Fall 12-19-2022

ACQUIRED AND USEFUL ABILITIES: THREE ESSAYS ON HUMAN CAPITAL DEVELOPMENT

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BY

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DISSERTATION

Submitted in Partial Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy
Economics

The University of New Mexico
Albuquerque, New Mexico

May 2021

ACKOWLEDGEMENTS

A great many people have inspired the ideas this dissertation explores. I have been fortunate to hear life stories of many wonderful people. These stories made me wonder why some people flourish and others do not. And I would like to thank them for sowing those ideas and making me wander.

Without the help my dissertation committee, this dissertation would not have materialized, and I am, above all, grateful to them. Dr. Berrens consistently challenged me to think like an economist. Dr. Bohara instilled in me a deep admiration for numbers and methods. Dr. Villa inspired me to pursue research on early childhood. Finally, I would like to thank Dr. Adhikari for his friendship.

The Department of Economics has been an excellent support for me. And my friends – thank you!

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ABSTRACT

While early childhood circumstances influence the accumulation of skills and abilities, parental and policy responses can magnify or mitigate the effects of childhood circumstances. This work explores the two ideas mentioned above.

Chapter 1 briefs the historical and philosophical roots of the study of human capital and discusses the economic approach to the understanding of child wellbeing before the age of five. Because childhood circumstances influence the accumulation of skills, **Chapter 2** estimates the impact of temperature shock during pregnancy on early childhood health. Evidence from Nepal shows that prenatal exposure to high-temperature days impedes child growth; however, the damage appears to be transitory as opposed to persistent – as the effect decreases with age and becomes almost undetectable by age five. Both market and non-market mechanisms are explored.

Because parental and policy responses can magnify or mitigate the effects of childhood circumstances, **Chapter 3** investigates parental response and **Chapter 4** explores policy response. Using the socio-economic context of Nepalese children under five, Chapter 3 shows that mothers equally invest time among boys and girls, irrespective of activity types. Son preferences among Nepalese mothers, therefore, may not be an actual preference, but rather

arises due to cultural and social constraints. More importantly, maternal time input is an important determinant of a child's cognitive and behavioral outcomes.

Using a sample of under-five children whose childcare was subsidized by the state of New Mexico, Chapter 4 analyzes the behavioral effects of families' childcare cost (copayment) on childcare arrangements, focusing on the non-parental care characteristics that promote child development. The results show that higher copayment increases the likelihood of selecting lower-quality rated childcare and home-based childcare, suggesting that reducing copayment may be an effective policy tool for better childcare arrangements. Finally, **Chapter 5** provides the concluding remarks, the direction of future research, and policy perspective.

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Chapter 1: Introducing Human Capital Development in Early Life

1.1 Background

> The difference between the most dissimilar characters, between a philosopher and a common street porter, for example, seems to arise not so much from nature as from habit, custom, and education. When they came into the world, and for the first six or eight years of their existence, they were, perhaps, very much alike, and neither their parents nor playfellows could perceive any remarkable difference. About that age, or soon after, they come to be employed in very different occupations.
> (Smith, 2003, p. 17)

From Aristotle to Adam Smith, philosophers have often contemplated why some people flourish and others do not. Prominent economists, in the history of economic thought, considered human talents or their skills as the capital necessary for human flourishing (e.g., Sir William Petty, Adam Smith, Jean-Baptiste Say, and Lean Walras). In fact, Smith recognized that the "acquired and useful abilities," as one of the four types of capital, were "part of his [individual's] fortune" and the fortune of the society (Smith, 2003, p. 217). Since, economists have tried to estimate the value of human skills.[1] The idea of useful abilities as a capital slowly developed over centuries, despite seldom objections from economists and non-economists.[2] It gained more prominence when Jacob Mincer, in mid-twentieth century, stumbled upon a form of capital while attempting to understand the relationship between income and education in the United States (Adamson, 2009). This form of capital came to be known as "human capital."

[1] Sir William Petty attempted to estimate the capital value of a human being or their skills through monetary valuation of labor (Kirker, 1966). Because labor is the "father of wealth," Petty argued that money-value of labor must be included in any estimate of the wealth of a nation (Kirker, 1966). Later economists (e.g., Ernst Engel) modified this idea to incorporate cost of rearing a child to working age when estimating monetary value of human capital.

[2] For example, Jonathan Swift satirized Sir William Petty for monetary valuation of human in his famous book *A Modest Proposal*, attacking Petty's "fake precision of the numerological style" in measuring human beings (Rothbard, 2010). John Stuart Mill denounced the idea of human being as capital, arguing that wealth exists for sake of man, and human skills are means to wealth (Mill, 1872, p. 30). Alfred Marshall discarded the notion of human being as a capital because such reasoning is "unrealistic," as human are unmarketable (Kirker, 1966). Theodore Shultz argued that human should not be equated with property or marketable assets (Schultz, 1961).

After its insurgence in mid-twentieth century, human capital gained substantial attention because "useful abilities" became increasingly necessary for economic growth, poverty alleviation, and inequality reduction (Schultz, 1961).[3] It was not long after that, economists started developing and quantifying the concept of human capital. To quantify, economists approached with two methods: cost-of-production (or investment) and return on investment (Kirker, 1966). Besides quantifying, the idea of human capital was expanded. For example, Gary Becker argued that human capital is unlike physical or financial capital because a person cannot be separated from his "knowledge, skills, health or values" (Becker, 2009, p.16). As non-market behaviors (e.g., marriage, crime, and education) gained greater acceptation into economic models, economists recognized the importance of the multifarious nature of human abilities–like health and non-cognitive skills (e.g., perseverance, time preference, and risk aversion) in human flourishing. As a result, applied economists in recent years have empirically explored the nuances that creates variation in "acquired and useful human abilities"; thus, new evidence have emerged on the role of market and non-market influencers. In particular, the role of genetics (e.g., innate ability, genetic engineering), institutions (e.g., household, legal rights, religion), parental preferences and public policies seems to be critical in fostering human capital.

After decades of work, economists document stylized facts regarding human capital development. For example, skills are multidimensional; the developmental needs are diverse; the heredity component (i.e., nature or gene) interacts with environmental influencers (i.e., nurture) to form skills; deficiency in developmental needs limit children from reaching their full potential even with additional later-life investments; and the skill gap across population groups opens up

[3] The concept –that human capital is necessary for national wealth– is not new. It became more prominent in micro and macro-economic research (see, Solow Growth Model). Not limited to the wealth of a nation, economists (e.g., Johann Heinrich von Thunen) have argued that social injustice can be defeated, and human freedom and dignity can be elevated if labor productivity is treated within the human-capital analytical framework (Kirker, 1966).

early in life; (e.g., Currie & Almond, 2011; Cunha & Heckman, 2007; Heckman et al., 2006). As skill formation begins in early life, researchers assert three important findings about early life. First, early life conditions can have lifelong effects. Second, early life investments are important factors in producing skills during childhood. Third, the benefits are greater if invested in early life than later life stages.[4]

Broadly speaking, the empirical research on early life conditions has progressed in two distinct directions, incorporating cost and investment framework. The first line of research explores how skill accumulation responds to the early childhood environment. The second line of research concerns ameliorating the effects of negative childhood conditions through investment.[5] [6] This dissertation explores these two lines of research.

1.2 Skill Formation before Age Five

> We can state fairly definitively that at least some things that happen **before age five** have long-term consequences for health and human capital. Moreover, these effects are sufficiently large and general to shape outcomes at the population level.
> (Almond & Currie, 2011)

For a long time, researchers have recognized that early childhood (i.e., before age five) experience can influence skills accumulation, and thereby life outcomes. Economists have explored a wide array of circumstances, and their impact on economic and non-economic outcomes. For example, early life conditions impact education, labor market outcome, adult disability, income, marital status, health, welfare dependency, etc. (for discussion see, Almond &

[4] Early life is broadly defined from the conception to pre-teen years. There are critical periods (only effective period in producing skills) and sensitive periods (most effective period in producing skills).

[5] Both lines of research are not mutually exclusive. For example, study of home environment can be included in both categories.

[6] This categorization does not include the advancement in theoretical frameworks and empirical approaches. For example, the static models of skill formation advanced into complex dynamic models that includes complementariness, self-productivity, and non-cognitive abilities in skills formation (Cunha & Heckman, 2007). Econometrically, lagged and value-added models are more popular instead of contemporaneous models of skill formation (Todd & Wolpin, 2007).

Currie, 2011; Almond et al., 20017; Corman et al., 2017). Similarly, children may be exposed to a wide variety of conditions in early life that can positively or negative impact their life outcomes, such as natural disasters, environmental pollution, civil unrest, war, famine, pandemic, illness, lottery win, etc. (for discussion see, Almond & Currie, 2011; Almond et al., 20017; Corman et al., 2017).

Even before birth, a fetus can be exposed to shocks that have negative human-capital consequences in short and long-term. Early attempts to understand these effects exploited exogenous variations in the prenatal environment using uncommon and adverse incidents. Instead of idiosyncratic (e.g., loss of job, health) or adverse shocks (e.g., pandemic, famine), the recent focus has shifted towards mild (in terms of intensity) and covariate shocks (in terms of number of people affected). Because of the growing concern of climate change, economists are exploiting extreme weather events as a natural experiment to show the long-term impacts of fetal shocks. Such climatic shocks may directly and indirectly hinder children's developmental trajectories.

If a child experiences a shock or any unfavorable circumstance, investments can potentially ameliorate the negative effects. Parental investments and policy responses play a major role in magnifying or mitigating the effects of early life events (Currie & Almond, 2011). Parental preferences and constraints determine the optimal investment in a child, but, if parents are constrained in investments, then providing social resource (e.g., in-kind transfer) or public support (e.g., parental leave policies) may impact parent's choices and investments.

Moreover, parental investments nurture young children so that they have higher life-coping skills. The investments' quality and duration are shaped by parental preferences, and the preferences depend on the parental characteristics (e.g., gender of the parent, education level) and child characteristics (e.g., gender, birth order, and birth endowment). Parental investments can also vary across generations, institutional settings, and cultural norms. For example, mothers may invest equally in both genders even in a society with strong male preferences because of the decreasing fertility rate, maternal education, and legal right. Or, mothers may engage in reinforcing or compensating behavior, which can vary by child's gender or birth order.

In addition, lower-income parents face binding budget constraints, which influence their investment behavior and may fail to meet minimum expectation in child rearing. As a result, the child may fall behind in skill accumulation. Because childhood investments generate large net social benefits, social investments may have an important impact on parent's choices. Social investments or public policies aimed at promoting child wellbeing show positive effects in life outcomes during childhood, which transfer into adulthood. Therefore, government institutes various policies, and these policies can be targeted versus universal, mandated versus voluntary, and preventative versus treatment. For example, among an array of voluntary means-tested policy tools, researchers and policymakers, in recent years, have called for a more generous childcare assistance to low-income families as it expands childcare choices by partly covering the childcare costs. One way to help lower-income families is by reducing their share of childcare cost if the cost and childcare choices are related.

1.3 Research Outline

Taken together, this dissertation presents an economic approach to the understanding of child wellbeing before age five. It advances the old idea on human flourishing in the context of new evidence and has policy ramifications. In particular, this dissertation askes three questions. How does high-temperature due to climate change impact human health? Do mothers genuinely prefer boys over girls? And does copayment influence childcare selection for subsidy receiving families? To answer these questions, this dissertation uses survey data from Nepal, a developing country, and administrative data from the state of New Mexico (US), a low-income state in a developed country. All three empirical chapters focus on lower-income families or sample from a lower-income country or state, as well as rely on the conceptual and analytical framework of human capabilities formation. Moreover, this dissertation explores two key ideas: early childhood circumstances influence the accumulation of skills and abilities (Chapter 2), and parental and policy responses can magnify or mitigate the effects of childhood circumstances (Chapters 3 and 4).

Chapter 2 presents the causal relationship between a mild and persistent shock during pregnancy and early life health outcomes. Using high-temperature (daily mean temperature greater or equal to 32 degree Celsius) as a mild and persistent shock, a causal link between high-temperature days during pregnancy and height-for-age z-score is established for a sample of Nepalese children under five. While measuring the impact of high temperature on human health, there can be direct impacts (physiological changes) and indirect impacts (economic welfare). Two economic mechanisms are explored. First, temperature shocks impact high-commodity food prices, which can reduce household welfare. Second, mothers appear to respond with reduced prenatal care utilization. Thus, the high-temperature days due to climate change have both market (food prices) and non-market cost (reduced prenatal care utilization).

Chapter 3 revisits two familiar questions about parental investment in light of new evidence on the changing social and demographic context of Nepal: does gender of a child affect maternal time investment for preschool children? And, how does maternal time investment affect child educational and behavioral outcomes? Using a sample of Nepalese children under five, the result shows no gender differences in the maternal time input even though maternal input is an important determinant of preschool child outcomes. Contrary to the cultural beliefs where boys are preferred over girls, these results suggest a changing social norm. These changes may reduce historically observed adult outcome gaps between men and women.

Chapter 4 explores the impact of families' childcare cost on childcare choices for a sample of children receiving childcare assistance in New Mexico, United States. A voluntary and means-tested program, known as Child Care Assistance, aims at promoting child wellbeing by sharing the childcare cost with families. Families' childcare cost, even with subsidies, can be a financial burden to lower-income families to select high-quality, formal care while staying and continuing in the subsidy program. Using child fixed effects, the results show that a higher share of childcare cost decreases the likelihood of selecting higher quality care and decreases the probability of purchasing center-based care. This chapter concludes that reducing copayment may be an effective policy tool for better childcare arrangements.

The organization of the chapters follow the stages of the problem, beginning with skill accumulation and early childhood environment (Chapter 2), moving to parental investments by gender in childhood (Chapter 3), and finishing by analyzing the public subsidy generosity and parental choices (Chapter 4). Finally, Chapter 5 provides a general set of conclusions, policy implications, and future research.

Chapter 2: Effects of High-Temperature Days in utero on Early Childhood Health: Evidence from Nepal

2.1 Introduction

Research shows that adverse events during pregnancy can have wide-ranging and persistent effects, including health outcomes at birth and in adulthood (Almond & Currie, 2011; Almond et al., 2017; Currie & Vogl, 2012). Early attempts to understand these effects (e.g., Barker, 1995) exploited exogenous variations in the prenatal environment using uncommon and adverse incidents such as famine, armed conflicts, natural disasters, pandemics and extreme weather (for the review of literature, see Almond & Currie, 2011; Almond et al., 2017).[7] However, such adverse conditions may either take many years to unfold (e.g., war) or are infrequent in occurrence (e.g., drought). On the other hand, mild stressors occur frequently and are experienced commonly. Hence, a burgeoning literature uses mild uterine stressors (e.g., weather events, mild nutritional deprivation, and pollution) to capture exogenous variations in utero environment (Almond et al., 2017; Rosales-Rueda, 2018).[8] In particular, as global climate change models predict increasing average temperatures and the frequency of high-temperature days, incidence of high-temperature events/days during pregnancy, as a mild uterine stressor, presents a not so uncommon yet relevant shock during pregnancy.

Moreover, studies on the health impacts of prenatal shock, including weather shock, primarily focus either on health outcomes at birth or in adulthood. The impact of weather shock

[7] Referred to as the fetal origin hypothesis, it postulates that *in utero* condition influences outcomes later in life. Since the outset of the seminal fetal programming hypothesis (Baker, 1995), studies on uterine stressor show a wide range of impacts on later-life outcomes, including test-scores, educational attainment, income, risky behavior, crime and health (for an excellent review of the literature, see Almond and Currie, 2011; Almond et al., 2017).
[8] Mild shocks during pregnancy include mild nutrition deprivation (e.g., daytime fasting during Ramadan), maternal stress, seasonal diseases, exposure to pollution and weather shocks, alcohol and tobacco consumptions (for an excellent review, see Almond et al., 2017).

on birth outcomes is well documented in the literature.[9] Although health damages during pregnancy can remain latent for many years (e.g., heart disease) only to appear in adulthood (Almond & Currie, 2011), the outcomes in adulthood, in addition, can suffer from self-productivity and investment due to the dynamic nature of health. Therefore, the impact of mild prenatal shock on later-life health outcomes can be indiscernible as the effect can fade out if further removed in time (Heckman, 2007). One approach to understand the impact of mild uterine stressors on long-term health outcomes is by focusing on the cumulative measure of health at early or middle childhood.

The objective of this analysis is to econometrically investigate the impact of a mild but persistent event during pregnancy on early childhood health status in a developing country context. The analysis uses climate data on the frequency of high-temperature days (ambient daily mean temperature greater or equal to 32 degree Celsius) during pregnancy as a mild and persistent uterine stressor. We then combine the climate data with a national household survey from Nepal that contains information on children born in between 2009 and 2014. A variety of possible explanations are explored.

Consistent with the fetal origin hypothesis, results from econometric analysis indicate that exposure to an additional high-temperature day in gestation impedes child growth (measured in-terms of height-for-age z-score) by 0.008-0.011 standard deviations for children under five. The impact is stronger in the third trimester when the fetus dramatically grows in mass and

[9] Recent studies from developing countries show negative effects of weather shock (extreme temperature and/or rainfall, drought and flood) during pregnancy on birth outcomes and infant mortality: in Nepal (Mulmi et al., 2016; Regmi et al., 2008; Tiwari et al., 2016) in Sub-Saharan Africa (Wang, et al., 2014; Wilde et al., 2017); in Mexico (Agüero, 2014; Skoufias & Vinha, 2012); in Nigeria (Rabassa et al., 2014); in Mongolia (Groppo & Kraehnert, 2016); in India (Banerjee & Maharaj, 2019); and in China (Mueller & Gray, 2018).

size.Unlike the persistent effects observed for adverse shocks, the damage appears to be transitory, i.e., the effect decreases with age and becomes almost undetectable by age five.

As the total impact of high-temperature days in utero is not entirely a biological phenomenon, we hypothesize that some of this impact is mediated through indirect economic mechanisms. We explore the impact of high-temperature days on food prices and antenatal care utilization. The results show a statistically significant and positive impact of high-temperature days on selected food prices. We find that the effects on high commodity food (e.g., rice and meat) are stronger compared to low commodity staples (e.g., wheat or lentils). In addition, we explore how pregnant women respond to heat stress when the market only provides inadequate climate amenities. We do so by focusing on the impact of high-temperature days on healthcare-seeking behavior during pregnancy. Our findings suggest that the mothers react with reduced utilization of antenatal care.

These findings add to the fetal programming literature in the following ways. First, existing research focuses overwhelmingly on adverse events like drought or heat-wave when exploring the impact of high-temperature during pregnancy on health outcomes (e.g., Kumar et al., 2016). Our focus on high-temperature days, a mild and persistent shock in utero, and complements the current literature and calls for a renewed attention on the role of moderate shocks in fetal development. Second, previous studies look at either birth outcomes (e.g., child mortality or birthweight) or health outcomes many years after birth or in adulthood (Almond et al., 2017). Our focus on the cumulative measure of early childhood health partially addresses the research gap for “middle years” – between infancy to adulthood (Almond et al., 2017). Third, our analysis improves previous studies on the assignment of temperature exposure. We use ground-level station data within 50 kilometers radius of the household cluster – providing a more accurate exposure to ambient temperature due to fine level of geographic disaggregation (mostly at the village level). Finally, when assigning temperature, previous studies use birth month or data covering larger geographical area (e.g., Agüero, 2014; Kumar et al., 2016; Skoufias & Vinha, 2012). A detailed birth date allows us to assign temperature more accurately at a daily level.

The paper is organized as follows. Sections 2 and 3 discuss the conceptual framework and background. In Section 4, we outline data sources and discuss how the survey data is linked with meteorology data. Sections 5 and 6 offer an empirical model and results, repectively. In section 7, we present robustness checks and address selection issues. Section 8 discusses economic mechanisms. Finally, we conclude in Section 9.

2.1 Theoretical Model

Using the dynamic health production function approach (e.g., Cunha & Heckman, 2007; Currie & Almond, 2011; Grossman, 1972; Heckman, 2007; Rosales-Rueda, 2018), we illustrate the role of high-temperature days on early childhood health. The central proposition is that health, as a dynamic stock, is a durable commodity, which can be augmented by investment and is subject to depreciation. A simple two-period model of health production is represented as:

$$H_{t+1} = f(P_t, H_t, I_t, T_t, X_t) \quad (2.1)$$

Health stocks, H_{t+1} and H_t, represents health at time $t+1$ (in early childhood) and t (in utero). Heath in early childhood is influenced by fetus health at time t (also known as self-productivity). Genetic or parental endowment at conception is represented by P_t. Health investment in utero (I_t) such as nutritional food, healthcare utilization, etc., is a twice continuously differentiable and concave function (Cunha & Heckman, 2007). A vector of unobserved inputs (X_t) also influences health capital accumulation (e.g., quality of healthcare utilization). Finally, number of high-temperature days during pregnancy (T_t) is the mild but persistent uterine stressor. We assume that the high temperature in $t + 1$ does impact health at $t + 1$.

The temperature shock in utero, T_t, impacts health directly through physiological damages and indirectly through investment. Shocks during pregnancy directly impacts fetus development by causing fetal loss, shortened gestation period, and low birthweight (Rashid et al., 2017). It also can transmit through stress caused to maternal physiology (Lundgren et al., 2013). To capture the direct physiological damages caused by high-temperature days in gestation, fetal health (H_t) can be expressed as:

$$H_t = q(P_t, T_t) \tag{2.2}$$

High-temperature days indirectly impacts later-life health through economic channels. The economic channels influence later life outcomes through health capital investment. Investment behavior is endogenous and interacts with the parental endowment at conception (P), temperature shock (T), and other unobserved factors that influence investment decisions (Z). For example, when exposed to extreme heat, families may choose to invest more (or less) on the pregnant women (e.g., reduce their work and mobility). Thus, parents indulge in compensatory (or reinforcing) behavior. The investment behavior can be written as:

$$I_t = h(P_t,\ T_t,\ Z_t) \tag{2.3}$$

Replacing Equations 2 and 3 into 1, the partial derivatives can be presented as follows:

$$\frac{\partial H_{t+1}}{\partial T_t} = \underset{\Longleftrightarrow}{\underset{\text{Biological Effects}}{\frac{\partial H_{t+1}}{\partial H_t}\frac{\partial H_t}{\partial T_t}}} + \underset{\Longleftrightarrow}{\underset{\text{Economic Channel}}{\frac{\partial H_{t+1}}{\partial I_t}\frac{\partial I_t}{\partial T_t}}} \tag{2.4}$$

In Equation 2.4, the total effect ($\partial H_{t+1}\ /\ \partial T_t$) is decomposed into two channels; namely, biological and economical. The first-term on the right-hand side is the biological effects due to exposure to temperature shock in utero, which is expected to be negative.[10] The second term is the economic channel. High-temperature days can influence fetus development through various indirect channels: lack of food and safe drinking water, poor sanitation, population migration or changing disease pattern (Rylander et al., 2013). The net impact of the economic channels is unknown. For example, high-temperature can increase or decrease food prices either by increasing or decreasing agricultural yields or by reducing shelf-life of certain food items. If high-temperature days increases food prices, it shifts the household budget curve downwards, i.e., families have fewer resources for human capital investment. In such a scenario, the economic channel negatively impacts the future outcomes.

Both channels - biological and economic – cannot be discerned without comprehensive information on maternal and family responses to high-temperature during pregnancy. Due to data limitation, the first part of our analysis estimates the total effect. Using secondary data, the second part investigates the economic channels.[11]

2.3 Background

Growing scientific evidence documents three stylized facts regarding the global climate change, and its impact. First, the incidence of extreme temperature is rising with increasing frequency, intensity and duration (IPCC, 2014). Second, the physiological and psychological

[10] Extreme heat exposure uses water and salt in the body, which creates sweat in order to dissipate heat. If exposure to extreme heat is prolonged, and water and salt are not adequately replenished, then the maternal body experiences physical discomfort like dizziness, muscles cramps and fever. Although the effect of pregnancy on woman's heat tolerance is unclear, altered hormone levels, added weight, reduced adaptive capacity and the increased circulatory demands may effect fetus development (Lundgren et al., 2013). Similarly, woman's body is sensitive to temperature affecting chemistry, electrical properties, and function of vital organ which can be detrimental for a fetus to reach one's full capacity (Seltenrich, 2015; Wang et al., 2014). Medical literature shows that exposure to heat stress in utero is associated with multiple birth defects; for example, hypospadias (Kilinc et al., 2016) and atrial septal (Auger et al., 2017).

[11] Health production function strategy has several key assumptions. The model does not account for substantial geographic variation in health inputs, seasonal variability on exposure and the cost of health investment. We address these issues empirically with various fixed effects. We also assume that the contemporaneous investment does not impact health outcomes.

discomfort caused by high-temperature days is elevated among children and pregnant women (Rylander et al., 2013). Third, developing countries experience stronger impact as climate change channels through various indirect pathways (IPCC, 2014; Rylander et al., 2013). Ranked 24th in the Global Climate Risk Index (Kreft et al., 2017), Nepal is experiencing the direct and indirect consequences of global climate change. Below we discuss why Nepal provides an ideal scenario to study the impact of high-temperature days during pregnancy on early childhood health.

In Nepal, the incidence of extreme temperature is rising with increasing frequency, intensity and duration. Since 1975 to 2005, the annual mean temperature has increased by 0.06 degree Celsius (C) per year and is predicted to grow by 1.3C to 3.8C by 2060, which is higher than the corresponding global estimation (Government of Nepal, 2017). In addition, Nepal's topographical setting provides a wide range of micro-climates, creating a considerable variation in exposure, and on the effect of extreme temperature.

Similarly, climate change disproportionately affects Nepalese women as they are susceptible to injuries and death caused by environmental insults. For example, after accounting for casual household labor (e.g., cleaning, cooking), women work more than men, on average – especially among agricultural, pastoral and wage laborer households (Goodrich et al., 2017). Consequently, women are more likely to be exposed to high temperatures. Similarly, women are more vulnerable to environmental insults because they have little say in the decision-making process (e.g., outdoor labor time during hot days or technology adoption) even though they play a central role in agricultural and resource management (Goodrich et al., 2017). Moreover, women are less informed about the impact of climate change. A national survey on climate change finds 61 percent of women have not heard the term “climate change” or “global warming” compared to the overall rate at 50 percent (Government of Nepal, 2017).

Moreover, Nepal is experiencing increased incidences of climate-related disasters, heightened disease burden, and reduced agricultural production - all attributed to rising temperature (Ministry of Health and Population, 2012). In Nepal, poor infrastructure and resource constraints (to use climate amenities when the market allows), combined with the weak formal market (to provide climate amenities), limit the ex-ante or ex-post mitigations strategies to cope with extreme weather. Thus, the lack of mitigation strategies makes it easier to establish a causal link between heat stress during pregnancy and health outcome in early childhood.

2.4 Data

2.4.1 Child Data

We use the Multiple Indicator Survey (MICS) 2014 for children, mother and household characteristics. This nationally representative survey, MICS 2014, uses multi-stage, stratified cluster sample selection technique, and provides comprehensive information on the children and women, including information on early childhood development and complete birth history of the women ages 15 to 49. It collects information on 5,349 children under five from 519 household clusters.

Table 2.1 provides the definitions and descriptive statistics for the children, mother, and household characteristics. The final estimating sample consists of 4,704 children from 3,725 households in 506 sampling clusters.[12] The height for age z-score (HAZ) is calculated using the

[12] We lost 12 percent of the sample size due to following reasons: missing or biologically impractical height-for-age z-score (i.e., greater than 6 or less than -6 standard deviations); missing date of birth; and unable to match with a weather station within 50 kilometers of the household cluster.

2006 World Health Organization standard for the children age 0-59 months.[13] The mean HAZ is -1.65 – meaning, on average, children experience growth retardation (40.5% of the children in our sample are stunted, i.e., HAZ less than -2.).[14] Our sample consists of a lower percentage of females (47%). The mean birth order is 2.8 and the average maternal age is 27 years old. Finally, most households are rural (82%), non-Dalit (82.5%) and live in Hills or Terai plains (71.1%).

2.4.2 Temperature Data

The Department of Hydrology and Meteorology (DHM), Nepal, provides the daily maximum and minimum temperature data from 112 ground-level weather stations across Nepal. The weather stations with missing daily maximum or minimum temperature for more than 30 consecutive days are dropped. We also drop weather stations without any temperature data for the study period (2009-2014). This leaves us with 89 weather stations that are fairly expansive throughout Nepal (see Figure 2.1).

2.4.3 Exposure to High Temperature

The daily mean temperature is the average of the daily maximum and daily minimum temperatures. Daily mean temperature greater or equal to 32C (89.6F) is defined as the high-temperature days, which is a mild and persistent uterine stressor. As the thermal comfort zone is 18 to 22C, temperature greater than or equal to 32C can physically impact human body (e.g.,

[13] Negative HAZ reflects long-term, cumulative deficiencies in health and/or nutrition resulting in a child failing to reach his or her growth potential (World Health Organization, 1995). It is linked with increased morbidity, mortality, and reduced long-term health. It is also widely associated with a wide range of socio-economic outcomes such as education, cognitive ability, and adult economic productivity (e.g., Vogl, 2017; Strauss and Thomas, 2008; Victora et al., 2008). In addition, HAZ is correlated with socio-economic factors (e.g., maternal education, migration status, child's birth year, and household income), socio-cultural systems (e.g., ethnicity, marital status, type of marriage, and religion) and proximate determinants (e.g., survival status of the preceding sibling, preceding birth interval, maternal age at birth of child, source of water, and type of toilet facility), which has been extensively studied in the health literature (Jelenkovic et al, 2016).

[14] In developing countries, HAZ decreases with increasing age as we observe similar trend in Nepal (Appendix, Figure A.1). Similarly, children born during the hot months have lower HAZ than the children born during the winter season (Appendix, Figure A.2)

sunstroke, muscle cramps, heat exhaustion). However, this definition of high-temperature is somewhat arbitrary as there is no unanimous consensus on the threshold of high-temperature. In the literature, the threshold ranges from 25 to 32C (e.g., Deschenes & Greenstone, 2011; Hu & Li, 2016; Barreca et al., 2018; Banerjee & Maharaj, 2019). Throughout this paper, extreme temperature and high-temperature days are interchangeably used.

The total number of high-temperature days in gestation is a mild and persistent uterine stressor. MICS-2014, however, does not provide information on conception day to calculate accurate gestation length. So, we use the standard length of 40 weeks for gestation period. The conception day is determined by backward counting from birthday.

2.4.4 Linking Weather Stations with Household Clusters

Mountainous terrain and sparsely located weather stations challenge temperature assignment in Nepal. To link weather stations to the household clusters, we matched the nearest weather station within 50 kilometers of the household cluster. This technique can produce unlikely matches as there are sharp rises in the elevation within a narrow geographical area. For example, in the northern mountainous and hilly part of Nepal, a village may lie in the lowlands of a valley while the weather station is positioned at the hilltop, which is within the 50 kilometers radius. A large difference in altitude causes discrepancy between the assigned versus actual temperature exposure as a thousand meters increase in altitude decreases ambient temperature by 6.5C.

The concern on the linking weather stations to a household cluster can be omitted because of the following reasons. First, we observe that the mean distance between matched sample cluster and weather station is 17.4 kilometers and the mean difference in altitude is 23.33 meters (see Table A.1). Second, the weather stations and the household clusters are sparsely located on the mountainous northern part of the country (see Figure 2.1) – as the habitation is lower in the region. After the linking the data, the final the estimating sample consists of 506 households linked with 85 weather stations.

To provide a better outlook of temperature exposure during pregnancy, Figure 2.2 provides the distribution of daily mean temperature during gestation period across five temperature bins (less than 0C; between 0-7.22C, 7.22-18.33C, 18.33-32C, and higher or equal to 32C). The vertical axis represents the average gestation length in each temperature bin. On average, women experience four high-temperature days during gestation. On the other hand, women experience few days when the weather is extremely cold (0.05 days when the temperature falls below 0C).

2.4.5 Food Price Data

To examine the economic mechanism through investment in utero, we explore the impact of high-temperature days on food prices. The food price information is extracted from the annual reports published by the Agriculture Business Promotion and Marketing Development Directorate, Ministry of Agriculture Development (MAD), Nepal. These reports provide monthly mean prices for major food items sold in the selected districts across Nepal. The data is available from 2011 to 2014, when the surveyed women were pregnant. Although the data covers 46 districts (10 Mountain districts, 21 Hill districts, and 15 Terai districts), the districts are well-balanced throughout Nepal with fewer districts from sparsely populated mountain region of the country (see Figure A.3). [15]

[15] MAD provides either the exact address of the food retail market or the name of the district where a market is located. Instead of the retail market, if the district name is provided, we compute the geo-coordinates the centroid of the municipality or village development committee in which the District Agriculture Office (DAO), Government of Nepal, is located. We use the geo-coordinates of the centroid to match the nearest weather station with 50 kilometers. We use the centroid because DAOs are located in the district headquarters and collect the food price data. This study uses Nepali district units as defined by pre-2015 boundaries. Finally, as discussed earlier, sharp rise

Table 2.2 provides definitions and summary statistics for the six food categories. Rice, meat, and milk are high commodity food items, whereas wheat, vegetables, and lentils are low commodity food items. The mean price of rice is Nepalese Rupees (Rs.) 41.83 per kilogram. Similarly, the mean price of meat is Rs. 265.4 per kilogram and that of milk is Rs. 49.44 per liter. All prices are in constant 2016 Nepalese Rupees.

2.5 Empirical Model

The effect of high-temperature days during pregnancy on early childhood health status is estimated using the following linear fixed-effects model.

$$H_{imyr} = \alpha + \beta T_{imyr} + \pi X_{imyr} + \delta_m + \lambda_y + \eta_r + \epsilon_{imyr} \quad (2.5)$$

where H_{imyr} is the outcome variable (height-for-age z-score) for a child (i) born in the month (m) and year (y) in the agro-climatic region (r). X controls for the child, mother, and household characteristics. The child characteristics include gender, age, and birth order, whereas mother characteristics include mother's education and mother's age at birth. The household characteristics include household size, household wealth quintile, elevation from the sea level, indicator variable whether the household dwells in a rural or urban area, and an indicator variable whether a household is the member of a lower caste as defined by the National Planning Commission, Government of Nepal in 2011 census. δ_m controls for the birth-month fixed effect. Similarly, λ_y controls for the birth-year fixed effect and η_r is the agro-climatic region fixed effect. Finally, to account for the spatial correlation, ϵ is the robust standard error clustered at the household sampling cluster. The main variable of interest, T, is the number of high-temperature days in gestation.

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in altitude makes it difficult to assign the weather station to geo-codes of the retail food market. Again, the mean distance between weather station and market centroid is 11.78 kilometers.

Our estimation technique uses agro-climatic region, birth-year, and birth-month fixed effects to control for the permanent geographical and seasonal characteristics that may affect height-for-age *z*-score directly. This allows us to identify the impacts using only the random variation in temperature. We use the agro-climatic region fixed effects because each region is characterized by different sets of weather, economic activities, social norms, and population dispersion. For example, the mountainous northern region is dry with little or no rainfall, whereas the southern lowland (Terai) is fertile with hotter and wetter climate. Similarly, we observe an inverse relation between altitude and household poverty in Nepal. The Terai region is comparatively developed on availability of market and road (Gallup et al., 1999). Without agro-climatic region fixed effects, regional differences may bias the effects toward zero.

We use birth month fixed effect to control for the seasonality. First, the season of birth is associated with nutrition availability and likelihood of infection. Not only is temperature correlated with season, the season of birth (even birth month) is also associated with later life outcomes as documented in the literature (e.g., Buckles & Hungerman, 2012). Second, harvesting and wedding seasons can also influence birth rates.[16] For example, we observe higher number of children born nine months after the wedding season (see Figure A.4). To account for this heterogeneity due to seasonality, we rely on the birth-month fixed effect.

Moreover, children born in later years tend to be taller in low-income countries, mainly due to economic growth, improved access to health care and availability of nutritious food (Strauss & Thomas, 2008). Our sample consists of the children born from 2009 to 2014, which

[16] Accounting 95 percent of our sample, Hindu, Buddhist and many indigenous religions (e.g., Kirat) perform marriage ceremony only in certain dates. Traditional marriage can only occur in three distinct period: mid-January to mid-March; mid-April to mid-June; and mid-November to mid-December.

was marked by economic and political volatility following the decade-long armed conflict. So, we use the birth-year fixed effect to control for cohort-specific heterogeneity.

Finally, temperature bundles with other environmental agents to affect human health. For example, the effect of temperature amplifies or alleviates with the oxygen level, humidity, ozone, and air pollutions. Higher elevation reduces air quality and decreases humidity (Jans et al., 2018). This bundling weakens the causal link between temperature and health as it is difficult to isolate the effects of high temperature. To control for these confounders, we use the elevation of the household cluster, which minimizes any biases due to confounding environmental factors.[17]

2.6 Results

2.6.1 Effect of Extreme Temperature on Early Childhood Health

Table 2.3 presents the aggregate impact of the high-temperature days during pregnancy on early childhood health. Columns (1) through (4) incrementally add controls for the child, mother and household characteristics, including the controls for birth-month, birth-year, and agro-climatic region fixed-effects. All four specifications show statistically significant and negative association between number of high-temperature days during pregnancy and height-for-age z-score. When exposed to an additional high-temperature day during pregnancy, children's height-for-age z-score decreases by 0.008 to 0.011 standard deviations, on average.

2.6.2 Timing of Exposure

A typical, full-term pregnancy is equally divided into three trimesters, and each period is characterized with a specific role in fetal development. Medical literature characterizes the first trimester or embryonic stage as the period of a baby's body development. The second trimester is

[17] Although agro-climatic fixed effects can capture these confounders, the altitude variation is strikingly different with-in each agro-climatic region. For example, the elevation ranges from 300 meters to 2000 meters in the Hilly region, whereas the Mountain region has the difference of almost 2000 meters (the settlement above 4000 meters is non-existent).

characterized by the development of vital organs. The third trimester is important because the fetus grows dramatically in size and mass.

To investigate whether the effect of heat stress varies by trimesters, we modify Equation 5 by including high-temperature days in each trimester.

$$H_{imyr} = \alpha + \delta_1 T1_{imyr} + \delta_2 T2_{imyr} + \delta_3 T3_{imyr} + \pi X_{imyr} + \delta_m + \lambda_y + \eta_r + \epsilon_{imyr} \quad (2.6)$$

where $T1$, $T2$, and $T3$ are the total number of high-temperature days in the first, second and third trimesters, respectively. Counting backward from the birth date, we designate 280 to 171 days before birth as the first trimester, 170 to 91 days before birth as the second trimester, and 90 to the day of birth as the third trimester.

Results in Table 2.4 suggest that the negative effect on height-for-age z-score is largest in the third trimester, which is also statistically significant in all four specifications. In the third trimester, an increase by one high-temperature day during pregnancy leads to 0.0136 to 0.0163 standard deviations shorter in stature. This is consistent with the medical literature (Kramer, 1987). Therefore, the third trimester is most sensitive to high-temperature days as the fetus grows in mass and length.

2.6.3 Declining Effects by Age

When exposed to adverse events in utero, the impact can last for many years (Almond & Currie, 2011; Almond et al., 2017). We examine whether the impacts of high-temperature days in utero is persistent. For this analysis, we divide the estimating sample into four subgroups so that the sample size remains relatively large in each group: (1) children younger than 16 months old (<16 months); (2) children between 16 to 30 months old (16-30 months); (3) children between 31 to 45 months old (31-45 months); and (4) children older than 45 months (45< months). Using the baseline model (Table 2.2, Model 4), we estimate the impacts of high-temperature days in utero on height-for-age *z*-score for each subsample. The coefficients are plotted in the Figure 2.3. The coefficient estimates are statistically significant for the younger two subsamples (<16 months and 16-30 months); but the coefficients are smaller in magnitude and are statistically insignificant for the older two groups (31-45 months and 45< months). A joint test rejects the null hypothesis that the coefficients are equal at the 5 percent significance level. As the coefficients for the younger two groups are larger and statistically significant compared to older two groups, we infer that impact of mild shock during pregnancy is temporal. Unlike the persistent effect of adverse condition, the impact of high-temperature days – as a mild and persistent uterine stressor – decreases with age and becomes almost undetectable by age five.

2.7 Robustness Checks and Selection Bias

Allowing different definitions of high-temperature days and gestation length

As discussed earlier, we assume 32C as a threshold for the high-temperature days and 280 days for the gestation length. We allow some flexibility by using alternative definition of the high-temperature days and gestation length.

Figures 2.4 and 2.5 plots the coefficient using alternate definition of the high-temperature days and gestation length. Figure 2.4 plots the coefficient for different thresholds (30–34C) of high-temperature using our baseline model. As expected, assigning a higher threshold for extreme temperature has a stronger impact (the coefficient is larger) and statistically significant. These results are consistent with our baseline finding in Table 2.3 i.e., high-temperature days during pregnancy has negative impact on early childhood. Furthermore, Figure 2.5 plots the effects of high-temperature days (i.e., baseline threshold of 32C) on HAZ, while allowing the gestation length to vary (266-294 days). As expected, a longer gestation length is associated with better health status in early childhood.

2.7.1 Selection Issue

To estimate the causal link between high-temperature days in utero and early childhood health, the underlying assumption is that the exposure to temperature is exogenous and random, given individual, temporal and spatial controls. There are number of ways that undermines our assumptions. This section discusses some potential threat to the identification assumptions.

Fetal loss

Selection bias occurs if we exclude the lost-fetus due to high-temperature. If weaker fetuses are lost, then the remaining fetuses are inherently stronger and healthier, which means our sample is biased towards healthier fetus. This downward bias the coefficient estimate. In addition, medical literature postulates that the male fetus requires higher maternal resources; thus, adverse conditions in utero lead to higher survival probability for the female fetus (Almond & Currie, 2011; Trivers & Willard, 1973). If high-temperature days in gestation eliminates fragile fetuses, then a higher number of girls are conceived and born.

To test whether mild shock leads to fetal loss, we run a linear probability model to estimate the effects of high-temperature days during conception on the probability of a child being female. The dichotomous variable for the gender of a child is regressed on the number of high-temperature days along with other covariates.[18] As mentioned earlier, conception day is determined by backward counting from the birthday. Since the conception day is somewhat arbitrary, we count the total number high-temperature days 7 days prior and after the assigned conception date.

[18] Other covariates includes: mother's characteristics (mother's level of schooling, mother's age squared, and number of pregnancies); household characteristics (wealth index, household size, elevation). We also use birth-month, birth-year and agro-climatic region fixed effects.

We find that the impact of high-temperature days on the probability of the child being female is small and statistically insignificant (Table 2.5). From columns (1) to (3), we incrementally add mother and household characteristics. In all three models, the coefficient estimates are small and statistically insignificant, (i.e., the impact of high-temperature days on the probability of being a female child is non-existent). In addition, having a lower percentage of girls in our sample (47%) reinforces the results in Table 2.5. Although previous studies find that the adverse condition during pregnancy decreases the survival probability of the male fetus (Almond & Currie, 2011; Trivers & Willard, 1973), our finding that high-temperature days in gestation does not influence the probability of being a female child may be due to the fact that high-temperature days during pregnancy is a mild uterine stressor. Therefore, it is not as detrimental compared to more severe adversities (e.g., drought, natural disaster).

2.7.2 Additional Issues: Migration, Abortion, and Under-Five Mortality

Additional concern on the identification strategy arises from migration during pregnancy, sex-selective abortion, and under-five mortality. Due to data limitation, we are unable to test empirically if these consideration impacts our results. Nonetheless, below we discuss how these issues do not influence our estimates.

As a pregnancy lasts for nine months, temporary and permanent migration can occur during this period. If indeed temperature-induced permanent migration (e.g., residential sorting) has occurred in Nepal, we expect increased internal migration to cooler areas or vice versa. However, internal migration in Nepal is age and sex-specific, where women migrate largely due to marriage and men migrate seeking better economic opportunities (Suwal, 2014). According to 2001 and 2011 Nepalese Census, on average, four persons (male or female) per 1000 migrate crossing agro-climatic boundaries and six persons per 1000 cross district boundary (Suwal, 2014). Therefore, if residential sorting due to extreme temperatures exist, we deem that its impacts are negligible.

Similarly, women may travel temporarily during gestation. This contaminates the actual versus assigned temperature exposure, which can impact our estimation. In Nepal, we anticipate women traveling to the fraternal house for major festivals due to the patrilocal system. Such travels may be frequent and can occur during pregnancy.[19] However, our data does not provide information on maternal travel during pregnancy. Controlling for socio-cultural characteristics partly addresses this problem.

Finally, sex-selective abortion and under-five mortality also can bias our coefficient estimates. Nepal is characterized by strong son-preference because of patrilineal system. This can lead to sex-selective abortion against female fetus, and the higher under-five mortality for female child due to low human capital investment. Although sex-selective abortion is against the law, abortion in general is increasing due to accessible ultrasound technology in recent years (Frost, 2013). Compared to other South Asian countries (e.g., India and Pakistan), Nepal, however, has a low abortion rate (Singh et al. 2018). Using a 2014 nationally representative sample of 386 facilities data from legal abortion clinics and post-abortion care facilities, Puri et al. (2016) estimate the abortion rate to be 42 per 1000. This argument – the sex-selective abortion is low in Nepal – is further supported by the fact that the male to female ratio at birth is 1.04 in Nepal, which is very close to natural sex ratio of 1.05 (Lamichhane et al., 2011). Similarly, due to strong son-preference, female child may be subject to lower human capital investment in early childhood. This may lead to a higher female under-five mortality even

[19] In the following festivals, women are expected to travel to their father's or male sibling's house: *Teej* (in September), *Janai Purnima* (in August), *Dashain/Tihar* (in October/November), *Maghe Sankranti* (in January) etc. Such festivals occurs throughout the year. These festivals are celebrated by Hindus, Buddhist, and many indigenous religions (e.g., Kirat), which constitutes 95 percent of our sample.

though the female child has higher survival chances. On the contrary, under-five mortality for the male is higher than the female (35.8 versus 31.3 per 1000 live births) according to the World Bank (2018). Hence, we argue that neither under-five mortality nor sex-selective abortion contaminates our estimation.

2.8 Mechanisms

Theory tells us that the impacts of high-temperature days during pregnancy on early childhood health channel through two pathways, namely biological and economic channels. We estimated the aggregate impacts in the previous section. This section explores the economic channels.

To explore economic channels, we focus on the major drivers that rapidly reduced child stunting and undernutrition in recent years. Stunting reduction is attributed to four factors: health and nutritional intervention; improved sanitation; maternal education; and assets accumulation (Headey & Hoddinott, 2015). We focus on the health and nutritional interventions to explore the economic pathways through which high-temperature days lead to shorter stature among children. Health interventions include antenatal care utilization, and nutritional interventions include improved maternal nutrition during pregnancy. First, we explore how high–temperature days influence food prices. Second, we explore health intervention by focusing on the impact of high-temperature days on antenatal care utilization.

2.8.1 Effect of High-Temperature Days on Food Prices

High-temperature days can directly affect nutritional intervention through food availability and security. First, it may increase or decrease agricultural yield depending on the crop type and location.[20] If extreme temperature reduces crop yields, the food prices increase (or decrease) depending on the crop type. Second, high temperature reduces the shelf-life of certain agricultural products (e.g., meat and vegetables) in absence of food storage technologies. Both, crop yield and product shelf-life, influence the food prices, which directly affect food availability and security.

Using the following linear fixed-effects model, we estimate the impact of frequency of high-temperature days on major food prices:

$$P_{imr} = \alpha + \beta T_{imr} + \lambda_m + \phi_r + \epsilon_{imr} \quad (2.7)$$

where P_{imr} is the price of a food item (i), in the month (m), and sold in the agro-climatic zone (r). T is the number of high-temperature days in a month. Vector of month fixed effects, λ_m, captures all unobserved seasonal characteristics (e.g., the supply of certain locally grown food items). Similarly, agro-climatic region fixed effect, ϕ_r, controls for time-invariant characteristics of each market in the geographic regions (e.g., transportation costs, labor costs, and production costs). Finally, robust standard error, ϵ, is clustered at the district level.

Table 2.6 presents how high-temperature days impact the retail price of major food items. We estimate statistically significant and positive impact on rice, meat, and milk. One additional high-temperature day in a month increases the per kilogram retail price of rice and meat by Rs. 0.32 and Rs. 1.64 respectively. On the other hand, we do not find statistically significant impact of high-temperature days on wheat, vegetables, and lentils.[21] High-temperature days have

[20] Due to warmer winters, some hilly parts of Nepal can grow certain crop (e.g., millet) in winter that was not cultivated previously. Similarly, warmer winters have reduced livestock death during the cold season (Machhi et al., 2015).

[21] To put this into prospective, average per capita food consumption is Rs. 2,527 per month, in 2016 constant Nepali Rupees (Government of Nepal, 2016). Assuming a person consumes half a kilogram of rice per day, an additional high-temperature day in a month increases rice consumption budget by Rs. 4.80 or 0.2 percent. Similarly, assuming the same person also consumes one kilogram of meat per week, meat consumption increases the monthly budget by 0.3 percent. Together, they increase the monthly budget by 0.5 percent per person when there is an additional high-temperature day in a month. This can impact household welfare when the largest share of food expenditure is spent

stronger negative effects on high commodity food (rice and meat) compared to low commodity staples (wheat and lentils).

Increase in food prices, particularly in developing countries, reduces household welfare (Tiberti & Tiberti, 2018). The inward shift in budget curve limits opportunities for families to invest in human capital, including nutrition and health. This has long-term negative consequences on health capital accumulation. Evidence from Nepal shows that the increase in food prices reduces household welfare (Shrestha & Chaudhary, 2012).[22] Therefore, increase in high-temperature days negatively impacts food availability and security, which in turn affects health capital investment during pregnancy.

2.8.2 Effect of High-Temperature Days on Antenatal Care Utilization

High-temperature days can directly affect health intervention through antenatal care utilization (Wilde et al., 2017) or by altering the disease environment (Rylander et al., 2013). For antenatal care utilization in Nepal, distance to health post is a major hindrance as it requires considerable geographical mobility (Maleku & Pillai, 2016). About 23.4 percent of the women reported problems in accessing health care due to distance to health facility (World Bank, 2018). With 82 percent of the household being rural, it requires 1-4 hours for a rural resident to travel to a local health post (Garha, 2017). During hot days, women may reduce antenatal care visitation in order to avoid heat and heat related discomforts. Thus, we expect that the high-temperature days during pregnancy decreases antenatal care utilization.

on the rice and meat, and an average household spends 57 percent of household expenditure in food (Government of Nepal, 2016).

[22] Given that the 80 percent of our sample household own agricultural land, it should be noted that net food-selling and net food-buying households are likely to experience an opposite effects if the food price fluctuates due to high temperature.

To explore how high-temperature days impacts antenatal care utilization, the following linear fixed-effects model is used:

$$C_{imyr} = \alpha + \beta T_{imyr} + \pi X_{imyr} + \delta_m + \lambda_y + \eta_r + \epsilon_{imyr} \quad (2.9)$$

where C_{imyr} is the number of prenatal care visits for a woman (i) who gave birth in the month (m),year (y) and from the agro-climatic region (r). T is the number of high-temperature days in gestation. δ_m controls for the birth-month fixed effect. Similarly, λ_y controls for the birth-year fixed effect, and η_r is the agro-climatic region fixed effect. We also include controls for pregnancy characteristics (X).[23] Finally, to account for spatial correlation, ϵ, is the robust standard error cluster at the household sampling cluster.

As expected, Table 2.7 shows an inverse relationship between number of high-temperature days in gestation and number of antenatal cares. When adding maternal, household and pregnancy characteristics (column 2), we also observe that educated mothers utilize more care, while women utilize less antenatal care in later pregnancy. To avoid additional heat related discomfort, women respond by decreasing the antenatal care utilization.

2.9 Conclusion

We examined the impact of high-temperature days during pregnancy – as a mild exogenous variation in utero environment – on the cumulative measure of early childhood health. Consistent with the fetal programming hypothesis, our findings show that mild shock negatively affects early childhood health. Additional high-temperature day in utero (days with daily mean temperature equal or higher than 32 degree Celsius) reduces height-for-age *z*-score by 0.008 to

[23]Mother and household characteristics include age of the mother and its square, mother's level of schooling, wealth index, household size, and the indicator variable for the rural and Dalit households. Pregnancy characteristic includes the number of pregnancies a woman had (as proxied by birth order). We include pregnancy characteristics because mothers are likely to engage in risky behavior in earlier birth but frequently visit doctors or peruse pregnancy-related knowledge (Lehmann et al., 2014).

0.011 standard deviations for the children younger five. Unlike the persistent effects observed for adverse shocks, the damage appears to be transitory as opposed to persistent, i.e., the impact gradually decreases with age and becomes almost undetectable by age five. We also find that the timing of exposure is important. Compared to first or second trimester, the third trimester has the strongest impacts as the fetus grows dramatically in size and mass.

Besides the aggregate impact of high-temperature days during pregnancy on early childhood health, we use secondary data to investigate the economic channels. We explore the impacts of high-temperature days on food prices and antenatal care utilization. Our findings suggest that high-temperature days has a stronger and statistically significant impact on high commodity food (rice and meat). In addition, high-temperature days during pregnancy reduces antenatal care utilization as it requires considerable geographical mobility. Both channels, nutritional and health, can lead to negative health outcome in early childhood.

As climate change can fundamentally alter the earth's climate system threatening child wellbeing, our findings have important implication for policies that aim at increasing childhood health and mitigating damages from climate change. In the case of Nepal, the Sustainable Development Goal, 2016-2030, targets under-five stunting reduction to 1 percent by 2030, a bold target given the current stunting rate at 40 percent (Devkota, et al., 2016). High-temperature days not only slows progress in reducing child stunting and under nutrition, but it also has the potential to reverse the recent gain. Beside policies to tackle climate change, the child wellbeing policies should treat high-temperature days as an uterine stressor. When 61 percent of women are unaware of the climate change or global warming, such policies may include increasing awareness of climate change and its impact on pregnant women. More importantly, focus should be given to the fact that the impact of increasing high-temperature days can channel through various aspects of life and livelihood.

Figure 2.1: MICS household cluster and weather station distribution

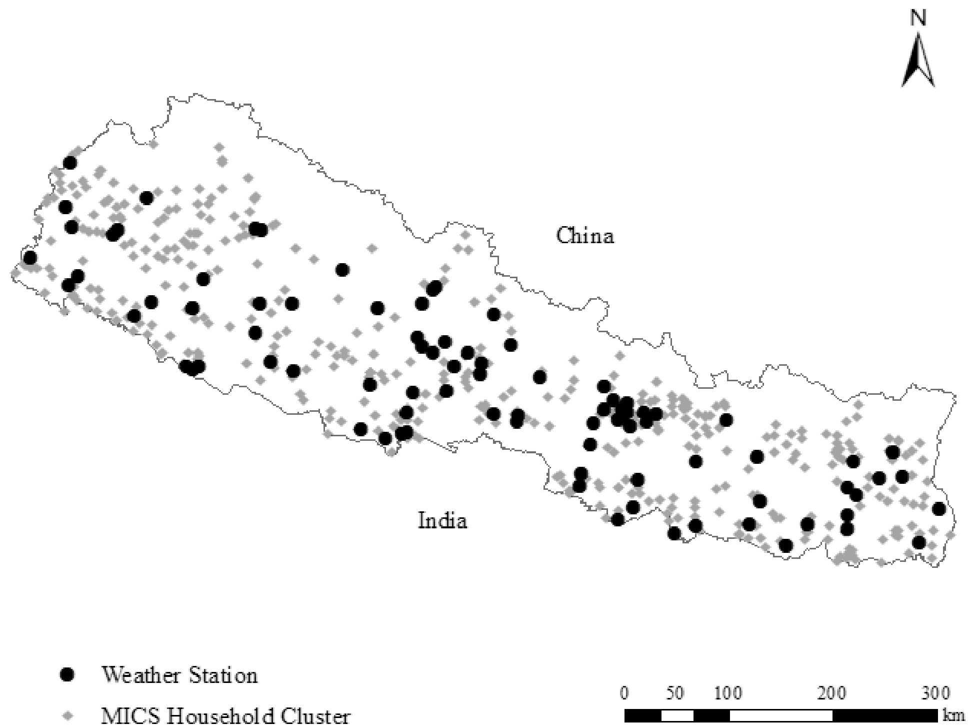
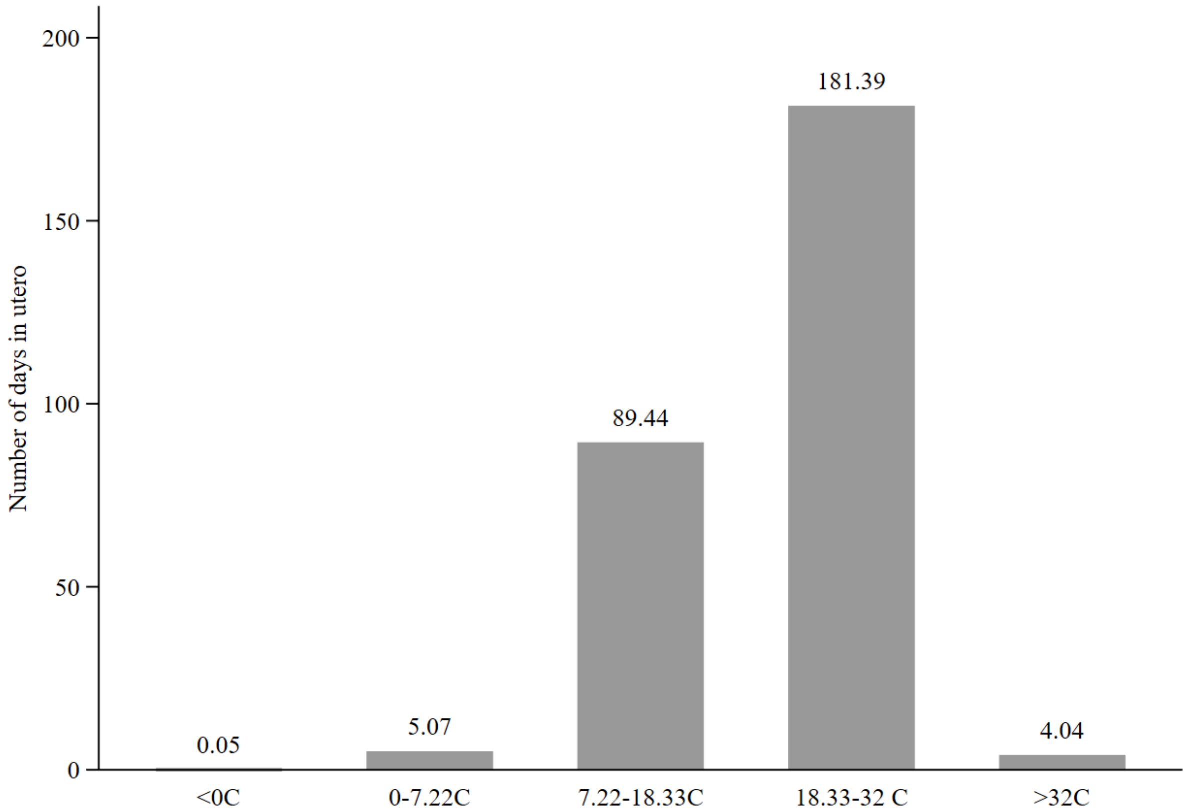
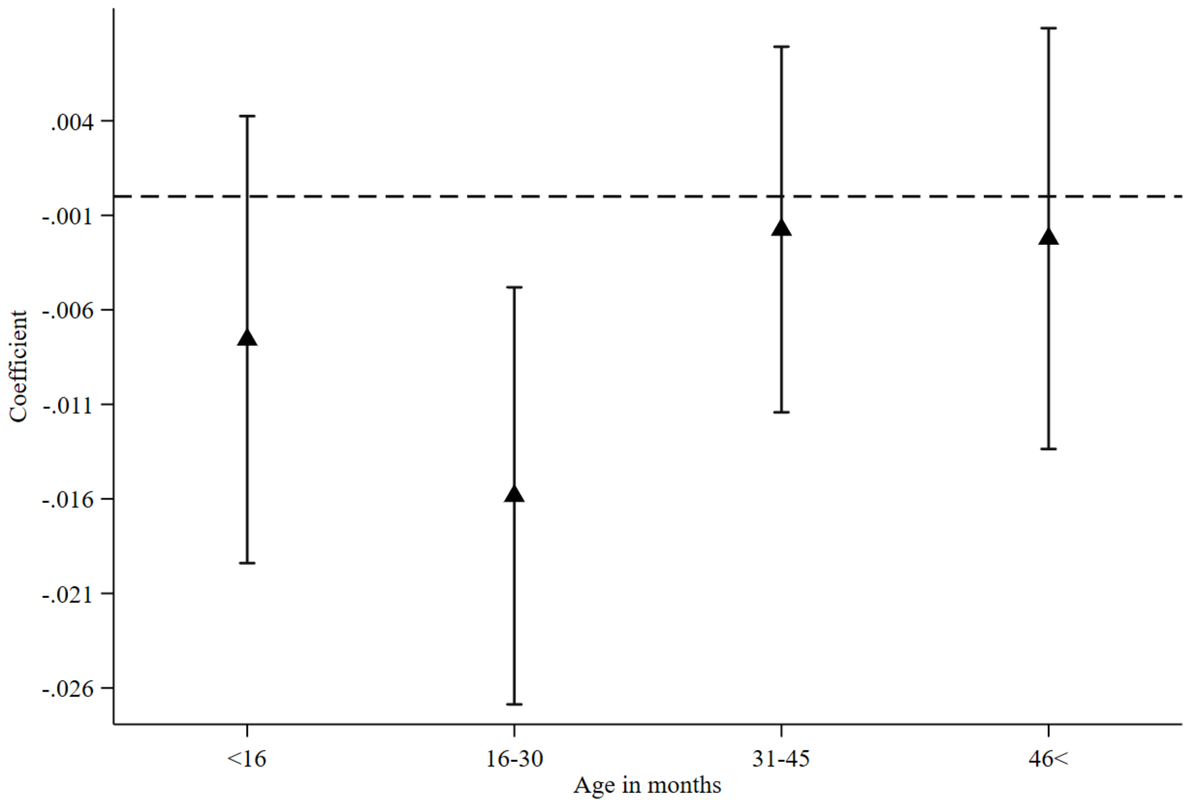


Figure 2.2: Distribution of daily mean temperature during gestation



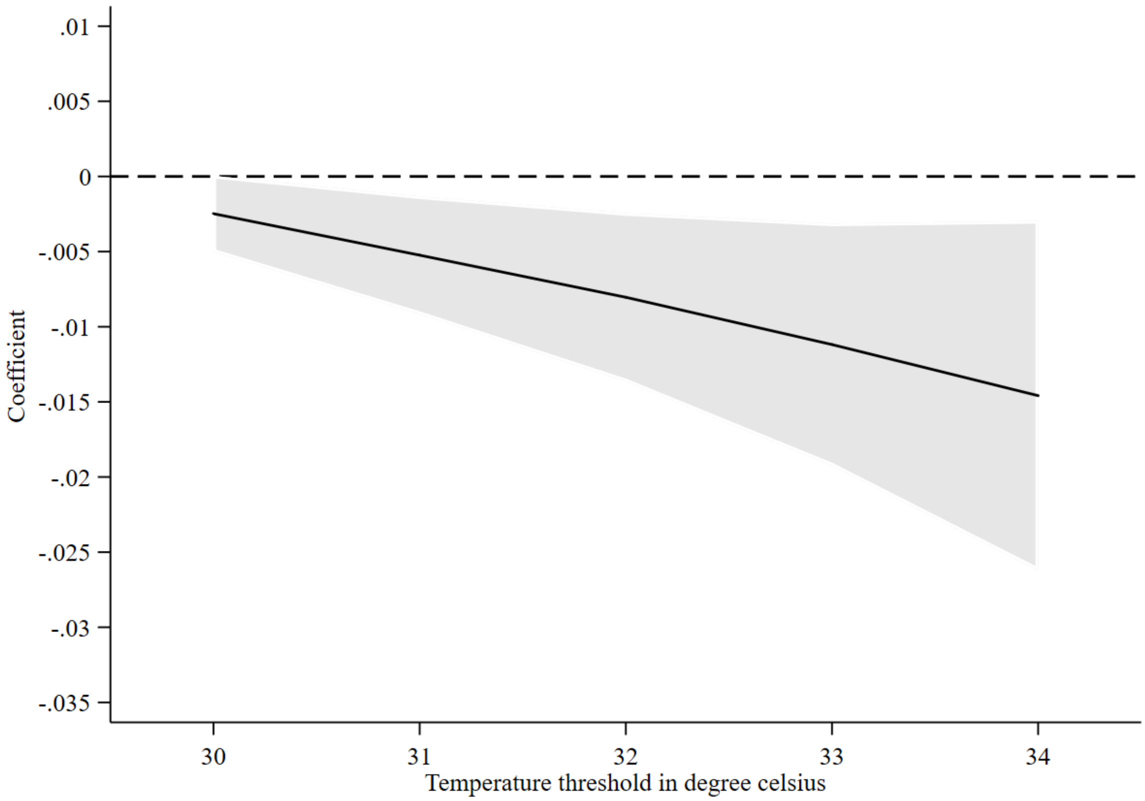
Note: Temperature reported in degree Celsius (C).

Figure 2.3: Effect of high-temperature days in utero on the height-for-age z-score for different sub-samples



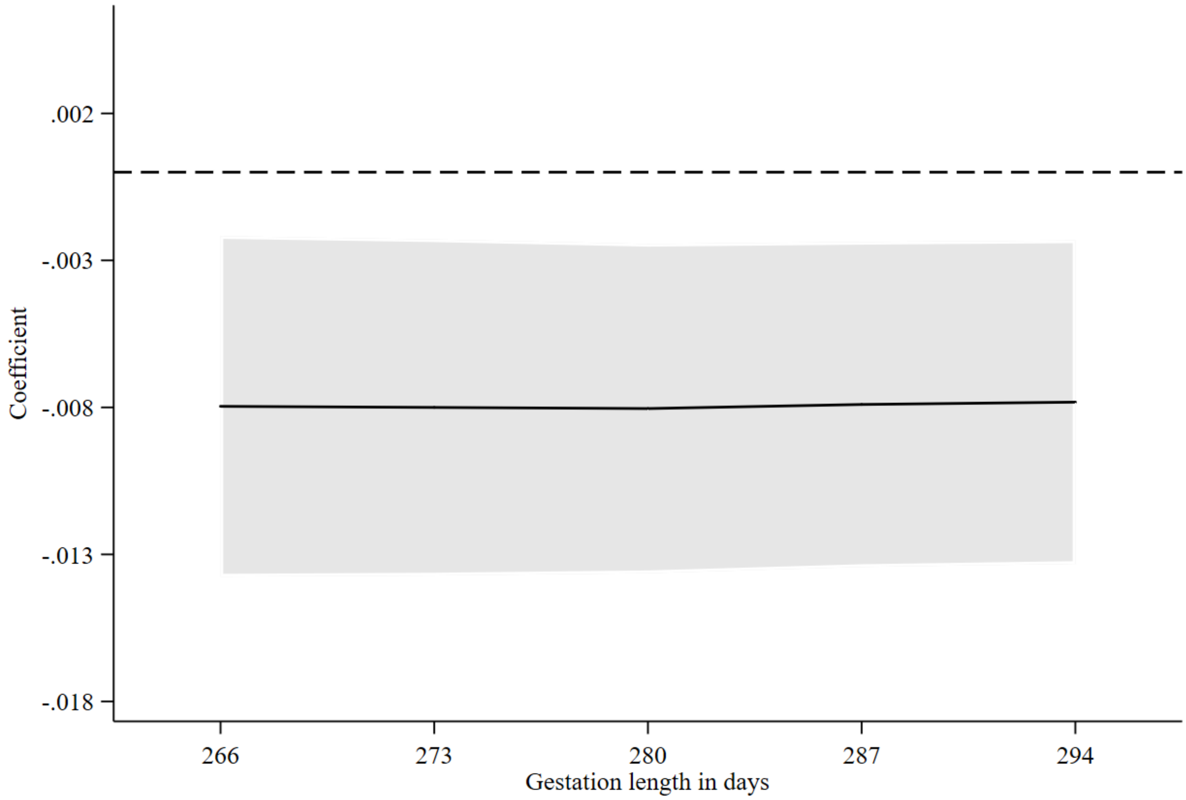
Note: Coefficient estimated using Model 4 Table 2 for different subsample.
The dot represents the point estimate with 95% confidence Interval.

Figure 2.4: Effect of high-temperature days in utero on the height-for-age z-score: Using different threshold for high-temperature day



Note: Coefficient estimated using Model 4 Table 2 for different threshold for high-temepature days.
The line represents the point estimate with 95% confidence Interval.

Figure 2.5: Effect of high-temperature days in utero on the height-for-age z-score: Using different definition of gestation length



Note: Coefficient estimated using Model 4 Table 2 for different definitions of gestation length.
The line represents the point estimate with 95% confidence Interval.

Table 2.1: Definitions and descriptive statistics for child, mother and household characteristics

Variable	Variable Description	Mean (std. dev.)
Height-for-Age z-score	Height-for-age z-score of the children between ages 0 to 60 months. Calculated by MICS using 2006 WHO child growth standards.	-1.653 (1.537)
Female	An indicator variable where 1 = female child and 0 = male child.	0.473 (0.499)
Age of child	Age of the children in months.	30.79 (17.28)
Birth order	Birth order of the children	2.878 (1.728)
Antenatal Care	Number of antenatal care received from skilled health professionals in the last pregnancy.	4.11 (1.71)
Mother's level of schooling	Mother's education level. Categorical Variable: None, Primary, Secondary and Higher.	
None	No formal schooling	0.43 (0.495)
Primary	One to eight years of schooling	0.18 (0.381)
Secondary	Nine to twelve years of schooling	0.21 (0.410)
Higher	More than twelve years of schooling	0.18 (0.386)
Age of Mother	Mothers age at birth (in years).	27.26 (5.931)
Wealth index	Composite indicator of wealth. Constructed by principal component analysis using the information on the ownership of consumer goods, dwelling characteristics, water and sanitation, and other characteristics that are related to the household's wealth.	
Poorest		0.37 (0.481)
Second		0.20 (0.402)
Middle		0.15 (0.357)
Fourth		0.16 (0.362)
Richest		0.13 (0.334)
Household size	Head-count of the people living under the same roof and sharing kitchen.	6.210 (3.068)
Rural	Indicator variable where 1 = rural household, and 0 = Urban household.	0.822 (0.383)

Dalit	Indicator variable: where 1 = Dalit or lower caste as defined by Nepal Census 2011, 0 = otherwise.	0.175 (0.380)
Agro-climatic region		
Mountain	Climate and agro-ecological zone of Nepal with elevation (from sea level) 2000 meters or above.	0.289 (0.453)
Hill	Second climate and agro-ecological zone with an elevation ranging from 300 to 2000 meters.	0.364 (0.481)
Terai	Third climate and agro-ecological zone with elevation ranging from 60 to 300 meters.	0.347 (0.476)
Observations		4704

Table 2.2: Definitions and descriptive statistics for major food items

Variable	Variable Description	Mean (std. dev.) [Observations]
Rice	Mean wholesale price per kilogram of various rice quality – coarse, medium, fine and flattened local rice.	41.83 (10.26) [1043]
Meat	Mean wholesale price per kilogram of chicken, mutton, and buffalo meat.	265.4 (56.99) [1021]
Milk	Mean wholesale price per liter of milk (could be cow or buffalo milk).	49.44 (12.15) [1029]
Wheat	Wheat flour wholesale price per kilogram.	40.19 (9.720) [1040]
Vegetables	Wholesale price of a vegetable basket consisting of one kilogram of each of the vegetables – potato, tomato, cauliflower, and cabbage.	134.5 (25.61) [995]
Lentil	Mean wholesale price of lentil, per kilogram.	105.8 (16.56) [994]

Note: All price are in 2016 constant Nepali Rupees, calculated using the Consumer Price Index from the World Bank.

Table 2.3: Effect of high-temperature days in utero on the height-for-age z-score

	Height-for-Age *z*-score			
	(1)	(2)	(3)	(4)
High-temperature	-0.0108***	-0.0107***	-0.00980***	-0.00804***
	(0.00303)	(0.00305)	(0.00291)	(0.00285)
Child Characteristics		√	√	√
Mother Characteristics			√	√
Household Characteristics				√
Birth-month fixed effects	√	√	√	√
Birth-year fixed effects	√	√	√	√
Agro-climatic region fixed effects	√	√	√	√
R-squared	0.117	0.117	0.150	0.176
Observations	4704	4704	4704	4704

Notes: The child characteristics include gender, age, and birth order, whereas mother characteristics include mother's education and mother's age at birth. The household characteristics include household size, household wealth quintile, elevation from the sea level, indicator variable whether a household is a rural or urban residence, and an indicator variable whether the household is a member of a lower caste. Robust standard errors in parentheses clustered at the household sampling cluster unit.
* p < 0.10, ** p < 0.05, *** p < 0.01

Table 2.4: Effect of high-temperature days in utero on the height-for-age z-score by trimester

	Height-for-Age z-score			
	(1)	(2)	(3)	(4)
First Trimester	-0.0117**	-0.0118**	-0.00957*	-0.00747
	(0.00578)	(0.00579)	(0.00541)	(0.00532)
Second Trimester	-0.00540	-0.00523	-0.00584	-0.00376
	(0.00451)	(0.00452)	(0.00450)	(0.00443)
Third Trimester	-0.0163***	-0.0161***	-0.0147***	-0.0136***
	(0.00519)	(0.00519)	(0.00504)	(0.00498)
Child Characteristics		√	√	√
Mother Characteristics			√	√
Household Characteristics				√
Birth-month fixed effects	√	√	√	√
Birth-year fixed effects	√	√	√	√
Agro-climatic region fixed effects	√	√	√	√
Observations	4704	4704	4704	4704
R-squared	0.118	0.118	0.150	0.176
P-value ($3^{rd} = 2^{nd}$)	0.05	0.055	0.10	0.07
P-value ($1^{st} = 2^{nd}$)	0.37	0.58	0.058	0.08

Notes: The child characteristics include gender, age, and birth order, whereas mother characteristics include mother's education and mother's age at birth. The household characteristics include household size, household wealth quintile, elevation from the sea level, indicator variable whether household is a rural or urban residence, and an indicator variable whether the household is a member of a lower caste. Robust standard errors in parentheses clustered at the household sampling cluster unit.
* p < 0.10, ** p < 0.05, *** p < 0.01

Table 2.5: Effect of high-temperature days on the probability of child being female

	Probability of being a female child		
	(1)	(2)	(3)
High temperature Days	0.0000619	0.0000875	0.0000263
	(0.000822)	(0.000822)	(0.000815)
Mother & pregnancy characteristics		√	√
Household characteristics			√
Birth-month fixed effects	√	√	√
Birth-year fixed effects	√	√	√
Agro-climatic region fixed effects	√	√	√
Observations	4704	4704	4704
R-squared	0.008	0.010	0.011

Notes: The results are using the linear probability model. Mother characteristics include mother's level of education, indicator variable whether mother is a rural resident and indicator variable for the caste. Pregnancy characteristics include mothers' age at conception and pregnancy order (or birth order). Household characteristics include wealth index, household size, and elevation. Robust standard errors in parentheses clustered at the sampling cluster unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.6: Effects of high-temperature days on food prices

	(1) Rice	(2) Meat	(3) Milk	(4) Wheat	(5) Vegetables	(6) Lentil
High-temperature days	0.315**	1.642**	0.249**	-0.0684	0.235	0.234
	(0.123)	(0.724)	(0.121)	(0.0742)	(0.204)	(0.204)
Month fixed effects	√	√	√	√	√	√
Agro-climatic region fixed effects	√	√	√	√	√	√
R-Squared	0.168	0.081	0.013	0.359	0.052	0.052
Observation	1,043	1,021	1,029	1,040	995	994

Notes: High-temperature days in month is defined as the number of days with daily mean temperature equal to or higher than 32C. The wholesale prices are in constant 2016 Nepali Rupees. Except column 3, which is measured in Liters, the foods are measured in kilograms. Further definition of the food items can be found in Table A.2. Robust standard errors in parentheses clustered at the district level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.7: Effect high-temperature days on antenatal care utilization

	Antenatal Care Utilization	
	(1)	(2)
High-temperature days	-0.0163***	-0.0110**
	(0.00478)	(0.00472)
Mother, pregnancy and household characteristics		√
Birth-month fixed effects	√	√
Birth-year fixed effects	√	√
Agro-climatic region fixed effects	√	√
R-Squared	0.061	0.207
Observation	2091	2090

Notes: Mother and household characteristics include age of the mother and its square, mother's level of schooling, wealth index, household size, and the indicator variable for the rural and Dalit households. Pregnancy characteristic includes the number of pregnancies a woman had (as proxied by birth order). Robust standard errors in parentheses clustered at the sampling cluster unit.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 3: Effect of Maternal Inputs on Child Outcomes: Does the Gender Matter?

3.1 Introduction

Differing parental investment by gender may be a source of worse adult outcomes in women compared to men. Girls face early life disadvantages in nutrition (e.g., Strauss & Thomas, 1995), vaccination rates (e.g., Barcellos et al., 2014), breastfeeding (e.g., Barcellos et al., 2014; Jayachandran & Kuziemko, 2011), child care (e.g., Barcellos et al., 2014), vitamin supplementation (e.g., Barcellos et al., 2014), time spent (e.g., Baker & Milligan, 2016; Bono et al., 2016), prenatal care (e.g., Bharadwaj & Lakdawala, 2013), health care (e.g., Ganatra & Hirve, 1994), money spent (e.g., Karbownik & Myck, 2017), and neglect and mistreatment (e.g., Koolwal, 2007).[24] These investment gaps, especially pronounced in the developing countries, create early disparity among boys and girls, are persistent over time, and limit girls from reaching full potential.

Higher demand for males is a common rationale for the investment gap between boys and girls from South Asian countries, mainly due to preferring to have sons over daughters because of the cultural and economic incentives (Jayachandran, 2015). However, son-preference varies within and across populations, and over time (Lundberg, 2005). In other words, son-preferences may change from one generation to another (e.g., Choi & Hwang, 2015) or among different institutional settings (e.g., bridal dowries vs. bride price). Moreover, in principle, son-preference does not necessarily imply that daughters are treated differently or receive less investment under normal circumstances (Duflo, 2005).

Like the gender differences in parental investment, the investment choices may vary by the gender of the parents, i.e., mothers and fathers may not have identical preferences in rearing

[24] Others have found no evidence of differential treatment in vaccination rates in India (Deaton, 2003) and in parental spending (Deaton, 1997).

boys versus girls (Lundberg, 2005).[25] Along with other resources, the gender of the parents may elicit differential parent-child interaction among young children. For example, fathers tend to spend more time with their sons, whereas mothers tend to prefer daughters (e.g., Lundberg, 2005; Lynch et al., 2018; Nikiforidis et al., 2018; Raley & Bianchi, 2006). More importantly, sons and daughters are treated more differently by fathers than mothers (Siegal, 1987). Mother's discriminatory treatment of boys and girls, if present at all, is comparatively fewer (Siegal, 1987).

As mothers are more likely to be egalitarian in treating boys and girls, Nepal provides an interesting scenario to examine the relationship between child gender, maternal time-input, and child outcomes. Known for strong son-preference due to the patrilineal system, Nepal has experienced a wave of legal reforms and institutional changes in recent decades, including governmental efforts to increase education and family planning.[26] Through legislative reforms, Nepal legalized abortion with the prohibition of sex-selective abortion in 2002 (Lamichhane et al., 2011) and allowed birthright citizenship through mother in 2006 (Nepal Citizenship Act, 2006). In 2007, the amendment of the Interim Constitution granted an equal claim to ancestral property to sons and daughters regardless of material status or age of the daughter. Besides, Nepal reformed divorce and domestic violence laws to protect women in 2009 (Domestic Violence Act, 2009). These reforms not only diminish the patrilineal social system but also elevate women's status in the society by empowering them, which may have facilitated the convergence in boy-girl outcomes in early life (e.g., Allendorf, 2007; Cunningham et al., 2019;

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[25] Age, education level, and working status influence how parents invest by a child's gender (e.g., Bharadwaj et al., 2014).

[26] Ministry of Health and Population, Government of Nepal, has prioritized child wellbeing by implementing policies and interventions in coordination with various international organizations like World Bank, World Health Organization, and United Nations Children's Fund. Such programs include prenatal care, childcare training, reproductive health, etc. The current and past programs are available on the website: https://www.mohp.gov.np/eng/#.

Self, 2015).

In recent years, Nepal has made considerable progress in boy-girl gap reduction in terms of childhood outcomes. Unlike countries with well-documented son-preference, the sex ratio at birth in Nepal, at best, shows weak bias towards girls. Nepal Census of 2011 reports the sex ratio at birth to be 1.07, which falls close to the natural rate of 1.05 (Frost et al., 2013). This shows that discrimination based on the sex of a fetus may not be prevalent, which means there is no systematic reason that boys receive greater prenatal care. Moreover, the gap between boys and girls is narrowing in terms of primary school attendance, child stunting, and infant mortality (Ghosh et al., 2009; Khanal, 2018). For example, the female-male primary school enrollment ratio and the gender-specific infant mortality rate ratio are converging toward unity. A recent reduction in child stunting was equally favorable for both sexes (Ghosh et al., 2009).[27]

Due to the reducing boy-girl gap in childhood outcomes and changing institutional settings, social scientists have observed an increasing favorable perception toward girls in Nepal. For a long time, Nepalese women have expressed their desire to have at least one living child of each sex for an ideal family (Karki, 1988). This sentiment is more obvious in recent years; young Nepalese mothers believe that "girls were just as good as boys" and that they do not "favor one over the other" (Brunson, 2010). Brunson (2010), therefore, concluded that Nepalese women might value daughters as much as sons on an ideological level. Despite stating the indifference to a child's gender, women "reluctantly admit" to needing a son because of "social continuity" (Brunson, 2010). Consequently, son-preference may not be as strong as it used to be a few decades ago, especially among young couples and mothers. As Lundberg (2005) argued that son-preference for mothers might not be an actual preference *per se*, rather, it may be the result of

[27] Some studies show persistent male preference in Nepal (see, for example, Hatlebakk, 2017; Koolwal, 2007; Rai et al., 2014).

social and cultural constraints, maternal preference for a child's particular sex may be exogenous in Nepal, at least in the early years of life.

If son-preference for Nepalese mothers results from social and cultural constraints, their preferences should be revealed when the constraints are less binding such as dealing with infants or young children. Young children spend more time with their mothers as they are the primary caregiver. Mothers have greater autonomy in resource allocation, especially the time inputs. Even though having a son can have a different intra-household dynamic than having a daughter (e.g., Lundberg, 2005; Raley & Bianchi, 2006), the social position of girls and boys can be similar at the young age, and their economic value is trivial. Similarly, compared to other resources, maternal time inputs give greater flexibility to mothers on how they engage with the young child. Unlike maternal time input, allocation of resources (e.g., nutrition, health care, vaccination, spending) within a household may depend on the household head or decision-maker, especially in the patrilineal system. Therefore, we expect no gender differences in maternal time input for young children if their son-preference is a result of social and cultural constraints.

With this background, we examine the maternal gender preference by revisiting two old questions in the context of Nepal: (a) does the gender of a child affect maternal time investment for preschool children? And (b) how does maternal time investment affect child educational and behavioral outcomes? Maternal time input is an important component of child development necessary for human capital accumulation (Bono et al., 2016; Campana et al., 2017; Fiorini & Keane, 2014; Hsin & Felfe, 2014). Yet surprisingly very little is known about how maternal time investment varies by gender in a strong son-preference, lower-income country, where mothers are usually the primary caretakers.

Using a sample of preschool children (ages 36 to 59 months) from a nationally representative Multiple Indicator Cluster Survey (2014) from Nepal, we find that the mothers invest fairly equal time among boys and girls. They do not show preferential treatment to a particular gender in educational or structural activities. We, therefore, infer that Nepalese mothers do not prefer sons over daughters, at least, among preschool children in time investment. If gender effect exists on how mothers treat boys versus girls, it should be from other unobserved variables. Alternatively, the outcome gap between boys and girls due to early life investment should be from other sources (i.e., fathers or other household decision-makers).

If, indeed, mothers do not discriminate based on a child's gender in early life, then, from a policy perspective, it is important to understand the relationship between maternal time inputs and child educational and behavioral outcomes. Compared to men, Nepalese women still suffer from worse life outcomes in terms of mean years of schooling, decision making power, and childcare responsibility (e.g., Lamichhane et al., 2011; Self, 2015). Consistent with prior research (e.g., Bono et al., 2016; Campana et al., 2017; Fiorini & Keane, 2014; Hsin & Felfe, 2014), the maternal time investment is an important predictor of child outcomes in our sample. We find a positive and significant effect of mother-child activities on preschool children's educational and behavioral outcomes.

The rest of this paper is organized as follows: Section 2 provides a brief overview of the existing research. Section 3 offers data and descriptive statistics. We discuss empirical models in Section 4. In Section 5, we present our findings. We discuss why mothers invest equally in both sexes in Section 6. Finally, we present our conclusions in Section 7.

3.2 Background

Disparities in later-life outcomes have led many researchers to explore the role of premarket factors like parental time inputs during childhood to explain the boy-girl gap. They document that these gaps emerge in early childhood as parents may invest differently based on gender. In this section, we summarize recent works on the gender effect on maternal time inputs, and the effect of maternal time input on preschool child outcomes.

3.2.1 Effect of Gender on Maternal Time Input

Becker (1957) popularized the study of discrimination in Economics, but Sen (1990) drew attention to gender discrimination in developing countries with a strong son-preference. Sen (1990) reported about 100 million *missing women* (i.e., a phenomenon of the involuntary death of young girls due to a lack of medical care and food in early life in countries like India, China, and Nepal). In contrast to Sen's account, Anderson & Ray (2010) found that missing women occur at later ages in India as instead of prenatal or early childhood factors. Before age five, missing women account for a mere 15 percent of death in India, mainly due to diseases (Anderson & Ray, 2010). Therefore, discrimination at an early age may not be as prevalent as previously reported.

Although time inputs are more productive than the monetary investment (Del Bono et al., 2014), economists have not emphasized time inputs in the empirical analysis (Francesconi & Heckman, 2016). In developing countries, research on gender differences at an early age primarily focuses on health inputs or nutritional intakes, as they remain relatively important in human capital accumulation (e.g., Barcellos et al., 2014; Jayachandran & Kuziemko, 2011; Pande, 2003). As a result, few studies focus on parental time investment, let alone maternal time investment. Our understanding – the relationship between parental time investments and gender – are mostly drawn from developed countries. Even in developed country settings, there is much less evidence of boy-girl differences in maternal inputs for preschool-aged children.

Earliest studies use the tradeoffs between labor supply or hours worked and parental time investment to predict time allocation among the children of different sexes (e.g., Bernal, 2008; Guryan et al., 2008). If parental labor supply increases (or decreases) after the birth of a child, their work reduces the amount of time available to spend with the children. While showing an increase in the father's labor supply after the birth of a son, Lundberg & Rose (2002) confirmed "substantial" prior evidence that mother's labor supply decreases after birth, which means mothers have more time to invest in infants or young children. Nonetheless, even if employed, mothers equally spend time with children of both sexes (Hsin & Felfe, 2014). In a study using a sample of children in the US, Yeung et al. (2001) found that women spend more time with daughters, or parents are more likely to provide enriched caregiving (like engaging in more responsive interactions) with children who are of the same gender as them than those of the opposite. Recent research, however, exploit time-use surveys to link maternal time investment and the child's gender.

In a sample of children from Canada, the United States, and the United Kingdom, Baker & Milligan (2016) showed that parents spend more time in teaching activities with preschool girls than boys. For non-educational mother-child interactions (like playing games), mothers invest equally in boys and girls. However, boys receive more total time compared to girls, a result of extra time input from the father. Fiorini and Keane (2014) found similar results (i.e., parents spend more time with girls in educational activities) in an Australian study.[28]

[28] While preparing this manuscript, we were unable to find economic empirical papers on the maternal time investment by gender in the lower-income countries. There are a few possible explanations. First, mothers are generally primary caregivers for preschool children and have low labor force participation. Mother's time investment, thus, may not attract researchers. Second, it may be due to data limitation; the time-use survey or mother-child interaction data are not widely available for developing countries. Third, health and nutritional inputs still is a bigger issue in relation to policy and developmental goals.

3.2.2 Effect of Maternal Time Investment on Child Outcomes

Maternal time input is a part of the total cost of rearing children, i.e., human capital production function connects the child outcomes resulting from a combination of inputs, including maternal (or paternal) time input. Time input is linked with better cognitive and non-cognitive outcomes (e.g., Baker & Milligan, 2016; Bono et al., 2016). In particular, mother-child interaction seems to be relatively more important as most human capital models focus on maternal input (Francesconi & Heckman, 2016). While maternal time input is positively correlated with cognitive outcomes, a higher frequency of mother-child interaction is related to lower hyperactivity, less physical aggression, more prosocial behavior, and less anxiety at age four (National Institute of Child Health and Human Development, 2003). Surprisingly, little is known regarding maternal time input and child outcomes in a developing country context as most of the research still focus on health inputs and nutritional intakes (Barcellos et al., 2014; Jayachandran & Kuziemko, 2011; Pande, 2003).

The earliest research linked maternal time inputs and child outcomes using maternal employment or hours worked as a proxy for the time input, assuming maternal employment leads to fewer hours available for child-rearing. Because not all the non-employment hours are allocated for childcare (Del Boca et al., 2016), recent studies apply time-use surveys. Using a sample of British children ages 3 to 7, Del Bono et al. (2016) found that maternal time investment is related to better cognitive and non-cognitive outcomes. A positive relationship between maternal time investment and various child outcomes is documented in Australia (e.g., Fiorini & Keane, 2014), the United States (e.g., Guryan et al., 2008; Del Boca et al., (2012); Hsin & Felfe, 2014), and the United Kingdom (e.g., Bono, 2016; Dickson et al., 2016).

Although maternal time investment is an important predictor of life outcomes, children's age is sensitive toward time inputs. Del Boca et al. (2016) showed that the value of maternal time inputs decreases with the child's age. Similarly, Del Boca et al. (2012) documented that a child's own time investment is important during adolescence, albeit maternal time inputs are more important when children are 6-10 years old. More importantly, while a mother's time investment helps both young and old children to perform better in cognitive tests, the effect is stronger among younger children who are 3-6 years old. In another study that employs time-use diaries of Australian mothers, Kalb & van, Ours (2014) found significant associations between mother's time investment and a range of child development for children ages 4 and 5 years. In conclusion, maternal time input may be most important during preschool years than in infancy or much later.

Not only that the child's age is sensitive towards maternal time investment, but the type of maternal activities is also equally important. In some instances, the type of mother-child interaction may matter more than the total time spent together (Fiorini & Keane, 2014; Hsin & Felfe, 2014). For example, reading and storytelling help children in cognitive development, whereas leisure activities (e.g., playing games, taking outsides) helps behavioral growth. Disaggregating maternal time investment into various components, Hsin & Felfe (2014) analyzed the effects on child outcomes by three types of time investment: time spent in educationally oriented activities (e.g., reading and doing homework), time spent in structured activities (e.g., performing music and playing sport), and time spent in other unstructured activities (e.g., watching television and doing nothing). They find that engaging children in educational activities have a positive effect on children's cognitive development in a sample of children from the United States. In another study, Fiorini & Keane (2014) find that cognitive skills are affected by the education inputs (such as reading a story); however, non-cognitive skills are insensitive to alternative time allocation.

Furthermore, maternal characteristics influence parenting style, which ultimately dictates how a mother chooses to invest time among children. One characteristic, education level, seems to stand out (e.g., Guryan et al., 2008). Although all children benefit from spending time with mothers and spending time on educational activities, well-educated mothers tend to spend larger share of time with their children and on educational activities. For example, college-educated mothers, all else equal, spend 4.5 hours more per week in child care than mothers with a high school degree or less for a sample of children in the United States (Guryan et al., 2008). They also documented that mothers from a higher socio-economic class tend to spend more time with their preschool children. Hsin & Felfe (2014) reached a similar conclusion – that college-educated mothers spend more time with their children compared to mothers with a high-school diploma by 1.6 hours per week.[29] Despite lower labor force participation, educated mothers in developing countries devote more time to educational childcare (Campana et al., 2016).

3.2.3 Theory and Background: Why would a Nepalese mother treat girls and boys differently?

Economists propose three non-mutually exclusive explanations that potentially lead to differential parental investment based on gender: production function, cost of investment, and preferences (Baker & Milligan, 2016). The production function hypothesis maintains that the same sets of input can yield different outcomes for boys and girls due to the biological processes. Further, boys and girls may possess a natural advantage in specific skill sets. For example, girls perform better in language performance than boys, with differences appearing as early as 2- to 3-year-old children (Burman et al., 2008). To overcome the natural deficit among boys and girls,

[29] It should be noted that better-educated mothers tend to be fully employed. Because of the employment, it is also possible that educated mothers may not spend a lot more time with the children (for discussion see, Guryan et al., 2008; Hsin & Felfe, 2014; Yeung et al., 2002).

parents may invest differently by gender to supplement developmental needs—or, they may believe that boys and girls should be reared differently. In the case of Nepal, we are unable to find any evidence of differential maternal investment due to the production function.

The second explanation is that the boy-girl investment disparity may arise because of the monetary and non-monetary (e.g., time inputs) cost differences in child-rearing. The goods and services marketed for girls are usually expensive compared to boys. For example, parents pay a higher cost for female clothing, recreation (e.g., toys), and hobbies (Karbownik & Myck, 2017). In the case of Nepal, there is no clear evidence of cost differences by gender, at least among preschool children. Given strong son-preference, it is convincing to assume that girls face higher childcare costs. For example, relatives (particularly grandparents) may prefer to look after sons but not daughters, thereby limiting childcare options for the parents.

Parental preferences and constraints also influence differential investment by gender. In Nepal, son-preferences are largely motivated by economic reasoning and social norms, as discussed by Jayachandra (2015) for developing countries. Economically, maternal investments are a cost of production (in this case child's skills); mothers invest in that child who may yield the highest return in the future. They have higher incentives to invest in a male child compared to the female child, as men tend to participate in the labor market more frequently and at a younger age. Males also have higher labor market opportunities. In addition, sons not only inherit family wealth but also are responsible for providing for the family and supporting older parents. They also bring women to the household through marriage, and often with dowry payments. Therefore, boys may receive favorable maternal treatment at an early age than girls.

Culturally, maternal investments may be more or less for girls compared to boys. On the one hand, the patrilineal system permits male children with greater or, in many instances, sole authority in ritual and religious ceremonies (Jayachandra, 2015). They are viewed as a continuity of the family lineage and have greater social status. Due to these social norms, Nepalese mothers have higher incentives to treat boys well (Brunson, 2010). On the other hand, culture shapes how women and men spend time with a child. In terms of maternal time investment, girls may be favored by default through the implementation of strict gender roles. First, males being the preferred gender, father and grandparents have higher incentives to spend time with boys than girls; thus, mothers have less time to spend with sons compared to daughters. Second, a typically socialized mother will likely teach girls different household duties such as cleaning and cooking, mirroring the gendered division of labor in adulthood. Thus, girls may receive more maternal time investment.

3.3 Data and Descriptive Statistics

To examine the relationship between child gender, maternal input, and child outcomes, we use Multiple Indicator Cluster Survey 2014 (MICS), a nationally representative survey from Nepal. MICS-2014 has comprehensive information on mother-child interaction for preschool children (ages 36 to 59 months). It also surveys measures of childhood developmental outcomes and provides a complete birth history of women between the ages of 15 to 49. The final estimating sample has 2309 children from 2216 households.

3.3.1 Maternal Time Input

The MICS-2014 collects information on household members who engage in activities that promote learning and school readiness in the three days preceding the survey. There are seven mother-child interactions recorded: reading books, telling stories, taking the child outside the home, singing songs, playing, and spending time with children in naming, counting, or drawing.

Following Fiorini & Keane (2014), mother-child activities are divided into two categories - educational and structural activities. First, educationally oriented activities include reading, storytelling, and naming/counting that may help a child's cognitive development. Second, structured activities include singing songs, playing, and taking children outdoors that impact behavioral outcome. The MICS-2014 does not collect time-use diaries or frequency of mother-child interaction. Instead, the responses are in binary values – "yes" or "no." The maternal time input is the summation of responses of individual activities.

The frequency of mother-child interaction has been used as a proxy for maternal time inputs. For example, Todd and Wolpin (2007) used the maternal response to create home input measures using the National Longitudinal Survey of Youth -79 Child Supplement section, where the maternal response is binary. Similarly, Bono et al. (2016) exploited the frequency of mother-child interactions as a maternal time investment proxy. Following these studies, we use mother-child interaction as a proxy for maternal time input.

3.3.2 Child Development Outcomes

United Nations Children's Fund (UNICEF) developed and validated the Early Child Development (ECD) Index as a measure for "children's outcomes in a holistic manner" for children between the ages of 36 to 59 months (Loizillon et al., 2017). ECD Index is measured on the four domains of childhood development: language/cognitive, physical, socio-emotional, and approaches to learning, where a child is developmentally on track if s\he is on track in at least three of the four domains. Nested in the four domains, it provides information on ten child outcomes. For this analysis, we also divide the outcomes into two groups: cognitive outcomes and behavioral outcomes. Cognitive questions include whether a child identifies alphabet, words, number, logos, symbols, and count, while the behavioral questions indicate whether a child follows directions, works independently, fights with other children, and distracts easily.

The primary respondent (usually mothers) or the person most knowledgeable about the child provides ECD Index information on child development. The MICS-2014 does not collect data on a scale. Instead, the responses are recorded in binary values – "yes" or "no." The child's developmental measures are the summation of each response. Appendix B, Table B.1 provides the description and construction of child outcome measures.

3.3.3 Descriptive Statistics

Relating early life household environment and child outcomes, researchers have identified two features that can vary for boys and girls. First, boys and girls may grow up in systematically different households. Second, girls demonstrate better cognitive and non-cognitive outcomes in the early years.

Girls may experience a different early life environment than boys. Even if families treat all their children equally, family characteristics are an important determinant of time investment and developmental outcomes (e.g., Kugler & Kumar, 2017). For example, children born to larger families receive fewer resources compared to smaller families, i.e., as family size increases, resource per capita decreases (Bishwakarma & Villa, 2019). In Table 3.1, we observe that girls tend to live in a larger, poorer, and rural household. Growing up in a poorer, rural, and larger household does not necessarily mean that children receive differential maternal time input. On average, boys receive higher maternal input on educational and structural activities. The difference, however, is statistically insignificant.[30]

The differences in cognitive and behavioral outcomes by gender emerge at young ages,

[30] Having a daughter also affects family structure like marriage stability, father's presence in the household, mother-father relationship, and treatment of the women, which impact resource allocation including maternal time input (for example, see, Bharadwaj et al., 2013; Lundberg, 2005; Raley & Bianchi, 2006). In our sample, 99.26 percent of the child lives with both biological parents. Thus, divorce, absentee parents, mother's age at first birth have little impact.

well before preschool (e.g., Baker & Milligan, 2016). In preschool, boys trail girls by about a month in developmental measures (Nakajima et al., 2016). Consistent with these findings, we do observe a slightly better performance of girls in the cognitive outcome, behavior outcome, and Early Childhood Development Index (Table 3.2). In column 4 of Table 3.2, the equivalency test rejects the null hypothesis that boys and girls have the same developmental outcomes.

Overall, our sample consists of fewer female children (48%) but are similar to boys in birth order and age. Mothers of the girls have fewer years of schooling. On average, children of both sexes are from rural (83%), larger (family size is 6.25), and poorer (wealth score is -0.23) household.

3.4 Empirical Models

3.4.1 Effect of Gender on Maternal Time Input

We begin by examining the impact of child gender on maternal input. Because of the ordinal nature of the outcome variable - maternal time investment, it has three levels in increasing investment, coded as 1 = low investment, 2 = moderate investment, and 3 = high investment. Theoretically, the model can be represented as:

$$Input_i^* = \beta_i Female + x_i\beta + \epsilon_i \,, \tag{3.1a}$$

The latent continuous outcome variable, $Input_i^*$, is linear combination of the predictors, x_i, plus a disturbance (ϵ_i). In our model, maternal time investment is the function of the child characteristics, mother characteristics and household characteristics. Since our observed ordinal maternal time investment has three values, and the observed $Input_i$ is generated by the latent variable $Input_i^*$, the probability for each outcome can be written as:

$$\begin{aligned} P[Input_i &= Low\ investment] &&= \Phi(\theta_0 - \beta_i Female + x_i\beta] \\ P[Input_i &= Moderate\ Investment &&= (\theta_1 - \beta_i Female + x_i\beta) - \Phi(\theta_0 - \beta_i Female + x_i\beta) \\ P[Input_i &= High\ investment] &&= \Phi(\theta_2 - \beta_i Female + x_i\beta) - \Phi(\theta_1 - \beta_i Female + x_i\beta) \end{aligned} \tag{3.1b}$$

The equations in 3.1a give the probability of observing an ordinal outcome, where θ is the thresholds or cut points to be projected for each level. The corresponding probabilities for each input level are calculated using maximum likelihood method. With this background, the econometric model can presented as follow:

Female is an indicator variable that takes on the value 1 if the child is a girl. Since girls and boys are living in the systematically different households, we also control, (X), for predetermined characteristics: child characteristics (e.g., age in months and birth order), parental characteristics (e.g., mother's age, mother's education), and household characteristics (e.g., indicators for caste and rural, household size and household wealth index). The identifying assumption is that child sex at birth is random and exogenous, i.e., families with girls and boys are similar in gender preference, and any differences in maternal input can be attributed to the gender of a child. Since the gender variable (*Female)* is binary, the coefficient β captures the average difference in the time investment between girls and boys, given the control variables. We assume that the disturbance, (ϵ_i), is normally distributed.

The data collection process, MICS-2014, ran through five months, meaning mother-child interaction occurred in different months. Given that Nepalese women are central to agricultural and resource management (Goodrich et al., 2017), the survey period can influence mother-child interaction. For example, mothers are busier during the planting period (June-July) compared to the growing period (February – March). Since the MICS-2014 annals the mother-child interactions three days prior to the survey date, we include the survey month fixed effect (Δ_t) to control for the seasonal characteristics that may directly affect mother-child interaction.

3.4.2 Effect Maternal Time Input on Child's Cognitive Outcomes

Theoretically, skill formation is a cumulative process by which current and past inputs interact, along with child endowment, to produce cognitive and non-cognitive outcomes. For example, children who benefit from early human capital investments may benefit more from later investment (dynamic complementarities); or human capital in the earlier period also influences human capital in a later period (self-productivity). In addition, mothers may involve in reinforcing or compensatory investment behavior; that is, inputs are endogenous to the initial child endowment. Since MICS-2014 does not provide information on the past inputs or human capital level, we use contemporaneous specification method, as described by Todd & Wolpin (2007).[31] In contemporaneous specification method, contemporaneous inputs generate the current skills with two assumptions: inputs do not accumulate over time, and inputs are not endogenous to child endowment or initial human capital.

To estimate the effect of maternal input on child outcomes, we use the following contemporaneous linear model.

$$Outcome_i = \alpha_i + \alpha_1 Input_i + \alpha_2 X_i + u_i \tag{3.2}$$

The outcome for the child, i, is the function of the contemporaneous input (i.e., maternal time investment) and a set of the child, maternal, and household characteristics (X). The residual u, includes the effect of lagged inputs and human capital, child endowment, and measurement error. It also captures unobserved maternal or child characteristics. For example, mothers may invest equally in both genders, but the quality of time investment may vary by child gender. For an unbiased estimate of α_1, the omitted factors are assumed to be orthogonal to maternal time

[31] While cross-validating best performing models, Todd & Wolpin (2007) considered different specification on skill accumulation. They found that value added with lagged inputs specifications are better models compared contemporaneous model. Although contemporaneous specification is the least preferred model, it does not demand high quality data.

inputs.

3.3.5 Results

This section documents our main results: the effect of gender on maternal time input and effect of maternal input on child outcomes. We also provide robustness checks and address selection issues.

3.3.5.1 Effect of Gender on Maternal Time Input

Table 3.3 presents the estimate of maternal time input by gender using an ordered probit model. In the first column, we use the sum of all maternal input. In columns 2 and 3, we disaggregate the total input into educational activities and structural activities. In all three models, mothers invest equally in boys and girls; that is, the null hypothesis that the coefficient of *Female* is equal to zero is not rejected.

Our result challenges the maternal son preferences notion in Nepal. Since preferences are less binding for maternal time investment among young children, son preference for mothers may not be an actual preference, as their discriminatory treatment is nonexistent. If mother discriminate based on a child's sex, then it must occur later in life when the social and cultural needs are immensely different. Son preference for mothers, therefore, may be the result of social and cultural constraints.

3.5.1.1 Selection Issues:

To estimate the link between gender and maternal time input, the underlying assumption is that the child's gender at birth is exogenous and random. However, this assumption is only valid in the absence of sex-selective abortion and the gender-specific stopping rule.

In a son-preference lower-income country, sex-selective abortion and the gender-specific stopping rule can be unfavorable to the female child, biasing our sample with a higher number of male children than the natural rate. For sex-selective abortion, the Nepal Census of 2011 reports the sex ratio at birth to be 1.07, which falls within the biologically normal range of 103-107 (Self, 2015). In addition, criminalized sex-selective abortion complicates the availability and use of abortion, particularly for low income and rural households, which constitutes the majority of our sample population. Sex-selective abortions, at best, have a weak impact on our estimates.

Furthermore, the male-biased fertility-stopping rule is that if a male child is born, the family stops having children, but if a girl is born, the family continues to have more children. Because of this, females live in a larger household with more siblings (gender is correlated to family size). As family size increases, resource per capita decreases, including maternal time input.

To address sex-selective abortion and the gender-specific stopping rule, we estimate the gender effect on a sample of firstborn and second-born children in Nepal. Prior literature suggests that sex-selective abortion and gender-specific stopping rules are less important among earlier births (e.g., Bharadwaj et al., 2013). Firstborn children are usually assumed to be more random (e.g., Baker & Milligan, 2016; Choi & Hwang, 2015).[32] Given the higher fertility rate in Nepal and the sample size, we restrict the sample to first and second born. The results in Table B.2 are consistent with the main findings from Table 3.3, i.e., mothers equally investment on both sexes. Using common practice in the literature, i.e., restricting the sample of the firstborn (e.g., Baker & Milligan, 2016), Table B.3 in Appendix reports the effect of gender on maternal input among the firstborn children. Again, the results are consistent with the findings in Table 3.3.

[32] It is possible that families stop having children if the first-born is a boy. However, the fertility rate in Nepal is higher than two children per woman. In our sample, we do not see a higher percentage of the boy until after the third birth. Therefore, the need for the son is not pressing in earlier birth (see, Frost et al., 2013).

Finally, we argue that under-five mortality does not create a sample selection issue due to a higher proportion of female mortality. The common assumption is that female children should experience higher under-five mortality due to lower investment in health and nutrition. Surprisingly, under-five mortality for male children is greater compared to female children (29.9 versus 34.3 per 1000 live births) (World Bank, 2018). Thus, the selection issue does not contaminate our estimates.

3.5.1.2 Heterogeneity

Maternal investments can vary by maternal characteristics, especially among rural and less educated mothers (e.g, Barcellos et al., 2014; Guryan et al., 2008). In Tables B.4 and B.5, we report results for rural households, and mothers with less than or equal to five years of formal schooling. These results are similar to the main results, that is, neither rural mothers nor less educated treat boys and girls differently.

3.3.5.2 Effect of Maternal Time Investment on Child's Cognitive Outcomes

Table 3.4 presents the effect of maternal time investment on child's cognitive outcomes. In the first column, child outcome is a binary variable equal to one if children are developmentally on track on at least three of the four domains as described by UNICEF. The result shows that maternal time input increases the likelihood of a child being developmentally on track. In column 2, we use the composite score of the ECD Index for child developmental measure. Using linear regression, we find a strong positive relationship between child outcome and maternal inputs. In columns 3 and 4, we disaggregate the child outcomes into cognitive and behavioral. Both results show that increasing in mother's input increases the probability of better outcomes. Overall, the results show strong evidence that maternal time input is an important determinant of child outcomes.[33]

We further provide evidence that type of activities – structural or educational – matters in skill formation. Consistent with earlier research (e.g., Fiorini & Keane, 2014; Hsin & Felfe, 2014), we find that maternal cognitive inputs only affect cognitive outcomes but not behavioral outcomes. Moreover, structural input influences behavioral outcomes, not cognitive outcomes (Table 3.5). Our finding means that the type of investment is important in different skill formation.

Finally, in Figures 3.1, 3.2, and 3.3, we plot the predicted probabilities of child outcomes based on maternal and child characteristics. Using the model from Table 3.4 and Column 1, Figure 3.1 shows the predicted probabilities of a child's outcome by age, showing that a child's outcome increases with age while slowly decreases as child age increases. Figure 3.2 shows that the predicted probabilities increase with a mother's years of schooling, meaning that children born to well-educated mothers have better outcomes than those born to less educated mothers. In Figure 3.3, we categorize the mother's time investment into low, medium, and high. Then, estimate the predicted probabilities of a mother's time input by the child's age. Compared to mothers who invest less, the impact maternal input on cognitive outcome decreases for both sexes but increases for mothers who invest more. For high investing mothers, the difference between boys and girls slowly vanishes with a child's age.

3.3.6 Discussion

Our main result shows that Nepalese mothers, at least in observable characteristics, do not discriminate between preschool boys and girls in time investment. In the theoretical section,

[33] In Figure B.6, we present the interaction effect of gender and maternal time input. Consistent with the results presented, the interaction effect is insignificant.

we highlight that if mothers prefer sons over daughters, then discrimination should be from their preferences as sons are economically and culturally more desirable. Our finding is at odds with previous research in Nepal, which consistently show differential maternal investment by gender (e.g., Hatlebakk, 2017; Koolwal, 2007; Rai et al., 2014).

The obvious question is: why would Nepalese mothers equally invest in preschool boys and girls? One possible explanation may be that maternal preference has shifted, which usually occurs when the per capita income increases or the economy moves toward the service industry (Jayachandran, 2015). Economically, changing per capita income or moving toward the service sector means that the relative productivity of females may have increased. Thus, the rate of return on female investment raises, incentivizing mothers to invest in their girls. However, this is not the case in Nepal. Agricultural sector dominates the economy, and the per-capita income is relatively low at $787 (World Bank, 2018).

Alternatively, mothers are spending equal time with boys and girls because the mothers' socialization is passed on to their daughters when teaching them how to perform gender-specific roles, thereby upholding societal expectations of a gendered division of labor. If this is the case, we expect mothers to spend more time in structural activities compared to educational activities. Again, our findings contradict this premise – mothers are equally involved in both activities for sons and daughters. Additionally, it is also possible that the mothers understand the gender-specific needs of the child. Since father and grandparents may spend more time with boys compared to girls, mothers may invest less time, or have fewer hours, with sons compared to daughters. If the mother's concern is that the daughters do not receive enough time in educational activities, then we should expect higher maternal investment in educational activities. As stated earlier, mothers spend equally on boys and girls in education activities.

Furthermore, from a pragmatic point of view, mothers should prefer boys over girls as they enjoy greater wellbeing after the birth of a son than a daughter (Jayachandran, 2015). In this case, mothers would respond with less investment in girls compared to boys in both activities. Again, mothers do not treat young children differently based on sex. Overall, for a sample of Nepalese preschool children, maternal time investments are equal for both genders.

As preferences are not exogenous, markets, economic institutions, and social norms can shape a mother's values, tastes, and personalities, including how they invest in young children. With changing social, legal, and economic scenarios, Nepalese mothers are treating boys and girls equally, at least among preschool children. Because mothers believe that "girls were just as good as boys" and that they do not "favor one over the other" (Brunson, 2010), maternal preferences may not be due to preference *per se*, rather the results of social and cultural constraints. Therefore, when the constraints are less binding (e.g., among preschool ages and time investment), mothers invest equally in boys and girls. However, this does not mean that mothers will not treat their children differently in adulthood.

Our second finding shows the importance of maternal input on child outcomes. This finding can have critical policy implications, i.e., mothers may be the pivotal link that helps young girls catch up with young boys in later life outcomes. With changing socio-economic conditions, female labor force participation will likely increase in the coming decade, shifting the childcare responsibilities from mothers to commercial care providers or other family members. As previously evidenced, parents invest differently in education (i.e., sending boys to high-quality private schools compared to their girl siblings) (Khanal, 2018), they may continue applying the same investment trends in childcare. In that case, the boy-girl gap can stretch further.

3.3.7 Conclusion

Compared to strong evidence of son-preferences in Nepal, our results show a decline in gender-bias in Nepal, especially in terms of maternal time investment among preschool children. That is, we do not observe gender discrimination on educational and structural activities by mothers. Maternal preferences, therefore, may not be due to preference for a particular gender, but due to social and cultural constraints. In part, the large-scale efforts to improve education, women's empowerment, and family planning by the government may have contributed to the change. This finding is particularly significant because maternal time input is an important determinant of both cognitive and behavioral outcomes.

Our study can be improved in a few ways. First, our data do not provide information in minutes or hours spent on childcare. It may be that mothers spend more extended periods caring for sons compared to daughters. The duration of care could be a major concern because mothers tend to misreport based on gender. Second, the contemporaneous specification model for skill accumulation can be improved by adding lagged investments or human capital. Finally, we cannot fully account for sex-selective abortion. Using firstborns reduces our sample by 25 percent.

Figure 3.1: Predicted probabilities of child outcome by gender and child's age

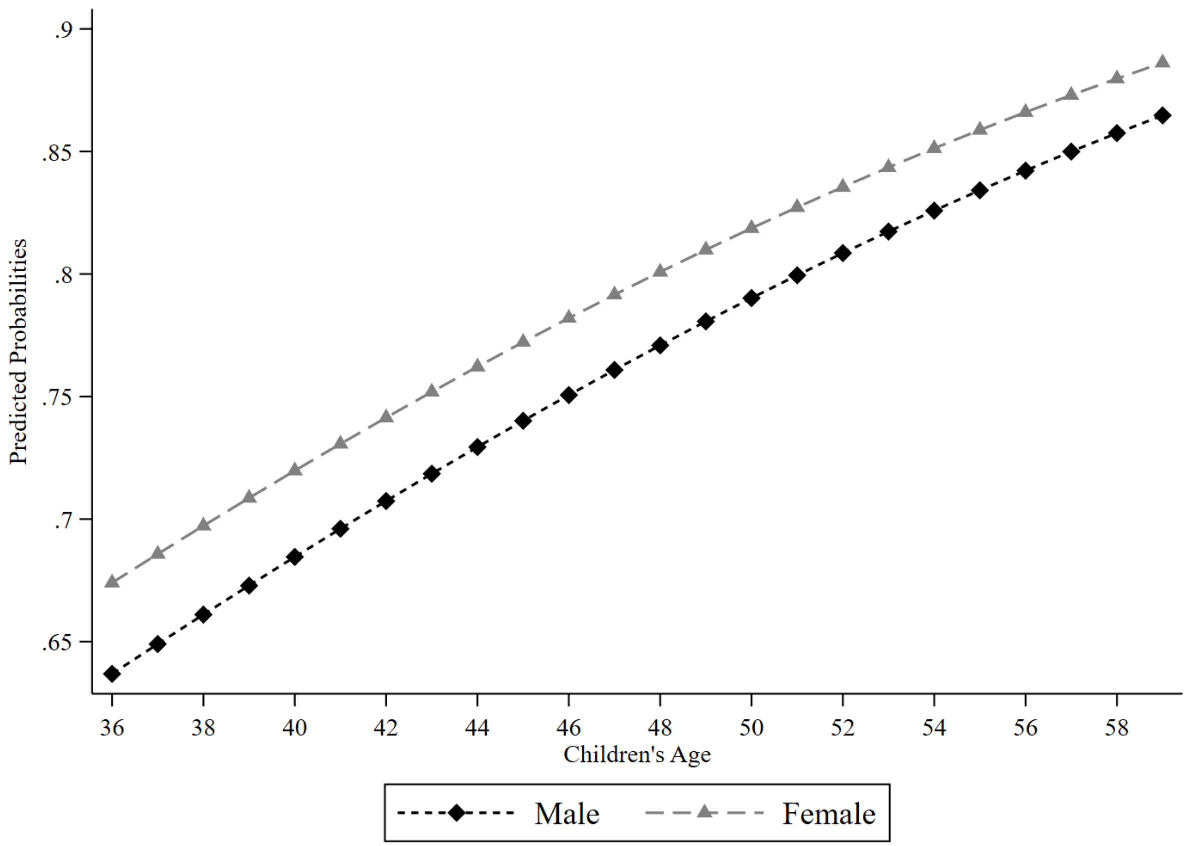


Figure 3.2: Predicted probabilities of child outcome by gender and mother's education

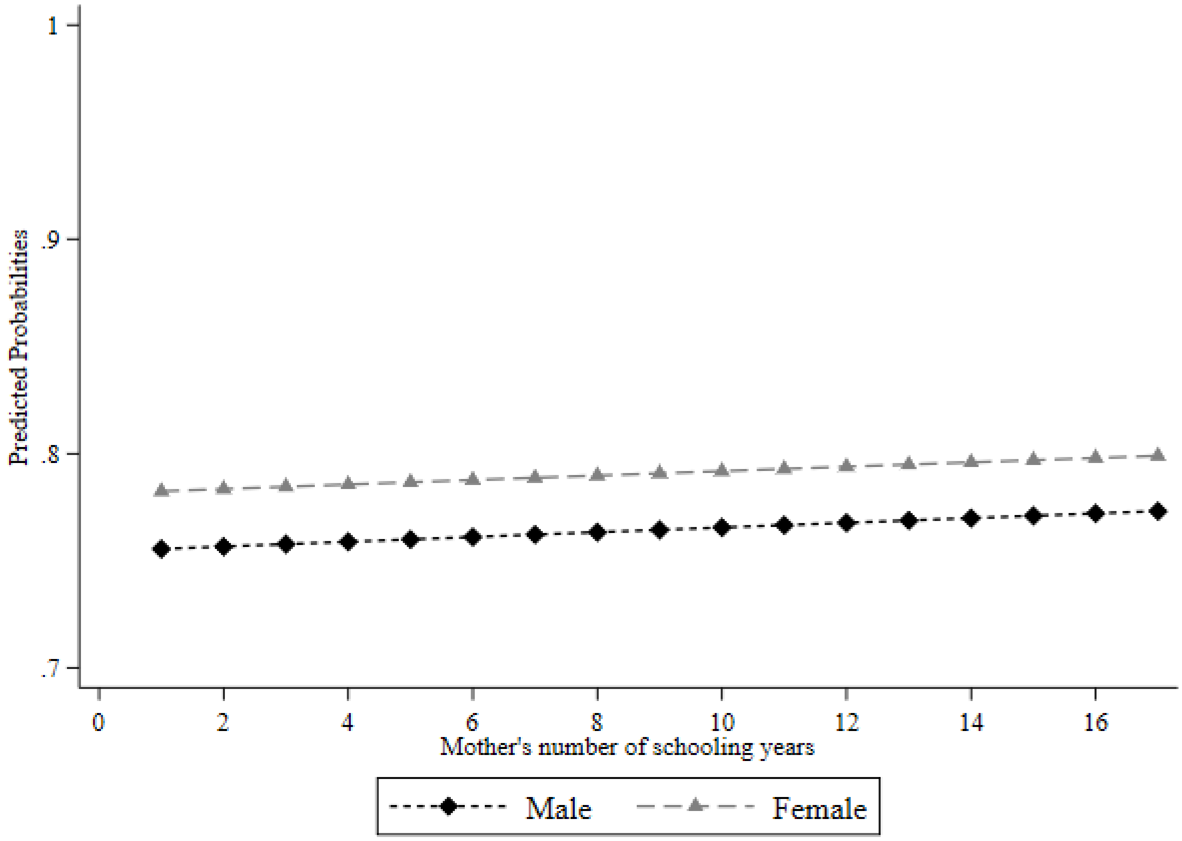


Figure 3.3: Predicted probabilities of maternal time investment by gender and age

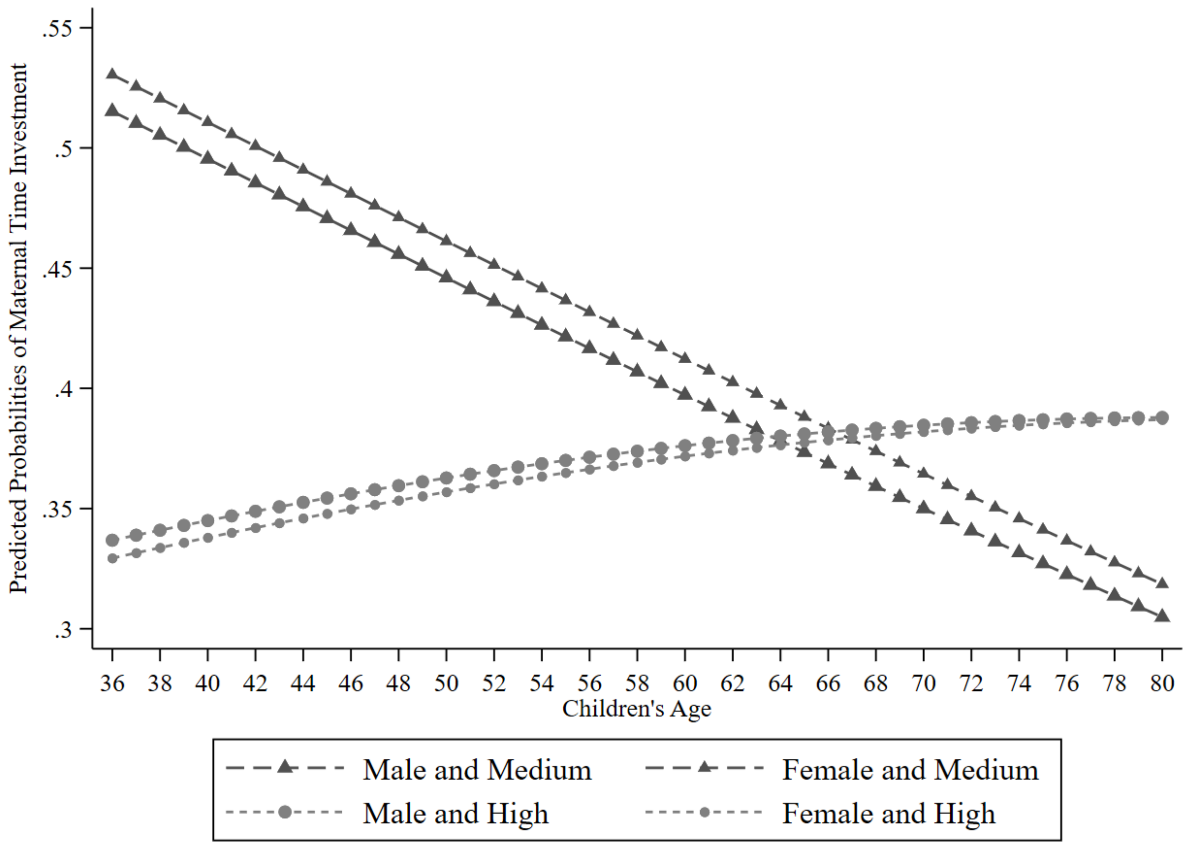


Table 3.1: Descriptive statistics: Gender differences in household and maternal characteristics

Variable	Variable Description	All	Boys	Girls	Diff./t-stat
Maternal Time Input					
Total maternal input	Sum of total mother-child interaction	2.16	2.20	2.11	0.09
		(2.05)	(2.05)	(2.05)	1.03
Educational time input	Sum of mother's educational interaction of the child (reading, storytelling)	1.02	1.05	1.00	0.05
		(1.16)	(1.18)	(1.15)	0.98
Structural time input	Sum of mother's non-educational interaction with the child (like playing, singing song)	1.14	1.16	1.12	0.04
		(1.11)	(1.10)	(1.12)	0.87
Child Characteristics					
Female	An indicator variable where 1 = female child and 0 = male child	0.48			
		(0.50)			
Child age in months	Age of the children in months	47.31	47.45	47.16	0.29
		(7.26)	(7.22)	(7.31)	0.96
Birth order	Birth order of the children	3.16	3.23	3.09	0.14
		(2.15)	(2.15)	(2.14)	1.59
Mother's Characteristics					
Mother's age in years	Birth order of the children	28.68	28.80	28.55	0.25
		(5.89)	(6.00)	(5.77)	1.03
Number of years in school	Mother's education level. Categorical Variable: None, Primary, Secondary and Higher	3.73	3.88	3.57	0.32*
		(4.43)	(4.46)	(4.38)	1.71
Household Characteristics					
Household size	Headcount of the people living under the same roof and sharing kitchen	6.25	6.04	6.47	-0.44***
		(3.23)	(3.03)	(3.42)	-3.24
Wealth Score	Composite indicator of wealth. Constructed by principal component analysis using the information on the ownership of consumer goods, dwelling characteristics, water and sanitation, and other characteristics that are related to the household's wealth	-0.23	-0.20	-0.26	0.07*
		(0.86)	(0.88)	(0.84)	1.85
Lower caste (Dalit)	Indicator variable: where 1 = Dalit or lower caste as defined by Nepal Census 2011, 0 = otherwise	0.18	0.18	0.18	0.01
		(0.38)	(0.39)	(0.38)	0.46
Rural	Indicator variable where 1 = rural household, and 0 = Urban household	0.83	0.81	0.85	-0.03**
		(0.38)	(0.39)	(0.36)	-2.18
Observations		2309	1195	1109	

Note: Mean and standard deviation are reported for all observation, boys and girls samples. Column 4 shows the differences and mean and t-statistics for equivalency test.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.2: Gender differences in child outcome variables

Variable	Variable Description	(1) All	(2) Boys	(3) Girls	(4) Difference /t-statistic
ECD Index - Binary	If three out of the four domains are on track, the children are considered developmentally on track overall. An indicator variable equal to 1 if a child is on track.	0.77	0.76	0.79	-0.03
		(0.42)	(0.43)	(0.41)	-1.46
ECD Index- composite score	Sum of four domains of childhood development: literacy/ numeracy, physical, socio-emotional, and approaches to learning. The value ranges from 0 to 10.	5.87	5.78	5.96	-0.19**
		(1.76)	(1.74)	(1.79)	-2.52
Cognitive composite score	Sum of two domains of childhood development: Literacy/Numeracy and Approaches to learning. Value ranges from 0 – 5.	2.27	2.21	2.33	-0.11*
		(1.58)	(1.55)	(1.61)	-1.73
Behavioral composite score	Identical to the socio-emotional domain. Value ranges from	1.78	1.76	1.81	-0.05**
		(0.63)	(0.64)	(0.60)	-2.04
Observations		2309	1195	1109	

Note: Mean and standard deviation are reported for all observation, boys and girls' samples. Column 4 shows the differences and mean and t-statistics for equivalency test. ECD Index is the Early Childhood Development Index designed by UNICEF. Table B1 provides variable description.

* p < 0.10, ** p < 0.05, *** p < 0.01

Table 3.3: Effect of gender on maternal time input

	(1) Total maternal time input	(2) Educational time input	(3) Structural time input
Female	-0.00316	0.0119	-0.0107
	(0.0448)	(0.0489)	(0.0464)
Birth order	-0.0146	-0.0118	-0.0204
	(0.0120)	(0.0132)	(0.0124)
Child's age in months	0.0163***	0.0211***	0.00855***
	(0.00314)	(0.00344)	(0.00324)
Number of years in schools	0.0688***	0.0949***	0.0383***
	(0.00618)	(0.00667)	(0.00633)
Mother's age in years	-0.00681	-0.00752	-0.00462
	(0.00429)	(0.00472)	(0.00443)
Lower caste (Dalit)	0.0717	0.0373	0.102*
	(0.0591)	(0.0642)	(0.0612)
Wealth index	0.174***	0.205***	0.0990***
	(0.0354)	(0.0383)	(0.0367)
Rural	-0.150**	-0.0899	-0.189***
	(0.0672)	(0.0724)	(0.0697)
Household size	-0.0506***	-0.0453***	-0.0529***
	(0.00722)	(0.00792)	(0.00762)
N	2304	2304	2304

Notes: The estimates are from ordered probit regression. Besides the control listed above, survey-month fixed is used. Standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01

Table 3.4: Effect of maternal time input on child outcomes

	(1) ECD Index	(2) ECD Index-Composite score	(3) Cognitive Composite score	(4) Behavioral Composite score
Maternal Input	0.116***	0.158***	0.119***	0.0336***
	(0.0174)	(0.0180)	(0.0124)	(0.0130)
Female	0.134**	0.275***	0.158***	0.101**
	(0.0609)	(0.0641)	(0.0451)	(0.0474)
Birth order	0.134**	0.275***	0.158***	0.101**
	(0.0609)	(0.0641)	(0.0451)	(0.0474)
Child's age in months	-0.00276	0.0227	0.0140	-0.0208*
	(0.0158)	(0.0173)	(0.0119)	(0.0126)
Number of years in schools	0.0348***	0.0597***	0.0507***	-0.00790**
	(0.00422)	(0.00457)	(0.00322)	(0.00330)
Mother's age in years	0.00393	0.0357***	0.0351***	-0.00307
	(0.00885)	(0.00904)	(0.00640)	(0.00674)
Lower caste (Dalit)	-0.00572	0.00781	-0.00230	0.0116***
	(0.00565)	(0.00630)	(0.00424)	(0.00448)
Wealth index	-0.283***	-0.237***	-0.238***	-0.0694
	(0.0752)	(0.0807)	(0.0591)	(0.0624)
Rural	0.144***	0.517***	0.305***	0.0525
	(0.0474)	(0.0493)	(0.0344)	(0.0359)
Household size	-0.0691	-0.0840	-0.0630	-0.0883
	(0.0975)	(0.0974)	(0.0683)	(0.0722)
N	2304	2304	2304	2304

Notes: Column 1 estimates are from probit regression. Column 2 estimates uses ordinary least square with robust standard error. Columns 3 and 4 estimates are from ordered probit regression. Standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01

Table 3.5: Effect of maternal time input on child outcomes

	(1) Cognitive outcome – Composite score	(2) Behavioral outcome – Composite score
Educational time input	0.258***	0.00501
	(0.0275)	(0.0289)
Structural time input	-0.0114	0.0604**
	(0.0260)	(0.0275)
Female	0.158***	0.101**
	(0.0451)	(0.0474)
Birth order	0.158***	0.101**
	(0.0451)	(0.0474)
Child's age in months	0.0130	-0.0206
	(0.0119)	(0.0126)
Number of years in schools	0.0495***	-0.00759**
	(0.00323)	(0.00331)
Mother's age in years	0.0274***	-0.00142
	(0.00655)	(0.00691)
Lower caste (Dalit)	-0.00208	0.0116***
	(0.00424)	(0.00448)
Wealth index	-0.228***	-0.0721
	(0.0592)	(0.0624)
Rural	0.294***	0.0552
	(0.0345)	(0.0360)
Household size	-0.0780	-0.0853
	(0.0684)	(0.0722)
N	2304	2304

Note: The estimates are from ordered probit regression. Besides the control listed above, survey-month fixed is used. Standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01

Chapter 4: Childcare Choices of Families Receiving Subsidy: The Effects of Copayment on Childcare Arrangements

4.1 Introduction

Evidence consistently supports two key findings: childhood investments generate large net social benefits (e.g., Currie & Almond, 2011; Heckman et al., 2006), and the benefits are greater if invested in early childhood rather than later life stages (e.g., Currie & Almond, 2011; Heckman et al., 2006; Heckman, 2007). To expand childhood investment, and encourage maternal employment, US federal and state governments coordinate to provide mean-tested, voluntary childcare assistance to low-income families through the Child Care and Development Fund (CCDF), which partially covers the childcare cost. As a result, non-parental childcare utilization for lower-income families is at a historically high level (Herbst, 2018). Yet, children from lower-income families, even with the subsidy, are less likely to attend quality childcare arrangements that promote improved cognitive and socioemotional outcomes.[1] Given that the families are sensitive towards cost-sharing arrangements (Kiil & Houlberg, 2014), researchers and policymakers have called for a generous childcare assistance to subsidy-receiving families (e.g., Lipscomb, 2013; Weber et al., 2014), focusing on the childcare costs – and by extension childcare subsidy and families' contribution to the childcare cost (or copayment).

The US federal government, through CCDF, has prioritized childcare assistance with a broad objective of improving quality and promoting continuity of the childcare program, along with other policy goals (Administration for Children and Families Department of Health and Human Services, 2014). However, subsidy-receiving families select home-based, low-quality

[1] For discussion, see Adam & Rohacek, 2010; Krafft et al., 2017; Lipscomb, 2013; Magnuson & Waldfogel, 2016; Pilarz, 2018; Ruzek et al., 2014; Weber et al., 2014.

care due to their portion of childcare cost, despite ‘parental choice’ feature that allows parents to choose the care provider based on their needs (e.g., Lipscomb, 2013; Weber et al., 2014). In fact, childcare subsidy is associated with lower-quality care (Lipscomb, 2013). Moreover, subsidy-receiving families are more likely to change their provider (i.e., increased instability) with shorter spells in the program (i.e., decreased continuity in the program) (Lipscomb, 2013; Weber et al., 2014). Because policymakers have many tools, such as changing eligibility criteria, assigning quality rating of the provider, practicing efficient reimbursement, lessening hassles in the application process, and reducing copayment rate, few effective policy strategies are identified that can improve better childcare arrangement for subsidy-receiving families (Lipscomb, 2013).

Policy generosity can influence parental behavior such as selecting center-based, high-quality care while increasing stability and continuity in the program. One way to improve better childcare arrangement is to reduce families’ contribution towards childcare cost as it is associated with how families purchase childcare (Lipscomb, 2013; Weber et al., 2014). Principally, economic theory predicts that the copayment may influence demand in cost-sharing arrangement by transferring the cost burden to the consumers (Kiil & Houlberg, 2013). Theoretically, reducing copayment rate or transaction cost (e.g., lessening hassles in the application process, eligibility criteria) should decrease income constraints or increase purchasing power, thus, expanding childcare options.

Although the income-transfer program allows equitable access to quality childcare (Baker et al., 2008), reducing families’ burden of childcare cost means the government shoulders a larger burden, raising concern about the government’s spending trade-offs (Pilarz, 2018), higher taxes and reduced economic efficiency (Baker et al., 2008), and the unintended negative consequences of a generous childcare policy (e.g., welfare-state paradox).[2] Because of the CCDF guideline, the parental choice provision allows subsidized families to purchase childcare from any provider, regardless of its quality or type. Therefore, a natural question is whether reducing copayment is an effective policy strategy to incentivize subsidy-receiving families to select better childcare arrangements.

This paper empirically examines the behavioral effects of copayment on childcare arrangements, focusing on the four policy outcomes – the type of care purchased, continuity in the program, quality of the care, and stability in the program. The analysis uses the administrative data from monthly snapshots of childcare subsidy recipients under the age of five, in the State of New Mexico, who attended childcare from 2011-2015. A key identification assumption is that the copayment rate is exogenous and random because of the parental choice provision and voluntary participation in the program.

There are four key findings. First, increasing families' contribution toward childcare cost decreases the likelihood of choosing high-quality provider, where quality is measured in-terms of Quality Rating and Improvement Systems (QRIS). Second, the increase in copayment decreases the probability of selecting a center-based childcare provider. Third, there are positive effects of reduced copayment on continuity in the program, where continuity is defined as the length of subsidy utilization. Fourth, the copayment does not affect stability in the program, where stability is a dummy variable if a child switches care provider during the subsidy period. The results are consistent across various models. Finally, the paper concludes that reducing copayment may be an effective policy tool for promoting better childcare arrangement.

These findings add to the literature of childcare choices for subsidy-receiving families in

[2] When a state provides generous public childcare services, there is a trade-off between employment and earnings for women (Mandel & Semyonov, 2006).

the following ways. First, previous research compares families receiving subsidies with similar non-recipient families when examining the relationship between reduced childcare cost due to subsidy and childcare choices (e.g., Krafft et al., 2017; Lipscomb, 2013; Magnuson & Waldfogel, 2016; Pilarz, 2018; Ruzek et al., 2014; Weber et al., 2014). Obviously, income transfer through subsidy expands choices by moving the budget constraints outward, and subsidy recipients have better childcare arrangements than similar non-recipients. Childcare subsidy, however, does not necessarily result into higher quality care (Lipscomb, 2013). In some studies, copayment might not affect the childcare arrangements, suggesting that the co-payment rates are not a barrier to childcare selection (e.g., Burstein& Layzer, 2004; Zaslow et al., 2006). A major drawback in these studies is that families not receiving the subsidy and those who participate in the subsidy program, or at least chooses to participate, can be characteristically different in their priorities for childcare investment. It may be that only families who value certain types of childcare seek childcare subsidies. These studies, on the one hand, fail to account for the role of families' childcare cost on childcare arrangement. On the other hand, families' preferences (between subsidy recipients and non-recipients) for childcare can bias the observed relationship between copayment and childcare selection, causing a biased estimation. When examining systematic variation within the subsidy recipients, a robust relationship between copayment and childcare selection can be established.

Second, previous research primarily examines the effect of policy generosity on childcare choices before and after the policy changes.[3] When a new or a modified policy is implemented, several policy components are usually bundled, particularly for the welfare programs such as

[3] For example, many states changed childcare policy along with reduced copayment rate. The outcomes of policy changes are summarized in Oregon (e.g., Scott et al., 2011; Weber et al., 2014), Cook County, Illinois (Michalopoulos et al., 2010), in Texas (Schexnayder & Schroeder, 2008), in Minnesota (Krafft et al., 2017), in Washington (Michalopoulos, 2010), in Rhode Island (Witte et al., 2004) and in Wisconsin (Ha & Meyer, 2010).

childcare assistance, where policy objectives can be achieved through various components (e.g., changing eligibility criteria, practicing efficient reimbursement, lessening hassles in the application process, and reducing copayment rates). For example, when legislating a modified childcare assistance policy in Oregon in 2007, lawmakers changed copayment rates, eligibility criteria and reimbursement rate at the same time (Weber et al., 2014). A family's decision to participate in the program could be influenced by many factors such as eligibility criteria or ease at application process (Weber et al., 2014). Thus, clustering of policy tools and their interactions not only changes the type of families enrolled in the program (Weber et al., 2014), but also makes it harder to estimate the impact of a single component because the subsidy-receiving families experience the combined effects. This potentially impacts the demand and supply of the childcare (Lipscomb, 2013) among families willing to participate in the program. Even though policy change can influence the behavioral response of the families, it does not explain how generosity in income transfer is associated with the policy outcomes. This is particularly important because the level of generosity in income transfer has declined in the US (Weber et al., 2014), while CCDF aims to expand the quality childcare. Using variation in copayment rate within the subsidy recipients, we can observe the relationship between families' childcare cost and its impact on how lower-income families choose childcare.

Third, considerable variations exist between state subsidy programs in terms of eligibility criteria, and copayment and reimbursement rates, even though states follow the same federal guidelines for the childcare assistance set by the CCDF. For example, states like Washington and Rhode Island (Michalopoulos, 2010, Witte & Queralt, 2005) use a tiered copayment system compared to New Mexico, which uses a sliding copayment rate. Because of the sliding copay rate in New Mexico, subsidy-recipients observe considerable variation in families' contribution in childcare cost. The variation helps us to establish a robust relationship between copayment and policy outcomes.

Fourth, this study identifies that reducing copayment may be an effective policy strategy in the US context, where the cost is rising, and demand is concurrently increasing (Herbst, 2018). With a renewed childcare priority (primarily to improve childcare quality) of the CCDF, it is important to understand the relationship between level of copayment and childcare arrangements. Specially, level of copayment influences care buying behaviors of the subsidy receiving families (Kiil & Houlberg, 2014). Hence, it is imperative to understand the relationship between copayment and parental behavior from a policy perspective.

4.2 Childcare Policy in New Mexico

Following the CCDF guidelines, state of New Mexico (NM) sets childcare policies (e.g., eligibility criteria, reimbursement rate, copayment rate, frequency of recertification) and manages the subsidy program.[4] In particular, Children, Youth and Families Department (CYFD) administers the Childcare Assistance program targeted at lower income families with young children and the children at risk. Childcare assistance is funded through a combination of NM state general funds and the federal CCDF. In fiscal year 2019, NM served around 20,000 children each month while spending $139 million (New Mexico Legislative Finance Committee, 2019).

Any parent, grandparent or legal guardian can apply for the childcare assistance if their income is at or below 200 percent of the federal poverty level and have children age six weeks to age 13. However, the families only qualify for the subsidy if they are either employed, attends

[4] Child Care Assistance **of 2016 NMAC §§** 8.15.2. The complete statue can be found at: https://casetext.com/regulation/new-mexico-administrative-code/title-8-social-services/chapter-15-child-care-assistance/part-2-requirements-for-child-care-assistance-programs-for-clients-and-child-care-providers (accessed February 15, 2020)

school, or participates in a training program. The assistance lasts for a year and can be renewed if the qualification criteria is met. While receiving subsidy, families can change the provider at any time and choose any CYFD approved childcare provider. In addition, New Mexico requires copayment from all applicants receiving childcare assistance unless waived because of special circumstances (e.g., if a child is in Child Protective Service care or at-risk). Partially shared childcare cost of the family, copayment, increases with family income and decreases with family size.[5] However, maximum copayment can never exceed the state's monthly reimbursement rate for the provider.

The NM state's share of the childcare cost is directly compensated to the provider for the cost of serving lower-income families. Unlike copayment rate, which is fixed for all license types and quality ratings of the provider, the state reimburses private care providers based upon the age of the child, average number of hours per week needed per child, and an additional differential rate according to the license of the provider, quality level (based on Quality Rating and Improvement Systems quality rating) and non-traditional hours (like weekend or after hours).

New Mexico applies Quality Rating and Improvement Systems (QRIS) to differentiate quality of the childcare providers, awarding programs between one to five stars based on various quality measures, where five indicates the excellent care and one indicates the lowest quality.[6] A childcare provider can qualify as a 5-STAR by either meeting quality standards in the state's

[5] The formula for calculating the co-payment for the first full time child is:

$$\text{Copay} = \frac{\text{low end of the monthly income bracket}}{\text{200 percent of annual FPL}} * 1.1$$

Where: FPL is the federal poverty level. Low end of the monthly income bracket is based on the copayment schedule published by New Mexico CYFD. This copayment formula is for the first full time child, which is defined as the child requiring most hours of childcare. Ranked based on the most number of hours needed for childcare, each additional child's base co-payment is determined at one half of the co-payment for the previous child. New Mexico copayment rate and chart can be accessed at: https://cyfd.org/docs/Child_Care_Assistance_Co-pay_Example.pdf (accessed February 15, 2020).

[6] Such quality measures include staff qualifications, children's progress, curriculum development, employee benefits.

tiered rating quality improvement system, Focus On Young Children's Learning, or through an approved national accrediting body.

Finally, New Mexico adheres to the principle of "parental choice," that is – giving parents the right to choose any childcare provider based on their needs rather than the state mandating specific care. Therefore, subsidy- receiving parents are able to purchase childcare from any CYFD approved provider. However, the copayment remains the same, regardless of the quality and license types.

4.3 Theoretical Considerations

The childcare models incorporate cost, preference, access, and quality whether it is the neoclassical economic model of household production function (Becker, 2009) or the new home economic model of utility maximization (Blau, 1999). These models assume that the families select the care arrangement that best meets the family's needs given the constraints faced by the household, as well as their preferences and priorities (Casper & Smith, 2004).

Childcare subsidies may influence the type, quality, and stability of the childcare program, as well as the family's continuity in the program. Economic theory predicts that subsidy decreases the income constraints and expands childcare options; however, copayment may reduce the demand for childcare by increasing the price for the families. These models assume that a rational utility-maximizing agent will select the best childcare option available to them, because of the parental choice provision in the CCDF guidelines.

Beside budget constraints (thus subsidy and copayment), families' preferences seem to be an important predictor of childcare choices (Casper & Smith, 2004). Preference is influenced by the child-care program (e.g., education and training of the childcare instructors, reliability of the provider), geographic context (e.g., safe neighborhood, distance to childcare provider), social network (e.g., networking groups, community groups), and social norms (e.g., shared values, religion). Childcare selection is also based on the family structure, parents' labor-force participation, parenting style, and the number of adults in the household (Casper & Smith, 2004). Moreover, selection of a childcare depends on the child characteristics (e.g., age, gender), and their likes and dislikes (Casper & Smith, 2004). In the US, socio-cultural factors also impact the childcare arrangement. For example, non-white families tend to utilize informal cares, and non-English speakers and ethnic minorities are more likely to use home-based care (Weber et al., 2014).

Furthermore, market factors restrict lower-income families to access quality childcare programs. First, market may not provide the desired childcare. For example, quality childcare programs are often scarce in low income neighborhoods (Forry et al., 2014). Second, quality childcare providers may choose not to serve in the low-income neighborhoods as they cannot cater quality services because of the lower willingness to pay (Ryan et al., 2011). This crowd outs the quality childcare providers from the low-income neighborhoods. Third, programs with a higher proportion of income coming from the subsidy program have fewer resources to maintain quality (Forry et al., 2014; Lipscomb, 2013). In addition, rural areas generally have lower-quality care as the market is unable to provide center-based care options (Bratsch-Hines et al., 2017).

Sorting through quality childcare can be difficult for families. Some studies show that parents tend to over-estimate the quality of the childcare (e.g., Cryer & Burchinal, 1997), or, in other cases, they are unable to differentiate quality of the childcare providers (e.g., Mocan, 2007). They also allocate little time to search for quality childcare (Forry et al., 2014). In addition, some parents value convenience and reliability compared to quality (Krafft et al., 2017).

In summary, childcare selection is a complex decision-making process where many factors interact. Theoretically, families with childcare subsidy should purchase higher quality care irrespective of the copayment because of the parental choice provision. To support this theory, two assumptions must be true. First, parent prioritizes childcare, meaning they must be able to differentiate and value quality. Second, market provides desired childcare options. If the market fails to provide desired childcare, parents have to settle for a lower-quality care.

4.4 Data and Empirical Strategy

4.4.1 Data

To estimate the impact of families' contribution towards childcare cost on childcare choices of the lower-income families receiving childcare subsidies, this paper uses monthly longitudinal data from New Mexico Children, Youth, and Families Department (CYFD) for the period from July 2011 to July 2015. The data provides information on all the families that received childcare subsidies in New Mexico during the study period. The data contains information on the child characteristics that include age, gender and race/ethnicity. It also includes information about family characteristics, such as household size, monthly income, indicator variable whether child lives in a single-parent household, residence zip codes, and the indicator variable whether families received other governmental welfare. Finally, the data includes information about the childcare providers, such as quality rating, service types.

The data contains beginning and ending dates of childcare utilization. Because of this information, two variables of interest are computed: stability in program and continuity in the program. Following Krafft et al. (2017), stability is defined as the frequency of changes in childcare arrangements over the study period irrespective of the type and quality. Continuity in the program is defined as the total number of months a child enrolls in the subsidy program.

The data provides information on the childcare provider (e.g., the type of care and QRIS-STAR rating of the provider). New Mexico has four types of childcare mode, which are broadly categorized into two groups – home- and center-based cares. The Registered Homes provide childcare for up to four children in private homes and do not have QRIS rating. The Licensed Family Homes, which are included in the state's QRIS rating system, provide childcare for up to six children in private homes. Similar to the Licensed Family Homes, the Licensed Family Group Homes can accommodate more children (7-12 children). These three groups are considered home-based care. The Licensed Childcare Centers provide childcare for larger groups of children in a classroom setting, which is assigned as center-based care.

Several exclusion criteria are employed to create the final estimating sample. First, sample size is restricted to the children who received childcare subsidies when under five and attended New Mexico public school systems in the academic year 2016/2017. This removes children who enroll in subsidies for a few months and move out of the state. To create this sample, CYFD data is matched with the data from the New Mexico Public Education Department based on the name and date of birth as these two state agencies do not share a common identifier. The matching produced 32,329 observations of 7,899 unique children, who received childcare assistance in the study period.

Second, the sample is limited to children under five years. Childcare needs vary with age as the developmental needs are different, and the families with children under five report larger impacts of the program (e.g., Casper & Smith, 2004; Lipscomb, 2013). Children attending schools have different needs than toddlers. Children attending schools, for example, need childcare in odd hours, and after school programs can cover them. With this exclusion, the final estimating sample has 4918 unique children.

In addition to the exclusion criteria, the data do not provide key information to address theoretical and empirical issues. First, we were unable to identify siblings in the data. As noted earlier, after the firstborn, the copay for each additional child is determined at one-half of the copayment for the previous child. Because of the low fertility rate[7] and exclusion criteria (children less than 5 years old), it is safe to assume that a sibling, if present at all, does not contaminate the estimation. Second, if the children are concurrently using multiple childcare providers, we use the first provider listed in the data as their focal provider as there is no information to differentiate the main provider. Third, the data do not provide information on informal care (e.g., care by other family members like grandparents, older siblings, etc.) and the total hours of care utilized. Informal care and hours used do not impact copayment; but they can influence care selection. Thus, I assume that the informal care and childcare hours are constant for all the sample children. Finally, the data does not provide information on whether the copay is waived because of the special circumstances that meet the state's eligibility criteria (e.g., children at risk) or the copayment is equal to zero due to income. Thus, we assume that zero copay means family does not have to pay copayment not that the children are at risk.

Table 4.1 presents descriptive statistics of the children and their families for the estimating sample of 4918 children. Just under half of the children in the sample are girls. The average age of the children is 45 months. The socio-economic status of the families in our sample appears to represent mostly Hispanic (76%), and single parent household (93%). About 76 percent of the principal guardian (caretaker) have some form of employment. Only one fourth of families receive Temporary Assistance to Needy Family. The average monthly childcare cost for families is around $60.40 in 2017 constant dollars.

[7] The fertility rate is 1.8 per women in New Mexico (Martin et al., 2019).

Table 4.2 summarizes the information on childcare selection for the families receiving childcare assistance. About a third of the children attended 5-QRIS STAR (hence forth STAR) childcare, whereas 47 percent of the children used 2-STAR rating. That is, about 78 percent of the families share 5- and 2- STAR childcares. This raises concerns whether the market provides only high-quality care (5-STAR) or low-quality care (2-STAR). In terms of type of care, most children are enrolled in the center-based childcare (79%) – meaning that the New Mexican families with large minority population mostly prefer center-based childcare. For the estimating sample, childcare, on average, is utilized for 12 months. For stability, most childcare arrangement is stable at 78 percent – meaning few families switch to any other childcare provider.

4.4.2 Empirical Strategy

The identification strategy is that the copayment is exogenous because of the parental choice provision, which empowers families to choose the childcare that best meets their needs irrespective of the provider's cost. In other words, parents can choose any type or quality of childcare, but the copayment remains the same as government shoulders the remaining burden of the childcare cost. One issue with the copayment is that it is the function of family income and family size (see footnote 8), where it decreases with family size and increases with income. Family income and size, being the predictors of the childcare choices, can be endogenous to childcare selection. Consequently, then copayment may be endogenous to the childcare selection. To address this issue, this paper uses several fixed effects, excluding family size and income from the model. For example, child fixed effect excludes family characteristics what may influence the childcare selection. In addition, the income distribution among subsidy recipients is small; thus, less variation in income decreases the likelihood of biased estimation. Hence, any variation in the childcare choices should come from the variation in the copayment.

Key assumptions are addressed using various fixed effects. Families' preferences for childcare can be time-invariant, and the child fixed effect (F_i) captures invariant parental preferences for the purchase and consumption of the type of care that does not changes over time (e.g., shared values, religion, and culture).[8] In addition, the structure of the local childcare and the labor market are important determinant of childcare choices, along with other community characteristics (like public transportation) (Herbst & Tekin, 2016). For example, quality childcare programs are often scarce in low-income neighborhoods (Forry et al., 2014). Rural areas generally have lower-quality care, and the market is unlikely to provide center-based care. To address these problems, we hold a county of residence constant at the first observed location (Δ_l). Finally, I use year fixed effects Γ_t to capture control for cohort-specific heterogeneity.

4.4.2.1 Estimating the Effect of Copayment on Quality of the Care

To estimate the impact of copayment on the quality of the care, I use the following reduced form model:

$$Quality^*_{itl} = \beta_0 + \beta_1 CoPay_{itl} + X_{itl} + F_i + \Delta_l + \Gamma_t + \epsilon_{itl} \qquad (4.1)$$

Copayment ($CoPay$) is the out-of-pocket parental contribution to childcare in 2017 dollars. Because of the ordinal nature of the quality rating, it has five levels in increasing quality, coded as 1 = 1 STAR rating, 2 = 2 STAR rating, 3 = 3 STAR rating, 4 = 4 STAR rating, and 5 = 5 STAR rating. The latent continuous dependent variable, $Quality^*$ generates the observed $Quality$.

The corresponding probabilities for each input level are calculated using maximum

[8] Research has found that families often desire different types of childcare, depending on the ages of their children.

likelihood method for the following specification. The θ is the thresholds or cut points to be projected for each level.

$$\begin{cases} Prob.(Quality = 1\ |x_i, \beta_0) = \Phi(\theta_0 - \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl}) \\ Prob.(Quality = 2\ |x_i, \beta_0) = \Phi(\theta_2 - \beta_1 + \ \beta_1 CoPay_{itl} + X_{itl}) - \Phi(\theta_0 - \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl}) \\ Prob.(Quality\ = 3\ |x_i, \beta_0) = \Phi(\theta_3 - \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl}) - \Phi(\theta_2 - \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl}) \\ Prob.(Quality\ = 4\ |x_i, \beta_0) = \Phi(\theta_4 - \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl}) - \Phi(\theta_3 - \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl}) \\ Prob.(Quality\ = 5\ |x_i, \beta_0) = \Phi(\theta_5 - \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl}) - \Phi(\theta_4 - \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl}) \end{cases} \quad (4.1a)$$

The parameter of interest is β_1, which measures the impact of copayment on the quality of childcare family chooses using an ordered probit regression analysis. In addition, I use three specification: the first specification does not include controls. Then, I incrementally add time varying family characteristics and fixed effects.

4.2.2 Estimating the Effect of Copayment on Type of the Care

To estimate the impact of copayment on the type of the care (center-based care vs. home-based care), the reduced form model is as follow.

$$Type^*_{itl} = \beta_i + \ \beta_1 CoPay_{itl} + X_{itl} + \ F_i + \ \Delta_l + \ \Gamma_t + \ \epsilon_{itl} \qquad (4.2)$$

$Type^*_{itl}$ is a latent variable, which takes a value of 1 (center-based) or 0 (home-based). Assuming ϵ_{itl} is normally distributed, a probit regression is used while controlling (X) for age of the child, indicator variable for single parent household, indicator variable for the families' employment, and the indicator variable for TANF recipients. The model also includes year fixed effects (Γ), county fixed effects (Δ) and child fixed effects (F).

4.2.3 Estimating the Effect of Copayment on Stability in the Program

To estimate the impact of copayment on the stability, the reduced form model is as follow.

$$Stability^*_{tl} = \beta_0 + \ \beta_1 CoPay_{itl} + X_{itl} + \ \Delta_l + \ \Gamma_t + \ \epsilon_{itl} \qquad (4.3)$$

$Stability*$ is a latent variable that takes a value of 1 if a child does not change the care provider and 0 if otherwise. Assuming ϵ is normally distributed, a probit regression is used with controls (X) for age of the child, indicator variable for single parent household, indicator variable for the families' employment, and the indicator variable for TANF recipients. The model also includes year fixed effects (Γ) and county fixed effects (Δ).

4.2.4 Estimating the Effect of Copayment on Continuity in the Program

I use the following reduced form fixed effects linear model to estimate the effect of copayment on continuity in the program.

$$Continuity_{itl} = \beta_0 + \beta_1 CoPay_{itl} + X_{itl} + \Delta_l + \Gamma_t + \epsilon_{itl} \qquad (4.4)$$

The outcome ($Continuity$) is a continuous variable, an ordinary least square regression is used with controls (X) for age of the child, indicator variable for single parent household, indicator variable for the families' employment, and the indicator variable for TANF recipients. The model also includes birth-year fixed effects (Γ) (children born in the same year more likely to use same amount of care.) and county fixed effects (Δ).

4.5 Results

Results are provided sequentially for each of the outcome variables of interest: (i) quality of care; (ii) the type of care purchased; (iii) stability in the program; and (iv) continuity in the program.

4.5.1 Quality of Care

Table 4.3 presents the results using Equation 1. Column 1 shows that the higher monthly copayment decreases the likelihood of selecting higher quality care, which is significant at the one percent significance level. Adding covariates and fixed effects in the subsequent models, I observe a similar relationship between copayments and STAR QRIS ratings in the columns 2 and 3, showing that the higher copayment increases the probability of lower-quality care utilization.

This result is consistent with earlier findings that showed reduction in copayments led families to purchase high-quality care (e.g., Scott et al., 2011).

To better understand the estimated coefficients of the ordered probit models, marginal effects are provided using the model in Column 3 (see Figure 4.1 and Table C1). Figure 5.1 illustrates trends in the probability of using each type of care as families' childcare cost increases from 0 to 150 dollars. Since more than two thirds of New Mexican families either use 5-STAR or 2-STAR childcares, the figure only shows the predicted probabilities for these two care-types. As the cost increases, the probability of using 2-STAR care increases while it decreases for 5-STAR care. For the rest of the STAR ratings care, the marginal effects are relatively small as seen in the Table C1. For example, the probability of 4-STAR care utilization is 9 percent at the mean. In contrast, the probability of 2-STAR and 5-STAR care utilization is 53 and 24 percent, respectively.

There are two possible explanations for why families with a higher copayment select lower quality care. First, families account for the risk related to sudden termination of the childcare assistance, i.e., higher copay families select cheaper, lower quality care in case the assistance terminates. Losing subsidy results in families bearing the full childcare cost, which may be due to income rise or other policy components that nullify subsidy application. For example, losing financial support can significantly increase the childcare cost, ranging from as little as $39 a month in Idaho to as much as $1,525 in New York (Minton & Durham, 2013). Subsidy loss also forces parents to switch to a lower quality, less expensive care (Lipscomb, 2013). This is particularly important because employment characteristics are key in childcare selection, as subsidy recipients experience high job instability, irregular or variable work schedules, and changing hours and wages (Chaudhary et al., 2012). As such, job loss causes most exits from Wisconsin's subsidy program (Ha & Meyer, 2010). To protect from such scenarios, families with higher copayments may select cheaper, lower quality care even with the parental choice provision.

The second possible explanation is related to information gap, i.e., families may lack key information on providers and subsidy policies. For example, families tend to over-estimate or are unable to differentiate the childcare quality (Cryer & Burchinal, 1997; Mocan, 2007), while allocating little time to search for childcare (Forry et al., 2014). Because sorting through cost and quality is increasingly difficult for many families (Bishwakarma & Berrens, 2018), it may be the case that families perceive higher copayment is a result of higher quality because of information asymmetry. Hence families may select affordable lower quality care when the copayment is higher, despite parental choice provision.

4.5.2 Type of Care Purchased

Using Equation 2, Table 4.4 shows that the higher monthly copayment decreases the probability of families purchasing center-based care. The results are consistent in all three specifications. The relationship – copayment and type of care purchased – is consistent with previous empirical findings that examined the effect of policy changes, including reduction in copay, and type of care selected (e.g., Michalopoulos et al., 2010; Schexnayder & Schroeder, 2008; Krafft et al., 2017).

As discussed earlier, families with higher copayment may select cheaper, lower quality care to protect from uncertain future of subsidy eligibility, as center-based care is often considered to be of higher-quality. Additionally, the characteristics of home-based care may appeal to families if their copayment is higher and are more expensive. On the one hand, home-based care is relatively cheaper (Minton & Durham, 2013). On the other hand, if a family loses childcare subsidies, families purchasing center-based childcare would face higher percentage increase in childcare expenses, compared to home-based care (Minton & Durham, 2013). As home-based care is usually within their network, sudden termination of subsidy means parents can negotiate payments as one of the possible coping mechanisms (Lipscomb, 2013).

Moreover, the finding of Table 4.4 may be driven by the population characteristics of the study sample. Previous research suggest that minority families tend to have lower use of center-based childcare (Weber et al., 2014). Those families choose childcare from their social network and social norms with shared values. The fact that two thirds of the sample consists of minority populations may have impacted the outcome of this analysis.

4.5.3 Stability in the Program

Table 4.5 presents the effect of copayment on stability in the program – whether a family switches the childcare provider. Using Equation 3, the results indicate that the copayment does not affect the decision to switch childcare providers, which is consistent in all specifications. This finding confirms earlier work (e.g., Kraftt et al., 2013), but remains at odds with other research showing that the families receiving subsidies experience unstable care arrangement (e.g., Pilarz & Hill, 2014; Schexnayder & Schroeder, 2008; Witte et al., 2004).

Subsidy-receiving families may or may not prefer to send their kids to the same childcare provider. Exposure to stable childcare is associated with positive outcomes (Lipscomb, 2013), but families may choose to switch providers so as to expose children to different environments (Kraftt et al., 2013). Furthermore, transaction costs (e.g., re-certification period) seem to influence stability in the program (Adams & Rohacek, 2010). The result in Table 4.5 can be explained by the relatively generous childcare policy in New Mexico, particularly the recertification process. For example, once approved, families do not need to recertify the eligibility for a period of 12 months even if they switch providers. In addition, families change providers when a high-quality provider enters the market (Speirs et al., 2015). As 77 percent of the children utilize either 2 or 5 STARS rated childcare, the market may not provide higher-quality childcare to incentivize families to switch childcare. Finally, the sample consists of children who attend the New Mexico public school system and received childcare subsidies when they were 5 years or younger. Because of the sample construction, families are likely to select care provider within their network or their neighborhood. Therefore, it is unlikely that they switch providers irrespective of the copayment.

4.5.4 Continuity in the Program

Using Equation 4, Table 4.6 shows a positive relationship between copayment and the total number of months in subsidized childcare. Consistent in all specifications, the result shows that an increase in copayment leads to longer spell in the subsidy program. If the copayment increases by ten dollars, the average length of childcare utilization increases by 0.23 to 0.26 months. In earlier research, some findings showed that increase in copayment increased the continuity in the program (e.g., Schexnayder & Schroeder, 2008; Witte & Queralt, 2004), while other research has found that the policy changes, along with copayment reduction, increased continuity in the program (e.g., Grobe et al., 2009; Michalopoulos, 2010; Weber et al., 2014). For the New Mexican families receiving childcare subsidy, copayment and continuity in the program are positively related.

Why does higher copayment lead to a longer spell in the program? One possible explanation is related to job and income. In the US, families exit the subsidy program mainly due to eligibility or job loss (Grobe et al., 2008). Since copayment is associated with income, the childcare demand can be different for a high earner among subsidy-receiving families. These families may be working more or odd hours, increasing their demand for childcare. They need childcare to continue working. Or, it may be the case that families are able to work more due to childcare, which increases income and copay. Hence, these families continue to use childcare for a longer duration. Moreover, the families with higher income are expected to have more human capital. And, the families with higher human capital are expected to select higher quality care for a longer duration (Weber et al., 2013).

4.6 Conclusion

Despite receiving childcare assistance, copayment can add financial hardship to the lower-income families, as budgetary constraint remains a major barrier to access high quality, center-based care. Yet, for the families receiving childcare subsidies, how copayment impacts policy outcomes remain generally vague. To understand the relationship between copayment and various policy outcomes, this paper examined the effect of copay on type of care purchased, continuity in the program, quality of care, and stability in the program using a sample of under five children whose childcare was subsidized by the state of New Mexico from July 2011 to July 2015. Largely consistent with earlier research, an increase in copayment decreases the likelihood of selecting higher quality care and decreases the probability of families purchasing the center-based care. Moreover, the estimation does not find the effect of copayment on the stability of the care. But, the impact on continuity in the program is positive and significant.

These results should be interpreted cautiously for several reasons. First, the data lacks information on family characteristics that may be helpful in understanding their preferences and tastes in childcare. For example, there is no information on how families prioritize childcare and rank their quality. Additionally, the data lacks information on the childcare market, i.e., whether the market provides families' desired childcare. This is particularly important as New Mexico is sparsely populated, where one-fourth of the residents are living in the rural areas, and rural areas generally have underdeveloped markets. Second, we are unable to use the exact number of childcare hours that a family demands or utilizes, including informal care. This can influence the childcare choices. Finally, while this study provides credible evidence on the effects of copayment on policy outcomes in New Mexico, the demographic and socioeconomic composition of the state is very different from the rest of the country, which may limit the generalizability of our finding within another state context.

Nevertheless, our results can have important policy implications, especially for a state in need of human capital investment to accelerate economic development. Previous results mainly focus on the impact of bundled policy changes, which cannot directly link the effect of families' childcare cost on care choices. These results establish a strong connection between copayment and policy outcomes. Among all the policy components available to lawmakers, reducing copayment rate for the lower-income families can improve the CCDF goal of improving center-based, high-quality care.

Figure 4.1: Predicted probabilities by quality type and Copayment

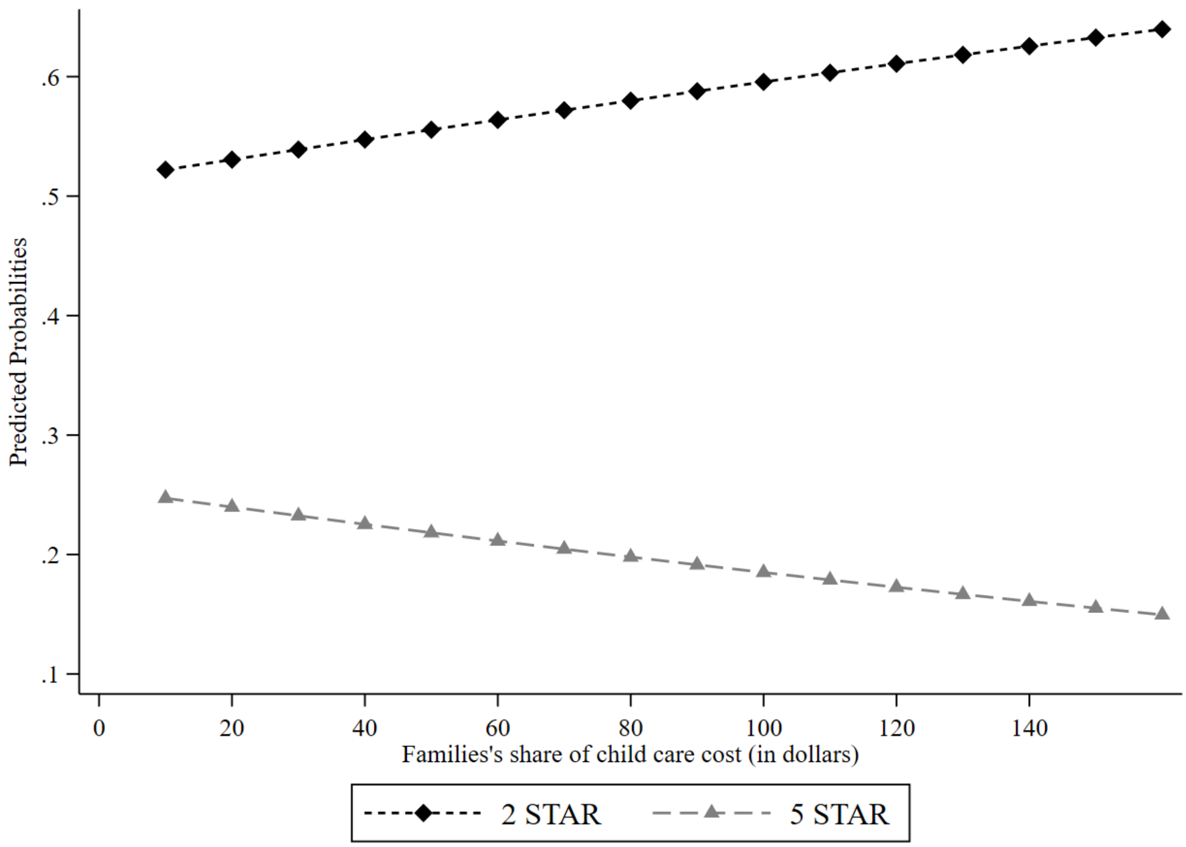


Table 4.1: Summary Statistics – Children and Households

Variable	Mean /Proportion	SD
Children		
Child age in months	45.71	9.78
Proportion female	0.49	0.50
Proportion Native American	0.08	0.27
Proportion White	0.12	0.32
Proportion Hispanic	0.76	0.43
Household		
Copayment	60.40	63.44
Proportion single parent	0.93	0.25
Monthly income	1355.05	868.88
Proportion Temporary Assistance for Needy Families	0.25	0.39
Employment	0.76	0.38
Family size	3.49	1.25

Notes: This table reports means and standard deviations of the characteristics for the study sample size of 4918. Monthly copayment is in constant 2017 dollars.

Table 4.2: Summary Statistics – childcare arrangement

Variable	Description	Mean /Proportion	SD
Quality	Quality Rating and		
Proportion 5 STAR	Improvement Systems (QRIS)	0.31	0.46
Proportion 4 STAR	childcare quality rating,	0.09	0.29
Proportion 3 STAR	where five stars indicates the	0.12	0.32
Proportion 2 STAR	highest quality	0.47	0.49
Proportion 1 STAR		0.01	0.12
Type	Home vs. center care, Type =		
Proportion center-based care	1 if center-based care.	0.79	0.41
Stability	Binary variable = 1, if a child		
Proportion no changes in childcare	does not change the childcare provider	0.76	0.43
Continuity	Total number of months		
Months in childcare	childcare subsidy received	11.91	9.65

Notes: This table reports means and standard deviations of the characteristics for the study sample size of 4918, except for the quality of care (4220). Registered Homes child are not included in the state's rating system.

Table 4.3: Effect of Copayment on the probability of high-quality care

Quality	(1) No Controls	(2) Controls	(3) + Fixed-effects
Copayment	-0.00405***	-0.00307***	-0.00249***
	(0.0007)	(0.0008)	(0.0008)
Constant cut1	-2.207***	-2.212***	-2.409***
	(0.0157)	(0.0348)	(0.0381)
Constant cut2	0.0790***	0.0807**	0.0746**
	(0.0073)	(0.0321)	(0.0346)
Constant cut3	0.400***	0.403***	0.416***
	(0.0074)	(0.0321)	(0.0347)
Constant cut4	0.671***	0.674***	0.701***
	(0.0077)	(0.0321)	(0.0347)
Observations	47107	47107	47107
No. of children	4,220	4,220	4,220

Notes: All three specifications use child fixed-effects and ordered probit regression. Controls include age of the child, indicator for single parent household, indicator for families' employment, and indicator variable for TANF recipient. Fixed-effects include county fixed-effect and year fixed-effect. Standard error in the parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.4: Effect of Copayment on the type of care purchased

Type	(1) No Controls	(2) Controls	(3) + Fixed-effects
Copayment	-0.0162***	-0.0124***	-0.0151***
	(0.000689)	(0.000764)	(0.000800)
Constant	0.674***	0.636***	1.110***
	(0.00746)	(0.0336)	(0.0377)
Observations	58541	58541	58541
No. of children	4,918	4,918	4,918

Notes: All three specifications use child fixed-effects and probit regression. Controls include age of the child, indicator for single parent household, indicator for families' employment, and indicator variable for TANF recipients. Fixed-effects include county fixed-effect and year fixed-effect. Standard error in the parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.5: Effect of Copayment on the stability in the program

Stability	(1) No Controls	(2) Controls	(3) + Fixed-effects
Copayment	-0.00384	-0.00107	-0.000642
	(0.00316)	(0.00367)	(0.00374)
Constant	0.673***	0.395**	0.173
	(0.0271)	(0.154)	(0.165)
Observations	4,918	4,918	4,918

Notes: All three specifications are estimated using probit regression. Controls include age of the child, indicator variable for the gender of the child, race, indicator for single parent household, indicator for families' employment, and indicator variable for TANF recipients. The mean of the controls is used. Fixed-effects include county fixed-effect and year fixed-effect. Standard error in the parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.6: Effect of Copayment cost on the continuity in program

Continuity	(1) No Controls	(2) Controls	(3) + Fixed-effects
Copayment	0.265***	0.229***	0.228***
	(0.0240)	(0.0256)	(0.0247)
Observations	4918	4918	4909
R-Squared	0.030	0.139	0.221

Notes: All three specifications are estimated using ordinary least square estimation. Controls include age of the child, indicator variable for the gender of the child, race, indicator for single parent household, indicator for families' employment, and indicator variable for TANF recipients. The mean of the controls are used. Fixed-effects include county fixed-effect and cohort fixed-effect. Robust standard error in the parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 5: Conclusion Human Development in Early Years

5.1 Dissertation Summary

Skills and abilities are probably the most important factors in human flourishing. As means of production and exchange, they are necessary for the utility maximizing and rational "economic man" (also referred to as "homo economicus"). From a societal perspective, they promote economic growth and inequality reduction. Fortunately, these skills can be acquired or developed through investments. Economists, and non-economists, have been untangling the intricate details of the skill production process. The consensus on child development is: skills and abilities are multidimensional; there are critical and sensitive periods in skill development; and early childhood circumstances influence the accumulation of skills, among others. As a result, parental and policy responses can magnify or mitigate the effects of childhood circumstances.

The preceding chapters explore ways that are imperative for human capital accumulation during early life years. After a brief background on human capital and skill formation in Chapter 1, the subsequent chapter adds to the discussion of climate change and human health in a lower-income country context, where resources are limited, and institutions are weak. Additionally, children and pregnant women from lower-income countries face the greatest risks because of few options to avoid heat and a multitude of impacts from extreme heat. This chapter uses high-temperature days as a mild uterine stressor to explore the fetal origin hypothesis and examines the effects of high-temperature days during pregnancy on the cumulative measure of childhood health (height-for-age z-score). Evidence from Nepal shows that prenatal exposure to high-temperature days impedes child growth; however, the damage appears to be transitory as opposed to persistent – as the effect gradually decreases with age and becomes almost undetectable by age five. Two economic mechanisms are explored. First, temperature shocks impact high-commodity food prices, which can reduce household welfare. Second, mothers appear to respond with reduced prenatal care utilization. Thus, the high-temperature days due to climate change have both market (food prices) and non-market cost (reduced prenatal care utilization).

Chapter 2 also draws attention to the effects of climate change, that is increasing high-temperature days can channel through various aspects of life and livelihood. These results demonstrate both market (food prices) and non-market (reduced antenatal care) impacts. In sum, this analysis shows that children are unable to achieve their full potential because of increasing high-temperature days due to global warming. When children fail to reach full potentials during their formative years, the effect can reverberate into other skills acquisition processes. For example, past skills influence the productivity of future investments (dynamic complementary) and promote the skills attained at later stages (self-productivity). Overall, global warming can be detrimental to skill formation. Nevertheless, parental investments can mitigate the early life damages.

Parental investments are a strong predictor that children will accumulate the skills necessary to succeed in life. Because parental investments are a cost of production (in this case child's skills), parents invest in that child who may yield the highest return in the future. They may have higher incentives to invest in a male child compared to the female child, as men tend to participate in the labor market more frequently and at a younger age. In many institutional settings, males are also culturally more desirable. Therefore, boys receive more favorable parental treatment at an early age than girls, especially in lower-income countries. Also, parental preferences play a major part in the investment decision.

As mothers are the primary care giver, and especially so in lower-income countries, maternal time investment is crucial in skill formation. Chapter 3 explores the maternal time investment by gender in context to Nepal, a low-income country with strong evidence of son preference (Brunson, 2010). With a large body of research focused on parental investment by gender, this chapter revisits a well-known gender discrimination issue in Nepal because of a wave of legislative reforms and institutional changes in the last two decades, which has been prominent in narrowing the boy-girl gaps in early life outcomes (e.g., Allendorf, 2007; Cunningham et al., 2019; Self, 2015). Chapter 3 presents two sets of findings from for the period 2009-2014: mothers invest time equally between preschool boys and girls; and the maternal time investment significantly impacts cognitive and behavioral outcomes. The former inference, to a certain extent (at least in observable attributes), supports the argument that son preferences by mother may not be due to preference *per se*, rather it may be the result of social and cultural constraints. It also highlights the fact that differential boy-girl treatment can diminish over time and place. The latter inference – a positive link between maternal time input and child outcomes – can have important policy implications, i.e., mothers may be the pivotal link to help young girls catch up with young boys in later life outcomes.

Furthermore, if parents face binding resource constraints, they may be unable to provide enough support for child wellbeing. As a result, a child may fall behind in skill formation in the early years. Providing social support can ease parental stress and provides resources necessary for human capital accumulation, allowing equitable opportunities for resource constrained children. Therefore, the government enacts welfare programs to help low-income families lessen their resource constraints. One such program, namely *Child Care Assistance*, serves needy families to help pay partial childcare costs in New Mexico, US. A voluntary and means-tested program, Child Care Assistance subsidizes childcare costs for families, while adhering to parental choice features. Despite receiving childcare subsidy, families' childcare costs can influence the type of care a family chooses. Type of care matters more in skill accumulation; a center-based, high-quality childcare is associated with better childhood developmental outcomes compared to home-based, lower quality care. For example, higher quality means the childcare providers have more resources (e.g., child to care provider ratio, well-trained care provider) to invest in children.

Chapter 4 examines the relationship between families' childcare cost (copayment) and type of care families choose for a sample of children receiving childcare subsidies in New Mexico. Because of the parental choice provision, the copayment should not impact childcare choices for subsidy receiving families. The results show that the higher copayment decreases the likelihood of selecting higher quality care and purchasing the center-based care. For other policy outcomes, higher copayment does not affect stability in the care but positively influences continuity in the program. Although subsidy leads to better quality childcare arrangements, higher families' childcare cost is associated with lower quality and informal childcare utilization. The chapter concludes that reducing copayment may incentivize subsidy-receiving families to seek better childcare arrangements.

5.2 Limitations and Future Research

The goal of this research has been to explore the ways human capabilities can be formed during early childhood (i.e., before age 5). This dissertation began with an investigation of the impact of mild shock during pregnancy and moves on to investigate the maternal time investments by gender. Then, examines the relationship between copayment and childcare selection for families receiving childcare subsidy. Future research on child wellbeing can be advanced in a number of ways.

First and foremost, future researchers need to take advantage of quality data. Skill formation is a cumulative process by which current and past inputs combine to produce cognitive and non-cognitive outcomes. Along with birth endowment, intergenerational attributes influence skill formation, which means a large-scale longitudinal data is necessary for evaluating the impact of early life circumstances. For example, longitudinal data can used for lagged models instead of contemporaneous family information in health production (Chapter 2) and cognitive skill production (Chapter 3). Theoretically and empirically, better models have been developed using lagged information, where past skills (health or cognitive) produces later skills. Moreover, Chapter 4 utilizes large scale administrative data from different state agencies. Due to the lack of common identifiers among state agencies, there is a high attrition rate while matching the data based on name and date of birth. Given the increasing computing power and the availability of big data, future research on child wellbeing should consider using higher quality data.

Secondly, the idea explored in Chapter 2 – mild shocks during pregnancy and early life health – needs further investigations. Relatively mild shocks in utero can have substantial impacts, but the effects can vary because of the birth endowment, resource constraints, and production function. For example, Chapter 2 shows that the impact of a mild shock during pregnancy gradually decreases and is almost undetectable by age five as the affect fades over time. This finding differs from previous research on the effects of mild shocks on later life outcomes; hence it should be externally validated. Future research should use mild stressors that occur frequently and experienced commonly to validate the findings from Chapter 2.

Finally, economists have often overlooked the presence of multiple shocks during childhood. In recent years, Nepal experienced different shocks: political (armed conflict), natural (earthquake), and economic (economic blockade). Children and pregnant women, who experienced climatic shocks, may have experienced other shocks during that period. Results from Chapter 2 can be advanced by considering temporal and spatial variation on the intensity of multiple shocks and their combined or individual effects on children and their later life outcomes.

5.3 Policy Perspective

This dissertation provides three general findings. First, high-temperature due climate change during pregnancy retards physical growth in early childhood, for the observed Nepalese sample. Second, mothers spend time equally between boys and girls for the preschool children in Nepal, showing that mothers do not prefer sons over daughters. And third, families' contribution toward childcare cost impacts childcare choices for families receiving a subsidy, for the observed New Mexico sample, where higher cost is associated with home based and lower quality care. Each chapter provides different the policy recommendations. For example, Chapter 2 argued for policies aimed at raising awareness on the detrimental effects of climate change on human health. Chapter 4, on the other hand, recommended that policymakers may want to reduce families' childcare costs for better care arrangements. When there are a lot of policy options, policymakers may struggle to balance child wellbeing policies.

Policymakers may struggle to balance policy approaches and tools in order to encourage child wellbeing. Whether it is better to approach with a targeted policy or provide a universal coverage? How does a mandated or voluntary assistance impact? Or, should policymakers focus on preventative program rather than treatment program? Moreover, different policy instruments are available for the policymakers (like economic incentives and legislation). When a government implements a policy, there is always concern about spending trade-offs, higher taxes, reduced economic inefficiency, and unintended consequences. For example, a voluntary assistant targeted to lower income families, childcare subsidies do not necessarily lead to higher quality and center-based care because of copayments for a sample of families receiving child care assistance in New Mexico (Chapter 4).

In addition, there are ideological challenges in implementing effective child wellbeing policies. First, decision-making power on choices are shared between the state and family. Policymakers may struggle on levels of parental autonomy (or parental choice). Second, ideological differences on the role of market and state can influence the policy design. Above all, budgetary constraint can severely limit appropriate policy like implementing new intervention. Then, the question remains open: how can states balance child development and parental choice policies, given the budgetary constraint and ideological variation.

Because of the complexities in designing and implementing child development policies, the preceding three chapters do not recommend one policy, neither there seems to be one, but all three chapters promote one theme, i.e., financial constraint may be the biggest hurdle in human capital accumulation in early life. Because of increase in food price due to high temperature (Chapter 2) and inverse relationship between copayment and quality, formal child care choices (Chapter 4), resource constraints seem to be the biggest hurdle in child development in a sample of children from developing country (Chapter 2 and 3) and lower-income families (Chapter 4). Therefore, the broad policy initiative should be about reducing parental stress associated with lack of resources, or, at least voluntary offer of assistance should be available to the families in need.

Finally, as the saying goes, “it takes a village to raise a child,” rearing a child requires a great deal of resources. Parental investments and policy responses both play key roles in the accumulation of the “acquired and useful abilities” (Smith, 2003, p.17). As the Adam Smith quote that opened this work, where he observed that most dissimilar people are similar “for the first six or eight years of their existence” (Smith, 2003, p.17). It is precisely these few years of life that opens the gap between the “most dissimilar characters, between a philosopher and a common street porter” (Smith, 2003, p.17). Therefore, every individual can be successful, enjoy freedom, and live with dignity if the right set of human capital investments are given during the formative years.

A Appendix for Chapter 2

Figure A.1: Height-for-age z-score by age in month

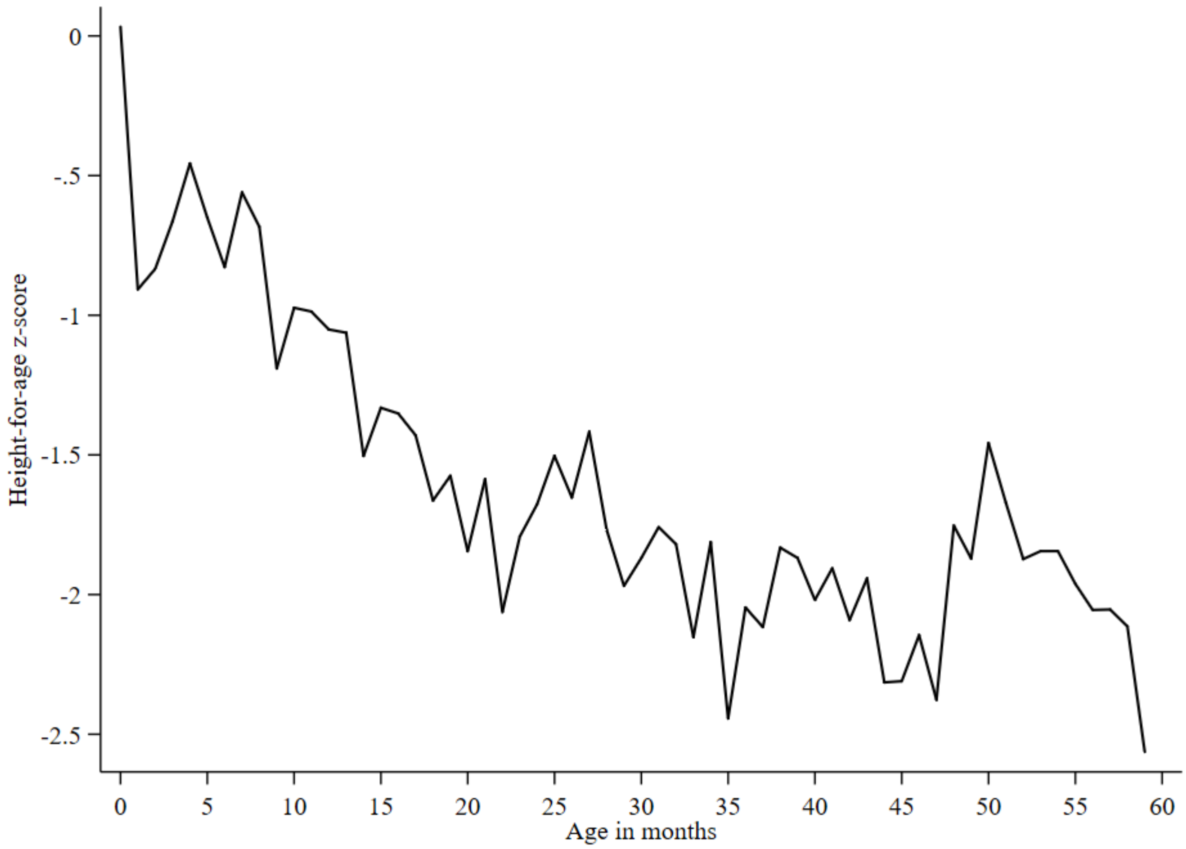
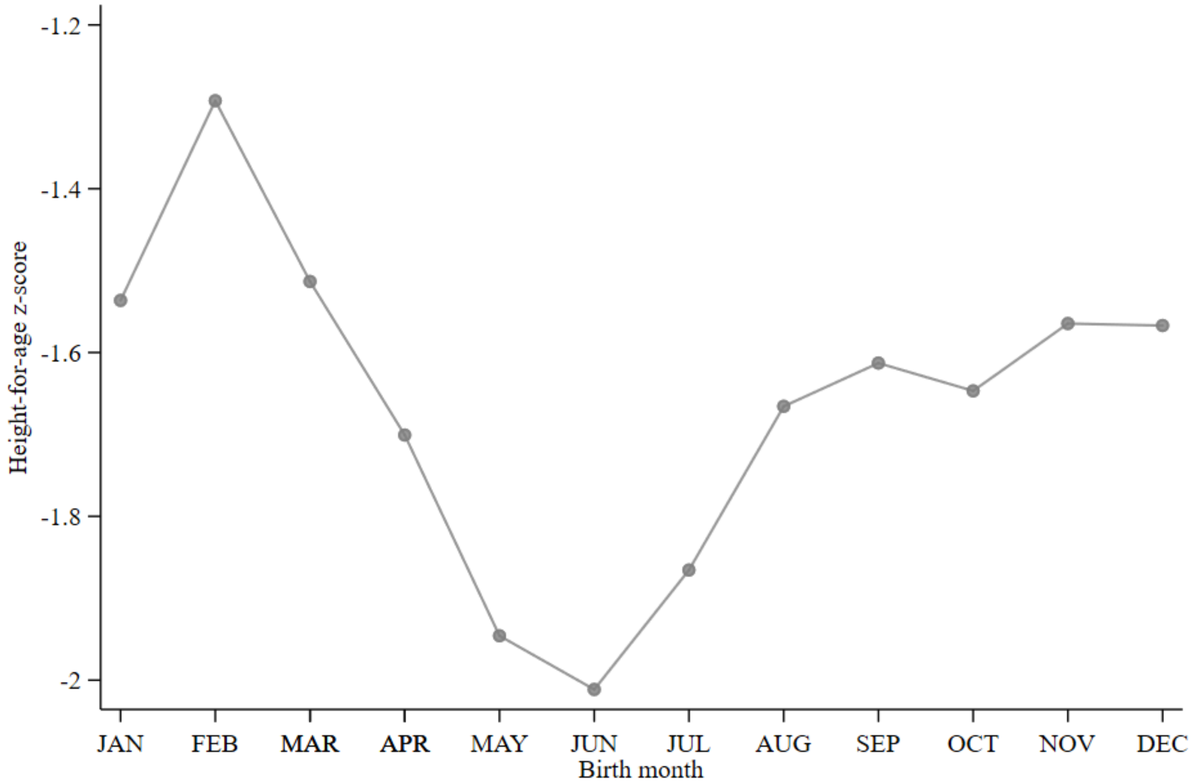


Figure A.2: Height-for-age z-score by birth month



Note: MAR, APR and MAY is the *Spring* Season; JUN, JUL, and AUG is the *Monsoon* Season; SEP, OCT and NOV is the *Autumn* Season; and DEC, JAN and FEB is the *Winter* Season

Figure A.3: Districts with available food prices (administrative boundary before 2015)

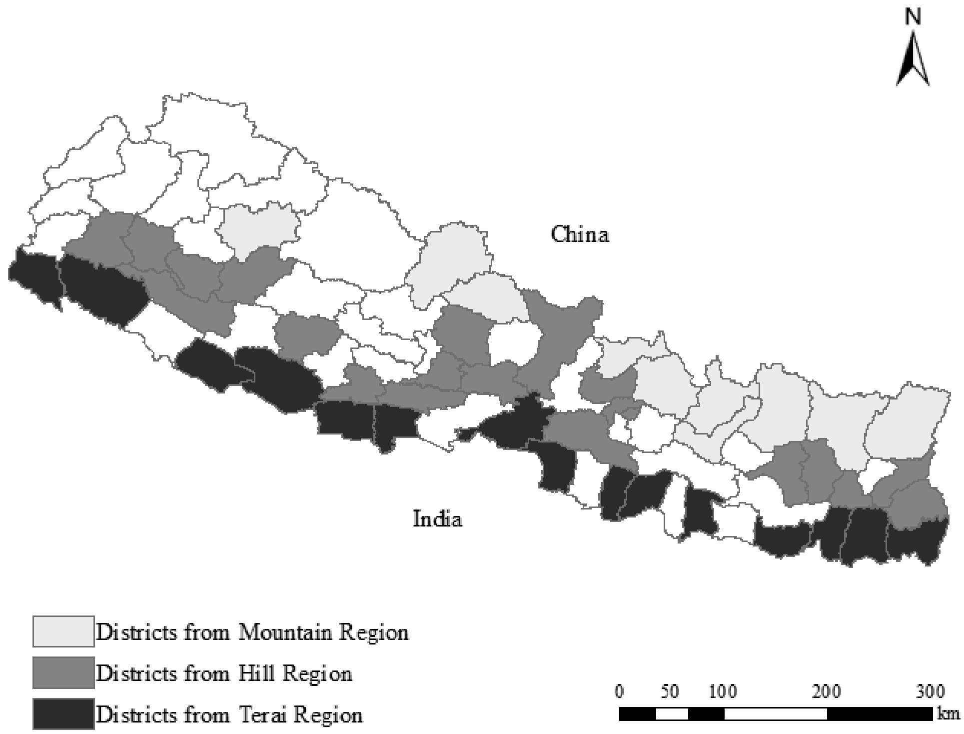


Figure A.4: Frequency of birth by birth month

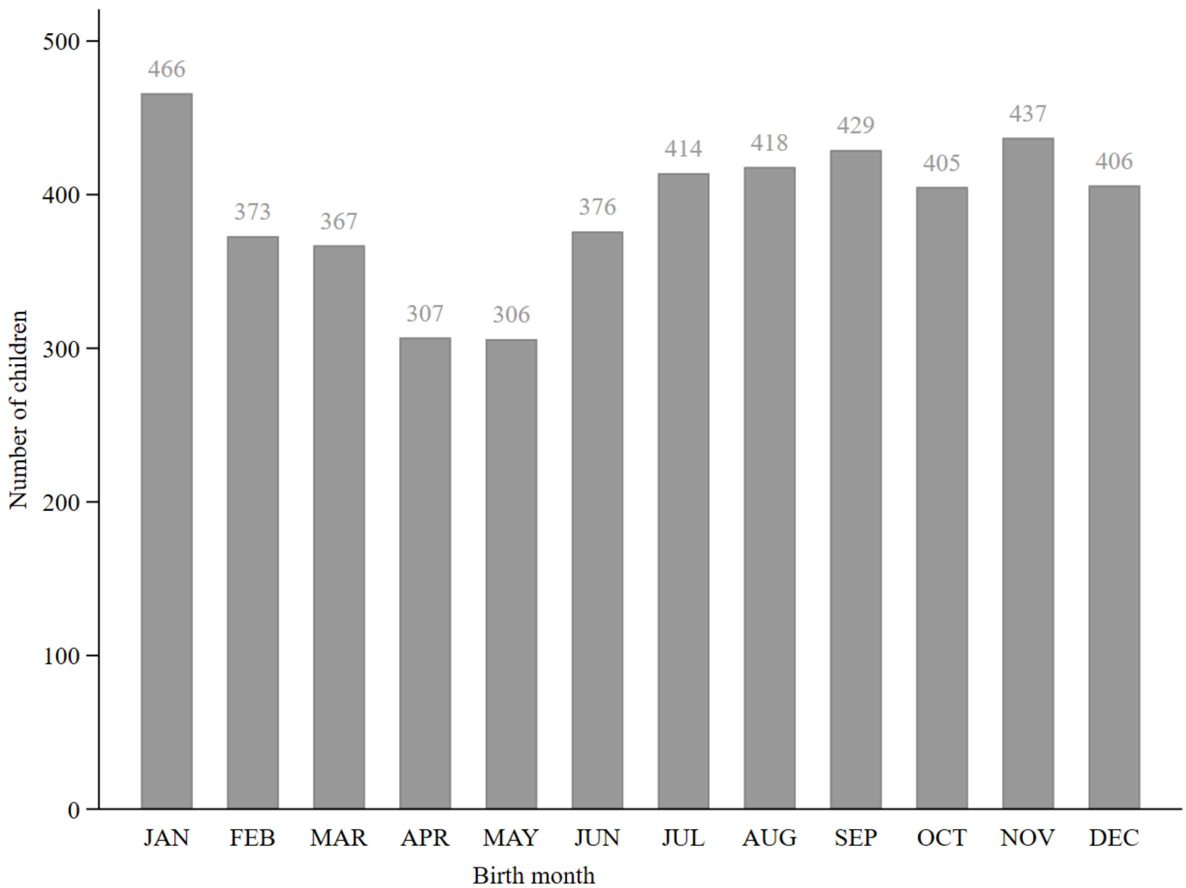


Table A.1: Descriptive statistics for high-temperature days and matching distances

Variable	Variable Description	Mean (std. dev.)
Temperature	Number of days in gestation with daily mean temperature higher or equal to 32 degree Celsius (98.6 Fahrenheit).	4.043 (9.641)
Difference in elevation	Differences between household cluster elevation and matched station elevation. The elevation is measured in meters.	23.33 (262.4)
Distance	The distance between household cluster and matched meteorological station. The distance is measured in kilometers.	17.47 (11.52)
Observations		4704

B Appendix for Chapter 3

Table B.1: Construction of child outcome variables

Variable	Variable Description
Four Domains of childhood development	
Physical	A child is developmentally on track if at least one of the two question is true: can pick up a small object with two fingers, and is not sometimes too sick to play.
Literacy/Numeracy	A child is developmentally on track if at least two of the three questions are true: can identify or name at least ten letters of the alphabet, can read four simple words; knows the name and recognizes the symbol of all numbers from 1 to 10.
Social-emotional	A child is developmentally on track if at least two questions are true: gets along with other children, does not kick bite or hit other children, and does not get distracted easily.
Approaches to learning	A child is developmentally on track if at least one of the question is true: follows simple directions on how to do something correctly, and able to do something independently when given it to do.

Table B.2: Effect of gender on maternal time input for the first born and second born children

	(1) Total maternal input	(2) Cognitive maternal input	(3) Behavioral maternal input
Female	-0.000703	-0.0115	-0.00474
	(0.0646)	(0.0701)	(0.0668)
N	1102	1102	1102

Note: The estimates are from ordered probit regression. Besides the control listed above, survey-month fixed is used. Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.3: Effect of gender on maternal time input for the first born children

	(1) Total maternal input	(2) Cognitive maternal input	(3) Behavioral maternal input
Female	0.0150	-0.0142	0.0123
	(0.0908)	(0.0990)	(0.0941)
N	568	568	568

Note: The estimates are from ordered probit regression. Besides the control listed above, survey-month fixed is used. Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.4: Effect of gender on maternal time input for rural households

	(1) Total maternal input	(2) Cognitive maternal input	(3) Behavioral maternal input
Female	0.0166	0.0371	0.0104
	(0.0495)	(0.0542)	(0.0511)
N	1910	1910	1910

Note: The estimates are from ordered probit regression. Besides the control listed above, survey-month fixed is used. Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.5: Effect of gender on maternal time input for less educated mothers

	(1) Total maternal input	(2) Cognitive maternal input	(3) Behavioral maternal input
Female	-0.00144	0.00236	0.0169
	(0.0552)	(0.0608)	(0.0571)
N	1559	1559	1559

Note: Less educated mothers are defined as mothers less than or equal to five years formal schooling. The estimates are from ordered probit regression. Besides the control listed above, survey-month fixed is used. Standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01

Table B. 6 Effect of maternal time input on child outcomes

	(1) ECD Index	(2) ECD Index-Composite score	(3) Cognitive Composite score	(4) Behavioral Composite score
Maternal Input	0.0988***	0.136***	0.0940***	0.0374**
	(0.0227)	(0.0227)	(0.0163)	(0.0171)
Female	0.0691	0.177	0.0472	0.118
	(0.0831)	(0.0946)	(0.0654)	(0.0686)
Input X Gender	0.0371	0.0455	0.0516	-0.00785
	(0.0323)	(0.0316)	(0.0221)	(0.0230)
Birth order	-0.00257	0.0228	0.0140	-0.0208*
	(0.0158)	(0.0173)	(0.0119)	(0.0126)
Child's age in months	0.0346***	0.0596***	0.0505***	-0.00788**
	(0.00423)	(0.00457)	(0.00322)	(0.00330)
Number of years in schools	0.00388	0.0354***	0.0349***	-0.00303
	(0.00886)	(0.00907)	(0.00640)	(0.00675)
Mother's age in years	-0.00590	0.00752	-0.00262	0.0117***
	(0.00565)	(0.00629)	(0.00424)	(0.00448)
Lower caste (Dalit)	-0.284***	-0.238***	-0.240***	-0.0693
	(0.0753)	(0.0806)	(0.0592)	(0.0624)
Wealth index	0.145***	0.518***	0.306***	0.0524
	(0.0475)	(0.0493)	(0.0344)	(0.0359)
Rural	-0.0730	-0.0887	-0.0676	-0.0874
	(0.0976)	(0.0973)	(0.0683)	(0.0722)
Household size	-0.0204**	-0.0136	-0.0278***	0.000376
	(0.00921)	(0.0104)	(0.00717)	(0.00752)
N	2304	2304	2304	2304

Notes: Column 1 estimates are from probit regression. Column 2 estimates uses ordinary least square with robust standard error. Columns 3 and 4 estimates are from ordered probit regression. Standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01

C Appendix for Chapter 4

Table C.1: Marginal effects: star level

	1 STAR	2 STAR	3 STAR	4 STAR	5 STAR
Copayment	0.015***	0.528***	0.123***	0.091***	0.242***
	(0.000)	(0.002)	(0.002)	(0.001)	(0.002)

Notes: Marginal effects using Table 4.3 Specification 3.
* p < 0.10, ** p < 0.05, *** p < 0.01

Table C.2: Marginal effects: Center-based care and Stability in the program

	Type	Stability
Copayment	0.711***	0.757***
	(0.002)	(.006)

Notes: Marginal effects using Table 4.4 Specification 3 for center-based and Table 4.5 Specification 3 for stability.
* p < 0.10, ** p < 0.05, *** p < 0.01

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