] The authors used data from the IHDS on 27,365 ever-married women aged 25–49 to explore ways in which different dimensions of gender in Indian society shape the decisions regarding age at marriage. The authors explored economic factors, indicators of familial empowerment and for seclusion. The practice of seclusion was associated with a decrease of about one year in the age of marriage among the women in the study sample. In another study, Stroope (2015) demonstrated that seclusion is associated with higher prevalence of hypertension among women in Indian households.[96] The authors also assessed the effect of seclusion on the health of the men in the household. They found that women's seclusion is associated with lower odds of hypertension among the men of the household. A major limitation of the study by Stroope is that the main outcome of hypertension was self-reported.

Gaps in literature

Despite the evidence that gendered household practices may be related to women's health,[68,96] to my knowledge, no prior studies have investigated whether such practices are related to body weight outcomes among Indian women. A small body of research[62,63] evaluates body weight outcomes of Indian women. However, this literature does not consider gender inequality as determinant of women's body weight. Further, this literature has generally used cross-sectional data. Thus, such studies on the topic of Indian women's weight outcomes lack the ability to draw causal inferences. Finally, much of the literature on the topic of gender inequality has evaluated only a single dimension of gendered practices such as seclusion or participation in decision-making.[68,96] Such an approach provides only a limited perspective for comprehensively evaluating gender inequality's influence on Indian women's health and specifically on body weight outcomes.[73] Finally, some studies from prior research used self-reported health outcomes such as hypertension instead of objective measures of health collected via surveyors.

Current study and research questions

The purpose of this study is to examine the relationship between gender inequality expressed as gendered household practices, urbanization and weight outcomes among Indian women. Specifically, I use information on household practices in a nationally representative sample of Indian households in the Indian Human Development Survey (IHDS) and evaluate the impact of such practices on women's body weight outcomes. This study contributes to two streams of literature: the literature on the socioeconomic determinants of women's health in developing countries and the literature on how urbanization alters the impact of traditional societal structures on the health of women. To my knowledge, it is the first study to explore the relationship between household gendered practices and body weight outcomes among Indian women. Findings from the study can help policymakers understand how the social practices influenced by gender inequality can affect tangible health outcomes. The use of panel data containing detailed information on household practices and household characteristics from two rounds of a large, nationally representative survey of women in India is an improvement over prior literature on Indian women's body weight, which has only used cross-sectional data. Finally, measurement of body weight of women in IHDS was done by surveyors and was not collected via self-reports. Self-reporting of body weight can be inaccurate and suffer from reporting errors. Specifically, I examine the following research questions:

Research questions

1. Are gendered household practices, including seclusion and lack of participation in household decisions, associated with Indian women's body weight outcomes?
2. Does urban residence modify the associations between gendered household practices and Indian women's body weight?

Study hypotheses

Based on the research questions mentioned above, I propose the following hypotheses for this study-

H1: Gendered household practices are associated with body weight outcomes among Indian women.

H2: The association between gendered household practices and body weight is different among urban compared to rural Indian women.

Conceptual framework and study hypotheses

In this section, I develop a conceptual framework for the research questions outlined earlier. To the best of my knowledge, there is no existing theoretical model that provides a framework for analyzing the direct association between gender inequality and the physical health of Indian women. Frameworks used in other populations may not apply to Indian women due to their unique social context.[96,108] To create an interdisciplinary framework for assessing the research questions, I use theories from sociological, psychological and demographic literatures.[75,76] In all, the model includes four components that interact and establish a connection between the study's main outcomes– Indian women's body weight and the main predictors – gendered household practices, which are representative of household gender inequality. Boxes in solid outline represent the outcomes, the modifiers and the predictors of the study. Relevant concepts that are not operationalized in the study are denoted with dashed outlines.

Figure 1a

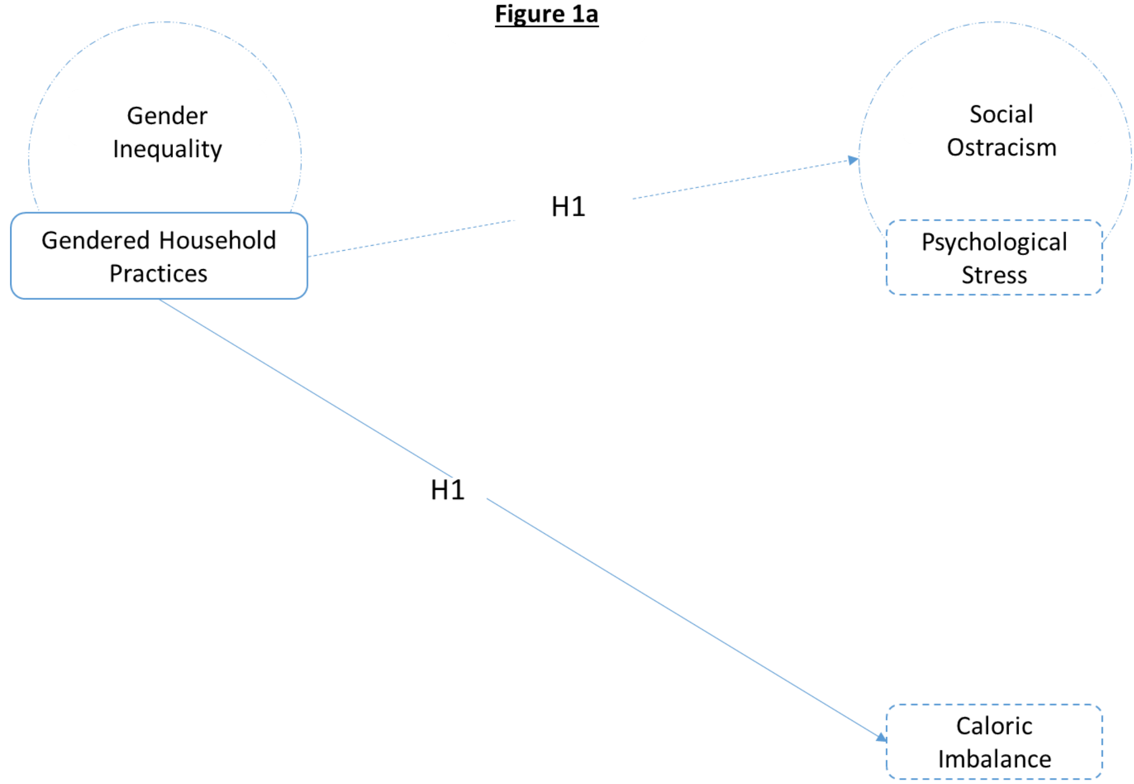


Figure 1a graphically presents how gender inequality in the Indian household causes stress in Indian women and may produce caloric imbalance. Sociocultural practices originating out of gender inequality have the potential to affect women's caloric balance through inequalities in household food distribution. I hypothesize that due to gendered household practices, women may receive less food than they need to suffice their caloric needs. In addition, I also hypothesize that exposure to household practices increases the emotion of social ostracism among women. The direct result of a heightened sense of ostracism is psychological stress. To describe the relationship between ostracism and dietary behaviors, I use theories from social psychology.

Figure 1b

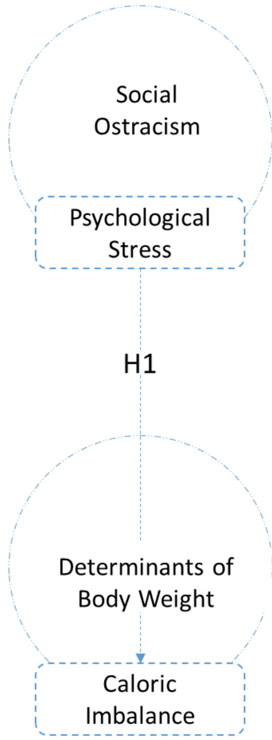
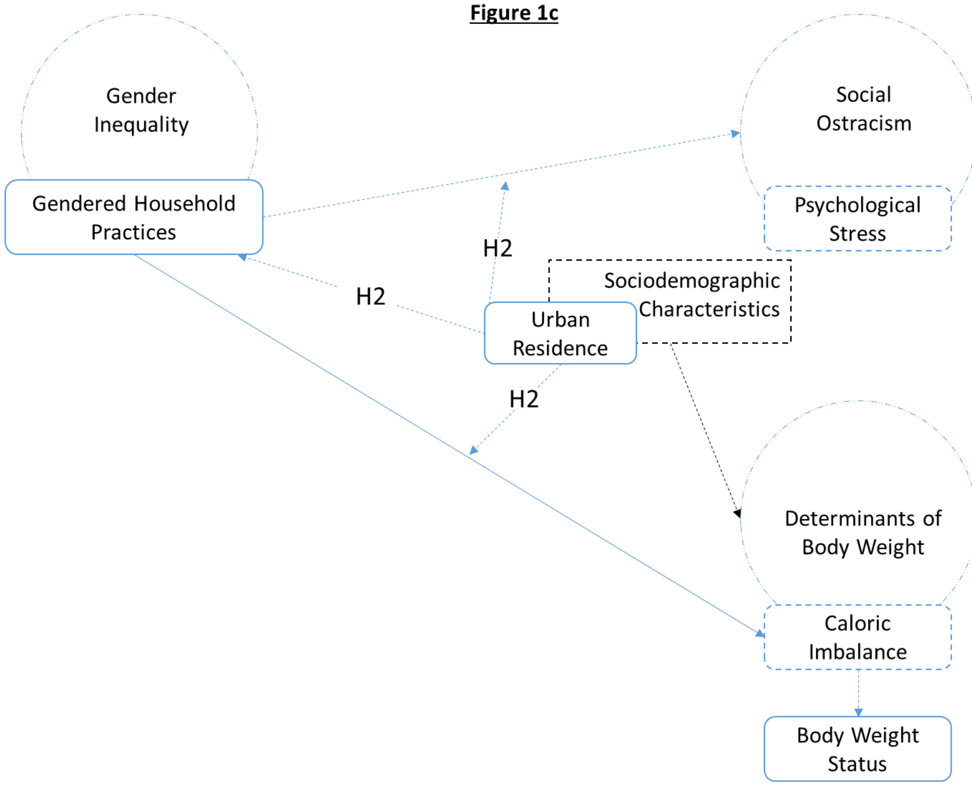


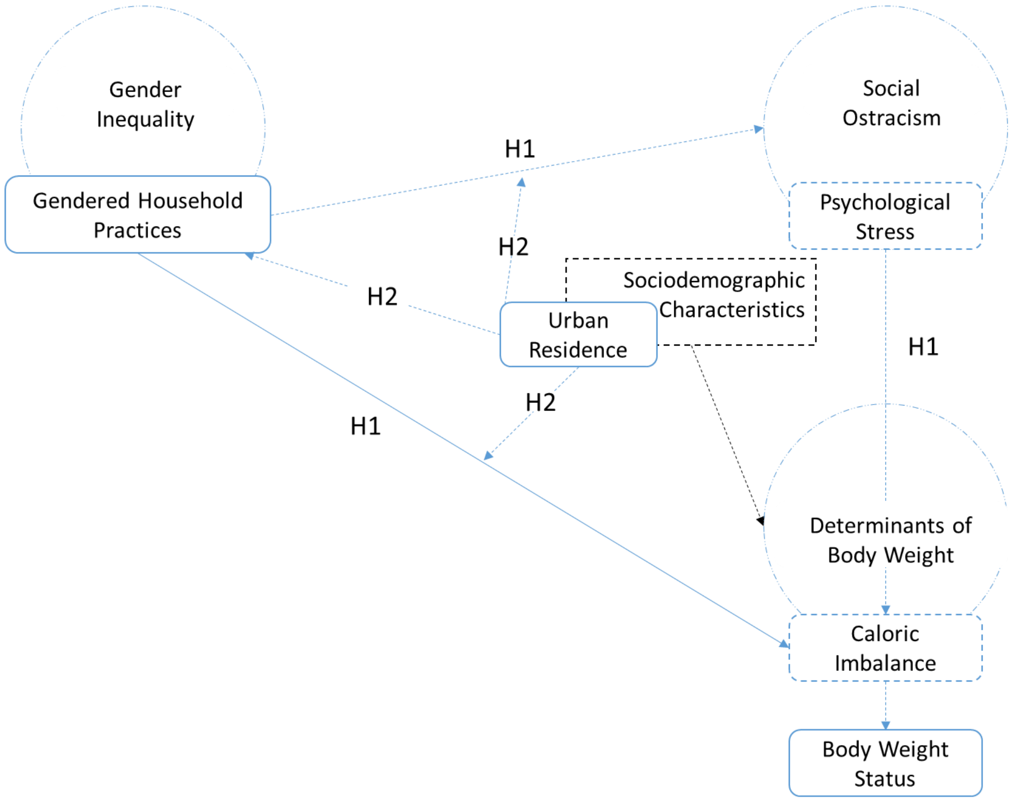
Figure 1b describes the next part of the framework. Social psychology theorizes that human beings are social animals and depend upon social relationships to fortify their physical and psychological well-being.[76] The effect of ostracism is quite powerful because it undermines fundamental acceptance and belonging needs, which leads to negative emotional and psychological reactions.[76] For example, under the gendered practice of seclusion, Indian women are expected to cover their faces in the presence of elders and strangers. This can create a physical barrier to participation in household discussion, thus heightening the feeling of ostracization. Experimental studies on the effect of ostracism on dietary behaviors show that it can reduce a person's self-regulation about food consumption and the motivation to eat healthy food.[109] This can generate caloric imbalance in those subjected to ostracism and influence their body weight.

Figure 1c



Finally, **Figure 1c** graphically shows the possible modifying effect of urban residence on the relationships described earlier in the framework. Urban residence can directly weaken the link between the gendered household practices and psychological stress by giving more opportunities to Indian women to engage in wage work. Wage work can provide women socialization beyond the household, which can decrease the feeling of ostracism among them. As a result, women may be less inclined to ignore their health in general and their caloric need. Thus, stress reduction because of socialization can limit caloric imbalance among urban Indian women. Next, the framework shows that the direct link between household gendered practices and caloric imbalance can weaken due to living in urban environment. This is possible through two pathways. First, the smaller family sizes in urban Indian could result in less 'gendering' of household practices. For example, in contrast to rural India, men in urban households may have to participate in household activities such as cooking food or caring for children. Thus, the net inequality between genders may decrease since the gender-based division of household duties is lower in urban areas. Secondly, women in urban India can benefit from easier availability of food in urban areas compared to rural areas. They can choose to eat food that fits their preferences and supplement the food cooked at home in case it is not sufficient for their daily calorie needs. This can weaken the link between gendered household practices and caloric imbalance. Additionally, the figure describes that sociodemographic characteristics other than urban residence may simultaneously affect the major determinants of body weight. For example, age and marital status can affect both: women's required calories per day and their daily physical activities. Such characteristics would serve as controls when evaluating body weight as an outcome.

The final conceptual framework of the study is presented in **Figure 1 d**. It summarizes the hypothesized relationships between study outcomes and predictors and the direction of such relationships. As described in **Table 17**, I hypothesize that the practice of seclusion is an indicator of gender inequality within the household and thus seclusion will have negatively impact Indian women's body weight. On the other hand, participation in all household decisions is an indication that there is lower gender inequality in the household and such a practice will have a positive impact on Indian women's body weight.



Data and methods

Data source

This study uses panel data from the first and second waves of the India Human Development Surveys (IHDS).[17] The IHDS was conducted by researchers from the University of Maryland, USA and the National Council of Applied Economic Research (NCAER), New Delhi, India. IHDS-I (2004-05) was a multi-topic, nationally representative household survey designed to collect information on the economic and social conditions at the household and individual level. It covered the non-institutionalized population living in private households. The sample was drawn using stratified random sampling. Villages and urban blocks (comprising of 150-200 households) formed the primary sampling unit (PSU) from which the households were selected.

An in-person interview was conducted with the head of each household. The Household questionnaire collected information about demographic characteristics of household members, sources of income, expenditure patterns and other information pertaining to the household. The Education, Health and Learning Tests questionnaire collected information on education of children, health of the women in the household and marriage practices. A section of this questionnaire was answered only by ever-married women aged 15-49 years (termed 'eligible women' throughout the rest of this study) and collected information on fertility and various topics pertaining to gender relations in the household. In addition, interviewers collected anthropometric measurements for all eligible women, including height and weight. Data collection for IHDS-I began in November 2004 and ended in September 2005. The sample for IHDS-I consisted of 41,554 households including 13,900 rural households that were interviewed during 1993-94 in a previous survey by NCAER. Robustness checks and comparisons of IHDS-I rural sample with other data sets from India confirm that the new households added to IHDS-I rural sample provided a nationally representative sample.[36] IHDS-I was conducted in all states and union territories of India. Of the 612 districts in India in 2001, 382 were included in IHDS-I. The people in the IHDS sample lived across 1503 villages and 971 urban blocks in India.

IHDS II (2011– 2012) followed the same sampling and interview procedures as IHDS-I. IHDS-II re-interviewed about 85% of the households interviewed during the baseline survey. About 2,341 new households were added to IHDS-II to account for those who were lost to follow-up. (These households are not included in the sample for the current study.) Data collection for IHDS-II began in November 2011 and was almost completed by October 2012. The sample size for IHDS-II was 42,152 households. These households were spread across 33 states and union territories, 384 districts, 1420 villages and 1042 urban blocks. IHDS data sets are publicly available through the Inter-University Consortium for Political and Social Research (ICPSR). Information about IHDS data collection procedures, funding and quality assurance is available elsewhere. [17]

The main sample for the current study was derived by linking the original datasets of the two waves of IHDS. Link variables (household and individual identification numbers) to merge IHDS-I with IHDS-II are available from the IHDS website.[37] The website also provides detailed guidance on the linking procedure.[84] Using this information, I created a panel of 40,018 households that were interviewed during both rounds of IHDS. This was consistent with IHDS estimates of the sample size of a panel created out of its two surveys.[17,36]

Information on gender relations within the household was collected during both rounds of the survey. In the gender relations supplement of the survey, questions on gendered household practices such as seclusion, restrictions on women's movement out of the house, their participation in household decisions and other related household practices were included. I make use of this rich information to create measures of gendered household practices. Further, direct measurement of eligible women's height and weight was done during IHDS data collection. In order to increase accuracy, two anthropometric measurements were taken for height and weight of each woman. The analysis for the present study uses average of the two measurements of height and weight.

Sample derivation

The sample for this study includes only the 'eligible women' (ever-married women between the ages 15 to 49 years during IHDS-I) who were interviewed during both rounds of the IHDS. I include women for whom the data on height and weight are available in each round of the IHDS. This yielded an initial analytical sample of about 20,360 women. I then excluded observations for which the data on gendered household practices was missing. Next, I excluded those women for whom the values of height and weight were out of plausible range (weight less than 35kgs (70 lbs.), which either indicates severe malnourishment or is more likely an error in measurement and height more than 181 centimeters (about 6 feet), which is highly unusual in India).[44,110] Finally, to strengthen identification, I exclude observations for whom the household practices changed during the period between the two IHDS surveys. In other words, I only include those households that remained consistent with their baseline household practices from IHDS-I. For example, if women from a household A surveyed in IHDS-I practiced seclusion but did not practice seclusion when they were interviewed during IHDS-II, then women from household A were excluded from the sample. There are two main reasons for this exclusion. First, for the households that 'switched', it is not possible to determine the time at which the switch occurred. Secondly, this method provided two distinct groups of women – those who were subjected to gendered practices and a group of women that were not subjected to gendered practices. The latter served as a control group in the analysis. As a sensitivity check, I conducted separate analysis of the 'switcher' households and also reanalyzed the main models without excluding the 'switching' households. The results of this analysis are included in **Appendix A**. After applying the exclusions, a final analytical sample of 15,144 women was used for analysis. The sample derivation process is displayed graphically in **Figure 7**.

Measures

Women's bodyweight outcomes are the main outcome of interest. Using height and weight information from each round of the study, the Body Mass Index (BMI) was calculated for each woman. Women were then categorized as underweight, normal weight, overweight or obese using Asian Indian population-specific BMI cutoffs[111] that are described in **Table 19**. Using this information, I created three variables that measure women's weight outcomes. The first is a continuous variable indicating BMI of the women during the second wave of the survey. The second dependent variable is an indicator for being overweight and obese in the second period (IHDS-II). This is a binary variable which takes the value of one if a woman is categorized as overweight or obese and zero otherwise. The third independent variable is an indicator for being underweight in the second period (IHDS-II). This is a binary variable which takes the value of one if a woman is categorized as underweight or is coded as zero otherwise.

Operationalizing gendered household practices

Multiple methods of operationalizing gendered household practices are available in prior literature. In their review of over 60 studies, Upadhyay et al. (2014) describe as many as 19 dimensions related to the topic of gender inequality and its expression in household practices.[61] However, there is no consensus on which measures are most suitable.[85,112] In prior research, investigators have used various individual characteristics such as age at first marriage, educational attainment and woman's occupation.[93] The ability to make household decisions is an essential aspect of household equality and of gendered household practices.[112] This includes decisions such as purchasing expensve goods, number of children that a woman and her husband should have and daily activities such as what to cook for meals. [96] Some studies such as Desai et al. (2010) have used a combination of these measures to operationalize household gendered practices.[68] After considering multiple approaches and the relevant literature, I selected information on various dimensions of gendered practices within the household[17] and operationalize two dimensions of household gendered practices: women's unequal status defined by the practice of seclusion in a household and women's participation in household decision-making.[113] **Table 17** describes the operationalization and the hypothesized relationships between each measure and the study's outcomes.

Based on the discussion above, I selected two main *independent variables*, each of which measures a unique dimension of household gendered practices. The first is an indicator for the practice of seclusion in the household. Eligible women were asked the survey question "Do you practice *ghungat/purdah/pallu (veiling)*?" Those who answered "yes" to the question were considered to practice seclusion in the household. The second independent variable is a binary indicator for the woman participates in major household decisions. Eligible women were asked whether they participate in decisions about (1) what to cook, (2) whether to buy an expensive consumer durable item, (3) how many children the respondent and her husband should have. Based on women's responses, a binary variable was created which took the value of one if a woman participated in all three decisions and value of zero if she did not.

The area of residence of each women was categorized as either urban or rural using classification of the village/neighborhood in IHDS-I which was based on 2001 Census of India. About 14 out of 1503 neighborhoods in IHDS-I changed classification during IHDS-II. Consistent with India's rapid urbanization, all such changes were for villages which were considered 'rural' in IHDS-I but were categorized as 'urban neighborhoods' in IHDS-II. I use the variable indicating rural/urban status from IHDS-II to maintain consistency and avoid errors. So if a village shifted from being classified as a 'rural area' in IHDS-I to an ''urban neighborhood' in IHDS-II, it is considered as an urban area in the current analysis.

The control variables used in the current study include women's education, religion and caste. A household asset score computed by IHDS was used as a control measure for household wealth. Number of persons in the house of women was also used as a control. Details about the study variables are described further in **Table 18**. Education of the woman were classified into 4 categories: No education, Primary education (1 to 4 years of schooling), secondary education (5 to 10 years of school) and higher secondary or more (10 or more years of education). Women's religion was categorized as Hindu, Muslim or Other religion. Caste was categorized as Forward, Other Backward Caste (OBC), Scheduled Caste (SC), Scheduled Tribes (ST) or others. The religion and caste categories used here are commonly used in sociological studies in India.[4,13,14,114]

Identification strategy

The aim of the study is to assess the role of gender relations in the health production function of individual members. To this end, I leverage the panel data structure of IHDS surveys and use panel estimation methods that identify the effects of household gendered practices on women's body weight outcomes.

Model Specification

The first aim of this study is to evaluate the association between gendered household practices and women's weight outcomes. I estimate the correlates of women's weight outcomes using the following basic specification –

$$W_{ih} = \beta_0 + \beta_1 G_i + \beta_2 \boldsymbol{X}_{ih} + \varepsilon_{ih} \qquad (1)$$

Where W_{ih} is a weight outcome of woman *i* in household *h*. W_{ih} can be either her BMI, the likelihood of being underweight or the likelihood of being either overweight or obese. G_i is an indicator of gendered household practice. It can either indicate the practice of seclusion or indicate women's involvement in the household decision-making. X_{ih} is a set of explanatory variables including the woman's age, weight outcome in the first period, educational attainment, household asset score, household size, religion and caste. ε_{ih} is the random error term. The coefficient β_2 on the indicator for gendered practices is the main coefficient of interest.

There may be unobserved variables at the household level that affect women's body weight. To control for such variables, I estimate a household random effects model, which is an altered version of equation (1). The estimated equation is -

$$W_{ih} = \beta_0 + \beta_1 G_i + \beta_2 \boldsymbol{X}_{ih} + v_h + \epsilon_{ih} \qquad (2)$$

Apart from the variables in (1), the error term in equation (2) is separated into a component common to members in the same household (v_h) and an error component ϵ_{ih} which is independent and identically distributed.

The second aim of the study is to estimate whether the association between household gendered practices and women's weight outcomes is moderated by urban residence. For this aim, I estimate model (2) separately for rural and urban women. The estimated model is

$$W_{ihp} = \beta_0 + \beta_1 G_i + \beta_2 \boldsymbol{X}_{ihp} + v_{hp} + \epsilon_{ihp} \qquad (3)$$

Here *p* is the place of residence of each woman. It can be either a rural or an urban area.

I use ordinary least squares (OLS) regression models to analyze the continuous variable of BMI and multivariate logistics regression models to analyze the likelihood of being underweight and the likelihood of being either overweight or obese. I report the coefficients from the OLS regressions and report the results of logistic regressions as odds ratios. P-values and confidence intervals were used to determine the statistical significance of results. The alpha was determined at the traditional level of 0.05. All statistical analyses were performed using Stata 14.[43]

Results

Sample characteristics

The summary statistics for the study sample are described in Panel A and B of **Table 20**. In Columns (1) and (2), I report the characteristics of the rural sample in IHDS-I and in IHDS-II respectively. In Columns (3) and (4), I report the same for the urban sample. The body weight trends are similar for both groups of women. The average BMI for rural women increased from 20.79 to 21.78between the two surveys while the BMI of urban women increased from 22.66 to 24.31. Accordingly, the proportion of each weight category also changed. The proportion of rural women that were underweight in IHDS-I was 18.8% while the same was 9.8% among urban women, which decreased to 16.7 % and 5.9% for rural and urban women respectively. Nearly 63 % of rural women in IHDS-I practiced seclusion as reported by the head of the household, which was about 45 % for urban Indian women. The proportion rural women that reported participating in all household decisions was 74 % while the same in urban women was about 78%

Panel B of **Table 20** reports the characteristics of women and their household including age, education, religion, caste and the household asset index (calculated by IHDS). Overall, women in rural areas were younger compared to those in the urban areas. More than half of the rural women in the sample reported having no formal education or less than primary education (55.7 % Column (1)) while the proportion of the same among urban women was about 26.4% Column (3). In both periods, about 84% of the rural sample was Hindu and about 9.6 % was Muslim. This is similar to the estimates from the 2001 Census of India, which reported that Hindus and Muslims were 80.5% and 13.4 % of India's population respectively. The household asset index was higher in the urban sample compared to the rural sample.

Results of multivariate regressions

Main sample

Table 21 displays the results of Model (2) in the full sample for the analysis of the study outcomes - women's BMI, the likelihood of being underweight and the likelihood of being overweight or obese. The practice of seclusion was significantly associated with the BMI of women in the sample at statistically significant levels (-0.367, p-value (p) <0.01). Seclusion was also associated with higher likelihood of being underweight (Odds Ratio (OR) = 1.357; 95% Confidence Interval (CI) = 1.120, 1.644) and lower likelihood of being either overweight or obese (OR 0.781, CI 0.661, 922). Participation in all household decisions was not associated with any body weight outcomes in the sample.

Urban-rural differences

Table 22 displays the results of Model (3) separately for rural and urban women in the sample for the analysis of the effect of seclusion on study outcomes. Columns (1), (2) and (3) display results for rural women, while columns (4), (5) and (6) show results for urban women. Overall, the practice of seclusion was significantly associated with the BMI of both rural and urban women at statistically significant levels (-0.417, p-value (p) <0.01 and -0.612, p<0.01 for rural and urban women respectively) (Columns (1) and (4)). For both groups of women, the practice of seclusion in the household seemed to significantly increase the likelihood of being underweight (Odds Ratio (OR) = 1.383; 95% Confidence Interval (CI) = 1.064, 1.797 and OR = 1.819; 95% CI = 1.224, 2.702). For urban and rural women that were subjected to seclusion, the likelihood of being overweight or obese was lower (OR = 0.729; 95% CI = 0.588, 0.902 and OR = 0.638; 95% CI = 0.470, 0.867).

In **Table 23,** results from Model (3) that included an indicator for women's participation in household decisions for the analysis of the study outcomes (women's BMI, the likelihood of being underweight and the likelihood of being overweight or obese) are shown. As in Table 4, columns (1), (2) and (3) display results for rural women, while columns (4), (5) and (6) show results for urban women. Participation in household decision-making was significantly associated with the BMI of rural women (a reduction of 0.339 in BMI, Columns (1)). For rural women, participation in all household decision-making was associated with a lower likelihood of being underweight (OR = 0.746; 95% CI = 0.587, 0.946). However, participation in all household decisions was not significantly associated with any other body weight outcomes in the study sample for rural or urban women.

Discussion

In this study, I examined whether a key social determinant of health in South Asia- gender inequality, is associated with physical health outcomes among Indian women. To my knowledge, this was the first study to formally investigate whether gender inequality affects is associated with Indian women's body weight. To address a gap in the literature on this topic, this study operationalized the concept the gender inequality in terms of the presence of household practices that are unique to India and evaluated whether such practices were significantly associated with Indian women's body weight. I used panel data that provided reliable measures of both – gendered household practices and of women's body weight from a large nationally representative survey of Indian households. I found that the practice of seclusion was negatively associated with BMI of both rural and urban Indian women. Seclusion was also associated with higher likelihood of being underweight and lower likelihood of being either overweight or obese. Participation in all household decisions was generally not associated with body weight outcomes among Indian women, except for rural Indian women for whom it was associated with a lower likelihood of being underweight. The association between gendered household practices and women's body weight outcomes was generally similar among rural and urban Indian women.

Results from the first set of analyses showed that the practice of seclusion was significantly associated with body weight outcomes among the women in the sample. Seclusion was associated with lower BMI, lower likelihood of being overweight or obese and higher likelihood of being underweight. Thus, the overall impact of seclusion on body weight seems to be negative as hypothesized in the conceptual framework and described in **Table 17**. I reject the null hypothesis that gendered household practices are not associated with body weight outcomes of Indian women. However, the magnitude and the direction of association between the presence of seclusion in the household and women's body weight was quite similar among rural and urban women. Thus, I fail to reject the null hypothesis that rural and urban women are similar in terms of how gendered household practices affect their body weight. In both groups, seclusion seems to increase the likelihood of being underweight and reduce the likelihood of being overweight or obese. Thus, seclusion seemed to have a negative effect on body weight trajectories of Indian women.

In contrast, the second set of results do not fully support hypothesized relationships between gendered household practices and women's body weight. Participating in all household decisions was not associated with any weight outcomes in the study sample except for the likelihood of being underweight for rural women. This is an interesting result which demands a nuanced interpretation. Allowing the participation of women in household decision-making by in itself may not mean that they are provided equal status in the household. However, it is a still a useful measure of gender equality and captures a different dimension of gender relations in the household.[61] In summary, the results of this study indicate that the expression of gender inequality in terms of socio-cultural practices is more strongly associated with women's body weight compared to its expression in practical matters of household decision-making.

Weight outcomes among rural and urban Indian women did not appear to be differently associated with gendered household practices in the analytical results. This indicates that the issue of gendered household practices is relevant in both the rural and urban contexts in India. As hypothesized earlier, urbanization could help women counter the effects of gender inequality in multiple ways. However, the results from the study seem to suggest that this is not the case. More research is required to better understand how urbanization alters social and household dynamics in a traditionally patriarchal society such as India. Further, the data used in this study was collected in the first decade of this century. Since the Indian society is changing at a rapid pace, perhaps a more recent data set could be used to replicate the analysis of this study and reassess the effect of urbanization on women's health.

The findings of the current study are generally consistent with prior literature on Indian women's weight outcomes. Similar to the reports in previous studies, higher proportion of rural women were underweight compared to urban women in our sample. Further, as seen in other studis[68,96] the practice of gendered household practices was higher in the rural sample compared to the urban one. As seen in available studies[51,62,63], along with the main study outcomes, significant predictors of women's body were women's parity (the number of children they gave birth to), their age, higher educational attainment, the economic conditions of the household and the ST (scheduled tribes) caste status.

In a new contribution, I showed that gender inequality expressed in the form of seclusion is significantly and negatively associated with body weight outcomes among Indian women. I hypothesized a pathway that links gender relations to health by introducing disparities in the allocation of food in the household. This has relevance to social policies specifically targeted at the health of women. Specifically, the food-guarantee scheme launched a few years ago[83] can adjust the program design to assure that all members of a family receive adequate nutrition regardless of their gender. In terms of lessons for other countries, results from this study reinforce the fact that governments in developing countries can greatly benefit by incorporating theories of gender while implementing social programs.

There are several limitations of the current study. First, I relied on self-reported data on the practice of seclusion. The head of the household, who was generally an adult male, answered the question. There could be reporting errors in the actual practice of seclusion or of women's decision-making participation either due to either differential interpretation of the question or due to a social desirability bias. Despite these issues, if an adult male in the household answered 'yes' to a question about seclusion regardless of whether women actually practice it, then it is likely that women in such households are not considered equals. In other words, the survey response can still be considered as a valid measure of gender inequality within the household. Further, there is no evidence of whether such reporting errors would be correlated with either the study outcomes (women's bodyweight) or other variable of interest (urban or rural location). Secondly, as theorized in the conceptual framework and stated elsewhere, the immediate predictors of weight outcomes are the balance between personal behaviors such as diet and physical activity. In statistical analyses, controlling for women's nutritional intake and for caloric expenditure was essential. However, such information is not available in the IHDS and could not be included in the model.[17] Finally, a critical issue for identification is the possibility of migration between the rural and urban areas by households in the sample. Male migration to urban areas for jobs is common among families living in rural India. However, migration of the entire household is less common. Fortunately, in the IHDS panel data used for this study, no families changed their place of residence during the two rounds of the survey. IHDS did collect information on migrant members of a household who were not present during the survey interviews. Almost all such migrants were men who moved away from the household for economic reasons such as jobs or education. However, the proportion of households with a migrant is limited to less than 4 percent of the total IHDS sample. I do not expect the presence of a migrant in the household to induce bias in the estimates.

Despite its limitations, this study extends current knowledge about the negative effects of gender inequality in India and in other developing countries. An unexplored area for future studies is identifying the factors that can reduce gendered household practices such as seclusion in Indian households. For example, programs that transmit information about how cultural practices can adversely influence the health of the next generation may encourage households to cease practices such as seclusion. Information campaigns on social practices have been successful under policies to improve sanitation practices in India.[115] For example, a social messaging campaign promoted that not having a toilet in the house as an undesirable social characteristic when selecting a family for a daughter's marriage.[116] Generating change in social norms in the Indian society is a slow process. However, the findings of the current study can help public health professionals design specific programs targeted at the social practices that are most harmful for the health of Indian women.

Figures and tables

Table 17: Operationalization of Gendered Household Practices

	Dimension	Operationalization	Expected Relationship with body weight
1	*Status*		
	Seclusion	Indicator for whether women in the household practice *purdah* (Muslim term) or *ghunghat* (Hindu term).	Negative
2	*Decision making*		
	Participation in decision-making	An indicator of a woman for having any say in all for the following household decisions - 1) what to cook 2) whether to buy an expensive consumer durable item 3) how many children the respondent and her husband should have	Positive

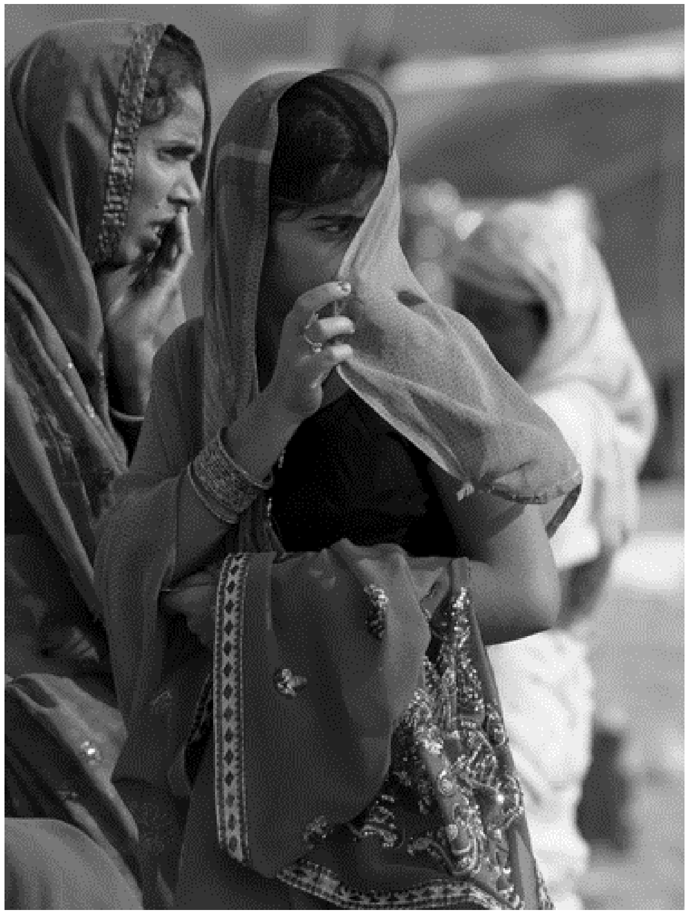


Photo credit: rajesh satankar via Visualhunt / CC BY-NC-SA

Title	ghunghat ki aad se (From behind the veil)
Source	flickr.com
Author	rajesh satankar / photo on flickr

Figure 5: The Practice of Veiling in India

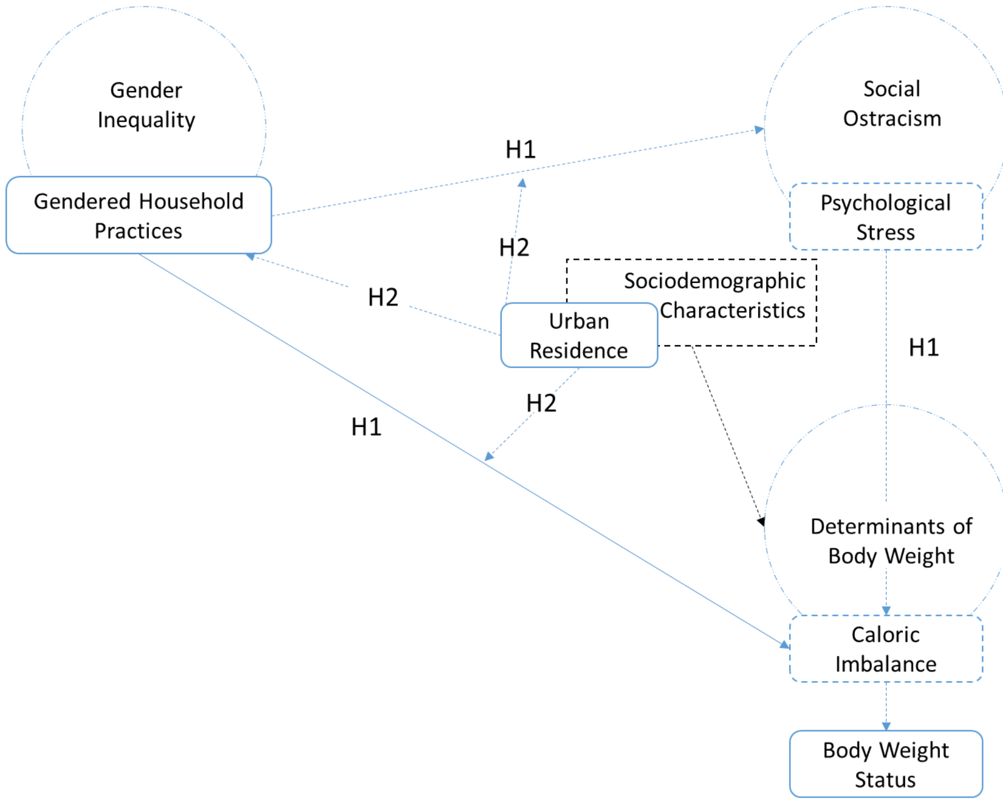


Figure 6: Conceptual Framework - Gendered Household Practices and Weight Outcomes among Indian Women

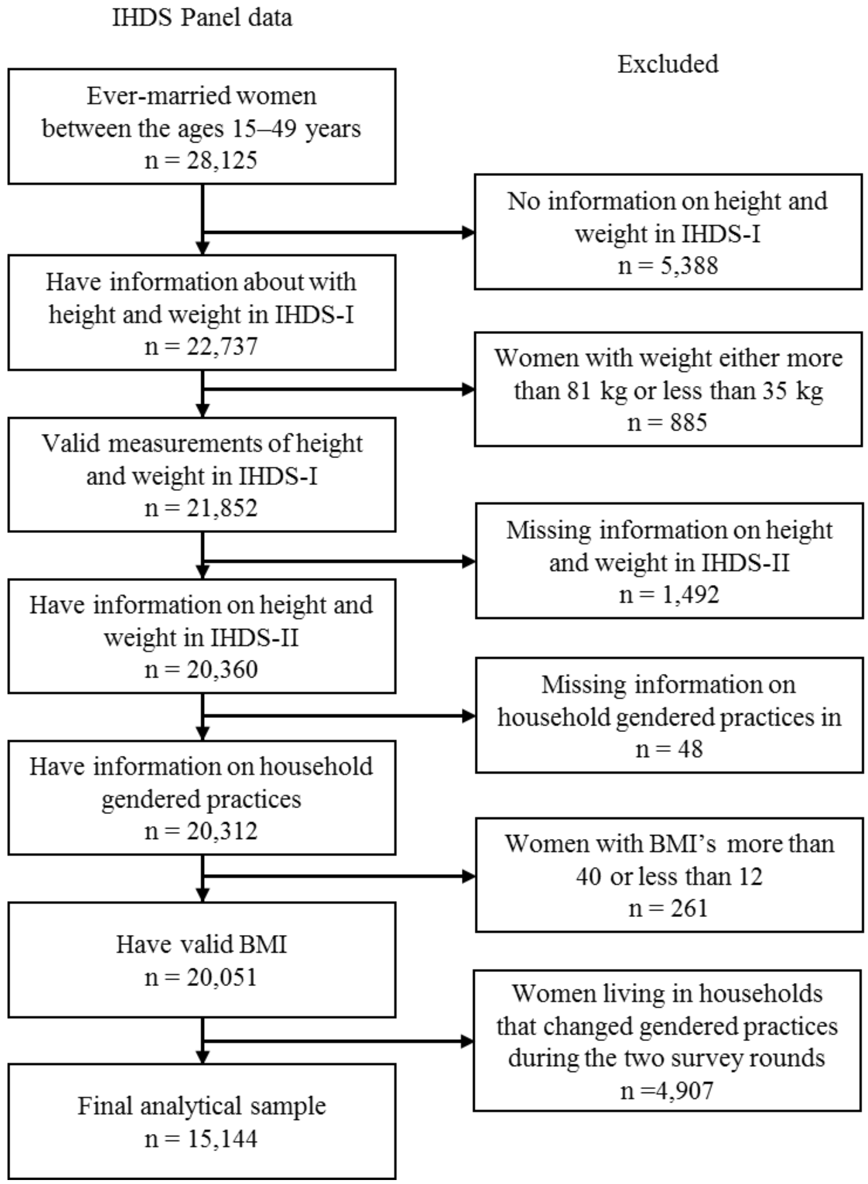


Figure 7: Sample derivation

Table 18: Variable Definitions

Variable	Type	No. of categories	Definitions/Categories	Notes	IHDS survey files
Outcomes/Dependent Variables					
Body Weight Outcomes					
Body Mass Index (BMI)	Continuous	NA	Average of two anthropometric measurements for a woman's height and for body weight in IHDS-II was taken. Using averaged values, BMI was calculated using the formula - *height (in meters)/weight(in Kgs)*^{2}	Anthropometric measurements of women's height and weight were taken by IHDS surveyors Observations with erroneous values were deleted from the sample (see text for details)	Eligible women's File IHDS-II
Overweight or Obese Status	Categorical	2	Coded = 0 if a woman is not obese or overweight Coded = 1 if a woman is obese or overweight	Based on a woman's BMI, she is classified as: underweight, normal weight, overweight or obese. Asian Indian population-specific BMI cutoffs recommended by WHO were used for categorization	Eligible women's File IHDS-II
Underweight Status	Categorical	2	Coded = 0 if a woman is not underweight Coded = 1 if a woman is underweight	See above	Eligible women's File IHDS-II
Independent Variables					
Gendered Household Practices					

Seclusion	Categorical	2	Based on a woman's response to the survey question: “Do you practice ghungat/purdah/pallu (veiling)?” coded = 0 if the woman does not practice seclusion coded = 1 if the woman practices seclusion	This question was translated in local Indian languages to ease interpretation. Since the Eligible Women were mostly interviewed by a female surveyor, this question is likely to have received valid responses	Eligible women's File IHDS-I Eligible women's File IHDS-II
Participation in Household Decisions	Categorical	2	Based on a woman's response to a survey question about the number of household decisions in which she has a ay They could be 1) what to cook 2) whether to buy an expensive consumer durable item 3) how many children the respondent and her husband should have Coded = 1 if a woman participates in all the decisions listed above coded = 0 if a woman does not participate in all the decision	This question was translated in local Indian languages to ease interpretation.	Eligible women's File IHDS-I Eligible women's File IHDS-II
Socio-demographics					
Individual-level Characteristics					
Age	Continuous	NA	NA	Original age was reported in IHDS-I	Individual File IHDS-I
Education: respondent woman	Categorical	4	No education, primary school, secondary school and higher secondary or higher	Very small proportion of women had education higher than secondary school and will be grouped together	Individual File IHDS-I Individual File IHDS-II

Religion	Categorical	3	Hindu, Muslim or other	Hinduism and Islam are the two major religions of India. The proportion of women from other religions was relatively small in the sample.	Individual File IHDS-I Individual File IHDS-II
Caste	Categorical	5	Upper, Other Backward classes, Scheduled castes, Scheduled tribes, others	This classification is consistent with categorization of castes in the Indian census	Individual File IHDS-I Individual File IHDS-II
Household-level characteristics					
Household assets index	Continuous	5	Poorest, poor, middle, richer and richest quintile	IHDS calculated an idex of household assets based on the information about household income and assets. The same was used for analysis	Household File IHDS-I Household File IHDS-II

Table 19: Asian-population specific Body Mass Index (BMI) categorization for body weight

Weight status	**BMI range/cutoff**
Underweight	< 18
Normal weight	18 - 23
Overweight	23-25
Obese	>25

Table 20: Characteristics of women in the study sample

	(1)	(2)	(3)	(4)
	Rural		Urban	
	IHDS-I	IHDS-II	IHDS-I	IHDS-II
N	10,185	10,185	4,959	4,959
Panel A				
Body Mass Index	20.788	21.777	22.664	24.309
	(0.032)	(0.039)	(0.055)	(0.063)
Underweight	0.188	0.167	0.098	0.059
	(0.004)	(0.004)	(0.004)	(0.003)
Normal Weight	0.600	0.497	0.485	0.353
	(0.005)	(0.005)	(0.007)	(0.007)
Overweight	0.112	0.140	0.168	0.185
	(0.003)	(0.003)	(0.005)	(0.006)
Obese	0.099	0.196	0.250	0.403
	(0.003)	(0.004)	(0.006)	(0.007)
Overweight or Obese	0.211	0.336	0.417	0.588
	(0.004)	(0.005)	(0.007)	(0.007)
Participated in all household decisions	0.741[#]	0.741[#]	0.779[$]	0.779[$]
	(0.004)	(0.004)	(0.006)	(0.006)
Practiced seclusion	0.627	0.627	0.454	0.454
	(0.005)	(0.005)	(0.007)	0.007)
Panel B				
Woman's age: 15 to 19 years	0.036	0.036	0.019	0.019
	(0.002)	(0.002)	(0.002)	(0.002)
Woman's age: 20 to 29 years	0.350	0.350	0.314	0.314
	(0.005)	(0.005)	(0.007)	(0.007)
Woman's age: 30 to 39 years	0.392	0.392	0.410	0.410
	(0.005)	(0.005)	(0.007)	(0.007)
Woman's age: 40 to 49 years	0.222	0.222	0.258	0.258
	(0.004)	(0.004)	(0.006)	(0.006)
Married	0.913	0.913	0.933	0.933
	(0.003)	(0.003)	(0.004)	(0.004)
Woman’s Education Less Than Primary School	0.557	0.557	0.264	0.264
	(0.005)	(0.005)	(0.006)	(0.006)
Woman’s Education Primary School	0.071	0.071	0.060	0.060
	(0.003)	(0.003)	(0.003)	(0.003)

Woman's Education Secondary School	0.325	0.325	0.478	0.478
	(0.005)	(0.005)	(0.007)	(0.007)
Woman's Education Higher than Secondary School	0.047	0.047	0.198	0.198
	(0.002)	(0.002)	(0.006)	(0.006)
Household Asset Index	10.076	13.893	16.208	20.163
	(0.051)	(0.059)	(0.077)	(0.074)
Number of Household Members	5.926	5.926	5.384	5.384
	(0.026)	(0.026)	(0.031)	(0.031)
Religion: Hindu	0.840	0.840	0.784	0.784
	(0.004)	(0.004)	(0.006)	(0.006)
Religion: Islam	0.096	0.096	0.148	0.148
	(0.003)	(0.003)	(0.005)	(0.005)
Religion: Other	0.064	0.064	0.068	0.068
	(0.002)	(0.002)	(0.004)	(0.004)
Caste: Upper	0.042	0.042	0.072	0.072
	(0.002)	(0.002)	(0.004)	(0.004)
Caste: OBC	0.415	0.415	0.417	0.417
	(0.005)	(0.005)	(0.007)	(0.007)
Caste: SC	0.226	0.226	0.177	0.177
	(0.004)	(0.004)	(0.005)	(0.005)
Caste: ST	0.094	0.094	0.028	0.028
	(0.003)	(0.003)	(0.002)	(0.002)
Caste: Other	0.223	0.223	0.306	0.306
	(0.004)	(0.004)	(0.007)	(0.007)

Source: India Human Development Survey, 2005 and 2011
N = 7,607; $ N = 4,100
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes

Table 21: Regression Results for Women's Body Weight Outcomes, India Human Development Survey 2005-12

	1	2	3	4	5	6
	Seclusion			Participation in household decisions		
	BMI	Underweight	Overweight or Obese	BMI	Underweight	Overweight or Obese
N	39,410	39,410	39,410	39,410	39,410	39,410
Seclusion	-0.367***	1.357***	0.781***			
	(0.098)	(1.120 - 1.644)	(0.661 - 0.922)			
Participation in All Household Decisions				0.089	0.871*	1.069
				(0.079)	(0.757 - 1.003)	(0.944 - 1.210)
Age	0.053***	0.980***	1.049***	0.054***	0.979***	1.050***
	(0.005)	(0.970 - 0.989)	(1.041 - 1.057)	(0.005)	(0.969 - 0.989)	(1.041 - 1.058)
Mother's parity	-0.253***	1.194***	0.795***	-0.258***	1.202***	0.791***
	(0.026)	(1.120 - 1.272)	(0.744 - 0.849)	(0.026)	(1.127 - 1.281)	(0.741 - 0.845)
Number of household members	-0.057***	1.018	0.950***	-0.066***	1.025*	0.944***
	(0.016)	(0.992 - 1.044)	(0.924 - 0.977)	(0.018)	(0.996 - 1.054)	(0.916 - 0.972)
Marital Status	0.163*	0.940	1.191**	0.167*	0.939	1.193**
	(0.085)	(0.818 - 1.081)	(1.020 - 1.390)	(0.086)	(0.815 - 1.081)	(1.020 - 1.396)
Mother’s Education primary	0.157	0.845	1.210*	0.182*	0.829	1.230*
	(0.099)	(0.637 - 1.121)	(0.985 - 1.486)	(0.103)	(0.625 - 1.100)	(0.998 - 1.516)
Mother’s Education secondary	0.402***	0.814**	1.436***	0.437***	0.794**	1.471***
	(0.108)	(0.687 - 0.963)	(1.211 - 1.703)	(0.115)	(0.663 - 0.951)	(1.225 - 1.765)
Mother’s Education higher	0.422***	0.725*	1.460***	0.501***	0.682**	1.541***
	(0.129)	(0.514 - 1.022)	(1.152 - 1.851)	(0.125)	(0.483 - 0.964)	(1.211 - 1.962)
Household Assets	0.215***	0.884***	1.185***	0.216***	0.882***	1.186***
	(0.009)	(0.868 - 0.900)	(1.156 - 1.214)	(0.009)	(0.867 - 0.898)	(1.157 - 1.216)
Religion: Islam	0.952***	0.644**	2.285***	0.865***	0.684**	2.155***

	(0.213)	(0.426 - 0.973)	(1.698 - 3.077)	(0.201)	(0.469 - 0.998)	(1.619 - 2.869)
Religion: Other	0.503**	0.639**	1.683**	0.582**	0.598***	1.777***
	(0.242)	(0.452 - 0.904)	(1.092 - 2.594)	(0.243)	(0.419 - 0.853)	(1.149 - 2.747)
Caste: OBC	-0.187	1.083	0.928	-0.181	1.080	0.933
	(0.158)	(0.886 - 1.325)	(0.712 - 1.210)	(0.157)	(0.888 - 1.313)	(0.715 - 1.217)
Caste: SC	-0.123	1.147	0.966	-0.122	1.147	0.967
	(0.137)	(0.961 - 1.368)	(0.781 - 1.195)	(0.138)	(0.966 - 1.362)	(0.778 - 1.202)
Caste: ST	-0.597***	1.476***	0.513**	-0.583***	1.461***	0.517***
	(0.224)	(1.150 - 1.896)	(0.307 - 0.857)	(0.210)	(1.156 - 1.847)	(0.315 - 0.850)
Period	0.784***	0.857	2.030***	0.775***	0.863	2.017***
	(0.126)	(0.684 - 1.074)	(1.646 - 2.504)	(0.126)	(0.688 - 1.083)	(1.633 - 2.492)
Constant	17.409***	0.504**	0.006***	17.111***	0.676	0.005***
	(0.316)	(0.277 - 0.918)	(0.003 - 0.011)	(0.293)	(0.407 - 1.125)	(0.002 - 0.010)

Source: India Human Development Survey, 2005 and 2011
Robust standard errors for OLS regressions and confidence intervals for logistic regressions in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes

Table 22: Regression Results for Women's Body Weight Outcomes, India Human Development Survey 2005-12

	1	2	3	4	5	6
		Rural Women			Urban women	
	BMI	Underweight	Overweight or Obese	BMI	Underweight	Overweight or Obese
N	20,374	20,374	20,374	9,918	9,918	9,918
Seclusion	-0.417***	1.383**	0.729***	-0.612***	1.819***	0.638***
	(0.139)	(1.064 - 1.797)	(0.588 - 0.902)	(0.208)	(1.224 - 2.702)	(0.470 - 0.867)
Age	0.040***	0.989*	1.043***	0.075***	0.947***	1.059***
	(0.005)	(0.977 - 1.000)	(1.035 - 1.051)	(0.008)	(0.927 - 0.967)	(1.045 - 1.073)
Mother's parity	-0.257***	1.202***	0.769***	-0.197***	1.192**	0.885***
	(0.034)	(1.116 - 1.294)	(0.701 - 0.844)	(0.067)	(1.003 - 1.416)	(0.814 - 0.962)
Number of household members	-0.028**	0.997	0.970**	-0.065**	1.040	0.944***
	(0.014)	(0.974 - 1.020)	(0.942 - 0.999)	(0.027)	(0.989 - 1.095)	(0.907 - 0.982)
Marital Status	0.101	1.058	1.210**	0.201	0.571**	1.001
	(0.098)	(0.855 - 1.309)	(1.035 - 1.414)	(0.227)	(0.365 - 0.894)	(0.753 - 1.331)
Mother’s Education primary	-0.007	0.991	1.064	0.298	0.453***	1.299*
	(0.135)	(0.752 - 1.305)	(0.773 - 1.464)	(0.184)	(0.266 - 0.771)	(1.000 - 1.687)
Mother’s Education secondary	0.378***	0.796***	1.468***	0.569***	0.714**	1.554***
	(0.102)	(0.670 - 0.946)	(1.212 - 1.779)	(0.136)	(0.524 - 0.972)	(1.288 - 1.873)
Mother’s Education higher	0.233	0.658*	1.436*	0.327**	0.856	1.305**
	(0.241)	(0.429 - 1.011)	(0.946 - 2.178)	(0.150)	(0.602 - 1.219)	(1.051 - 1.622)
Household Assets	0.176***	0.908***	1.161***	0.186***	0.886***	1.144***
	(0.013)	(0.886 - 0.931)	(1.129 - 1.194)	(0.011)	(0.864 - 0.910)	(1.114 - 1.175)
Religion: Islam	0.830***	0.603*	2.244***	0.904***	0.705	2.040***
	(0.265)	(0.356 - 1.022)	(1.527 - 3.296)	(0.212)	(0.459 - 1.082)	(1.441 - 2.888)

Religion: Other	0.819***	0.554**	2.054***	-0.099	1.064	0.997
	(0.315)	(0.334 - 0.921)	(1.235 - 3.415)	(0.282)	(0.661 - 1.712)	(0.672 - 1.480)
Caste: OBC	-0.260**	1.061	0.852	-0.253	1.164	0.957
	(0.129)	(0.839 - 1.340)	(0.679 - 1.071)	(0.191)	(0.898 - 1.509)	(0.742 - 1.234)
Caste: SC	-0.322***	1.161	0.811*	-0.134	1.137	0.953
	(0.122)	(0.897 - 1.502)	(0.632 - 1.041)	(0.202)	(0.809 - 1.599)	(0.714 - 1.271)
Caste: ST	-0.836***	1.597***	0.419***	-0.009	0.895	0.902
	(0.188)	(1.196 - 2.131)	(0.272 - 0.646)	(0.428)	(0.472 - 1.696)	(0.494 - 1.647)
Period	0.660***	0.904	2.094***	1.065***	0.718**	2.063***
	(0.177)	(0.699 - 1.171)	(1.551 - 2.827)	(0.148)	(0.554 - 0.930)	(1.605 - 2.652)

Source: India Human Development Survey, 2005 and 2011

Robust standard errors for OLS regressions and confidence intervals for logistic regressions in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes

Table 23: Regression Results for Women's Body Weight Outcomes, India Human Development Survey 2005-12

	1	2	3	4	5	6
		Rural Women			Urban women	
	BMI	Underweight	Overweight or Obese	BMI	Underweight	Overweight or Obese
N	15,214	15,214	15,214	8,200	8,200	8,200
Participation in All Household Decisions	0.339**	0.746**	1.273*	-0.130	0.746*	0.988
	(0.136)	(0.587 - 0.946)	(0.992 - 1.633)	(0.142)	(0.550 - 1.014)	(0.822 - 1.186)
Age	0.041***	0.988*	1.042***	0.090***	0.940***	1.063***
	(0.007)	(0.976 - 1.000)	(1.031 - 1.054)	(0.009)	(0.918 - 0.962)	(1.048 - 1.079)
Mother's parity	-0.256***	1.162***	0.756***	-0.202***	1.166	0.844***
	(0.043)	(1.074 - 1.257)	(0.668 - 0.854)	(0.066)	(0.948 - 1.434)	(0.783 - 0.911)
Number of household members	-0.034**	0.991	0.962**	-0.083**	1.060*	0.951**
	(0.017)	(0.968 - 1.016)	(0.929 - 0.997)	(0.033)	(0.994 - 1.132)	(0.912 - 0.992)
Marital Status	0.038	1.049	1.111	0.293	0.717	1.116
	(0.105)	(0.800 - 1.375)	(0.887 - 1.390)	(0.211)	(0.386 - 1.332)	(0.869 - 1.434)
Mother’s Education primary	-0.097	1.172	0.944	0.468**	0.531**	1.455***
	(0.121)	(0.908 - 1.513)	(0.687 - 1.298)	(0.213)	(0.289 - 0.978)	(1.106 - 1.914)
Mother’s Education secondary	0.273**	0.901	1.303**	0.435**	0.895	1.317*
	(0.132)	(0.748 - 1.084)	(1.065 - 1.593)	(0.189)	(0.629 - 1.275)	(0.994 - 1.745)
Mother’s Education higher	-0.022	0.942	1.114	0.550***	0.763	1.582***

	(0.249)	(0.537 - 1.654)	(0.741 - 1.676)	(0.207)	(0.471 - 1.234)	(1.138 - 2.199)
Household Assets	0.201***	0.889***	1.183***	0.179***	0.891***	1.122***
	(0.012)	(0.871 - 0.907)	(1.151 - 1.216)	(0.014)	(0.860 - 0.924)	(1.095 - 1.149)
Religion: Islam	0.864***	0.659	2.412***	0.673***	1.010	1.632***
	(0.317)	(0.379 - 1.146)	(1.585 - 3.671)	(0.170)	(0.670 - 1.521)	(1.234 - 2.159)
Religion: Other	1.005***	0.413***	2.552***	0.197	0.805	1.234
	(0.265)	(0.245 - 0.696)	(1.520 - 4.286)	(0.335)	(0.491 - 1.320)	(0.770 - 1.979)
Caste: OBC	-0.221	0.987	0.853	-0.136	1.019	0.949
	(0.151)	(0.764 - 1.274)	(0.651 - 1.118)	(0.244)	(0.746 - 1.391)	(0.680 - 1.326)
Caste: SC	-0.252*	1.152	0.838	0.006	1.153	1.014
	(0.143)	(0.905 - 1.467)	(0.614 - 1.142)	(0.200)	(0.771 - 1.724)	(0.749 - 1.373)
Caste: ST	-0.677***	1.374*	0.541**	-0.386	1.132	0.752
	(0.224)	(0.988 - 1.910)	(0.299 - 0.979)	(0.468)	(0.467 - 2.743)	(0.383 - 1.476)
Period	0.662***	0.937	2.142***	1.017***	0.713*	1.877***
	(0.161)	(0.722 - 1.217)	(1.612 - 2.847)	(0.191)	(0.487 - 1.042)	(1.435 - 2.455)

Source: India Human Development Survey, 2005 and 2011
Robust standard errors for OLS regressions and confidence intervals for logistic regressions in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes

Appendix A – Analysis of households that switched patterns of gendered household practices

In this appendix, I describe the sensitivity analyses undertaken to test an assumption in this study's sample derivation. In all analytical models, the households that 'switched' their gendered household practices were excluded. As explained earlier, this was done for two main reasons – first, the timing of 'switching' could not be established and secondly, it provided two distinct groups of women with those who were never subjected to gendered household practices becoming the control group for the study. In addition, there were several issues in running the analysis on this sample due to missingness of data and also in terms of interpreting the results from the analysis.

I adopted two strategies to test the 'exclusion of switchers' assumption. First, I reanalyzed the main models without excluding the 'switchers'. The results are attached in **Tables 24 and 25**, which can be compared to **Tables 23 & 24** respectively. As seen in the tables, the results are generally similar to the study's main results. Next, I conducted a series of descriptive analyses on the 'switchers'. The results of these analyses are displayed in **Table 26**.

In **Table 26**, Panel A displays the results for the main study outcomes of BMI, underweight, normal weight, overweight and obese while Panel B displays the observed change in the outcomes across two rounds of the IHDS survey. Columns 1 and 2 display results for the full sample of households that used to practice seclusion during IHDS-I and stopped it before IHDS-II. Columns 3 to 6 display results for the same sample separated by rural residence. Similarly, columns 7 and 8 show results for the full sample of households that did not practice seclusion during IHDS-I but started practicing it before IHDS-II. Columns 9 to 12 show the results for the same sample separated by rural residence.

As seen in Panel B, the change in the BMI of women that belonged to households that stopped gendered practices increased slightly more than the women that belonged to households in which gendered practices commenced between the two IHDS surveys (1.243 Kg/m2 compared to 1.19 Kg/m2). The difference is not large (0.053 Kg/m2). Nevertheless, this finding still supports the main study results, which showed that the practice of seclusion was negatively associated with BMI. Similar to the study results, in households that stopped gendered practices, women's body weight increased at a faster rate compared to women's body weight in households that started gendered practices. Finally, there are clear differences in terms of change in BMI for rural and urban women. In both types of 'switchers', rural women's BMI increased at a slower rate compared to urban women. Changes in body weight categories are also described in Table 9.

There could be multiple reasons why the differences are small and not more pronounced. First, the timing of the 'switching' could have played a role in minimizing the differences between groups. For example, if a household stopped gendered practices immediately after IHDS-I, then the BMI among its women of this household may have increased more quickly compared to another household which stopped gendered practices just before IHDS-II. Secondly, the sample size for this analysis is quite limited, which means that there was not enough variation in the sample. This could have prevented the full effect of starting or stopping gendered practices from showing up in the analysis. Finally, household that 'switch' could be quite different from the main study sample in terms of the intra-household dynamics. While measures of socioeconomic factors are available in the IHDS data, they may not fully articulate the differences. Thus, we may not expect trends seen in the main study sample to appear in this sensitivity analysis. Despite these issues, this sensitivity analysis largely supports the sample derivation strategy of excluding 'switchers'.

Table 24: Regression Results for Women's Body Weight Outcomes, India Human Development Survey 2005-12

	1	2	3	4	5	6
	Rural Women			Urban women		
	BMI	Underweight	Overweight or Obese	BMI	Underweight	Overweight or Obese
N	25,910	25,910	25,910	13,500	13,500	13,500
Seclusion	-0.308***	1.281***	0.810**	-0.343**	1.517**	0.806*
	(0.098)	(1.076 - 1.526)	(0.687 - 0.955)	(0.144)	(1.076 - 2.141)	(0.637 - 1.020)
Age	0.040***	0.989**	1.044***	0.076***	0.948***	1.056***
	(0.005)	(0.979 - 0.999)	(1.035 - 1.052)	(0.007)	(0.932 - 0.966)	(1.042 - 1.071)
Mother's parity	-0.262***	1.194***	0.769***	- 0.252***	1.223***	0.838***
	(0.029)	(1.118 - 1.275)	(0.705 - 0.839)	(0.056)	(1.074 - 1.392)	(0.775 - 0.906)
Number of household members	-0.033**	0.999	0.964**	-0.061**	1.056**	0.952**
	(0.014)	(0.976 - 1.023)	(0.938 - 0.992)	(0.026)	(1.013 - 1.102)	(0.914 - 0.991)
Marital Status	0.129	1.000	1.225***	0.247	0.691	1.131
	(0.089)	(0.821 - 1.218)	(1.058 - 1.419)	(0.193)	(0.443 - 1.075)	(0.869 - 1.474)
Mother's Education primary	0.047	0.967	1.099	0.360**	0.503***	1.338**
	(0.114)	(0.743 - 1.259)	(0.845 - 1.430)	(0.176)	(0.318 - 0.794)	(1.071 - 1.672)
Mother's Education secondary	0.325***	0.820**	1.390***	0.468***	0.826	1.393***
	(0.094)	(0.704 - 0.957)	(1.179 - 1.639)	(0.154)	(0.617 - 1.107)	(1.115 - 1.740)
Mother's Education higher	0.200	0.769	1.430*	0.465***	0.816	1.405***
	(0.214)	(0.494 - 1.198)	(0.983 - 2.081)	(0.120)	(0.564 - 1.180)	(1.093 - 1.808)
Household Assets	0.181***	0.906***	1.169***	0.189***	0.879***	1.141***

	(0.013)	(0.886 - 0.926)	(1.137 - 1.203)	(0.011)	(0.858 - 0.900)	(1.110 - 1.174)
Religion: Islam	0.850***	0.658*	2.354***	0.740***	0.742	1.693***
	(0.283)	(0.400 - 1.081)	(1.543 - 3.591)	(0.164)	(0.505 - 1.092)	(1.287 - 2.228)
Religion: Other	0.865***	0.568**	2.217***	0.069	0.829	1.205
	(0.287)	(0.368 - 0.877)	(1.344 - 3.658)	(0.290)	(0.506 - 1.360)	(0.769 - 1.888)
Caste: OBC	-0.205	1.083	0.889	-0.227	1.111	0.941
	(0.147)	(0.865 - 1.356)	(0.684 - 1.156)	(0.188)	(0.892 - 1.384)	(0.710 - 1.248)
Caste: SC	-0.226	1.151	0.890	-0.134	1.309*	0.950
	(0.140)	(0.921 - 1.439)	(0.687 - 1.151)	(0.178)	(0.975 - 1.756)	(0.727 - 1.242)
Caste: ST	-0.776***	1.594***	0.424***	-0.083	0.828	0.959
	(0.209)	(1.209 - 2.102)	(0.247 - 0.726)	(0.374)	(0.452 - 1.519)	(0.526 - 1.746)
Period	0.652***	0.898	2.093***	1.048***	0.693***	1.941***
	(0.159)	(0.697 - 1.156)	(1.595 - 2.748)	(0.138)	(0.547 - 0.880)	(1.555 - 2.422)

Source: India Human Development Survey, 2005 and 2011
Robust standard errors for OLS regressions and confidence intervals for logistic regressions in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes

Table 25: Regression Results for Women's Body Weight Outcomes, India Human Development Survey 2005-12

	1	2	3	4	5	6
	Rural Women			Urban women		
	BMI	Underweight	Overweight or Obese	BMI	Underweight	Overweight or Obese
N	25,910	25,910	25,910	13,500	13,500	13,500
Participation in All Household Decisions	0.196***	0.873*	1.181**	-0.177	0.890	0.894
	(0.075)	(0.745 - 1.023)	(1.025 - 1.362)	(0.118)	(0.672 - 1.178)	(0.728 - 1.097)
Age	0.041***	0.988**	1.045***	0.077***	0.947***	1.057***
	(0.006)	(0.978 - 0.998)	(1.036 - 1.053)	(0.007)	(0.930 - 0.965)	(1.042 - 1.072)
Mother's parity	-0.267***	1.201***	0.766***	-0.255***	1.228***	0.836***
	(0.029)	(1.125 - 1.283)	(0.703 - 0.836)	(0.056)	(1.081 - 1.395)	(0.775 - 0.902)
Number of household members	-0.038***	1.004	0.961***	-0.074***	1.067***	0.944***
	(0.015)	(0.979 - 1.028)	(0.935 - 0.989)	(0.027)	(1.016 - 1.121)	(0.905 - 0.984)
Marital Status	0.133	0.998	1.229***	0.247	0.693	1.133
	(0.091)	(0.818 - 1.217)	(1.056 - 1.431)	(0.194)	(0.448 - 1.074)	(0.869 - 1.475)
Mother’s Education primary	0.067	0.951	1.114	0.374**	0.496***	1.350***
	(0.114)	(0.732 - 1.234)	(0.857 - 1.448)	(0.180)	(0.315 - 0.782)	(1.075 - 1.694)
Mother’s Education secondary	0.348***	0.806***	1.412***	0.512***	0.793	1.432***
	(0.099)	(0.689 - 0.944)	(1.187 - 1.679)	(0.161)	(0.578 - 1.087)	(1.132 - 1.811)
Mother’s Education higher	0.254	0.739	1.486**	0.551***	0.739	1.485***

	(0.210)	(0.471 - 1.159)	(1.016 - 2.174)	(0.122)	(0.498 - 1.095)	(1.142 - 1.930)
Household Assets	0.182***	0.905***	1.170***	0.190***	0.878***	1.142***
	(0.013)	(0.886 - 0.925)	(1.137 - 1.204)	(0.011)	(0.857 - 0.900)	(1.111 - 1.174)
Religion: Islam	0.786***	0.689	2.254***	0.639***	0.824	1.590***
	(0.268)	(0.431 - 1.101)	(1.504 - 3.377)	(0.175)	(0.581 - 1.168)	(1.206 - 2.095)
Religion: Other	0.950***	0.535***	2.358***	0.126	0.766	1.251
	(0.292)	(0.342 - 0.836)	(1.422 - 3.909)	(0.279)	(0.478 - 1.226)	(0.809 - 1.935)
Caste: OBC	-0.205	1.081	0.889	-0.206	1.101	0.955
	(0.143)	(0.867 - 1.349)	(0.687 - 1.150)	(0.188)	(0.883 - 1.374)	(0.721 - 1.265)
Caste: SC	-0.231*	1.153	0.885	-0.113	1.305*	0.963
	(0.132)	(0.926 - 1.435)	(0.689 - 1.137)	(0.183)	(0.962 - 1.769)	(0.732 - 1.268)
Caste: ST	-0.769***	1.580***	0.424***	-0.082	0.840	0.960
	(0.198)	(1.206 - 2.070)	(0.251 - 0.717)	(0.374)	(0.446 - 1.583)	(0.531 - 1.735)
Period	0.644***	0.903	2.081***	1.036***	0.702***	1.927***
	(0.160)	(0.701 - 1.163)	(1.583 - 2.737)	(0.138)	(0.551 - 0.895)	(1.547 - 2.401)

Source: India Human Development Survey, 2005 and 2011
Robust standard errors for OLS regressions and confidence intervals for logistic regressions in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Abbreviations: OBC – Other Backward Castes, SC – Scheduled Castes, ST – Scheduled Tribes

Table 26: Descriptive analysis of the 'switcher households' in the study sample

	Households that stopped practicing seclusion						Households that started practicing seclusion					
	Panel A - Body Weight Outcomes											
	Full sample		Rural women		Urban women		Full sample		Rural women		Urban women	
	IHDS-1	IHDS-2	IHDS-1	IHDS-2	IHDS-1	IHDS-2	IHDS-1	IHDS-2	IHDS-1	IHDS-2	IHDS-1	IHDS-2
Observations	2,172	2,172	1,309	1,309	863	863	2,387	2,387	1,459	1,459	928	928
BMI	21.659	22.902	20.792	21.766	22.973	24.624	21.525	22.715	20.673	21.618	22.866	24.44
underweight	0.162	0.127	0.199	0.167	0.105	0.065	0.158	0.13	0.192	0.175	0.103	0.059
Normal weight	0.513	0.429	0.579	0.496	0.413	0.328	0.558	0.45	0.622	0.51	0.458	0.355
overweight	0.151	0.149	0.108	0.14	0.217	0.162	0.12	0.146	0.098	0.136	0.155	0.161
obese	0.174	0.296	0.114	0.197	0.265	0.445	0.164	0.275	0.088	0.179	0.283	0.426
	Panel B - Change in Body Weight Outcomes											
BMI	1.243		0.974		1.651		1.19		0.945		1.574	
underweight	-0.035		-0.032		-0.04		-0.028		-0.017		-0.044	
Normal weight	-0.084		-0.083		-0.085		-0.108		-0.112		-0.103	
overweight	-0.002		0.032		-0.055		0.026		0.038		0.006	
obese	0.122		0.083		0.18		0.111		0.091		0.143	

Chapter 3: Location, location, location? Is there an association between maternal perinatal food environments, gestational weight gain and early childhood weight outcomes?

Introduction

Approximately twenty percent American children are obese according to the latest estimates.[117,118] Childhood obesity is associated with early onset of diseases such as type-2 diabetes, hypertension and with higher likelihood of developing heart disease and cancer in later life.[119-122] To prevent the long-term harmful effects childhood obesity on US population health,[123] there is an urgent need to better understand the determinants of early childhood obesity – particularly the determinants in the perinatal period.

One such determinant [119,120] of obesity in a young child is maternal gestational weight gain (GWG) [117,118]. Research suggests that mothers that gain too much or too little weight during pregnancy are more likely to have offspring with overweight or obesity during childhood and adulthood.[57,119,124] Yet, only 30% of US women gain an adequate amount[125] of weight during pregnancy.[126] 'Adequate GWG' is defined by Institute of Medicine (IOM) through their guidelines published in 2009.[125] Pregnant mothers in the United States find it difficult to gain adequate GWG due to multiple reasons such as being obese or overweight prior to conceiving a child.[125] A growing body of evidence suggests that environmental factors may play a role in shaping maternal GWG.[127] 'Food environments' [128-130] in particular are known to be linked with both – maternal GWG[127,131] during the perinatal period and obesity during mid-childhood (around pre-school or kindergarten).[121,132] However, existing research has not assessed whether environmental factors during the perinatal period (such as perinatal food environments) are determinants of body weight in early life (referred to as early childhood weight (ECW) in this study).

The purpose of this study is to explore the associations between the maternal perinatal food environments, maternal GWG and ECW. Researchers have theorized multiple pathways linking GWG and ECW outcomes.[125,133] Maternal GWG may modify the intrauterine environment and program the fetus to acquire a range of characteristics that increase its risk of early childhood obesity.[134,135] Specifically, it is hypothesized that if a mother receives excessive nutrition during pregnancy (through consuming too many calories) may alter fetal body composition[136], gene expression[137] and brain pathways that regulate appetite.[138] Therefore, it is plausible to hypothesize that gaining excessive GWG may be associated with higher ECW.

There are two possible mechanisms linking food environments and ECW. First, maternal perinatal food environments could impact ECW indirectly through their impact on maternal GWG (i.e., via caloric intake[127,131]). Aspects of local food environments such as proximity to fast food restaurents[131] or to supermarkets [127,139] are associated with body weight outcomes in the general population.[128,129,140] A very few studies have also shown that among pregnant women, features of the food environment such as fast food restaurants are associated with higher GWG.[127,131]

Another possible mechanism is through the food environment's impact on maternal food choices (i.e., dietary quality[141]) during pregnancy.[128] Under this pathway, food environments may operate on ECW independent of their impact on GWG. Aspects of the food environments may alter maternal food choices during pregnancy via multiple methods. They can either make it harder for pregnant women to access healthier foods[142] or more positively, promote a healthier maternal diet.[139,142] These interlinked effects may expose a fetus to a maternal diet of poor dietary quality based on maternal food choices. Based on such intrauterine exposures, the fetus may be programmed to gain higher than normal amount of weight in early childhood.[143-145]

Available evidence on food environments, GWG and ECW outcomes has several issues. First, literature on the topic of food environment and its effect on perinatal outcomes such as GWG has not assessed its downstream impact on weight in early life.[131,134] Second, studies evaluating the GWG-ECW connections are often from clinical settings within a limited geographic location which limits the generalizability of their results.[146,147] Third, information on food environment of mothers' residence has generally not been part of the literature on GWG and ECW.[147-152]

To address these and other gaps in the literature and to explore the mechanisms linking food environment, GWG and ECW, I first investigate whether the adequacy of weight gained during gestation is associated with the body weight outcomes among 2-year-old children in the Early Childhood Longitudinal Survey- Birth cohort (ECLS-B). Next, I merge data from the ECLS-B with the Area Resource File (AHRF) and the Current Business Patterns (CBP) data sets. Each of these data sets supply additional information (sociodemographic characteristics and the food environment, respectively) about the county of prenatal residence of the mothers which is not available in the ECLS-B. I then assess whether the food environments are independently associated with ECW. Finally, I analyze whether the association between the food environments and ECW is mediated by GWG adequacy.

There are several unique features of this study. First, unlike much of the prior research,[127,131,134,148,149,152] I categorize gestational weight gain adequacy using the 'adequacy ratio' method. This method is based on the 2009 IOM guidelines for GWG[125] and accounts for the length of the gestation.[153] Nationally, more than 17% deliveries are not of full-term gestation (they are either pre- or post-term).[154,155] Using the adequacy ratio method allows for analyzing a sample of mothers that had a wider range of gestational duration (22 to 42 weeks), compared to studies that used other methods for GWG adequacy and could only include mothers with full-term deliveries (37 weeks).[127,131] Second, in contrast to prior literature, this study focuses on the weight outcomes at age 2-years. There are multiple reasons for the same. First, 2 years is an appropriately short post-gestation period for perinatal outcomes such as GWG to show measurable effects.[119] Secondly, studies that assessed the effect of GWG on older children (sometimes as much as 21-years old) have generally found null results.[133,152,156,157] This is unsurprising since the immediate determinants of the body weight of a 7-year-old or of a teenager are their own diet and physical activity and not the perinatal outcomes of their mother such as her GWG.[119] Information on diet and physical activity is generally not available to researchers using cross-sectional data. Therefore, when assessing the impact of maternal perinatal outcomes such as GWG on weight outcomes at ages beyond 2 years of age, researchers were unable to control for unobserved confounding factors. By focusing on the weight outcomes at a relatively early age of two years and adding a rich set of controls, this study limits confounding.

Research questions

Based on the discussion above, I seek to answer the following research questions

1. Is maternal gestational weight gain (GWG) adequacy associated with body weight outcomes (Body Mass Index (BMI) and weight-for-length Z-scores) at 2-years of age?
2. Is the maternal perinatal food environment directly associated with body-weight outcomes at 2-years of age?
    a. Does GWG adequacy mediate the association between the perinatal food environment and body weight?

Hypotheses

The following hypotheses are proposed in this study -

H_1: Gestational weight gain (GWG) adequacy is associated with early childhood weight (ECW) outcomes

H_2: The food environment of a mothers' prenatal residence is associated ECW outcomes

H_{2a}: GWG adequacy mediates the association between the perinatal food environment and body weight at age two years

Review of literature on the associations between GWG, ECW and Food Environment

In this literature review I first briefly evaluate the existing evidence on the GWG-ECW linkages and then examine the available literature on the relationships among food environments during pregnancy and perinatal outcomes such as GWG. After synthesizing the literature, in the following section I identify specific gaps in the evidence.

Association between maternal GWG and early childhood weight (ECW)

A sizable number of studies have examined the GWG-ECW relationship.[134,146,147,150-152,156-159] This review was limited to literature relevant to the research questions of the current study. It is restricted to recently published studies that met most of the following inclusion criteria defined *a priori*:

- conducted in the United States
- modeled the GWG-ECW relationship explicitly
- focused on younger children (generally, less than 7-years old)

- used anthropometric measures of child obesity based on national or international growth charts (provided by either the CDC or the World Health Organization (WHO)[160]), instead of other methods such as air displacement plethysmography (ADPT)[161]
- used the latest available IOM guidelines for classifying GWG (barring a few exceptions such as a Oken (2007)[162] which was conducted prior to the release of IOM guidelines)

Numerous studies have found an association between gaining high amount of GWG and the condition of higher body weight among children.[134,148,150,158] For example, in a study based in Boston, Oken et al. (2007)[162] found that an additional 5 kg of GWG was associated with 0.13 units of Body Mass Index (BMI) z-scores among children at age 3 years. In a study from Arkansas, Ludwig (2013)[134] found that 1 kg of additional maternal GWG was associated with 0.02 increase in child BMI at age 12 years. In addition to using a measure for total GWG, few studies have used also IOM guidelines to categorize GWG (as either inadequate, adequate or excessive) and evaluated associations with ECW.[146,148,150] For example, Olson et al. (2009) found an association between mothers gaining weight in excess of IOM 1990 guidelines and children's higher weight at age 3 years.[146] Similarly, Zilko et al. (2010) used a nationally representative data (National Longitudinal Survey of Youth, 1979 (NLSY 1979)) and found that mothers gaining excessive weight according to the 2009 IOM guidelines increased the likelihood of their children being overweight.[163] Finally, Sridhar (2014) found that GWG in excess of the 2009 IOM recommendations was associated with increase in the odds of having an overweight/obese child.[148]

In contrast, some studies have not found a significant GWG-ECW association.[152,159,164] For example, in a study from California, Bider-Canfield (2017)[159] did not find any association between a mother gaining excess GWG according to 2009 IOM guidelines and the likelihood of her child being overweight. Similarly, Branum (2011)[152] conducted a within-family analysis and did not find any associations between gaining excess GWG and child BMI z-score at age 4 years. Finally, Deierlein (2011)[164] found that gaining excess GWG was not associated with weight gain among infants. Thus, the overall evidence on the GWG-ECW outcomes association is inconclusive.

There are several important limitations of the reviewed literature. The source of the data used for analysis is a drawback in many studies. Some studies have small sample sizes drawn from a specific geographic region. For example, Olson (2009) had a sample of only 208 women from upstate New York.[146] Similarly, Oken (2007) had a sample size of just 1100 women from a single city of Boston.[162] Studies with larger samples, such as Deierlein (2011),[164] Ludwig (2013),[134] Bider-Canfield (2017)[159] and Sridhar (2014)[148] each used data from a single state in the United States. This is an important oversight which limits the generalizability of these studies. Next, while classifying the 'adequacy' of GWG, except for Deierlein (2011)[164] no study adjusted for the length of gestation period of mothers in the analysis. This is an important drawback since it limits the analysis to only those mothers that gave birth after a full-term delivery. Nationally, about 10 % deliveries are preterm as per the CDC [154] and another 7% post-term.[155] Thus, a better method for classifying GWG is called for in order to include a broader sample of mothers while assessing the GWG-ECW connection. Another issue with the evidence is not controlling for factors that can be confounders in the GWG-ECW relationship.[121] None of the studies reviewed here included measures of maternal perinatal food environment. This is problematic because inclusion of environmental characteristics while modeling the GWG-ECW relationship may provide the next piece of solution to the puzzle of the 'generational transfer of obesity'.[165] In the next part of the review, I analyze the available literature that evaluates such environmental influences on GWG.

Relationship between the perinatal food environment and perinatal outcomes

A few researchers have evaluated the effect of local food environment on various perinatal outcomes. Currie et al. (2010)[131] reviewed data from more than 3 million birth certificates to show that a fast-food restaurant within a half mile of a pregnant woman's residence results in a small increase in the probability of gaining over 20 Kgs. The level selected by authors for analyzing GWG (more than 20 Kg or 44.0925 lbs) was well beyond the range of adequate weight gain range (25 to 35 lbs. for normal weight and 28 to 40 lbs. for underweight women[125]). Thus, the results from Currie establish a possible connection between fast food restaurant proximity and higher GWG.

Next, Lhila (2011)[127] found that number of fast food restaurants, supermarkets and full service restaurants in the metropolitan statistical area (MSA) of a mother's residence is associated with her GWG. While the inference is not highly generalizable due to the inclusion of only urban mothers, two findings from Lhila that were robust to the inclusion a host of controls for individual and neighborhood factors are particularly significant. First, an increase in the number of fast food in the mother's MSA was associated with about 2 lbs. of additional GWG and second, the same was also associated with a 7 % higher likelihood of gaining more than 40 lbs. weight during pregnancy. weight during pregnancy. Thus, there seems to be an association between higher availability of fast food in the neighborhood food environment and higher GWG.

Gaps in literature

There are several gaps in the literature reviewed above. First, the nascent literature on how food environment and perinatal outcomes has not yet articulated whether food environment can alter downstream effects of perinatal outcomes such as GWG on ECW. Instead, such literature has focused on modeling the impact of food environment on perinatal outcomes including total GWG and infant size at birth.[131,134] Second, cohort studies conducted in clinical settings generally have small samples derived from a specific geographic region and are not generalizable.[146,162] Third, the method of classifying the adequacy of GWG in many studies limits study samples to only mothers that had a full-term birth. [146,148,150] This is an important limitation since more than 17% of births in the United States are to mothers that have a pre- or a post-term delivery. [154,155] Fourth, none of the reviewed studies include controls for any measures of the food environment of mothers' residence. [146,148,150,162]

Current study

To address the identified gaps in the literature, this study uses a large, nationally representative sample of mothers and children to produce inference that is more generalizable compared to some of the prior research conducted in clinical settings on smaller, geographically limited samples.[146] Next, I adjust for both – total weight gained during pregnancy and the length of the gestation period in the analysis while classifying GWG adequacy.[153] This allows for an inclusion of mothers with a wider range of gestational age. Further, the age of the children included in the analysis ranges from 23 to 25 months, which is young enough to show effect of perinatal outcomes.[119] Finally, I control for a diverse set of control variables including several measures of maternal perinatal food environment, which enables me to limit confounding in the analysis. Specifically, I examine three aspects of the food environment – the presence of fast food restaurants, of full service restaurants and of grocery stores in the maternal perinatal county of residence.

Conceptual framework

To the best of my knowledge, there is no existing conceptual model that provides a framework for analyzing the association between environmental factors and the GWG-ECW linkages. However, numerous theoretical perspectives exist in the literature to build a conceptual framework for the research questions of this study. This study is largely informed by a framework of childhood obesity proposed by Fuemmeler (2016)[119] and borrows from current evidence in the health economics and public health literatures.[127,131,166]

Along with factors related to childbirth, maternal perinatal outcomes such as GWG are one of strongest determinants of body weight during early years of life.[119] **Figure 1a** displays these linkages graphically in a Directed Acrylic Graph (DAG). Bold solid lines indicate the direct linkage between GWG and ECW.

Figure 1a

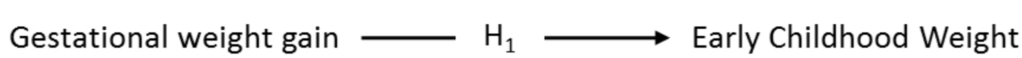
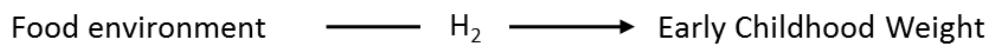


Figure 1b shows the second aspect of the framework. In this DAG, I indicate a direct association between the Food Environment (FE) & ECW. Body weight mid-childhood (around pre-school or kindergarten) is associated with environmental factors according to numerous studies.[121,132] . Food environments are also associated with perinatal outcomes.[131] I combine these perspectives and hypothesize an independent relationship between food environment and weight during the early childhood. As explained in the measures section, I use three measures of

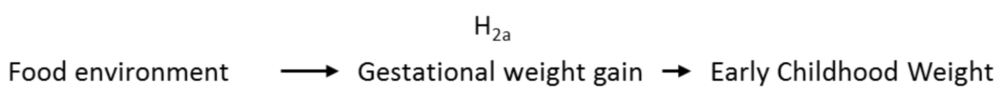
the perinatal food environment – count of the number of fast food and full service restaurants, and the number of grocery stores, per 1,000 population in the maternal perinatal county of residence.[127] I posit that all the measured aspects of FE influence ECW outcomes simultaneously and do not post associations between individual aspects of the food environment and ECW outcomes.

Figure 1b



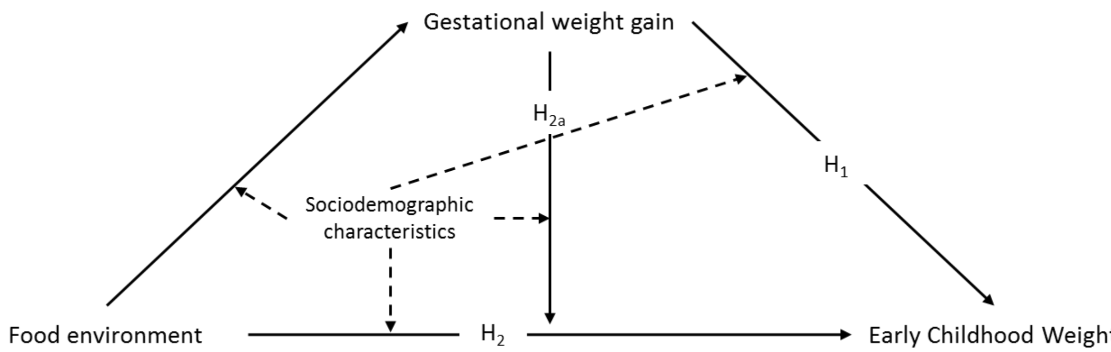
In **Figure 1c**, I show the next aspect of the framework. It indicates that GWG adequacy may mediate the relationship between food environment and ECW. As explained earlier, this can be driven by the direct impact of the food environment on GWG.

Figure 1c



Sociodemographic characteristics play an important role in shaping various outcomes during the perinatal period and early childhood.[119,121] Specifically, factors such as maternal race and ethnicity, age and income are known to be associated with both – GWG and early childhood weight.[121] Therefore, in the DAG of the final conceptual framework **Figure 1d**, I show how sociodemographic factors are related to the relationships tested in this study. In the interest of brevity and to ease understanding, I do not display the association between each sociodemographic factors and the study outcomes.

Figure 1d



According to the conceptual framework of the study, there are direct associations between GWG and ECW outcomes (indicated by H_1) and between food environment and ECW outcomes (indicated by H_2). In addition, there is a possible mediation of the relationship in H2 by GWG (indicated by H_{2a}).

Data and Methods

Data

The primary source of data is the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B), a longitudinal study that consists of a nationally representative cohort of children born in the United States in 2001.[167] The ECLS-B followed a sample of 14,000 children born in 2001 from birth through kindergarten entry and contains information about children, their families, early education, and childcare parallel providers and teachers across the United States. National Center for Education Statistics (NCES) within the Department of Education (DOE) was the primary sponsor of the ECLS-B. The ECLS-B is a restricted-use dataset that was obtained through a memorandum of understanding. As required by the DOE, I report sample sizes rounded to the nearest 50 and present all percentages as weighted population estimates.[133,151]

The second data set used in the study is the 2001 Area Resource File (ARF) [168], which was then linked to the ECLS-B in order to obtain a set of rich demographic characteristics about maternal prenatal residence not found in the ECLS-B. The use of the ARF is reasonable for this study. The ARF contains county-level information on socioeconomic, environmental, and economic characteristics. Since I required information about the food environment of the residence of mothers who gave birth in 2001, the 2001 ARF data were utilized for this study.[169]

The final data set used in this study is the 2001 County Business Patterns (CBP), which is an annual county-level data on the number of firms for each industry code.[127] The CBP provides information on businesses in a geographic location categorized as per the North American Industry Classification System (NAICS). This information is not available in either the ECLS-B or the ARF. I use the 6-digit NAICS code to identify fast-food restaurants (722211), full-service restaurants (722110), and grocery stores (445110) in order to measure the food environment of mothers' residence around childbirth.

Sample derivation

The sample for this study includes mother-child dyads in which the mothers had a singleton birth and were more than 15 years old at the time of the birth of the child, and the children who had their height and weight measured at the 2-year interview in the ECLS-B. This yielded an initial analytical sample of about 8,800 dyads. Following prior research on the ECLS-B, I included only those mothers who were born in the United States or in other countries and excluded women born in the U.S. territories.[170] I then excluded observations for which the data on mother's GWG was missing. Next, I excluded those children for whom information on height and weight at age 2 years was missing. In addition, to control for the effect of outlier observations on the analytical models, I excluded children for whom the age-sex-BMI-Z-score was more than 5 or less than -5.[159] Finally, I excluded observations for whom data was missing on the covariates used in the model, including maternal race, maternal pre-pregnancy BMI, mother's parity, childcare arrangements and measures of the food environment of maternal prenatal residence. After applying the exclusions, a final analytical sample of 5,950 dyads was used for analysis. The sample derivation process is explained graphically in **Figure 9**.

Measures

Outcomes variables

Children's Body Mass Index

The main outcome of interest is the child BMI at age 2 years which was calculated by using the height and weight measurements provided by the ECLS-B. Both height and weight were measured twice and the average of the two observations were entered in the data. Steps were taken in the field to ensure the validity of the physical measurements in the ECLS-B by minimizing the likelihood of errors in both anthropometric measurement and data entry, details of which are available elsewhere.[167]

Children's weight-for-length Z-scores

The second outcome variable of interest is child weight-for-length Z- scores for sex. Z-scores were determined using the WHO's 2006 Growth Charts.[171,172] A Stata macro provided by the WHO ('*igrowup_restricted*') was used to compute the Z-scores.

Independent variables

Maternal GWG Adequacy

The first independent variable is a categorical variable indicating the 'adequacy' of the GWG of the mothers. As explained earlier, I create a measure of the adequacy using: the IOM 2009 recommendations[125] on GWG, mother's pre-pregnancy weight status and the information about the length of the gestational period. I adopt a version of the 'adequacy ratio' method used in prior research.[153,173,174] There are multiple reasons why the 'adequacy ratio' method is the most suitable out of the three available methods for classifying GWG adequacy. First, methods that categorize whether a mother's total GWG was adequate or not by simply comparing the actual GWG to the IOM recommendation for total GWG are problematic. Weight gain is clearly correlated with gestational age at delivery because women who deliver at earlier gestation do not have as much time to gain weight as women who deliver at later gestational ages.[153] Secondly, the other option of analyzing GWG adequacy based on women's 'rate of weekly GWG' is not appropriate since during gestation, mothers do not gain weight in a linear manner.[153] I describe the GWG adequacy calculation process under the 'adequacy ratio' method in detail in **Appendix A**.

Food environment of the county of maternal perinatal residence

The second set of independent variables are the counts of number of fast food restaurants, of full-service restaurants and of grocery stores per one thousand residents in the FIPS code of the mother's residence during the prenatal period. I use the 6-digit North American Industry Classification System (NAICS) code to identify fast-food restaurants (722211), full-service restaurants (722110), and grocery stores (445110), as seen in Lhila 2011.[127] While there might be significant regional variations due to personal preferences, climate, distances and the time cost of travelling to and obtaining food from each of these establishments; I believe that each of these three categories represents an important aspect of the overall food environment. Even though I divide the supply of restaurants and grocery stores per thousand residents, from here on I refer to these variables simply as the number of fast food and full service restaurants and grocery stores.

Control variables

Based on prior literature, I controlled for various factors related to maternal GWG, ECW and the food environment. [127,134,148,150-152,158,159,164] The child, maternal and family control variables used in the current study include mothers' pre-pregnancy weight status, children's birth weight, child's sex, maternal parity, maternal age at birth, an indicator for whether the mother ever breastfed the child, WIC participation, gestational diabetes, maternal race/ethnicity, maternal nativity (whether U.S. born or born outside of the U.S.), maternal education, maternal income and number of household members. In addition, a host of county-level characteristics were used as controls including an indicator for whether the county is rural, the percent of NH Black population, the percentage of Hispanic population, the percentage of foreign-born population and the rate of unemployment among those aged 16 years or more. Inclusion of such county-level characteristics allowed controlling for unobserved confounding factors that might affect the food environment. Description of all study variables in included in **Table 27**.

Identification strategy

To identify the impact of GWG on ECW, I use a theoretical model in which ECW outcomes depend on maternal pregnancy related weight (PRW) outcomes such as pre-pregnancy (PPW) and gestational weight gain (GWG), along with the child's weight at birth and other related demographic characteristics.

Model specification

The first aim of the study is to examine whether GWG is associated with ECW outcomes. I estimated the correlates of ECW using the following basic specification –

$$W_{im} = \beta_0 + \beta_{GWG}GWG_m + \delta_{im}\boldsymbol{X}_{im} + \varepsilon_{im} \qquad (1)$$

where, W_{im} is a weight outcome of child *i* born to mother *m*. W_{im} can be one of the three ECW outcome measures discussed earlier (BMI, weight-for-length Z-score for age and sex or an indicator for obesity). GWG_m is an indicator for GWG adequacy. X_{im} is a set of controls for maternal, child and environmental characteristics. ε_{im} is the random error term. The coefficient β_1 on the indicator for GWG adequacy was the main coefficient of interest in this model.

Another aim of the study is to study how the perinatal food environment (FE) may be associated with ECW. To evaluate the same, I used the following model (2) –

$$W_{im} = \beta_0 + \beta_{FE}FE_m + \delta_{im}\boldsymbol{X}_{im} + \varepsilon_{im} \qquad (2)$$

where FE_m is the measure of FE in the mother *m*'s prenatal residence. It is either the number of fast-food restaurants, full service restaurants or grocery stores per one thousand residents. The coefficient β_1 on the FE measures was an additional coefficient of interest along with β_1.

Mediation analysis

Informed by the hypothesis H_{2a} of this study's conceptual framework, I examined the role of GWG in mediating the association of FE and ECW. I conducted a mediation analysis in four steps as described by MacKinnon.[175]

Under this mediation analysis, I first predicted ECW outcomes of the study using only FE and related control measures. This is analogous to model (2)

$$W_{im} = \beta_0 + \beta_{FE}FE_m + \delta_{im}\boldsymbol{X}_{im} + \varepsilon_{im} \qquad (Step\ 1)$$

Next, I predicted GWG using FE and related control variables.

$$GWG_m = \beta_0 + \beta_1 FE_m + \delta_m \boldsymbol{X}_m + \varepsilon_m \qquad (Step\ 2)$$

As a third step, I analyzed the effect of GWG on ECW outcomes without the measures for FE. This is analogous to model (1)

$$W_{im} = \beta_0 + \beta_{GWG}GWG_m + \delta_{im}\boldsymbol{X}_{im} + \varepsilon_{im} \qquad (Step\ 3)$$

Finally, after completing the first 3 steps to establish zero-order relationships between study variables,[175] I conducted a multiple regression model in which both GWG and FE measures were included, along with control variables.

$$W_{im} = \beta_0 + \beta_{1GWG}GWG_m + \beta_{FE}FE_m + \delta_{im}\boldsymbol{X}_{im} + \varepsilon_{im} \qquad (Step\ 4)$$

It is important to note that when assessing the impact of the food environment on ECW outcomes, I considered that all aspects of the food environment act simultaneously. Therefore, in the mediation analysis, I did not separately test for mediation by GWG for each aspect of FE (number of fast food, full-service restaurants or grocery stores).

Analytical approach

I conducted a descriptive analysis to understand the distribution of and trends in the outcome, independent as well as the control variables. Next, I used bi-variate analyses to check for statistical differences between groups. Finally, I used multivariate ordinary least squares (OLS) regressions to analyze continuous outcome variables and multivariate logistic regressions to analyze dichotomous outcome variables. Standard errors were adjusted in all analyses to account for the complex survey design of the ECLS-B using analytical weight provided in the data.[167] P-values and confidence intervals were used to determine the statistical significance of results. The alpha was determined at the traditional level of 0.05. The ARF and CBP data sets were merged separately and then the combined ARF-CBP data set was merged with the ECLS-B data. Data merging was done using Federal Information Processing Standards (FIPS) county codes. Issues with certain FIPS codes such as a change of the name of the county or missingness of data were addressed to ensure completeness and accuracy of information. Stata 12 was used for all statistical analyses.[176]

Results

Sample Characteristics

The summary statistics for the study sample are described in Panel A and B of **Table 28**. In Columns (1), (2), and (3) I report the characteristics of the part of the sample in which the mother gained inadequate, adequate and excessive gestational weight gain respectively. The children's body weight shows a clear increasing trend along with an increase in the maternal GWG. The average BMI for children born to mothers that gained inadequate GWG was the lowest (17.13), followed by the average BMI of children born to mothers that gained adequate GWG (17.25) and finally, the highest average BMI was seen amongst children born to mothers that gained excess GWG. Accordingly, the average weight-for-length Z-scores of children in each GWG sub-category increased from 0.747 in the inadequate GWG group to 0.828 in the adequate GWG group and finally 0.982 in the excess GWG group. The mean number of fast food, full-service restaurants and grocery stores per one thousand population in the maternal perinatal county of residence did not show any clear trend. For example, the average number of fast-food restaurants appeared to be the highest in the perinatal counties of residence of mothers that gained inadequate GWG (0.725/1,000 population), followed by that for mothers with excess GWG (0.719/1,000 population) and finally for mothers that gained adequate amount of gestational weight (0.711/1,000 population). However, in terms of full service restaurants, the highest average number was in the mothers that gained adequate GWG (0.743/1,000 population), followed by inadequate GWG group (0.742/1,000 population) and finally, (0.737/1,000 population). In each of the GWG category, the trends in the proportion of mothers based on their PPW status was as expected. For example, a far higher proportion of mothers that gained excess GWG was obese (17.8%) compared to the same among mothers that gained inadequate GWG (12.20%).

Panel B of **Table 28** reports the characteristics of women, children and their household including birthweight sex of the child, maternal parity, pre-pregnancy BMI, age, education, race/ethnicity, nativity and the household income. It also displays the characteristics of the maternal perinatal county of residence. Overall, mothers that gained inadequate GWG had the lowest BMI, had babies with lower birthweight, were less likely to be NH white and be foreign-born compared to women that gained adequate or excess GWG. Mothers that had an adequate GWG were more likely to be married, have college education, income higher than 185% of the Federal Poverty Line (FPL) compared to the other two GWG groups. Finally, mothers that gained excess GWG reported having babies with higher birthweight, had highest pre-pregnancy BMI, higher likelihood of being either overweight or obese before pregnancy, being first-time mothers and NH White compared to the other GWG groups.

Results from multivariate OLS regressions

Table 29 displays the results of analytical models for the study outcomes - children's BMI and their weight-for-length Z-scores. Column (1), I display the results of the models that analyzed the impact of FE measures on children's BMI, which also served as the first step of the mediation analysis. In column (2), I show results of models that analyzed the impact of GWG adequacy on children's BMI, which was the second step of the mediation analysis. Next, column (3) shows results of models in which the impact of FE on total GWG (in Kgs) was analyzed, this was the third step of the mediation analysis. Finally, column (4) shows results from models that assessed joint impact of both FE and GWG on children's BMI as the final step of the mediation analysis. I also used weight-for-length Z-scores using WHO growth charts as an alternate outcome for this last set of analysis display the results in column (5).

Overall, I found a statistically significant association between maternal GWG adequacy and ECW outcomes of their children. Gaining inadequate amount of GWG was associated with lower BMI at age 2 years (-0.185, $p < 0.01$). Further, food environment of the maternal perinatal county of residence was significantly associated with ECW outcomes. Specifically, having an additional full service restaurant per 1,000 residents in the county on residence during the perinatal period seemed to decrease the child BMI at 2 years of age by about 0.336 Kg/m^2 ($p<0.01$). Column (3) shows results of the model that analyzed the effect of food environment on GWG as part of the mediation analysis. Again, measures of the food environment did not seem to be associated with total GWG. Finally, in models that included measures of GWG and of the food environment, gaining inadequate amount of weight and the number of full-service restaurants was associated with ECW outcomes (-0.124, $p<0.01$ and -0.233 $p<0.01$ respectively). These associations were also observed when the analysis was repeated substituting children's BMI with child weight-for-length Z-scores as the outcome.

Results from mediation analysis

I now discuss the results from the mediation analysis. Overall, there did not appear to be a significant mediation by GWG in the FE-ECW association. For example, the coefficients for FE measures in step 1 did not alter substantially when GWG adequacy measures were added to the analytical models. Further, no significant association was found between FE and GWG. As the next step of the mediation analysis, I also calculated the indirect effect of food environment measures.

There are two methods of calculating indirect effects of FE on ECW outcomes.[177,178] I chose the method suggested by Judd (1982) since it was more suitable to this study's analysis.[178] Under this approach the coefficients for the main predictor obtained in step 4 of the analysis are subtracted from those found in step 1. Therefore, in case of the number of full-service restaurants, its indirect effect on ECW can be calculated as - (-0.336 (β_1, Step 4)) – (-0.331 (β_1, Step 1)) = -0.005. This effect is a small fraction of the direct effect (<1.5%). Thus, there does not seem to be mediation by GWG. I summarize these indirect effects for all FE measures in **Table 30**.

Discussion

In this study, I examined whether perinatal food environments (FE), maternal gestational weight gain (GWG) and early childhood weight (ECW) outcomes are associated. Prior literature indicated separate associations between maternal gestational weight and early childhood weight, between food environments with gestational weight and between food environments and mid-childhood obesity. However, no evidence was available on whether the perinatal food environments can influence early childhood weight either through their impact on gestational weight or independently. To address this gap, this study first evaluated the associations between GWG and ECW. Next, I assessed whether the food environments are associated with ECW. Finally, I assessed whether GWG adequacy mediates the relationship between food environment and ECW. I used data on mother-children dyads from the Early Childhood Longitudinal Study – Birth cohort (ECLS-B), Area Resource Files (ARF) and Current Business Practices (CBP). I found that maternal GWG was associated with ECW outcomes. Specifically, I found that gaining inadequate GWG was associated with lower BMI among children at age two years. Next, I found that measures of food environment were associated with ECW outcomes. Specifically, I found that having an additional full-service restaurant per one thousand population in the maternal perinatal county of residence was associated with lower BMI among children at age two years. Finally, I found that GWG did not mediate the association between food environment and ECW outcomes.

The first set of analyses suggested that maternal GWG adequacy was significantly associated with body weight outcomes among their children at age 2 years. Specifically, I found that gaining inadequate GWG was associated with ECW outcomes but gaining excessive GWG was not associated with ECW outcomes. A possible explanation for these results is that mothers that gain inadequate GWG tend to have babies with lower birthweight compared to babies of mothers that gain adequate GWG. Children born with low birthweight are known to have slower growth trajectories.[121,179] A recent study showed that birthweight can explain most of the impact of GWG on weight in early life[159]. Thus, the association between inadequate GWG and ECW may operate via birthweight.

I did not find any significant association between gaining excess GWG and ECW outcomes. The findings contrast with those of several studies, which suggest that gaining excess GWG is associated with ECW outcomes.[134,148,150,158] However, null associations between GWG and ECW have also been recorded by other set of studies.[152,159,164]. I believe that these results call for further exploration of how GWG and ECW are related.

Results from the second set of analyses suggest that measures of the food environment were significantly associated with ECW outcomes. Of the three measures of the food environments used in the study, only one (number of full service restaurants per one thousand population in the county of maternal residence during the pregnancy) was significantly associated with ECW outcomes. Specifically, I found that an increase in the number of full service is associated with lower BMI among children at age 2 years. Nevertheless, this is a remarkable result considering that the association was stable despite controlling for a wide range confounding factors. Further, models including measures on GWG adequacy and of food environments showed that both measures were significantly associated with ECW outcomes. This result differs slightly from Currie (2010) who found that having a fast food restaurant within a half mile radius of maternal perinatal residence was associated with higher odds of gaining more than 20 Kgs of GWG.[131] In Lhila (2011) the number of fast food restaurants was associated with higher probability of gaining more than 20 Kgs of GWG.[127] I believe two factors can explain the differences between this study's results and prior literature. First, I use an outcome that measures the 'adequacy' of the GWG and not the quantum of total GWG. As explained earlier, adequacy of GWG was measured using the 'adequacy ratio' method which accounted for the length of the gestational period. Thus, the association tested in this analysis are slightly different from the ones in either Currie (2009) or Lhila (2011). Secondly, Currie (2009) used the distance from fast food restaurant as a predictor while I used their number in the county of residence. Perhaps physical proximity to fast food restaurants is more relevant in terms of its impact on body weight rather than the 'density' of fast foods in a person's residential area. Literature suggests that proximity to fast food restaurants can reduce intake of healthy foods such as vegetables and fruits.[180]

The number of full service restaurants was negatively associated with ECW in this study's analyses. A possible explanation of this result is the second pathway that was hypothesized earlier, linking food environment and ECW through maternal food choices.[141] Fast food consumption is linked to higher intake of energy-dense food, saturated fat, sugar and carbonated soft drinks.[181,182] For example, French (2000) showed that among adult women intake of more than three fast food meals per week was associated with higher energy and fat intake.[181] It can be argued that full service restaurants may offer a relatively better set of foods for a mother to choose from. Better food choices may expose the fetus to a healthier diet during pregnancy and can show favorable effect on its early life weight. However, more research is required to test this hypothesis formally.

Finally, the mediation analysis showed that the GWG adequacy did not substantially mediate the association between food environment and ECW. Out of the three measures for the food environment used in the study only one was significantly associated with ECW outcomes. When the indirect effect of this measure was calculated, it showed that it was less than 2% of the overall effect. Similar results were also found for other measures of the food environment. Therefore, it is clear that GWG did not mediate the relationship between the food environment and ECW outcomes. This highlights the need to consider maternal perinatal food environment as an independent determinant of body weight outcomes among children.

In a novel contribution, I showed that perinatal food environment was significantly associated with children's body weight outcomes. These results draw attention to the need to focus on the food environment as a determinant of children's health in early life. Factors of the food environment that affect total quantity and quality of maternal diet during pregnancy should be carefully examined for their potential to impact early childhood health.

One of the major strengths of this study is the use of rich sociodemographic data that contained accurate and verified measures of children's weight. Secondly, the data linkages in the study are unique and have not been observed in prior literature. Finally, the classification of GWG adequacy using the ‘adequacy ratio’ method is an improvement over prior literature.

There are several limitations of the current study. First, the data on maternal perinatal weight measures used in the study were self-reported and could have reporting errors. Self-reporting of weight outcomes around pregnancy is quite common in large, nationally representative surveys.[155] Second, the measures of food environment used in the study may not fully capture all the aspects of food environment. However, these measures have been used in prior literature[127] Linking geospatial data to survey data sets may provide better measures of the perinatal food environment. Researchers should explore such linkages in future studies. Secondly, the families in the ECLS-B may have moved from when the mother was pregnant to when the children were 2 year old. This would affect the identification of an accurate perinatal food environment. Additional analyses shows that this is not a serious threat to the validity. First, families in the ECLS-B generally moved within the county of maternal perinatal residence (author’s analysis, results not shown). Second, the correlation between the perinatal food environment (in the year 2000) and that when the children were two years old (year 2003) was more than 93% (author’s analysis, results not shown). In other words, despite minor changes, the food environment largely remained the same throughout the study period. Finally, interpretation of the study results is tricky and should be done with caution. Food environments are complex and are formed by multiple interconnected facets of the built environment. The measures used to define the food environment are somewhat ‘noisy’ and are aggregated at a geographical level that is quite broad (county of residence). Future research should focus on analyzing additional methods of defining food environments more comprehensively and measuring their impact on maternal and child health.

Despite the limitations, this study makes a significant contribution to the literature on the topic of GWG-ECW linkages and the evidence that explores the role of the perinatal food environment as a potential determinant of early childhood health. Specifically, the results showed that having more full-service restaurants in the maternal county of residence during pregnancy is associated with lower weight in early childhood. These findings can be incorporated in future planning of urban and residential areas. The mediation analysis can be replicated in other data sets to further strengthen this study's findings that the food environment of maternal perinatal residence is an independent determinant of early childhood weight.

Figures and Tables

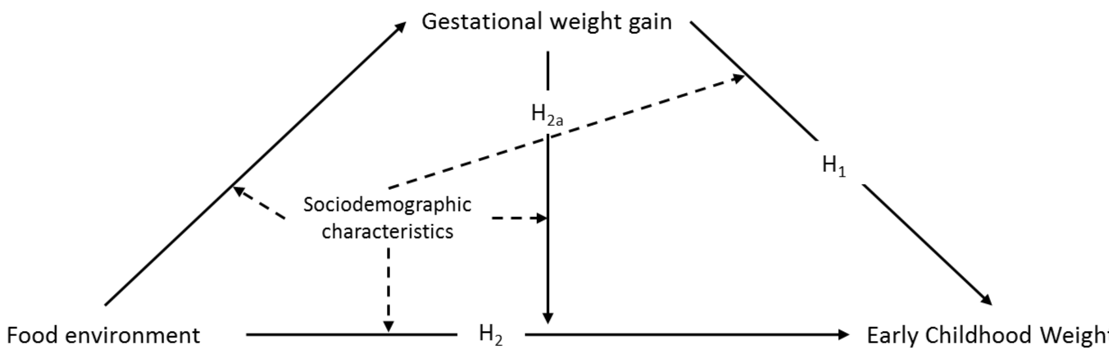


Figure 8: Conceptual framework

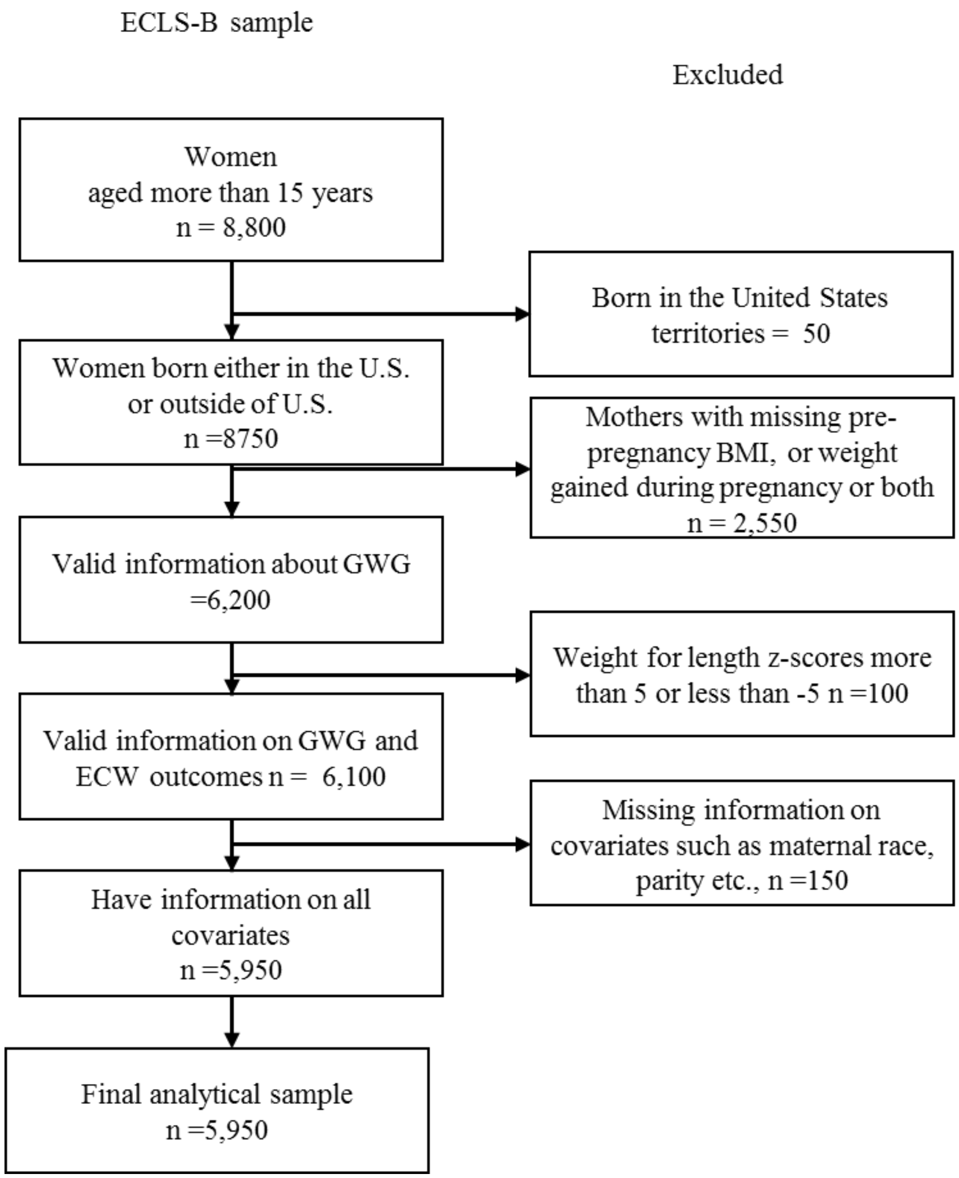


Figure 9: Sample derivation

Table 27: Variable definitions

	Variable	Type	No. of categories	Definitions/Categories	Notes	Data source
	Outcomes/Dependent Variables					
	Early Childhood Weight (ECW) outcomes					
	Body Mass Index (BMI)	Continuous	NA	Calculated using information about the height and weight in the Early Childhood Longitudinal Survey - Birth cohort (ECLS-B) when the children were 2-years of age using the formula - BMI = weight in kg/ (height in meters)^2	To obtain the child's weight, the ECLS-B Field Interviewer (FI) instructed the child to stand unassisted on the SECA® scale (Weights were obtained using the SECA® Model 840 scale), as demonstrated by the parent respondent. Children were asked to remove shoes and (if appropriate) jackets and heavy outerwear. Multiple measurements were taken at each wave, with the child stepping off of the scale to allow it to reset to 0.0 kg between measurements. For each wave, the two measurements recorded and their mathematical average are provided on the data file. If only one measurement was obtained, it was also saved as the average. Child height was obtained using a	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)

					SECA® portable stadiometer in the preschool and kindergarten waves. The child stood erect at the base of the stadiometer, with his or her head in the correct position—head upright, facing away from the stadiometer. Then, a crown piece was lowered, and the child's height was measured in centimeters. Again, multiple measurements were taken at each wave, with the child stepping off the stadiometer between measurements. The two measurements entered in the data set and their mathematical average are provided on the data file for each wave. If only one measurement was obtained, it was also saved as the average.	
	Weight-for-length Z-scores	Continuous	NA	Z-scores were determined using the WHO's 2006 Growth Charts. The Stata macro 'igrowup_restricted', provided by the WHO was used to compute the Z-scores.	The growth charts are separate for boys and for girls	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B) World Health Organization (WHO) Growth Charts
	Independent Variables					
	Maternal Gestational Weight Gain					

	Gestatinal Weight Gain (GWG) Adequacy	Categorical	3	coded = inadequate, if the actual GWG is less than 85% of the recommended GWG for a given gestational age coded = adequate, if the actual GWG is between 85% to 122% of the recommended GWG for a given gestational age coded = excess, if the actual GWG is more tha 122% of the recommended GWG for a given gestational age	I first used information from self-reports of pre-pregnancy body weight of mothers and of their weight gain during pregnancy to calculate the total weight gained by each mother. I separately calculated the recommended weight for each week of gestation (ranging from 22 weeks to 42 weeks). Next, I added a fixed quantity of weight to the assumed first trimester weight gain to obtain the recommended weight for each week of gestation, using the following formula – Recommended weight = Recommended first trimester weight gain for mother's pre-pregnancy weight category+ ((gestational age at delivery - 13) * (Recommended weekly weight gain rate for second and third trimester for the pre-pregnancy weight category)). Subtracting 13 from the total gestational age at delivery accounted for the length of the first trimester, which is of 13 weeks' duration. Recommended weekly weight gain rate is the mean of the range of recommended weekly weight	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B) Institute of Medicine (IOM) 2009 guidelines for GWG

					gain for the third and the second trimester.	
	Food environment					
	Fast food restaurants per 1,000 population in the maternal perinatal county of residence	Continuous	NA	I use the 6-digit North American Industry Classification System (NAICS) code to identify fast-food restaurants (722211) The actual count is calculated using the following formula - 1000*(Total number of fast food restaurants in the county of the mother's residence around birth/Total population of the county)	NAICS code used categorize fast food also includes carry-out pizza parlors, restaurants and delicatessens, and drive-in restaurants. Such restaurants are similar to fast-food restaurants based on their convenience, price, calorie content, and palatability.	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B) Area Resource File (ARF) Current Business Practices (CBP)
	Full service restaurants per 1,000 population in the maternal perinatal county of residence	Continuous	NA	I use the 6-digit North American Industry Classification System (NAICS) code to identify full service restaurants (722110) The actual count is calculated using the		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B) Area Resource File (ARF) Current Business Practices (CBP)

				following formula - 1000*(Total number of fast food restaurants in the county of the mother's residence around birth/Total population of the county)		
	Grocery stores per 1,000 population in the maternal perinatal county of residence	Continuous	NA	I use the 6-digit North American Industry Classification System (NAICS) code to identify grocery stores (445110) The actual count is calculated using the following formula - 1000*(Total number of fast food restaurants in the county of the mother's residence around birth/Total population of the county)		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B) Area Resource File (ARF) Current Business Practices (CBP)
	Control Variables					
	Child's characteristics					
	Age	Continuous	NA	Child's age in months		
	Birthweight	Continuous	NA	Child's weight at birth in Kg	I used weight in kgs in order to get numerically higher coefficients. If the weight was to be expressed in a smaller unit (gm), the coefficients were very	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)

					small (more than four zeros after the decimal point). This also made sense in terms of the outcome variable. which was BMI (kg/square meteres)	
	Breastfeeding	Categorical	2	coded=1 if the child was ever breastfed, coded=0 if otherwise	Mothers answered a question on breastfeeding in the parent survey	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Sex - Male	Categorical	2	coded=1 if the child was born as a boy, coded=0 if otherwise		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Maternal Characteristics					
	Pre-pregnancy weight status	Categorical	4	Pre-pregnancy weight status categorized as per CDC guidelines based on maternal pre-pregnancy BMI (below 18 - underweight, 18-24.9 - normal weight, 25-29.9 overweight, above 30 - obese)	Self-reported by mothers in the ECLS-B	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Age	Categorical	4	15-19 years, 20-29 years, 30 - 34 years and 35 years or more		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Parity	Categorical	5	Number of children previously born, either equal to 0, 1, 2 or 3 and more		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)

	Race/ethnicity	Categorical	5	Maternal race/ethnicity categorized as either Non-Hispanic (NH) White, NH Black, Hispanic (all races), NH Asian, NH Others (which inlcudes all other racial/ethnic categories along with multi-racial mothers)		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Marital status	Categorical	2	coded=1 if the mother was married at the time of birth, coded=0 if otherwise		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Nativity	Categorical	2	coded=1 if the mother was born outside of the United States, coded=0 if otherwise		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Gestational Diabetes	Categorical	2	coded=1 if the mother had gestational diabetes during pregnancy, coded=0 if otherwise		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Receipt of WIC support	Categorical	2	coded=1 if the mother received WIC support during pregnancy, coded=0 if otherwise		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Health Insurance	Categorical	2	coded=1 if the mother had private health insurance during pregnancy, coded=0 if otherwise		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Education	Categorical	4	Less than high school, high school, some		Early Childhood Longitudinal Survey

				college and college degree or higher		- Birth cohort (ECLS-B)
	Income	Categorical	4	Less than 100% of the Federal Poverty Line (FPL), 100-129% FPL, 130-185% FPL, 185% or more of the FPL		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Smoking during the last three months of pregnancy	Categorical	2	coded=1 if the mother smoked during the last three months of pregnancy, coded=0 if otherwise		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Smoking before pregnancy	Categorical	2	coded=1 if the mother smoked before pregnancy, coded=0 if otherwise	Used only in models that predicted GWG	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Pre-pregnancy BMI	Continuous	NA	Calculated using self-reported height and weight information	Used only in models that were restricted to certain maternal pre-pregnancy weight categories	Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	County-level characteristics					
	Rurality	Categorical	2	coded=1 if the county of mother's residence was rural, coded=0 if otherwise		Early Childhood Longitudinal Survey - Birth cohort (ECLS-B)
	Unemployment rate among 16 years or above	Continuous	NA	Unemployment rate of those aged above 16 years in the county		Area Resource File (ARF)
	Percent of NH Black popluation	Continuous	NA	Proportion of NH Black population in the county, expressed as a percentage		Area Resource File (ARF)

	Percent of Hispanic population	Continuous	NA	Proportion of Hispanic (all races) population in the county, expressed as a percentage		Area Resource File (ARF)
	Percent of foreign-born population	Continuous	NA	Proportion of foreign-born population in the county, expressed as a percentage		Area Resource File (ARF)

Table 28: Early Childhood Weight Outcomes, Pregnancy Related Weight and Food Environment, Early Childhood Longitudinal Study-Birth Cohort (N=5,950)

		Gestational Weight Gain Adequacy		
All numbers are percentages (%) unless specified otherwise		Inadequate	Adequate	Excess
	N	1,250	1,450	3,150
Panel A				
Early Childhood Weight Outcomes				
Body Mass Index (BMI)(mean)		17.13	17.25	17.49
Weight-for-length Z-score (mean)		0.747	0.828	0.982
Food Environment (FE)				
Number of Fast food restaurants per 1,000 population (mean)		0.725	0.711	0.719
Number of Grocery Stores per 1,000 population (mean)		0.236	0.234	0.233
Number of Full-service restaurants per 1,000 population (mean)		0.742	0.743	0.737
Panel B				
Child-related Outcomes				
Birthweight (in Kg) (Mean)		3.180	3.338	3.419
Child sex - Male		48.80	51.50	52.60
Child age (in months)(Mean)		24.39	24.38	24.36
Ever Breastfed		68.20	73.70	70.50
Maternal Prepregnancy Weight Status				
Pre-pregnancy Body Mass Index (BMI) (mean)		24.19	23.19	25.52
Underweight		8.10	6.80	3.20
Normal weight		63.40	67.50	49.00
Overweight		16.40	20.20	30.00
Obese		12.20	5.50	17.80
Maternal parity (number of prior live births)				
Zero		33.60	40.90	43.90
One		33.00	34.80	31.90
Two		21.90	16.40	14.80
Three or more		11.40	8.00	9.30
Maternal age at childbirth				
15 to 19 years		11.90	9.50	10.90
20 to 29 years		51.20	50.30	50.60
30 to 34 years		22.10	28.40	23.90
35 years or more		14.90	11.70	14.60
Maternal Race/ethnicity				
NH White		51.00	60.80	61.60
NH Black		16.40	11.60	13.90

Hispanic (all races)	24.40	20.70	19.80
NH Asian	5.10	4.30	2.20
NH Other	3.10	2.60	2.40
Maternal marital status			
Married	67.90	75.40	66.00
Maternal nativity			
Foreign-born	26.50	20.80	16.20
Maternal pregnancy complications			
Had gestational diabetes	3.20	1.60	2.90
Maternal WIC receipt			
Received WIC support	41.60	35.00	40.40
Mother's health insurance status			
Not private insurance	42.50	35.50	40.70
Maternal Education			
Less than High School	21.50	16.20	17.60
High School	31.60	26.50	31.20
Some college	24.90	24.90	25.90
College graduate	21.90	32.40	25.20
Maternal Poverty Level			
< 100% of Federal Poverty Line (FPL)	26.70	19.40	22.80
100-129% FPL	12.80	9.80	11.10
130-185% FPL	14.40	11.40	11.90
>185% FPL	46.10	59.40	54.30
Number of household members (mean)	4.46	4.22	4.21
Maternal employment			
Employed after pregnancy	49.70	50.40	52.90
Maternal before pregnancy			
Smoked	19.70	17.20	27.70
Maternal smoking during last 3 months of pregnancy			
Smoked	12.00	9.10	11.90
Maternal perinatal county of residence characteristics			
Rural	12.20	15.10	14.60
Percent Foreign-born population	12.51	12.03	11.70
Percent NH Black population	12.42	11.66	12.32
Percent Hispanic population	14.46	13.19	13.34

Table 29: Results from Multivariate OLS Regressions for Association Between Early Childhood Weight Outcomes, Pregnancy Related Weight and Food Environment, Early Childhood Longitudinal Study-Birth Cohort (N=5,950)

Mediation analysis order	Step 1	Step 2	Step 3	Step 4	
Outcome	Child BMI	Child BMI	GWG	Child BMI	Child Weight-for-length Z-score
Observations	5,950	5,950	5,950	5,950	5,950
Maternal Gestational Weight Gain (GWG) Adequacy					
Adequate (reference)					
Inadequate		-0.185**		-0.186**	-0.124**
		(0.088)		(0.088)	(0.058)
Excess		0.122		0.119	0.077
		(0.077)		(0.077)	(0.050)
Food Environment (FE)					
Number of Fast food restaurants per 1,000 population	0.345		0.437	0.348	0.207
	(0.228)		(0.875)	(0.228)	(0.152)
Number of Grocery Stores per 1,000 population	0.454		1.003	0.443	0.354
	(0.518)		(1.972)	(0.518)	(0.333)
Number of Full-service restaurants per 1,000 population	-0.336***		-0.869*	-0.331***	-0.233***
	(0.119)		(0.452)	(0.120)	(0.079)
Maternal Prepregnancy Weight Status					
Normal weight (reference)					
Underweight	-0.324**	-0.286**	0.882	-0.293**	-0.196**
	(0.127)	(0.127)	(0.555)	(0.127)	(0.088)
Overweight	0.236***	0.197**	-0.845***	0.196**	0.130**
	(0.079)	(0.080)	(0.284)	(0.080)	(0.052)
Obese	0.339***	0.300***	-3.545***	0.302***	0.200***
	(0.101)	(0.103)	(0.358)	(0.103)	(0.067)

Sex of the child					
Female (reference)					
Male	0.402***	0.399***	0.139	0.395***	0.128***
	(0.063)	(0.063)	(0.227)	(0.063)	(0.041)
Child age (in months)	-0.085***	-0.084***	0.146	-0.085***	-0.031*
	(0.027)	(0.027)	(0.101)	(0.027)	(0.018)
Breastfeeding					
Did not breastfeed (reference)					
Ever breastfed	-0.378***	-0.396***	0.328	-0.386***	-0.250***
	(0.080)	(0.079)	(0.286)	(0.079)	(0.052)
Maternal number of prior live births					
Zero (reference)					
One	-0.027	-0.014	-1.263***	-0.014	-0.024
	(0.081)	(0.081)	(0.295)	(0.081)	(0.053)
Two	-0.237**	-0.209**	-1.631***	-0.210**	-0.147**
	(0.105)	(0.106)	(0.403)	(0.106)	(0.070)
Three or more	-0.202	-0.174	-1.503***	-0.183	-0.147
	(0.152)	(0.152)	(0.576)	(0.152)	(0.099)
Maternal age at childbirth					
15 to 19 years (reference)					
20 to 29 years	0.017	0.010	0.457	0.010	0.004
	(0.119)	(0.119)	(0.497)	(0.118)	(0.077)
30 to 34 years	-0.136	-0.157	0.621	-0.148	-0.088
	(0.142)	(0.141)	(0.572)	(0.141)	(0.092)
35 years or more	-0.033	-0.059	0.677	-0.046	-0.020
	(0.157)	(0.156)	(0.604)	(0.156)	(0.102)
Maternal Race/ethnicity					
NH White (reference)					
NH Black	-0.251**	-0.239**	-1.479***	-0.232**	-0.159**

	(0.118)	(0.118)	(0.416)	(0.118)	(0.076)
Hispanic (all races)	0.389***	0.389***	-0.153	0.398***	0.250***
	(0.119)	(0.118)	(0.425)	(0.118)	(0.076)
NH Asian	-0.099	-0.089	-0.396	-0.078	-0.125
	(0.129)	(0.129)	(0.442)	(0.129)	(0.087)
NH Other	-0.098	-0.109	-1.418**	-0.079	-0.042
	(0.148)	(0.147)	(0.649)	(0.149)	(0.102)
Maternal marital status					
Unmarried (reference)					
Married	-0.141	-0.126	-1.027***	-0.129	-0.095
	(0.090)	(0.090)	(0.324)	(0.089)	(0.058)
Maternal nativity					
U.S.-born (reference)					
Foreign-born	-0.140	-0.113	-2.082***	-0.118	-0.046
	(0.111)	(0.111)	(0.392)	(0.111)	(0.073)
Maternal pregnancy complications					
Did not have gestational diabetes (reference)					
Had gestational diabetes	0.122	0.148	-1.201*	0.135	0.063
	(0.214)	(0.216)	(0.623)	(0.213)	(0.138)
Maternal WIC receipt					
Did not receive WIC support (reference)					
Received WIC support	0.023	0.016	0.824**	0.016	0.018
	(0.090)	(0.090)	(0.338)	(0.090)	(0.058)
Mother's health insurance status					
Private insurance (reference)					
Not private insurance	0.035	0.024	0.478	0.030	0.028
	(0.092)	(0.092)	(0.338)	(0.092)	(0.060)
Maternal Education					
Less than High School (reference)					

High School	0.049	0.054	-0.236	0.046	0.057
	(0.107)	(0.107)	(0.403)	(0.107)	(0.069)
Some college	-0.003	0.004	-0.554	-0.002	0.025
	(0.121)	(0.120)	(0.449)	(0.120)	(0.078)
College graduate	0.094	0.093	-1.030**	0.092	0.103
	(0.139)	(0.139)	(0.490)	(0.139)	(0.089)
Maternal Poverty Level					
< 100% of Federal Poverty Line (FPL) (reference)					
100-129% FPL	0.082	0.083	0.319	0.082	0.052
	(0.123)	(0.123)	(0.464)	(0.123)	(0.079)
130-185% FPL	-0.173	-0.171	0.038	-0.171	-0.090
	(0.117)	(0.117)	(0.449)	(0.117)	(0.076)
>185% FPL	-0.080	-0.096	0.866**	-0.089	-0.039
	(0.116)	(0.115)	(0.435)	(0.115)	(0.075)
Number of household members	0.021	0.022	-0.197*	0.022	0.014
	(0.027)	(0.027)	(0.118)	(0.027)	(0.018)
Maternal employment after pregnancy					
Unemployed (reference)					
Employed	0.144**	0.136**	0.273	0.144**	0.097**
	(0.067)	(0.067)	(0.236)	(0.067)	(0.044)
Maternal smoking during last 3 months of pregnancy					
Did not smoke (reference)					
Smoked	0.100	0.098	0.668	0.100	0.045
	(0.114)	(0.113)	(0.455)	(0.113)	(0.073)
Maternal perinatal county of residence charcteristics					
County rurality					
Not rural (reference)					
Rural	-0.011	-0.048	0.161	-0.014	-0.016
	(0.105)	(0.102)	(0.378)	(0.105)	(0.069)

Unemployment rate among 16 years or older	0.013	0.020	-0.108	0.014	0.004
	(0.022)	(0.019)	(0.068)	(0.022)	(0.014)
Percent NH Black population	-0.000	0.001	0.004	-0.000	-0.001
	(0.003)	(0.003)	(0.011)	(0.003)	(0.002)
Percent Hispanic population	-0.011***	-0.011***	-0.015	-0.011***	-0.007***
	(0.004)	(0.004)	(0.015)	(0.004)	(0.003)
Percent Foreign-born population	0.021***	0.022***	0.025	0.021***	0.014***
	(0.006)	(0.005)	(0.020)	(0.006)	(0.004)
Constant	19.147***	19.182***	14.127***	19.131***	1.523***
	(0.694)	(0.684)	(2.685)	(0.695)	(0.469)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Sample sizes rounded to 50 as instructed by Department of Education
Acronyms - GWG - Gestational Weight Gain, FE - Food Environment, BMI - Body Mass Index, NH - Non-Hispanic, FPL - Federal Poverty Line

GWG adequacy categorized using the 'adequacy ratio' method that is based on the 2009 IOM guidelines and adjusting for gestational age
FE measures used as counts per 1,000 population
Pre-pregnancy weight status categorized as per CDC guidelines based on maternal pre-pregnancy BMI (below 18 - underweight, 18-24.9 - normal weight, 25-29.9 overweight, above 30 - obese)
Child weight-for-length Z-scores separately for boys and girls based on WHO growth charts, using the 'igrowup_restricted' macro provided by WHO

Data source for maternal and child characteristics - ECLS-B, for FE characteristics - CBP, for county sociodemographic characteristics - ARF, except county rurality which was obtained from ECLS-B

Table 30: Results from Mediation Analysis: Calculated Indirect Effect of the Food Environment Measures on Early Childhood Weight Outcomes, Early Childhood Longitudinal Study-Birth Cohort (N=5,950)

Mediation analysis order	Step 1	Step 4	Indirect effect
Outcome	Child BMI	Child BMI	Step 1 - Step 4
Food Environment (FE)			
Number of Fast food restaurants per 1,000 population	0.345	0.348	-0.003
Number of Grocery Stores per 1,000 population	0.454	0.443	0.011
Number of Full-service restaurants per 1,000 population	-0.336***	-0.331***	-0.005

FE measures used as counts per 1,000 population, Coefficients from multivariate OLS regressions in Table 29
Data source for maternal and child characteristics - ECLS-B, for FE characteristics - CBP, for county sociodemographic characteristics - ARF, except county rurality which was obtained from ECLS-B

Appendix A: Calculating adequacy of GWG using the 'adequacy ratio' method

Under the 'adequacy ratio' method, to construct a measure of GWG adequacy, I first used information from self-reports of pre-pregnancy body weight of mothers and of their weight gain during pregnancy to calculate the total weight gained by each mother. I then compared the actual GWG to a pre-determined upper and lower limit (85% and 122% of the recommended weight, respectively) of recommended weight for a particular gestational length (expressed in weeks). If a mother exceeded the upper limit of recommended weight gain, her GWG was classified as 'excessive'. If she gained less than the lower limit of the recommended weight, then the GWG was classified as 'inadequate'. If the actual GWG was within the upper and lower limit of recommended weight gain, the GWG was considered 'adequate'. For example, suppose if the recommended weight for an underweight woman whose gestational period was 37 weeks is 14.24 kg. Then the upper and lower limit are (14.24*0.85 =12.104 kg) and are 14.24*1.22 =17.37 kg), respectively. Now suppose that the actual GWG was 15 kg. Since this falls within the range, the GWG would be considered 'adequate'.

I separately calculated the recommended weight for each week of gestation (ranging from 22 weeks to 42 weeks). First, I assumed that during the first trimester of their pregnancy, all mothers in the sample gained weight that is equal to the amount that was recommended for their pre-pregnancy weight status. For underweight, normal weight and overweight women, IOM recommends gaining 2 kg of weight during the first trimester. For obese mothers, the recommended weight gain is 1.1 kg. This is a strong assumption and is susceptible to be violated if there was a wide variation in the amount of weight gained by women in the first trimester. Unfortunately, ECLS-B did not collect information on weight gained during each semester of pregnancy. Consequently, I could neither test the assumption that all mothers gained the recommended amount of weight in the first trimester nor could I ascertain the variation in total first trimester weight gain. However, it can be argued that within a short span of 3 months, there is less likelihood of a substantial variation in the amount of weight gained by pregnant women compared to that gained during the overall pregnancy period of 9 months. Additionally, the IOM makes a similar assumption in their recommendations for total weight gain during pregnancy.[125] Although strong, this assumption has both – face validity and precedence in current literature.

Next, I added a fixed quantity of weight to the assumed first trimester weight gain to obtain the recommended weight for each week of gestation, using the following formula –

Recommended weight = Recommended first trimester weight gain for mother's pre-pregnancy weight category+ ((gestational age at delivery - 13) * (Recommended weekly weight gain rate for second and third trimester for the pre-pregnancy weight category)). Subtracting 13 from the total gestational age at delivery accounted for the length of the first trimester, which is of 13 weeks' duration. Recommended weekly weight gain rate is the mean of the range of recommended weekly weight gain for the third and the second trimester. For example, the recommended weight gain for a gestational period of 37 weeks for underweight women would equal = 2 kg + ((37-13) *(0.51)) kg = 14.24 kg. Where 2kg is the recommended first trimester weight gain for an underweight mother and 0.51 is the mean of the rage of recommended weekly rate of weight gain (0.45 to 0.58) for the third trimester for an underweight mother.

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Vita

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