AN ABSTRACT OF THE DISSERTATION OF

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Abstract approved:

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Alison Johnston

In resource constrained settings, missing markets and unregulated externalities can have a significant impact on human capital outcomes. High out of pocket expenditure due to the inaccessibility of insurance markets limits the use of healthcare, just as the inability to borrow in the face of a cash constraint may lead to below subsistence levels of consumption. Policy instruments designed around some of these market imperfections are gaining traction in developing countries influenced in large part by international experience. Global discourse around universal health care coverage and minimum basic income has given momentum to programs that provide some form of financial and risk protection to vulnerable populations in low -income countries. Yet, gaps in regulatory protection, for instance, ineffectual implementation of health, safety and environmental policies are also exacerbating the risks for disadvantaged groups. This research examines the health implications of public policy around three instances of market failures in the context of a developing country – Pakistan.

The first study examines maternal healthcare utilization following the introduction of a public health insurance program for low-income families. The market for health insurance addresses the income shock that presents itself in the form of catastrophic expenditure due to a severe illness or injury. In developing countries, well-

functioning private markets may not exist, or they may not cater to all segments of the population. Governments driven by equity concerns may then offer subsidized public insurance to protect families from high out of pocket costs. This paper is motivated by the consideration that institutional constraints within the health care system of a developing country may limit the effectiveness of even highly subsidized programs. Any gains in health outcomes are likely conditional on the adequate take up and low barriers to access for eligible population. Indeed, we find that the benefits of the program accrue largely to those in urban areas. The findings suggest that the lack adequately staffed health facilities may preclude the poorest groups from benefiting from such government initiatives. Given the potential of the program to improve health care utilization, complementary investment in infrastructure would make the program more inclusive and better address existing inequities in the use of healthcare.

Missing credit markets also impact household welfare by limiting their ability to borrow in the event of an income shock. As a safety net mechanism, cash transfer programs serve to mitigate the effects of extreme poverty and protect against deprivations caused by adverse shocks. In the second paper, I examine nutritional outcomes following the provision of supplemental income to cash constrained families. Existing evidence suggests that the under accumulation of human capital begins while the child is in utero (Black et al., 2013; Fink & Rockers, 2014; Sudfeld et al., 2015). Consistent with that body of evidence, our analysis highlights the importance of providing cash support during the prenatal period. Additionally, we find that positive nutritional impacts are linked to the birth order of the child. To improve child anthropometric outcomes, a complementary role of informational interventions is recommended for cash transfer programs implemented in low-income settings.

The third paper differs from the first two as it examines the public health implications of the *absence* of policy in regulating market failure. It explores the

externality associated with the agricultural practice of stubble burning. In agriculturally productive regions with access to irrigation, residue burning is used to clear land between cropping cycles in order to plant two or more seasons of crops in a year. It is an unregulated source pollution that imposes a cost on society and on populations with already low access to healthcare. Findings suggest that individuals with high exposure to fire emissions experience higher incidence of respiratory illness. Together, these three papers highlight the health policy nuances that must factor into our efforts towards reducing inequities in health outcomes between countries and among populations.

Health Outcomes in Pakistan: Empirical Essays for Policy Assessment

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Najam uz Zehra Gardezi, Author

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Chapter 1: Introduction

Health outcomes in developing countries are characterized by shorter life spans, higher infant mortality, and greater incidence of illness throughout life (Deaton, 2003). Households and individuals have limited resources to invest in health which impacts their economic productivity and results in lower standard of living. This perpetuates an intergenerational cycle of poverty and may also contribute to widening health gaps across countries. However, while there is a well-established link between income levels and health, the effectiveness of government policy is an important third factor that may impact the bidirectional relationship between economic and health outcomes. This is particularly true for instances where there are barriers to investing in health, and market failures that disproportionately impact low-income populations (Dupas & Miguel, 2016).

In resource constraints settings, market failures have a significant impact on health outcomes. For example, low education levels or lack of information may prevent individuals and households from investing in cost-effective preventative behaviors (Jalan & Somanathan, 2008; Madajewicz et al., 2007). Similarly, in the absence of well-functioning financial markets, households that are unable to purchase health insurance or accumulate precautionary savings, remain vulnerable to the negative monetary impacts of unexpected medical expenditure (Gruber, 2012).

The economic framework of market failure is useful for examining the role of government policy in healthcare markets. The standard market model may fail to bring about optimal health outcomes for a number of reasons. First, interest in healthcare outcomes extends beyond buyers and sellers to include the well-being of society at large. The presence of externalities can render the unregulated market inefficient. Second, purchasers of healthcare (patients) cannot adequately evaluate the value of treatment that is available, and this lack of information may preclude them from making optimal choices. Credible informational interventions may need

to be incorporated into public health policy. Thirdly, because socioeconomic characteristics strongly determine health status, insurance and credit markets may not cater to low-income populations because of the perceived risk of adverse selection. It may therefore be in the interest of policymakers to intervene and ensure more equitable outcomes. Additionally, externalities associated with economic activity outside of the healthcare market may have health implications and may therefore require regulatory measures to protect susceptible populations.

In the case of public insurance, which is the subject of chapter 2, a policy intervention is merited due to missing markets for low-income populations. The demand for insurance exists because people desire to limit volatility in consumption from uncertain outcomes. Individuals therefore prefer paying premiums that reduce current income (consumption) to hedge against the future risk of getting sick and incurring a large medical bill (Nyman, 2002). In a well-functioning private market, (health) insurance companies can meet this demand by charging premiums and in turn cover medical cost in the event of sickness or injury (Gruber, 2012).

The reason then that individuals may fail to insure themselves in a private market is that the cost of insurance is driven up by adverse selection within these markets. This occurs due to the problem of asymmetric information across buyers and sellers in the insurance market. Individuals seeking insurance possess more information about their own health and lifestyle (and consequently the probability of future illness) than the insurance companies. Since it is expected that the individuals most likely to seek insurance is those that face the highest risk (probability of sickness), insurance will either not be offered (because it is not profitable to insure these individuals), or it will be offered at very high premium that crowds out less risky (healthier) consumers of insurance with lower willingness to pay. Thus, due adverse selection equilibrium demand is below the social optimal (Akerlof, 1970). The insurers' reluctance to offer insurance to groups of individuals is indicative of a market failure that justifies government intervention.

The problem of adverse selection may persist and can arguably be more severe in the context of health insurance in a developing country. Among the low-income strata, lack of affordability combined with low levels of trust in and understanding of financial instruments can lead to a limited client base and consequently a riskier insurance pool. Additionally, administrative costs are high (Yao et al., 2015) and the willingness to pay for the subsequently higher premiums may only be present among individuals who anticipate incurring sizable healthcare costs. Government policy can subsidize insurance (to the extent of making it free as some countries aiming for universal healthcare coverage have attempted to do). The underlying logic of risk pooling is similar to how private markets attempt to overcome asymmetric information by offering group (and specifically employer) insurance. With a large enough number of people facing varying probabilities of getting sick and claiming insurance, it is easier to predict the average expected payout in terms of medical cost.

Missing markets also impact low-income households by constraining their ability for intertemporal borrowing. Health behaviors such as preventative measures and adequate nutrition require investment and households may underinvest in these behaviors due to liquidity constraints (Dupas, 2011). Cash transfer programs such as the Benazir Income Support Program (BISP) discussed in Chapter 3 are becoming ubiquitous in developing countries. Designed as poverty reduction initiatives, the supplemental payments made to low-income households can in theory be used for investment in human capital including health.

Existing studies have shown that by removing credit constraints, the purchase of health products can be increased (Tarozzi et. al., 2014; Meredith et al., 2013). In an experimental study, Tarozzi et al., 2014 examined the behavioral response to credit contracts on insecticide treated bed nets. The study was set in eastern Indian districts where malaria represents a significant public health concern. Despite a 20% yearly interest rate, 52 % of the households purchased a ITN on credit. Their study shows

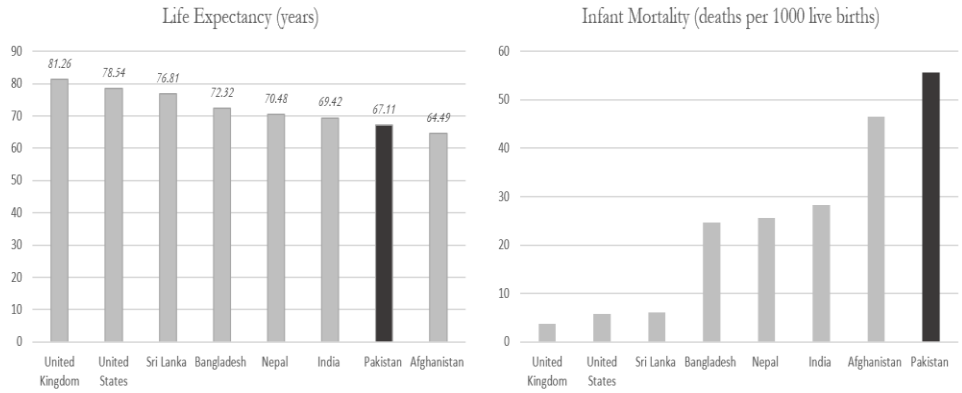
that easing liquidity constraints can increase the demand for health products. Similar results were found by Meredith et al., (2013) who examine the effect of liquidity on the purchase of rubber-soled shoes aimed at protecting children from worm infection.

In addition to examining the outcomes associated with government programs that address some market failures, this research also examines the public health implications of the *absence* of policy in regulating externalities. The social cost of an economic activity may not be accounted for in private cost-benefit analyses and gaps in regulatory protection, for instance, ineffectual implementation of health, safety and environmental policies exacerbate risks for disadvantaged groups. Among the many health challenges faced by low-income countries, one significant cause of mortality and morbidity is the prevalence of noncommunicable diseases linked to air pollution. Chapter 4 highlights a hereto unaddressed market failure and the need for policy intervention to remedy environmental externalities that result to poor health outcomes.

1.1. Study area and Problem Statement

Pakistan is a low-income country in South Asia with the fifth largest population in the world. Its poverty rate of 24.5 % (Planning Commission, 2016) translates into about 50 million people living below the national poverty line. The country faces high burden of disease from communicable disease, poor nutrition, and inadequate investment in healthcare. This is reflected in the dismal state of human capital outcomes including low life expectancy and high infant mortality rates compared to other countries in the region and more so in comparison to advanced nations (Figure 1.1).

Figure 1.1. Life expectancy and infant mortality - country comparisons



Source: Data from https://data.worldbank.org/

In 2016, Pakistan adopted UN's Sustainable Development Goals (SDGs) as its own national development agenda through a unanimous National Assembly resolution. An integrated approach to social, economic, and environmental strategies has since been adopted to reflect commitment toward the developmental goals outlined by the SDGs. Within the framework of these goals, targets for health that are of particular relevance to this research are:

SDG target 2.2: *End all forms of malnutrition, including achieving targets on stunting and wasting in children under the age of five*

SDG target 3.2: *To reduce neonatal mortality to as low as 12 per 1000 live births*

SDG target 3.9: *Substantially reduce the number of deaths and illness from air pollution*

The three targets listed above underscore the policy relevance of this work. Each of the subsequent chapters addresses developmental outcomes that are part of the global agenda for improvement in health. This research focuses on populations living in (or are vulnerable to) poverty for whom gains from government policy are likely to be substantial.

In context of these SDG targets, current indicators provide a compelling rationale for policy assessment. First, the rate of stunting (height for age less than 2 standard

deviation from the WHO growth standards) for children under the age of 5 is estimated to be 37.6% (UNICEF, 2018). Second, the neonatal mortality is 42 per 1000 live births (World Bank, 2016). These statistics suggest that 1 in 3 children do not achieve their linear growth potential and one in every 22 newborns dies within the first 28 days of life. This is an alarming state of child health outcomes even by developing country standards. The country's performance is not significantly better in terms of SDG target 3.9. Pakistan has witnessed significant deterioration of air quality in the past 10 years. It is among the top 10 countries of the world with the highest level of population-weighed annual average PM 2.5 exposure (Health Effects Institute, 2020). In light of these challenges, this research examines the impact of government policy on health outcomes that are tied to the country's broader developmental agenda.

1.2. Contribution

The three chapters in this dissertation contribute original analysis on issues of policy importance for health systems in Pakistan. The challenges of improving health outcomes for vulnerable and resource constrained groups are similar across a variety of settings and so the findings of this research are generalizable to other low-middle-income countries.

Chapter 2, to the best of our knowledge, offers the first empirical examination of the *Sehat Sahulat* public health insurance program in Pakistan. The program itself is the first of its kind in the country and represents a substantial outlay of the government's expenditure on health. As a result, there is considerable interest in building evidence around program participation and overall efficacy in reaching target beneficiaries A feature of the program that has invited skepticism, is that it covers only in-patient services even though there are other sizable costs associated with seeking healthcare. This, together with other institutional constraints common to developing countries, underscores the value of the research on healthcare utilization. The analysis in this chapter was conducted at an early stage of the

program implementation using a difference in difference approach. Findings provide an agenda for further evaluation of the program and highlight the value of such programs in improving healthcare utilization in developing countries.

The analysis in chapter 3, contributes to the rich and growing body of work that evaluates the impact of cash transfer programs on health. Moreover, the outcome of interest - stunting in children under the age of 5, is an issue of high policy salience in Pakistan and one that was even highlighted by the current Prime Minister in his inaugural victory speech. It The high incidence of stunting in the country is inherently tied to poverty related deprivations. The contribution of this paper is towards examining the behavioral response of low-income groups to the availability of supplemental income. Nutritional outcomes in children are documented to show improvement under conditional cash transfer programs, but there is less evidence on whether similar outcomes can be achieved in the absence of associated conditionalities. The program evaluated in this paper is a standard model of unconditional cash transfer targeted to female beneficiaries in a low income setting and findings are largely generalizable to other developing country contexts.

Finally, while Chapter 4 discusses an issue of a more localized significance, smoke from pollution has become a concern for many countries across the globe. The increased risk of wildfires due to the climate change makes it imperative that an adequate health policy response be in place. This paper contributes to a nascent body of work examining the health impacts of air pollution in developing countries. It also employs a unique methodological approach of matching household surveys and to satellite data in order to measure health impacts of pollution at an individual level. The practice of agricultural crop residue burning is likely to disproportionately impact low-income rural populations who have poor mobility and hence fewer options for avoidance behavior, in addition to already limited access to health care. Thus, this chapter also contributes to literature on environmental justice – a deeply underexamined area in the context of developing countries.

1.3. Thesis Organization

The current chapter provides an overview of the problem statement and research questions that are addressed in subsequent chapters. Chapter 2, 3 and 4 while a part of the whole, can also be taken as independent research papers each with introduction, data, methods, results, discussion, and conclusion sections. The final chapter concludes this dissertation.

Chapter 2: Public health insurance and birth outcomes

Abstract

Public health insurance targeted toward low-income households has gained traction in many developing countries. Rising incidence of disease and out of pocket (healthcare) expenditure together with donor promises of budgetary assistance have led to widespread support for such programs. This paper evaluates a recent health insurance initiative introduced in Pakistan and discusses whether eligibility for the program improves maternal and newborn health seeking behavior. Mother and child health are important developmental concerns in low-income countries of South Asia, where the rates of maternal mortality and infant mortality are alarmingly high. The *Prime Minister National Health Program* implemented by the government of Pakistan provides insurance coverage to the poorest members of society. It allows program beneficiaries to access private sector healthcare at little or no cost to themselves. The program evaluated in this paper is in the early phases of implementation and has, since 2016, only been rolled out in a few eligible districts within the country. This allows for a comparison of eligible households in districts where the program has been introduced to those that are eligible to receive insurance at a future date. Using repeated cross-sectional data from multiple rounds of representative household survey, a difference in difference model has been estimated. I find that at least for a specific beneficiary group (i.e., pregnant women), there has been a positive increase in utilization of hospital services. There is no evidence of moral hazard in that I do not observe an increased likelihood of caesarean births that would reflect over-utilization. Further, I provide evidence using mother fixed effects that the program increased the likelihood of a child's birth being documented - an unintended but positive outcome of the program.

2.1. Introduction

Public health insurance has gained traction among health systems reforms as a viable option for achieving universal health coverage in developing countries (Kremer & Glennerster, 2011, Acharya et al. 2012; Banerjee et al., 2019). For families living in poverty, serious illness can lead to a substantial decrease in income and non-health consumption (Gertler & Gruber, 2002; Wagstaff, 2007). Government supported insurance, as an alternative to sustaining large public health infrastructure, can provide protection against catastrophic expenditures[1] and increase the use of healthcare services (Miller et al, 2013; Gruber et al, 2014; Bernal et al., 2017).

This paper examines the use of obstetric delivery services following a public health insurance initiative in Pakistan. High rates of maternal and neonatal mortality pose a significant challenge for health care policy practitioners in South Asia. Ensuring that births occur in a safe environment and with the assistance of a skilled birth attendant, is a prominent strategy for improving maternal and newborn survival rates in developing countries. Policies such as the *Janani Suraksha Yojana* (JSY)[2] program in India, which provides cash transfers to poor pregnant women conditional on institutional birth reflect the emphasis on such measures in improving birth outcomes. For families living in poverty, maternal expenditure, particularly the cost of institutional care, can be a source of considerable financial distress (Bonu et al., 2009). There is often suboptimal spending and poor uptake of maternal services due to the high cost of quality care (Mohanty & Srivastava, 2012; Zaidi et al, 2017; Yaya & Ghose, 2019). A non-contributory insurance program that facilitates access to quality health services and provides free in-patient care, has the

[1] Out of pocket spending greater than 40% of household's non-subsistence spending (Barnes et al., 2017).
[2] Program details available at https://www.nhp.gov.in/janani-suraksha-yojana-jsy-_pg.

potential to increase utilization and subsequently lower the alarmingly high rates of maternal and infant mortality in the region.

However, any gains in health outcomes are likely to be conditional on adequate take up and low barriers to access for eligible populations. In low- and middle-income countries, a number of factors may limit utilization even among beneficiaries of fully subsidized insurance programs (Bauhoff et al, 2011; Neelson & O'Donnell, 2017). Inadequate administrative resources and lack of oversight mechanisms often result in improper targeting and poor enrollment into such programs. Additionally, numerous demand constraints may inhibit participation among resource constrained groups. Shahrawat and Rao (2011) highlight that even with public health insurance, expenses associated with transport and medicine can be a hurdle in increasing utilization amongst those living in poverty. Some programs such as the Health Equity Fund in Cambodia, attempt to reduce such barriers by offering support for transportation costs and food allowance (Jacobs et al., 2011) but the poorest may still face the obstacle that the cash is not available until it is reimbursed at the health facility (Ensor & Edoka, 2017). Moreover, supply side constraints in terms of service infrastructure and other non-financial barriers also impact the effectiveness of health insurance in developing countries (Wagstaff, 2009). Therefore, an initial step to evaluating such programs is to assess whether eligibility leads to improved utilization of healthcare services.

The *Prime Minister National Health Program* in Pakistan is the first national public insurance initiative in the country. The program was introduced in 2016 but so far it has only been implemented in a few eligible districts. The phased-in rollout of the program allows for the use of a difference in difference estimation to observe patterns of utilization over time and across program and non-program districts. This paper uses repeated cross-sectional data from representative household surveys conducted in the province of Punjab, Pakistan. Individual level data has been used for district fixed effect estimations to capture the impact of being in program

districts. Additionally, the impact on some child level outcomes has been estimated in a mother fixed effects model by exploiting the variation in date of program launch and birth date of the last-born child.

Few earlier studies have used rigorous empirical methods to examine the effect of eligibility on maternal heathcare utilization (Comfort et al., 2013 provide a review). A limitation of non-experimental methods for evaluating programs that do not have universal take-up, is that individuals who opt for the program are not comparable to those that do not (Imbens & Wooldridge, 2009). Selection bias limits the use of observational data for assessing policy impact. The empirical strategy in this paper attempts to overcome this concern by relying on a comparison across districts. A pre trend analysis shows that the districts where the program was introduced are not inherently different from other districts in the province.

In this paper, I add to the recent discourse on the impact of insurance coverage in a developing country context (Miller et al., 2012; Acharya et al., 2012; Lagomarsino et al., 2012; Barnes et al., 2017). While a comprehensive evaluation of the policy is outside the scope of this paper, the findings of this study do suggest that at least for a specific beneficiary group (i.e. pregnant women in urban areas), there has been a positive increase in utilization of hospital services, after the policy was in place for little more than a year. There is weak evidence of moral hazard in an increased likelihood of caesarean births that reflects over-utilization of services. Findings are reinforced by a sensitivity analysis that uses the date of program implementation to capture within district variation. Furthermore, evidence from mother fixed effects estimates suggests that the program increased the likelihood that a child's birth is documented. Birth certificates issued at hospitals are a valuable source of civil registration and can be fundamental in safeguarding a child's access to rights. This is likely an unintended and positive outcome of the program.

2.1.1. Institutional context and Program Details

Pakistan is a low-income country in South Asia with the sixth largest population in the world. Over the years, provincial governments have introduced various supply side initiatives to improve maternal health outcomes including increased provision of Emergency Obstetric and Neonatal Care (EmONC) services and training of community midwives under the Maternal and Child Health Program (M&CHP) (Economic survey of Pakistan, 2018). Despite these efforts, the country's maternal mortality ratio is at 178 death per 100,000 live births (UNICEF, 2015) and neonatal mortality rate[3] is 46 per 1000 live births (World Bank, 2016).

Almost 53% of the total population - 110 million people live in the province of Punjab (Population Census, 2017). Punjab has an extensive government-owned infrastructure in which successive administrations have made relatively large investments considering the meagerness of resources at the disposal of health policy implementers. While highly subsidized, service delivery at public facilities is plagued by numerous management challenges and resource constraints (Hussain et al., 2019). For women living in geographically remote areas, often the only available public sector services are at Rural Health Centers (RHCs) and Basic Health Units (BHUs) that do not offer tertiary services and are ill-equipped to deal with obstetric emergencies. Even with timely referrals to emergency care, low-income families struggle to mobilize resources to secure the required care (Mumtaz et al., 2014). In many instances therefore, women may rely on traditional birth attendants or seek care at low-cost private facilities foregoing the need to ensure hygienic and safe conditions for birth.

Figure 1 illustrates the disparities in the use of services across wealth quintiles in Punjab. Less than 40 percent of women belonging to the lowest income quintile give

[3] UNICEF measures maternal mortality ratio as the number of female deaths from any cause related to or aggravated by pregnancy and its management during pregnancy or childbirth or within 42 days of termination of pregnancy expressed per 100,000 live births for a specified time. Neonatal mortality rate is the probability that a child born in a specific year will die within the first 28 days of life.

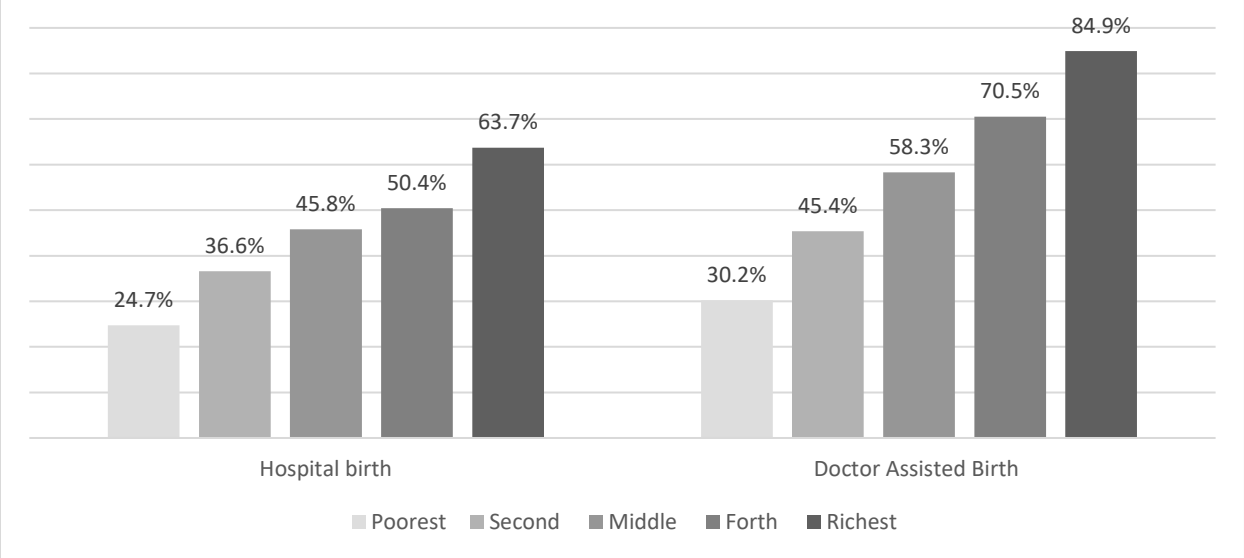
birth at a hospital and less than 50 percent give birth in the presence of a doctor. As the use of maternal healthcare is strongly correlated with socio-economic status, economically vulnerable women are at the highest risk of maternal deaths (Agha, 2015). These women have limited accessibility of essential obstetric care and in addition to significant financial constraints, they are also likely to disproportionately encounter socio-cultural barriers that inhibit access to healthcare (Agha, 2015; Mumtaz et al. 2014). The largely patriarchal society requires that women have the support of their husbands or the male household head to seek formal healthcare. A woman belonging to a lower social class is likely to be mobility constrained as travelling unaccompanied (to a health facility for instance), can have consequences such as loss of family prestige and susceptibility to sexual violence (Mumtaz & Salway, 2005). Other non-financial factors such as a woman's relative autonomy within a household also impact utilization of maternal care (Hiaohui & Hing, 2013; Mumtaz & Salway, 2005).

The Prime Minister Health Program (PMNHP) is a social assistance initiative that provides non-contributory health insurance to families living below the poverty line of 2 USD per day. The program is administered by State Life Insurance Cooperation is Pakistan, which receives a fixed premium per eligible family from the government. Since 2016, the program has been implemented at the district level in a phased in manner across the country. Eligible families with a Poverty Mean Score[4] of less than 32.5 can collect a health card from distribution centers set up in each district. The card may then be used at any of the empaneled public or private sector hospitals for a range of secondary and tertiary services. At the point of service, patients are required to present identifying documents together with the health card and they receive free services for which the hospitals are later reimbursed.

[4] A poverty scorecard was developed with assistance from the World Bank in 2008 and has been used to target other social assistance programs in the country. Enrollment for the program is at the household level. Program details can be found at phimc.punjab.gov.pk.

According to recent statistics available at the program website, an estimated 4.9 million families – approximately 30 million individuals - have been provided coverage in the province of Punjab. The program therefore represents a significant financial commitment on the part of the provincial government. It provides a secondary care coverage up to PKR 50,000 (USD $350 approximately)[5] per family per year. It includes maternity services (normal and caesarean section), maternal consultancy (up to four times before and once after delivery) as well as post hospitalization services. Other medical and surgical procedures including injuries, fractures and emergencies requiring hospital admission are also included in the secondary care coverage.

Figure 2.1: Maternal Health care use across wealth quintiles



Note: Calculations are based on MICS Punjab 2017/18 using responses from women who gave birth in the two years prior to the survey.

Transportation costs are covered up to three times a year with a maximum reimbursement of PKR 350 (USD 2.25) per visit. Additional coverage of up to PKR 250,000 (USD 1750) is provided for treatment of 7 priority diseases: Diabetes Mellitus, heart (angioplasty and bypass), burns and accidents, kidney disease

[5] This amount can cover up to 3 normal hospital births or one caesarean section as well as the cost of any post hospitalization services.

requiring dialysis, chronic infections (HIV, Hepatitis), organ failure and cancer. Since the re-launch of the initiative as the *Sehat Sahulat Program* in 2018, the benefits are set to increase to PKR 120,000 (USD 770) for secondary care and PKR 600,000 (USD 3850) for treatment of priority diseases.

For developing countries with limited availability of resources, targeted health reforms that improve access for the poor have often been advocated as means to address inequities in health (IMF, 2017). Funding accessibility to private sector services through a public health insurance scheme may be a viable policy for improving health outcomes among the lowest income communities.

2.2. Conceptual Framework

Public health insurance programs targeted toward low-income families aim to protect them against financial risk and improve health outcomes through increased healthcare use. However, since these programs are not universal, they only determine eligibility and cannot guarantee either enrollment into the program or increased utilization of services. There is some evidence from developing countries – Indonesia (Banerjee et al., 2019), Nicaragua (Thornton et al., 2010), Mexico (King et al., 2009) and India (Rajasekhar et al., 2011; Cole et al, 2013; Banerjee et al., 2014)- to suggest that take-up of even highly subsidized insurance is low. In 2007, an initiative similar to the Prime Minister National Health Program was introduced in the Indian state of Karnataka providing free in-patient care for people living below the poverty line. An evaluation of the program by Rajasekhar et al. (2011) found that even two years after the launch of the program enrollment rates were at 68% and that utilization of services remained low. In the six-month period after enrollment, only 0.4% of the beneficiaries obtained treatment through the program.

The analysis in this paper is limited to examining change in utilization of obstetric delivery care in districts that provide access to free in-patient services for beneficiaries. It is expected that by removing financial barriers, the program will increase the number of births that occur in hospitals and in the presence of skilled

birth attendants. However, such an impact of the policy is contingent upon adequate enrollment into the program as well as actual health seeking behavior.

Existing evidence on the link between insurance and use of obstetric care services in a low-income country setting is inconclusive. Brugiavini & Pace (2016) found that the expansion of medical coverage to pregnant women under the National Health Insurance Scheme in Ghana led to the increased probability of antenatal checkups, institutional delivery and likelihood of being assisted during delivery by a trained person. Similar results were found in an earlier evaluation of the program by Mensah et al. (2010) although other studies from Ghana (Chankova et al. (2010) and India (Aggarwal, 2010) found no impact of insurance on facility-based deliveries. Lu et al. (2012) also finds that insured women in Rwanda were more likely to give birth in the presence of a skilled birth attendant relative to their uninsured counterparts.

Barriers to healthcare coverage may arise in the form of enrollment cost as well as lack of information. Individuals though eligible may not be informed about the existence of the program or the process of enrolling into it. This is of relevance to a policy initiative that targets low income households and has been introduced only within selective districts of the province and for a relatively short period of time. Insurance coverage may be affected by the education level of target population (Wagstaff, 2009; Brugiavini & Pace, 2016) as well as their exposure to media campaigns (Meng et al. 2010). Additionally, in the case of the PMNHP, at least one household member is required to travel to the district's card distribution center. Therefore, transport cost and considerations of forgone daily earnings may also hinder or delay participation.

Furthermore, the utilization of healthcare, specifically the choice of giving birth at a hospital, can be influenced by a range of factors that may outweigh the benefits of having insurance. Individuals eligible for such a program may be concentrated in suburban and rural areas that are underserved by medical practitioners (Currie & Gruber, 1996). Geographical proximity to hospitals and associated cost of transport;

ease of mobility for women as well as perceived need can influence the uptake of services offered by the program (Henry et al., 2017; Gabrysch et al., 2011; Patience et al., 2011 & Javed et al. 2013). A number of studies have documented the preference for at home delivery among South Asian women due to reasons such as the lack of female doctors, community practices and the perceived quality of care available at health facilities (Iftikhar ul Husnain et al., 2018; Sarker et al., 2016; Bhattacharyya et al., 2013; Javed, 2013). These factors may limit the incentive to use insurance coverage and avail medical care at a facility. Finally, since the program places a limit on maximum annual coverage for a given household[6], intra-household bargaining may impact utilization of insurance for maternity services (Rasul, 2008).

It is important to highlight that while there are numerous determinants of actual maternal health seeking behavior, and the choice of empirical strategy must allow for estimating changes in outcomes that are attributable to the insurance alone. Many previous studies use propensity score matching to examine the treatment effect of insurance. This is a widely used technique for reducing the treatment-selection bias in observational data but has a number of limitations. King & Nielsen (2019) emphasize that *pruning* observations to meet the requirements of this method may inadvertently imbalance the data and make estimates unreliable. Additionally, the method has strong demands on data quality and requires accuracy in the choice of confounding variable included in calculating propensity scores.

This paper estimates the intent to treat effect of insurance by comparing districts with the program to others that at the time of the survey did not have the program in place. Health initiatives in the country are introduced at the provincial level and while other policies such as training of midwives and various awareness campaigns have also sought to increase the use of maternal health care in the same time period, these do not account for district level variation captured in this paper. The analysis is

[6] Families can apply for additional funding after the limit is exhausted, but this is subject to administrative review (as per the website: https://www.pmhealthprogram.gov.pk) and possible delays.

limited to the province of Punjab for comparability across districts and parallel trends are shown across treatment and control districts to establish the validity of the analysis.

2.3. Data

The data used for this study comes from the Multiple Indicator Cluster Survey (MICS) for Punjab, Pakistan. It is a household level data set collected by provincial governments in collaboration with the United Nations Children's Fund (UNICEF). The data are collected every three years and the latest rounds of survey covered 38,405 and 51,660 households in 2014 and 2018 respectively[7]. I use these two years of repeated cross-sectional data to estimate a difference in difference model that compares outcomes across program and non-program districts before and after the introduction of health insurance.

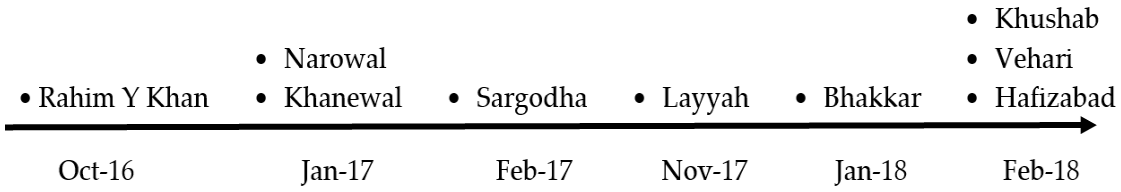
The Prime Minister National Health Program insurance program was initiated in 2016 and was introduced in a phased in manner across districts in the country. Figure 2 provides a timeline for the launch of the program across districts in Punjab. By the end of the most recent survey in March 2018[8], nine districts in the province had received the program. The combined population of these nine districts is almost 22 million people (Punjab Development Statistics, 2017) and given provincial statistics of poverty (Economic survey of Pakistan, 2018), a conservative estimate of 8 million individuals would be eligible for the program by this date. In these nine districts, women that gave birth after the program implementation were included in the treatment group while those in non-program districts serve as the control. A limitation of the current dataset is that it does not allow for us to identify the recipients of the program, thereby restricting the analysis to district level.

[7] Further details about the various modules, sampling frame and survey population of MICS Punjab can be found at http://www.bos.gop.pk/mics.

[8] The latest round of the MICS survey was conducted between December 2017 and March 2018.

The main analysis in this paper relies on information from the women's module of the MICS questionnaire that contains data for maternal health care utilization among women of reproductive age (15-49 years old). The module reports data for women with a live birth in the two years preceding the survey but only in reference to their last-born child. This limits the analysis in the sense that it is not possible to compare childbirth experiences across children born to the same mother. However, a separate child module provides some information on individual children within households, which is utilized to observe some child level outcomes using mother fixed effects.

Figure 2.2. Timeline the implementation of program across districts in Punjab



Health policies in Pakistan are made at the provincial level and Punjab is the largest province[9] with a population of over 110 million people. This paper measures the intent to treat effect of the district level insurance program within the province. The MICS dataset is representative at the district level and provides information on a range of household characteristics and behaviors, with a focus on mother and child health outcomes. The data also allows me to include district fixed effects in the model specification even with pooled cross-section data. Information on the number of hospitals in each district is collected from the Punjab Development Statistics (PDS)[10] for the years 2011 – 2016. I use this data to show that there is no significant difference in the number of hospitals across program and non-program districts (Figure 4). The launch plan and other details of the program are publicly available at the program's website.

[9] It is the largest province in terms of population – it is home to 52% of the country's population.

[10] Bureau of Statistics, Punjab http://www.bos.gop.pk/developmentstat.

Table 1 provides a summary of average characteristics across treatment and control districts in the pre-treatment time period using data from the 2014 survey. It indicates that households in the nine treated districts are relatively poorer given that a greater proportion of households belong to the lower wealth quintiles compared to households in the comparison districts. Households that are in our treatment group are more likely to belong to rural areas and to be a recipient of some form of social assistance from the government. Moreover, individual level data suggests that fewer women in program districts have received education beyond the secondary level and that on average a higher number of mothers in these districts belong to a younger age cohort. However, it appears that there is no significant difference in the average number of hospitals or household's exposure to mass media across districts in the two groups.

Table 2.1: Pre-treatment sample mean across control & treatment districts

	Treatment	*Control*	*Difference* [a]
Individual characteristics [b]	*n = 9,459*	*n = 31,878*	
Outcome variables			
Hospital birth (=1)	*0.56*	*0.62*	*0.06****
Skilled attendant at birth	*0.44*	*0.50*	*0.06****
Caesarean section	*0.19*	*0.24*	*0.39****
Age			
<25	*0.56*	*0.54*	*-0.01***
25-34	*0.21*	*0.21*	*0.00*
35-49	*0.06*	*0.06*	*-0.00*
Education			
None or less than primary	*0.27*	*0.22*	*-0.05****
Middle but below secondary	*0.27*	*0.23*	*-0.03****
Secondary and above	*0.28*	*0.35*	*0.06****

Household level characteristics	n = 8,839	n = 29,566	
Average family size	*6.41*	*6.42*	*0.01*
Average number of dependents	*3.05*	*3.01*	*-0.03*
Female head of household (=1)	*0.06*	*0.08*	*0.01***
Recipient of any social assistance (=1)	*0.07*	*0.06*	*-0.01***
Place of residence			
Rural (=1)	*0.67*	*0.61*	*-0.06****
Household wealth index			
Lowest quintile (=1)	*0.26*	*0.17*	*-0.09****
Second Quintile	*0.22*	*0.17*	*-0.05****
Middle Quintile	*0.20*	*0.18*	*-0.01***
Fourth Quintile	*0.15*	*0.20*	*0.05****
Top Quintile	*0.10*	*0.19*	*0.09****
District characteristics	n = 9	n = 27	
Number of hospitals	*6.67*	*11*	*4.33*
Exposure to mass media [c]	*57.9*	*63.9*	*6.08*

*** p<0.01, ** p<0.05, * p<0.1; Values are rounded off to nearest decimal.

a. Difference in means calculated using T-test for significance.
b. Individual characteristics of women aged 15-49 who gave birth in the two years preceding MICS 2014.
c. Mass media exposure is defined as the percentage of women in the district aged 15-49 who, at least once a week, read a newspaper or magazine, listen to the radio or watch television.

In the absence of randomization, it is possible that differences will exist in the average outcome levels across control and treatment groups. To establish comparability, we show parallel trends across program and non-program districts (Figure 5 a – 5c). The common trends assumption (Verbeek, 2017) requires the comparison (control) group barring the policy treatment to depict similar overall trend in outcomes and is a fundamental pre-requisite for the difference in difference

analysis. The period between 2011 and 2014 is used to observe pre-trends across the program and non-program districts. In addition, we rely on the fact that similar populations are targeted in each district and that implementation processes are similar across the province.

2.4. Empirical strategy

The objective of this paper is to investigate whether introduction of insurance led to greater utilization of obstetric services in districts that received the program. The phased-in nature of the policy allows the use of a difference in difference approach with the 'treatment' group comprising of women that gave birth after the program implementation in the nine program districts (see Figure 3). Women in all other districts in the province - that go on to receive the program at a later date - serve as the control group. To compare outcomes across treatment and control I use the following basic economic specification:

$$MH_{idt} = \beta_1(Post*Policy\ District)_{dt} + \upsilon_d + \nu_t + \varepsilon_{idt}$$

where MH_{idt} is the health utilization by woman *i* in district d in time period t; υ_d and ν_t are district and time fixed effects respectively; ε_{idt} is the idiosyncratic error term. *Post* is a dummy variable taking a value of 1 in the year 2018 i.e. the time after the implementation of the program; 0 for the year 2014. *Policy District* is also a dummy variable with a value of 1 for women that gave birth after the program was implemented in the treated districts, and 0 for observations in districts serving as the control. The intent-to-treat effect is captured by $\boldsymbol{\beta}$ as it is the effect of being in the treated districts in the post policy time period.

Outcome variables to observe maternal health utilization include binary measures of hospital births and birth in the presence of a skilled attendant. *Hospital births* takes the value of 1 for women who reported giving birth at a public or a private hospital

and 0 otherwise[11]. *Skilled birth attendant* is also a binary variable taking a value of 1 if birth was assisted by a trained professional[12] and 0 otherwise. Additionally, I include a binary variable for whether the respondent had a caesarean birth. Evidence based on earlier descriptive studies from low- and middle-income countries suggests that rates of C-Section births increase under public health insurance (Bogg et al., 2010 & Barros et al., 2005). Higher rates of caesarean births may result from supplier induced demand (Gruber & Owings, 1996). There is an asymmetry of information such that health practitioner can over-prescribe health services – in this case recommend a caesarean section to a patient without there being a need for one. The incentive to do so emerges from the design of the program whereby hospitals reimbursed through the insurance company will generate higher revenues for more expensive procedures. Conversely, Aggarwal (2010) found that for low income households, rates of caesarean section were lower among the insured, which the author attributes to below market rates to reimbursement under insurance.

Lastly, I also estimate a child level regression using – again only the 2018 round of survey – and mother fixed effects to examine the probability of having two important documents – birth certificate and vaccination cards – if the child is born during the policy period. The specification is as follows:

$$Document\ possession_{idt} = \beta_1(Post\ Policy)_t + \beta_2(Post\ Policy*Policy\ District)_{idt} + \upsilon_d + \gamma_i + \varepsilon_{idt}$$

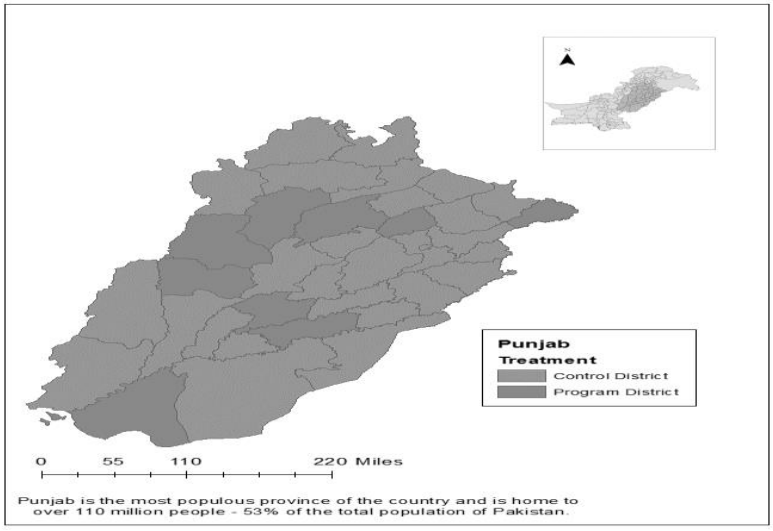
The equation above includes mother fixed effects (γ_i) in addition to the district fixed effects (υ_d). This allows me to observe the difference in outcome for a child born after the introduction of the policy relative to other children born to the same mother before the introduction of the program. Document possession is a binary outcome variable taking the value of 1 if the child is reported to have the specific document

[11] Responses coded 0 include the following: Birth at respondent's home, someone else's home, health center, community center, private clinic and private maternity home and other private sector options.

[12] There is a single category for assistance by nurse and midwives in the MICS questionnaire therefore SBA includes: births is assisted either by a doctor or by a nurse/midwife.

and 0 otherwise. In program districts, the variable for *Post Policy* takes on the value for 1 if the child is born after the program is implemented and 0 otherwise. In non-program districts, it takes a value of 1 for children born after 2017 and is 0 otherwise. *Policy District* takes on the value of 1 if the child was born in the district that had the program at the time of his/her birth and is zero otherwise. The interaction term captures the effect of the program on the probability of having a birth certificate for children born after the policy period.

Figure 2.3. Geographical coverage of sample



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The possession of a birth certificate is linked to hospital births as all hospitals generate this document and provide a copy to the parents upon discharging the mother and newborn. Increased likelihood of having a birth certificate may therefore be an indirect outcome of a program. It requires no effort on the part of households that may otherwise have to bear at least a minimal cost of get the birth documented – particularly if the birth took place at home. Moreover, possession of this document goes a long way in facilitating registration of birth with municipal authorities (Union Councils). Similarly, vaccination cards are generated at birth by hospitals and to a certain degree, these reflect the quality of care that is offered at hospitals.

Table 2.2: Difference in Difference estimates of the effect of the program on health utilization

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Hospital birth			Skilled attendant at birth			Caesarean birth		
Post*Policy Districts	0.07***	0.05***	0.05***	0.04***	0.04**	0.03**	0.04***	0.02	0.01
	(0.017)	(0.018)	(0.017)	(0.017)	(0.017)	(0.016)	(0.015)	(0.016)	(0.0151)
Age									
<25 (=1)			-0.02**			-0.01			-0.05***
			(0.008)			(0.007)			(0.007)
35 - 49 (=1)			0.04***			0.02***			0.04***
			(0.010)			(0.009)			(0.008)
Education									
None or less than primary			-0.14***			-0.14***			-0.09***
			(0.009)			(0.008)			(0.009)
Middle but below secondary			-0.08***			-0.07***			-0.07***
			(0.011)			(0.009)			(0.01)
Birth order			-0.02***			-0.02***			-0.03***
			(0.002)			(0.002)			(0.001)
Empowerment [a]			0.03***			0.009			0.007
			(0.007)			(0.006)			(0.006)
Rural (=1)			0.04***			0.02***			0.03***
			(0.008)			(0.008)			(0.008)
Wealth index			0.07***			0.07***			0.06***
			(0.003)			(0.003)			(0.003)
Post	0.09***			0.09***			0.04***		
	(0.008)			(0.007)			(0.007)		
Policy Districts	-0.06***			-0.06***			-0.04***		
	(0.011)			(0.011)			(0.009)		
District FE		✓	✓		✓	✓		✓	✓
Year FE		✓	✓		✓	✓		✓	✓
Mean	0.54	0.54	0.54	0.66	0.66	0.66	0.25	0.25	0.25
Observations	19,485	19,485	19,485	19,485	19,485	19,485	19,485	19,485	19,485
Adj. R-squared	0.01	0.07	0.16	0.01	0.10	0.19	0.01	0.04	0.12

Estimates capture the intent to treat effect of the insurance program. All outcomes are measured as binary variables. The unit of analysis are women between the ages of 15-49 who at the time of the survey has given birth in the last two years. For treated districts I limit the sample to only those women who gave birth during the policy period i.e. after the policy had been introduced in their respective districts. [a] Empowerment is measured as binary variable for attitudes toward domestic violence. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

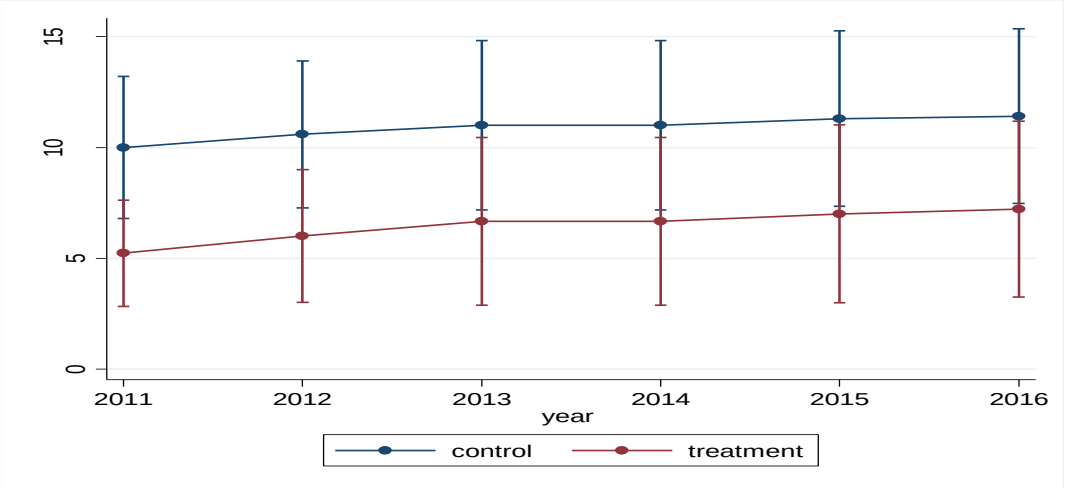
2.5. Results

I use the empirical specification above to observe likelihood of three outcomes: hospital birth, skilled attendant at birth and caesarean birth. Table 2 provides results for the difference in difference estimation with and without the use of district and time fixed effects. The coefficients on *post* and *policy district* variables indicate that average utilization increased in 2018 but was lower in program districts than others in the province. This is consistent with the program being rolled out earlier in low performing districts.

The intent to treat impact of the program is captured by the coefficient on the *Post * Policy District* variable. The results indicate that the probability of hospital birth and having a skilled attendant at birth is higher in the post policy time period within program districts compared to other districts in the same period. These results are consistent with the fixed effects estimations even after controlling for various maternal and household characteristics. The magnitude and direction of impact is similar across the various specifications. These findings can be attributed to free access to hospitals under the health insurance initiative, suggesting that the program was able to reach intended beneficiaries and that it encouraged healthcare utilization. There appears to be no difference in the average number of hospitals in the treatment and control districts that could explain the results (Figure 4).

The results in Column 6 - 9 (Table 2) also suggest that there is no significant difference across control and treatment districts in terms of the likelihood of having a caesarean birth once district fixed effects are included. In a limited sense, this provides evidence against moral hazard in that the findings indicate that hospitals or physicians are not over prescribing procedures to increase hospital revenue. At the same time, it shows that the increase in the other two outcomes of utilization cannot be attributed to a disproportionately higher probability of caesarean births within program districts.

Figure 2.4. Mean number of hospitals in program and non-program districts



Note: Using 95% confidence intervals the figure shows no significant difference in the average number of hospitals across program and non-program districts.

To support the results, I plot in Figure 5(a-c) the coefficients for the fixed effects estimations to reinforce the parallel trends across treatment and control districts. Using 2014 as the base year, I show that across districts, there is no significant difference in outcomes during the pre-treatment time period (i.e. 2011) but with the exception of caesarean births, there is a significant and positive difference in our policy period between 2014 and 2018.

If the sample is stratified into urban and rural, the subsample regressions suggest that results in the initial analysis are being driven largely by urban areas in the program districts. Looking at results based on the urban subsample alone (Table 3), there is a greater magnitude of impact of being in the program district on measures of health utilization. In contrast, the rural subsample results (Table 4) for skilled attendant at birth are insignificant with district fixed effects.

Similarly, the effect on hospital birth also becomes insignificant after the inclusion of maternal and household controls. This is consistent with Grogger et al. (2015) that rural populations with access to inadequately staffed health facilities, are less likely to benefit from public health insurance. Geographical access to hospital is an

important factor in explaining the lack of impact in rural areas. Fiestas Navarrete et al (2019) find that in Ghana, the reduction in out-of-pocket expenditure due to the National Health Insurance Scheme was lower for households that were more than an hour in travel time away from the nearest hospital. The data show lower mean values of all outcome variables in rural areas than in urban areas. To the extent that the program aims to improve utilization, this divergence of outcomes may require greater attention to the factors that are limiting access in rural areas.

To establish the robustness of the results that improved outcomes in treated districts can be attributed to the PMNHP, I present results based on a sensitivity analysis in Table 5. Using data from the last round of survey only and restricting the analysis to the nine program districts, I compare differences in outcomes before and after the introduction of the program. Using the implementation date of the program across districts and the date of birth of the last-born child, I create *birth after program* as a treatment variable which takes the value of 1 if the woman gave birth after the program was implemented in her respective district. The control group comprises of women who in the same districts gave birth before the program was implemented and also those in other districts that received the program at a different date. Out results show comparable improvement in the probability of hospital birth and of there being a skilled attendant at birth. This analysis also indicates that there is an increased probability of caesarean birth among women that gave birth after program introduction compared to other women in the same district or those that gave birth in another district at the same time. In light of earlier results however, this estimate cannot be attributed to moral hazard implications of the program.

Table 2.3: Difference in Difference estimates of the effect of the program on health utilization – Urban subsample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Hospital birth			Skilled attendant at birth			Caesarean birth		
Post * Policy District	0.12***	0.11***	0.09**	0.07*	0.07**	0.06*	0.07**	0.06	0.04
	(0.037)	(0.038)	(0.036)	(0.034)	(0.034)	(0.032)	(0.037)	(0.038)	(0.037)
Age									
<25 (=1)			-0.05***			-0.03**			-0.08***
			(0.015)			(0.013)			(0.015)
35 - 49 (=1)			0.02			0.016			0.03
			(0.019)			(0.017)			(0.018)
Education									
None or less than primary			-0.13***			-0.13***			-0.09***
			(0.017)			(0.015)			(0.016)
Middle but below secondary			-0.13***			-0.097***			-0.09***
			(0.018)			(0.016)			(0.017)
Birth order			-0.03***			-0.024***			-0.03***
			(0.004)			(0.004)			(0.004)
Empowerment			0.02			-0.00			0.00
			(0.014)			(0.013)			(0.013)
Wealth index quintile			0.08***			0.07***			0.06***
			(0.007)			(0.006)			(0.006)
Post	0.03**			0.06***			0.03**		
	(0.014)			(0.012)			(0.013)		
Policy District	-0.08***			-0.09***			-0.07***		
	(0.021)			(0.019)			(0.018)		
District FE		✓	✓		✓	✓		✓	✓
Year FE		✓	✓		✓	✓		✓	✓
Mean	0.63	0.63	0.63	0.76	0.76	0.76	0.32	0.32	0.32
Observations	5,835	5,835	5,835	5,835	5,835	5,835	5,835	5,835	5,835
R-squared	0.006	0.042	0.136	0.011	0.061	0.157	0.004	0.031	0.102

Estimates capture the intent to treat effect of the insurance program. All outcomes are measured as binary variables. The unit of analysis are women in rural households between the ages of 15-49 who at the time of the survey has given birth in the last two years. For treated districts I limit the sample to only those women who gave birth during the policy period i.e. after the policy had been introduced in their respective districts. [a] Empowerment is measured as binary variable for attitudes toward domestic violence. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

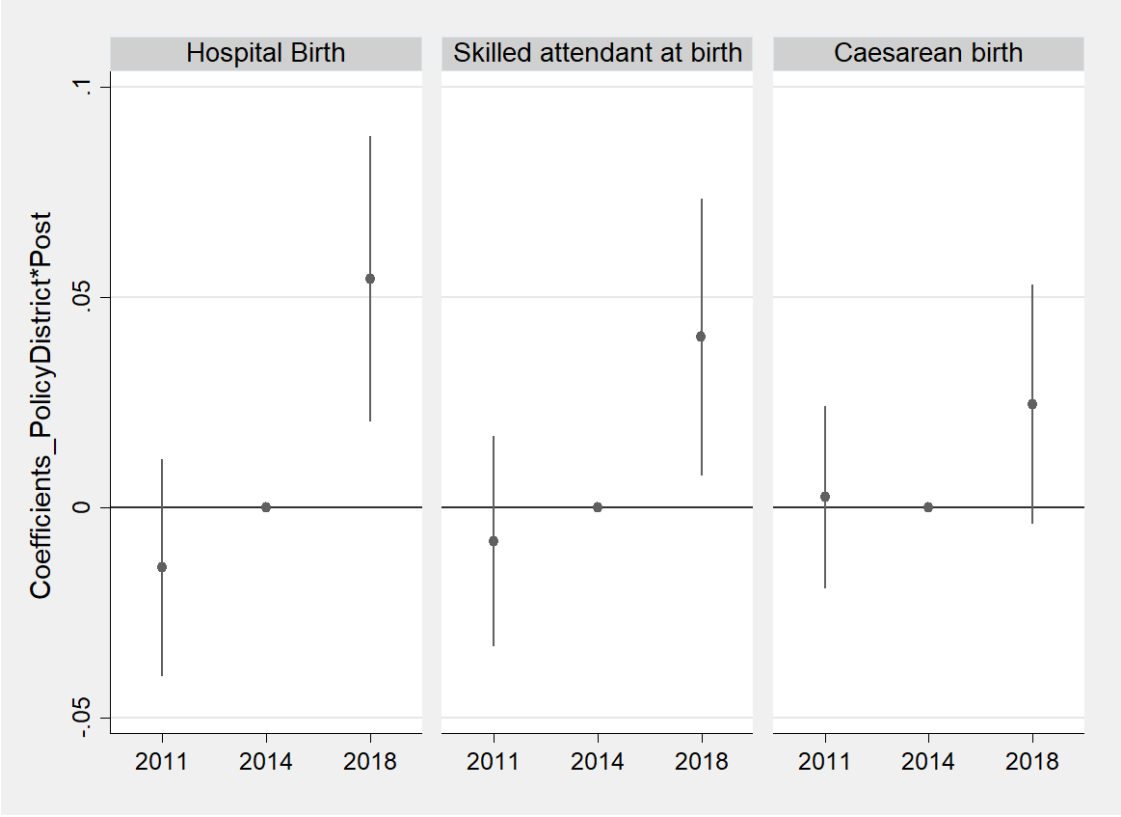
Table 2.4: Difference in Difference estimates of the effect of the program on health utilization – Rural subsample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Hospital birth			Skilled attendant at birth			Caesarean birth		
Post * Policy Districts	0.05**	0.04*	0.03	0.04**	0.03	0.02	0.03*	0.01	0.00
	(0.020)	(0.020)	(0.019)	(0.019)	(0.019)	(0.019)	(0.017)	(0.017)	(0.017)
Age <25 (= 1)			-0.013			-0.004			-0.04***
			(0.010)			(0.009)			(0.009)
35 - 49 (=1)			0.04***			0.03**			0.053***
			(0.012)			(0.012)			(0.010)
Education None or less than primary			-0.13***			-0.14***			-0.09***
			(0.012)			(0.011)			(0.011)
Middle but below secondary			-0.05***			-0.06***			-0.06***
			(0.014)			(0.012)			(0.013)
Birth order			-0.02***			-0.02***			-0.03***
			(0.002)			(0.002)			(0.002)
Empowerment			0.029***			0.015*			0.01
			(0.008)			(0.008)			(0.007)
Wealth index			0.07***			0.07***			0.06***
			(0.004)			(0.004)			(0.004)
Post	0.14***			0.13***			0.06***		
	(0.009)			(0.009)			(0.008)		
Policy Districts	-0.04***			-0.03**			-0.018*		
	(0.014)			(0.014)			(0.011)		
District FE		✓	✓		✓	✓		✓	✓
Year FE		✓	✓		✓	✓		✓	✓
Mean	0.51	0.51	0.51	0.61	0.61	0.61	0.22	0.22	0.22
Observations	13,650	13,650	13,650	13,650	13,650	13,650	13,650	13,650	13,650
Adj. R-squared	0.02	0.092	0.16	0.02	0.12	0.19	0.01	0.05	0.12

Estimates capture the intent to treat effect of the insurance program. All outcomes are measured as binary variables. The unit of analysis are women in rural households between the ages of 15-49 who at the time of the survey has given birth in the last two years. For treated districts we limit the sample to only those women who gave birth during the policy period i.e. after the policy had been introduced in their respective districts. [a] Empowerment is measured as binary variable for attitudes toward domestic violence. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Lastly, Table 6 and Table 7 provides results from the child level estimation using mother fixed effects (in Column 2) and the latest round of survey data. I find that a child born to the same mother has a higher probability of having a birth certificate if he/she is born after the introduction of the program and in the policy district. I suspect that this outcome is linked to there being a higher number of hospital births in policy districts. Hospitals are required to record this information and provide a document certifying the occurrence of a birth to the parents. This may therefore be an indirect and positive effect of the policy.

Figure 2.5: Difference in Difference estimates using pre-trends



Note: Estimates are based on 95% confidence interval and using district and time Fixed effects. We show that there is no difference in outcomes between control & treatment during out pre-treatment period or post treatment period.

Table 2.5: Sensitivity analysis – OLS estimates using subsample of nine program districts

	(1)	(2)	(3)	(4)	(5)	(6)
	Hospital birth		Skilled attendant at birth		Caesarean birth	
Birth after program	0.06***	0.04***	0.08***	0.05***	0.04***	0.03*
	(0.017)	(0.016)	(0.016)	(0.015)	(0.015)	(0.014)
Age						
<25 (=1)		-0.015		0.000		-0.06***
		(0.021)		(0.019)		(0.02)
35 - 49 (=1)		0.052**		0.034		0.049**
		(0.024)		(0.023)		(0.021)
Education						
None of less than primary		-0.06***		-0.071***		-0.07***
		(0.02)		(0.0205)		(0.025)
Middle but below secondary		0.02		0.017		-0.0597*
		(0.03)		(0.03)		(0.03)
Birth order		-0.03***		-0.02***		-0.03***
		(0.005)		(0.005)		(0.004)
Empowerment		0.07***		0.08***		0.05***
		(0.017)		(0.016)		(0.015)
Rural		0.02		0.039*		0.047**
		(0.023)		(0.021)		(0.022)
Wealth index quintile		0.08***		0.09***		0.06***
		(0.008)		(0.007)		(0.008)
Mean	0.57	0.57	0.66	0.66	0.26	0.26
Observations	3,429	3,429	3,429	3,429	3,429	3,429
R-squared	0.004	0.09	0.006	0.13	0.002	0.102

The estimation above is based on a sub-sample of policy districts. The unit of analysis are women in rural households between the ages of 15-49 who at the time of the survey has given birth in the last two years. We use the varied timing of the program to observe the effect of having given birth after the program is introduced in each district. Empowerment is measured as binary variable for attitudes toward domestic violence. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.6: Difference in Difference estimates of the effect of the program on having a birth certificate

	(1)	(2)
Post Policy*Policy District	0.021	0.026**
	(0.014)	(0.012)
District FE	✓	✓
Mother FE		✓
Observations	26,614	20,248
Mean	0.45	0.45
Adjusted R-squared	0.24	0.85

Note: The above estimates are based on child level regression that compares children born after the policy was introduced to those in the same districts prior to the introduction of the program. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2.7: Difference in Difference estimates of the effect of the program on vaccination cards

	(1)	(2)
Post Policy*Policy District	-0.038**	-0.029
	(0.015)	(0.022)
District FE	✓	✓
Mother FE		✓
Observations	19,233	7,968
Mean	0.53	0.53
Adjusted R-squared	0.04	0.71

Note: The above estimates are based on child level regression that compares children born after the policy was introduced to those in the same districts prior to the introduction of the program. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

However, the results do not indicate a significant difference in the likelihood of having a vaccination cards across siblings before and after the introduction of the program. The point estimate for the mother fixed effects estimation is negative,

though insignificant. Results in column 1 of Table 7 indicate that, without controlling for mother fixed effects, there is a negative likelihood of having a vaccination card among children born after the introduction of the program in policy districts. This may be a lingering effect of program districts being poorer and with worse outcomes (in this case, the lower vaccinations or lower value being attached to maintaining immunization records). Further research is needed to understand the mechanisms that are contributing to such results and to explore the quality of service that is being administered to patients that are beneficiaries of this government program.

2.6. Conclusion

This paper evaluates the impact of Prime Minister National Health Program (later renamed *Sehat Sahulat Program*) on two key measures of safe motherhood practices – hospital birth and skilled attendance at birth. The utilization of these two services is lowest among the poor communities to whom the program was targeted. I use repeated cross sections from a representative provincial dataset to estimate the intent to treat effect at the district level using a difference in difference empirical strategy. The results show that districts where the program was introduced have higher likelihood of hospital birth and of having skilled attendants at birth. However, I also find that these results are driven by the urban sub sample and that the program did not lead to an increase in utilization of these maternal health outcomes in rural areas.

Almost 99 percent of all maternal deaths occur in developing countries – mostly South Asia and Sub Saharan Africa (Alkema et al., 2016). A large number of these deaths can be prevented by ensuring access to skilled care during labor (Campbell & Graham, 2006; WHO 2018). For women who may otherwise give birth in a possibly risky and unhygienic environment and in the absence of a skilled attendant, the chances of surviving a complication are significantly higher (Moyer et al. 2013). Another mechanism through which improved outcomes are expected is the quality of service. Insurance programs often cover only qualified providers and for patients that lack the information, this may help to distinguish between good and bad health

suppliers (Kremer & Glennerster, 2011). Hospitals empaneled for delivery of service under the Prime Minister National Health Program provide quality healthcare and as a result of insurance low income households can avail quality services at no (direct) cost to themselves. Increased utilization and improved quality of health services are two channels through which such a program may improve maternal and child health outcomes (Comfort et al., 2013).

In this paper, I also use a mother fixed effects model to show that there is a greater likelihood of a child having a birth certificate if he or she is born after the introduction of the policy. This is an important indirect outcome of the program considering that Pakistan is among those countries in South Asia which have the lowest level of birth registration levels with 16 million children unregistered under the age of 5 (UNICEF, 2013). The possession of a birth certificate facilitates the process of getting the birth registered with local municipalities. Further, having a birth certificate removes the administrative barriers of enrolling in a government school (Human Rights Watch, 2018), and can reduce the risk of illegal child labor and underage marriage (UNICEF, 2013). In areas that are prone to natural disasters and conflict, identifying documents are essential to reuniting children with families and for receiving government assistance (Hunter & Brill, 2016).

There are a number of limitations of this study, the foremost of which is the absence of randomization in the implementation of the program. Districts where the program was introduced earlier, had on average worse utilization outcomes, fewer hospitals and more households belonging to the three lowest wealth quintiles. Our intent to treat estimates rely on the common trend assumption that in the absence of the program, the trend in outcomes would not vary across program and non-program districts. However, as the coverage expands to additional districts, the impact may vary based on how the program interacts with other factors, particularly with the quality of health infrastructure. For districts with better public health infrastructure, the eligible populations may have less of an incentive to rely on a program that

facilitates private health care. At the same time, the positive impact of public health insurance is documented to be higher for populations with greater geographical accessibility to hospitals and access to well-staffed facilities (Fiestas Navarrete et al., 2019; Grogger et al., 2015). These countervailing mechanisms will need to be explored as the program expands and more data becomes available.

Another limitation of the study is that it does not directly observe health outcomes in terms of maternal mortality and newborn survival. Given the current data, the analysis is restricted to the utilization of obstetric care services. Building on the findings of this paper, it is necessary that future research examines the impact on actual maternal, neonatal and infant mortality rates. Additionally, the lack of information to identify beneficiary households also limits the current analysis. Availability of more extensive data would allow for the use of experimental and quasi-experimental approaches to observe the treatment effect for households that enroll into the program.

Future evaluations of the PMNHP can explore how well the program meets its broader objectives. Evaluating effectiveness in offering financial protection and improving other health outcomes would be important areas of policy research. In the context of developing countries with limited health-system capacity it is also important to examine how policies incentivizing demand will impact overall quality of hospital services. Lastly, in terms of meeting global health targets, it is important to evaluate the relative efficiency of financing tertiary care, compared to alternative policy options that subsidize under-used preventative services in developing countries.

Chapter 3: Unconditional Cash Transfer and Child Nutrition

Abstract

Cash transfer schemes are a popular policy instrument for addressing poverty related deprivations in developing countries. This paper contributes to the discourse on whether unconditional cash transfers can serve as an effective mechanism for improving child development outcomes. It assesses one of the largest unconditional cash transfer programs in South Asia - the *Benazir Income Support Program* (BISP) - introduced in Pakistan in 2008. Using a national level panel dataset, we observe the effect of receiving supplemental income during the prenatal period on the anthropometric trajectory of a child. Nutritional shortfalls at an early age – particularly between the prenatal period to the child's second birthday – can result in stunted growth among children. We look at the cumulative effect of sustained exposure to the program and find positive nutritional impacts to be linked to the birth order of the child. Findings indicate a potential learning mechanism and a complementary role for informational interventions.

3.1. Introduction

Nutritional shortfalls at an early age have severe implications for long-term growth and development (Smith & Haddad, 2015, Hoddinott et al., 2013; Almond & Currie, 2011). Various studies have linked stunting – a measure of chronic malnutrition in children, to adverse outcomes in adults, including impaired cognitive development, poor education and health, and lower economic productivity (Black et al. 2013; Dewey & Begum, 2011). Ensuring adequate child nutrition is, therefore, an important developmental priority for improving global health outcomes and limiting intergenerational transmission of poverty.

A popular policy instrument for addressing poverty related deprivations in developing countries are cash transfer schemes. By adding to household income,

these programs have the potential to ensure a minimum level of consumption and to improve the nutritional outcomes of recipient households. This paper examines the impact of one of the largest unconditional cash transfer programs in South Asia - the *Benazir Income Support Program* (BISP) - introduced in Pakistan in 2008. Specifically, it observes the effect of receiving supplemental income during the prenatal period on the anthropometric trajectory of the child. The first 1000 days between conception and the second birthday of a child are identified as the critical period for interventions seeking to overcome nutritional deprivation (Black et al., 2013). In a previous study, albeit in the U.S. context, Currie and Almond (2011) recommend targeting transfers towards women of childbearing age in order to improve child health outcomes. Using data on children born between 2006 and 2016, I document a positive impact of prenatal exposure to the cash transfer program. Improvements in anthropometric outcomes accrue largely to the second and third born child which underscores the importance of the program in meeting nutritional deprivations associated with a larger family size. Additionally, these results together with heterogenous impacts based on mother's literacy, suggest that knowledge of better prenatal practices may allow households (mothers) to make better use of the supplemental cash.

This paper contributes to two strands of literature. It adds to the existing body of relevant work on early childhood development – particularly studies focusing on the first 1000 days of a child's life (Hoynes et al., 2016; Sudfeld, 2015; Villar et al., 2014). There is evidence that the under accumulation of human capital begins in utero with numerous studies highlighting the severe consequences of an adverse shock in this period (Carillo et al., 2020). In contrast, this study examines the impact of a positive income shock in the form of a cash transfer program received during the pre-natal period. Moreover, it contributes to the rich and growing body of work that evaluates the impact of cash transfer programs on health (Bastagli et al. 2016; Attanasio et al., 2015; Agüero et al., 2006). Initiatives like the Program Keluarga Harapan (PKH) in Indonesia and *Progresa* in Mexico, which make cash payment conditional on certain

required behaviors (e.g., medical checkups) have improved the nutritional status of young children (Cahyadi et al. 2018; Leroy et al., 2008; Behrman & Hoddinott, 2005). The evidence on whether similar outcomes can be achieved in the absence of associated conditionalities is less conclusive. Cash transfers that are unconditional, have their own merits, not the least of which are that they can address heterogeneous needs of diverse households, and limit the administrative burden of enforcing transfer conditionalities (Baird et al., 2016; & Haushofer & Shapiro, 2016). The program evaluated in this paper is a standard model of unconditional cash transfer targeted to female beneficiaries in a low income setting and findings may therefore be largely generalizable to other developing countries.

Improving child nutrition is an important component of social protection strategies in Pakistan where thirty eight percent of all children under the age of five suffer from stunted growth (UNICEF, 2018). For a country with the sixth largest population in the world, this statistic underscores the need for well-designed interventions within the framework of poverty alleviation. This study aims contribute to current understanding of whether cash transfers can serve as an effective mechanism for improving child development outcomes. The next section provides a brief overview of the program and is followed by a review of related literature. Details of data and empirical methods are provided in the subsequent section. The final section provides a discussion of the main results and concludes.

3.1.1. The Program

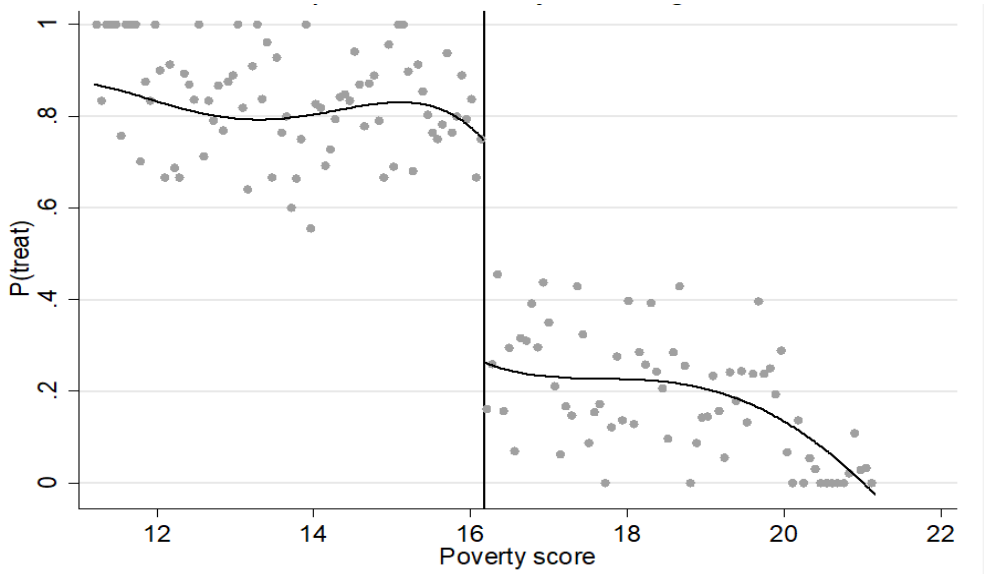
The Benazir Income Support Program is the largest social insurance program in Pakistan with over 6 million beneficiaries. In 2008, when the program was introduced, the monthly value of the transfer was set at PKR 1000 ($7) but by July 2015 this amount was raised to PKR 1566 ($10.5). The value of the transfer, if received in full, is estimated to be only 8.9% of the average value of per adult equivalent consumption expenditure (Cheema et al., 2016). Payments are made

through the BISP debit card with only a small proportion of beneficiaries in remote communities receiving money orders delivered by Post.

The objective of the program is to provide support for basic consumption needs and to insulate households against fluctuations in price (Cheema et. al, 2016). In the longer term, the program is also expected to facilitate the accumulation of human capital by allowing households to invest in nutrition, health, and education. Payments are made on a quarterly basis to (ever-married) female heads of beneficiary households. The choice of female recipient is consistent with the BISP's explicit goal of female empowerment, but the design may also serve to facilitate long-term objectives of the program. Extant studies suggest that the impact of a cash transfer is mediated by the gender of the recipient (Karlan et al., 2010 & Duflo, 2003) and that income transfers to women are associated with more child centric expenditure (Yoong et al, 2012).

The targeting of the program was done using a proxy means test approach whereby a national poverty census was conducted to assign each household a poverty score. The calculation of this score included multiple indicators including the number of dependents, earning potential and asset ownership etc. Households with a poverty score less than 16.17 were deemed eligible for the program. This eligibility threshold was used to target the poorest 20% of the country's population (living in extreme poverty). The probability of treatment assignment around the official eligibility cutoff (Figure 1) shows imperfect implementation of the eligibility rule. Nonetheless, the program reaches a significant number of low-income eligible families and continues to be the primary social safety net program in the country.

Figure 3.1: RD Plot - Probability of Assignment



Note: Based on author's calculations using the OPM household surveys. Eligibility cutoff: Poverty score ≤16.17.

3.2. Literature review

A large body of existing evidence on the impact of cash transfers in low and middle-income countries comes from programs in Latin America where these programs were first introduced (World Bank, 2018; Bastagli et al. 2016). Studies on conditional cash transfer programs such as the *Progresa* (later renamed Oportunidades) in Mexico and *Bolsa Familia* program in Brazil have shown substantial gains in health outcomes among children including higher birthweight (Barber & Gertler, 2008), improved anthropometric outcomes (Fernald et al., 2008; Assis et al., 2014), reduced incidence of diarrhea and anemia (Rivera et al., 2004; Huerta, 2006) and a reduction in infant and child mortality rates (Barham, 2011; Rasella et al., 2013). Experimental evidence from a similar program in Nicaragua suggests that the supplemental income received by a family can improve the quality of diet and increase expenditure on nutrient rich foods (Macours et al., 2012). Moreover, Buser et al. (2014) found detrimental effects on young children of families that stopped receiving cash transfers in Ecuador. The authors identify the shock to household's ability to

maintain food expenditure as a potential mechanism for these results. These effects were particularly pronounced for children whose families lost the income while they were in utero – a time when they are especially vulnerable to malnutrition.

Cash programs that are conditional on certain behaviors such as the nutritional monitoring of children, prenatal and post-natal checkups etc. have been found to improve child health through the adoption of targeted behaviors (Okeke & Abubalar, 2020; Cahyadi et al. 2018; Macours et al., 2012). The efficacy of unconditional programs in achieving similar outcomes is less clear and may depend on the value of the transfer (McIntosh & Zeitlin, 2018). A few studies have compared the health impacts of conditional vs unconditional programs within the same setting. Baird et al. (2019) provides experimental estimates on the impact of a (conditional) cash transfer in Malawi and in additional to using a pure control group (not treated), the authors also compare estimates to a group that was offered equal-sized unconditional cash transfers (UCT). Their study documents some evidence of improved height for age z-scores among children born to the unconditional cash transfer recipients.

A second relevant body of work focuses on resources available in utero and early childhood. Studies have leveraged extreme events such as famine and disease (Barreca, 2010; Painter et al., 2005) to highlight the consequences of childhood malnutrition for later life outcomes. Painter et al. (2005) document higher rates of obesity and lower self-reported health status for middle aged individuals that experienced periods of malnutrition in utero. Hoddinott & Kinsey (2001) observe growth faltering in young children aged 12 -24 months as a consequence of exposure to drought. Similarly, Galiano & Vera-Harnandez (2008) observe a decline in the nutritional status of girls following an illness event of an earning household member. There is some evidence that boys are affected more by negative shocks in utero than female children (Carrillo, 2020; Almond & Currie, 2011). In contrast to the more well documented negative shocks in literature, Hoynes et al., (2016) examine

the impact of an increase in economic resources experienced in utero and early childhood on adult health. They found that access to the Food Stamp Program in the U.S. led to a reduction in obesity, high blood pressure, diabetes, and heart disease for adults. These outcomes were not associated with program exposure that took place after the age of five. In another study on Food stamps, Almond et al, (2011) found that children exposed to the program during the third trimester had higher birth weight.

3.3 Data

The data for this paper comes from surveys of the BISP beneficiary and non-beneficiary households. These surveys were conducted by the Oxford Policy Management (OPM) for independent evaluation of the program. Data are available for the years – 2011, 2013, 2014 and 2016 with many of the same households repeatedly sampled over each year – leading to a panel of 13531 households. The survey covers cover 458 clusters (villages) across 90 districts in four provinces of Pakistan. It contains information on household and individual characteristics including information on child anthropometrics.

Height and weight are measured by the survey team for children between the age of 0-59 months. I use this information, together with the child's gender and age in months to compute two key measures of child nutrition. Height for age z score (HAZ) measures stunting status and weight for age z-score (WAZ) indicates whether a child is under weight for their age. Stunting status (height that is short relative to stunting status established for healthy populations) is widely used to measure chronic nutrition deficiencies because it is less sensitive to recent changes in food intake or health status.

Table 3.1: Trends in nutritional outcomes – proportion of children by survey round

	Survey round			
	2011	2013	2014	2016
Children 0 - 2 years				
Stunting	0.32	0.38	0.29	0.34
Underweight	0.37	0.41	0.38	0.32
Children 3 - 5 years				
Stunting	0.53	0.49	0.48	0.54
Underweight	0.43	0.45	0.41	0.39

Note: Stunting is defined as the height for age z-score of less than 2 SD below the WHO child growth standard for the reference population and underweight is weight for age below the WHO standard.

The overall sample reflects the alarming state of child nutrition among low-income families in Pakistan (Table 1). According to the World Bank (2008), rates of stunting higher than 30% are considered to be indicative of a child nutrition crisis. The proportion of children less than two years of age that are stunted is about or higher than the crisis level in all years and significantly higher among children age 3 – 5 years. In addition, around 40% of all children between 3 - 5 are underweight.

Table 2 shows differences in nutritional outcomes across gender for both age cohorts. For the 0 – 2 age group, boys fare worse than girls for both measures of child nutrition but the difference in stunting disappears among the older cohort and is reversed in the case of weight for age z-score. Height-for-age and weight for age z-scores reflect significantly worse nutritional outcomes for both male and female children in the 3 – 5-year age cohort than their younger counterparts.

Within the data, poverty scores assigned to each household are recorded, making it possible to identify families that are eligible to receive the cash transfers. As a first step to analyzing the impact of the program, I exploit the available eligibility criterion for a fuzzy regression discontinuity analysis. Using data from the most recent survey year, the plot of nutritional outcomes around the eligibility cutoff are shown in Figure 2. There appears to be no statistically significant difference in the

height for age and weight for age scores for children in eligible and non-eligible families.

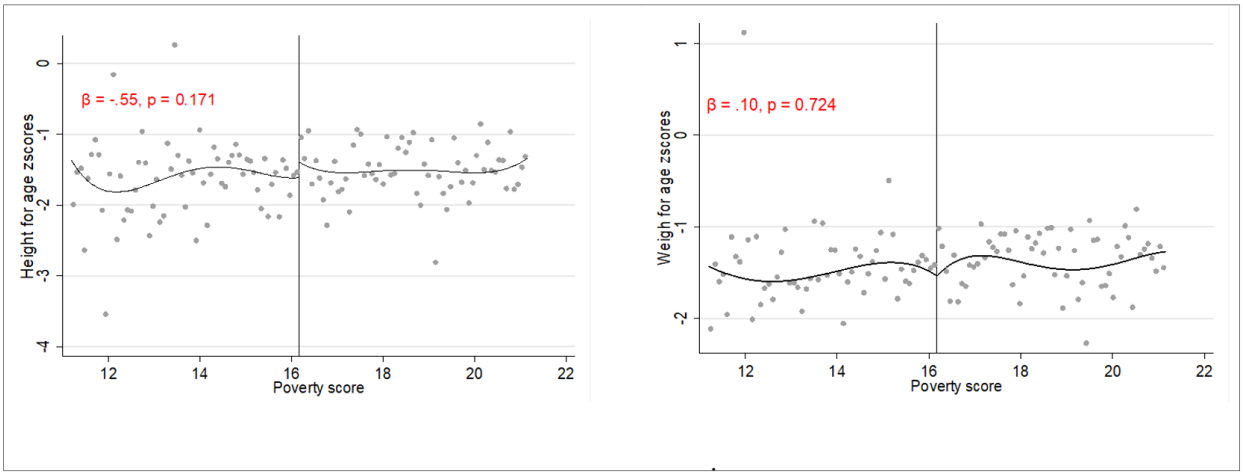
Table 3.2: Child nutrition outcomes by gender and age cohort

	Age 0 - 2			Age 3 - 5		
	N	Mean	SD	N	Mean	SD
Height for Age z–score (stunting)						
Male	2622	-1.33	1.86	2269	-2.12	0.03
Female	2448	-1.22	1.84	2169	-2.14	0.03
t test of difference		-2.18			0.6	
p - value		**0.03**			0.54	
Weight for Age z-score (underweight)						
Male	2790	-1.69	1.35	2412	-1.84	0.02
Female	2591	-1.54	1.39	2290	-1.92	0.02
t test of difference		-4.04			2.49	
p - value		**0.00**			**0.01**	

Note: Stunting is defined as the height for age z-score of less than 2 SD below the WHO child growth standard for the reference population and underweight is weight for age below the WHO standard.

In the subsequent empirical analysis, I examine whether the timing of the cash transfer is important i.e., whether receiving the supplemental income in the prenatal period impacts child nutrition outcomes. From the household survey, I use information on when the household first began to receive the transfer to compute the number of months a household has been receiving the transfer at the time of the survey. Using the age of each child – recorded in months, I am able to ascertain the exact duration of program exposure for every child under the age of five. Each round of survey includes anthropometric data on children under five, thus the complete panel includes all children born between the years 2006 and 2016.

Figure 3.2: RD Plot: HAZ & WAZ



Note: Based on estimations using 2016 round of OPM survey. Bandwidth Selection: +/- 5.

3.4. Empirical Analysis

I use the following specification to estimate the impact of the cash transfer if it is received during the prenatal period:

$$Y_{iht} = \beta_0 + \beta_1 \, Exposure\ since\ prenatal\ period_{iht} + \beta_2 \boldsymbol{X_{iht}} + \beta_2 \boldsymbol{Z_{ht}} + \beta_3 \boldsymbol{\delta_{h/m}} + \mu_{iht}$$

In the equation above, Y_{iht} is the height for age and weight for age z-score for each child *i* in household *h* at time *t*. Exposure since prenatal period is measured as a binary variable = 1 if the household started receiving the cash transfer at least 6 months prior to the birth of an individual child and 0 if there is no prenatal exposure[13]. X_{iht} is a vector of child covariates: age, gender, birth order and illness in the past two months; Z_{ht} a vector of time variant household characteristic. Additionally, household $\boldsymbol{\delta_h}$ and mother fixed effects $\boldsymbol{\delta_m}$ are included to control for average differences across households/mothers and any (time invariant) observable or unobservable predictors. μ_{iht} represents the standard error clustered at household level.

[13] For ease of interpretation, I omit child level observations (n=875) where the family started receiving the cash transfer less than 6 months before the birth of a child.

The analysis uses the variation in the year and month when a household received the first payment to assess the impact of program exposure during prenatal period. Since the program was gradually scaled up, not all households began receiving the transfer at the same time[14]. The survey records the month and year when a household first received the cash from the program. This information together with the date of the interview is used to compute the total months of exposure for individual households. Additional child level variation comes from child's date of birth.

Results from the main estimation are presented in Table 3. Household fixed effects estimations are reported in column (1) and (3) for height for age and weight for age z scores, respectively. Column (2) and (4) contain mother fixed effects estimations. Results are robust to the inclusion of a number of household and child level controls. In utero exposure to the program has a significant and positive impact on our measure of stunting. The impact on weight for age is positive with weaker significance for both household and mother fixed effects estimates.

Next, heterogeneous impacts across gender and birth order are presented in Table 4 and Table 5, respectively. Female children that were exposed to the program in the pre-natal period have better weight for age z-scores than those who were not. It is possible that prenatal exposure makes up for any gender discrimination in household allocation of consumption after the birth of the child. The impact of in utero exposure does not differ across gender for the more long-term measure of nutrition – HAZ. The impact of program exposure also varies by birth order. For a child that has two (or more) elder siblings, the impact of in-utero program exposure is significant for both measures. These results are intuitively plausible since an increase in the number children with the same consumption budget, implies a smaller share for each child. Children with a higher birth order are more likely to suffer in utero nutritional shortfalls in such cases.

[14] Appendix Figure 1 shows the year wise variation in program receipt for survey households.

Table 3.3: Panel regression estimates: Impact of cash transfer during pre-natal period on a child's anthropometry

	(1) HAZ	(2) HAZ	(3) WAZ	(4) WAZ
Exposure during prenatal period	0.213***	0.272***	0.086*	0.119**
	(0.062)	(0.067)	(0.045)	(0.048)
Program Exposure (=1)	0.031	0.006	0.037	0.024
	(0.074)	(0.076)	(0.057)	(0.057)
Female (=1)	0.043	0.0768**	0.039*	0.0454*
	(0.032)	(0.036)	(0.023)	(0.0263)
Age	-0.033***	-0.033***	-0.013***	-0.0134***
	(0.001)	(0.001)	(0.001)	(0.001)
Birth order	-0.137***	-0.192***	-0.143***	-0.173***
	(0.032)	(0.035)	(0.021)	(0.023)
Recent illness (=1)	-0.052	-0.039	-0.077***	-0.069***
	(0.032)	(0.034)	(0.023)	(0.025)
Number of recipients	-0.026	-0.035	-0.017	-0.008
	(0.043)	(0.044)	(0.0312)	(0.033)
Food Price Shock	-0.0505	-0.069*	-0.0415	-0.026
	(0.036)	(0.0372)	(0.025)	(0.026)
HH size	-0.002	-0.008	-0.009	-0.009
	(0.012)	(0.013)	(0.009)	(0.009)
Poverty Score	0.022	0.018	0.014	-0.0028
	(0.030)	(0.030)	(0.0196)	(0.0171)
Year FE	✓	✓	✓	✓
Household FE	✓		✓	
Mother FE		✓		✓
Observations	15,404	14,013	16,473	14,999
R-squared	0.46	0.49	0.48	0.54

Household clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.4: Panel regression estimates: heterogeneity of impact across gender

	(1) HAZ	(2) HAZ	(3) WAZ	(4) WAZ
Exposure during prenatal period	0.192***	0.239***	0.0236	0.0548
	(0.0724)	(0.0806)	(0.0541)	(0.0573)
Exposure * Female	0.0425	0.0676	**0.126****	**0.131***
	(0.0766)	(0.0936)	(0.0599)	(0.0694)
Female	0.0323	0.0630	0.00675	0.0185
	(0.0376)	(0.0405)	(0.0271)	(0.0294)
Additional Controls	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Household FE	✓		✓	
Mother FE		✓		✓
Observations	15,404	14,013	16,473	14,999
R-squared	0.464	0.497	0.485	0.536

Household clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Additional controls include: age, birth order, recent illness, program exposure, poverty score, food price shock, household size and number of recipients

Table 3.5: Panel regression estimates: heterogeneity of impact by birth order

	(1) HAZ	(2) HAZ	(3) WAZ	(4) WAZ
Exposure during prenatal period	0.172***	0.231***	0.0606	0.0851*
	(0.0639)	(0.0691)	(0.0473)	(0.0500)
Exposure * Birth order	**0.304****	**0.302****	**0.197****	**0.242*****
	(0.118)	(0.131)	(0.0858)	(0.0929)
Birth order (>3)	-0.0545	-0.110	-0.146***	-0.184***
	(0.0678)	(0.0720)	(0.0475)	(0.0487)
Additional Controls	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Household FE	✓		✓	
Mother FE		✓		✓
Observations	15,404	14,013	16,473	14,999
R-squared	0.463	0.496	0.483	0.536

Household clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Additional controls include: age, gender, recent illness, program exposure, poverty score, food price shock, household size and number of recipients

Table 3.6: Panel regression estimates: heterogeneity of impact by birth order

	(1) HAZ	(2) HAZ	(3) WAZ	(4) WAZ
Exposure during prenatal period	-0.112	-0.0465	-0.0569	-0.0420
	(0.0772)	(0.0869)	(0.0568)	(0.0617)
Birth order (=2)	-0.516***	-0.562***	-0.311***	-0.335***
	(0.0406)	(0.0431)	(0.0294)	(0.0311)
Exposure * second child	**0.435*** **	**0.408*** **	**0.159*** **	**0.160*** **
	(0.0732)	(0.0860)	(0.0523)	(0.0581)
Birth order (>3)	-0.439***	-0.536***	-0.423***	-0.492***
	(0.0788)	(0.0854)	(0.0551)	(0.0591)
Exposure *third child (>3)	**0.511*** **	**0.465*** **	**0.289*** **	**0.335*** **
	(0.122)	(0.137)	(0.0837)	(0.0906)
Additional Controls	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Household FE	✓		✓	
Mother FE		✓		✓
Observations	15,404	14,013	16,473	14,999
R-squared	0.471	0.504	0.488	0.540

Household clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Additional controls include: age, gender, recent illness, program exposure, poverty score, food price shock, household size and number of recipients.

Table 3.7: Panel regression estimates: heterogeneity of impact by mother's literacy

	(1) HAZ	(2) HAZ	(3) WAZ	(4) WAZ
Exposure during prenatal period	0.203***	0.236***	0.0894*	0.107**
	(0.0708)	(0.0719)	(0.0507)	(0.0512)
Literate mother (=1)	-0.385**		-0.104	
	(0.184)		(0.157)	
Exposure * Literate mother	**0.313***	**0.412** **	0.201	0.217
	(0.182)	**(0.194)**	(0.146)	(0.152)
Additional Controls	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Household FE	✓		✓	
Mother FE		✓		✓
Observations	13,009	12,949	13,883	13,860
R-squared	0.470	0.496	0.503	0.535

Household clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Additional controls include: age, gender, birth order, recent illness, program exposure, poverty score, food price shock, household size and number of recipients

An alternative explanation for birth order impacts may be that households (mothers) learn better prenatal practices after the birth of the first child. There may potentially be a learning mechanism which allows for better utilization of the cash received by the household. To explore this, I estimate an additional model to observe the magnitude of program exposure for each child (Table 6). The results show that the entire impact of prenatal program exposure accrues to the second and higher birth order children. In utero exposure to the program positively impacts the height for age and weight for age of the second child and the magnitude of (positive) impact is even higher for third or higher birth order children. Consistent with the possibility that learning drives positive anthropometric impacts, Table 7 shows that the impact of prenatal exposure to the program is higher if the mother is literate vs if she is not[15]. Together these results suggest that knowledge about beneficial prenatal practices may be important in improving child nutrition outcomes through unconditional cash transfer programs.

3.5. Discussion

Adequate child nutrition is a key input into future human capital accumulation and an important development policy agenda. This paper examines the impact of an unconditional cash transfer on anthropometric outcomes of children under the age of five. In utero program exposure is found to have a positive impact on the height for age and to a lesser extent, on the weight for age of a child. Findings align with the body of literature that emphasize the health gains of early childhood interventions (Hoynes et al, 2016; Conti et al, 2015; Almond & Currie 2011). Further, results indicate a heterogeneity in program impact based on gender, birth order and mother's literacy status. These results are largely consistent across various household and mother fixed effects specifications.

[15] Literacy status is used instead of mother's education due to the low income setting of the study where a large number of mothers report no formal education.

For families living in poverty, having additional children may severely limit per person consumption and this is reflected in the birth order results. Results indicate significant positive impacts for the second born child with the magnitude of impact being even greater for a third or higher birth order child. Primarily these findings show that the supplemental income relieves maternal stress around nutritional deprivation during pregnancy at the time of the second or third child. However, it is also possible that after the birth of the first child, mothers may learn to utilize the cash better at the time of the next pregnancy. In a recent study, Carneiro et al., (2019) show that information related channels are key mechanism in driving the association between unconditional cash transfers and anthropometric outcomes. The authors evaluated an intervention targeting early life nutrition for Nigerian households living in extreme poverty and found that combined with a high-value unconditional cash transfer, information provided to parents on recommended practices related to pregnancy led to an 8% reduction in stunting (Carneiro et al., 2019). In light of their findings, this current study stipulates that knowledge about prenatal practices – in this case from the experience of the first child, may be an important channel through which cash transfers impact child nutrition outcomes.

The current analysis provides only suggestive evidence as to the possibility that a learning mechanism may be driving birth order results. Further analysis on consumption patterns is needed to confirm mechanisms driving these results. Another limitation of this study is also that anthropometric data are only available for children below the age of five. Barham et al. (2013) provided experimental evidence that while the first 1000 days were critical, "catching up" in terms of anthropometric status was possible during adolescence. As more data on the Benazir Income Support program becomes available, it would be worthwhile to examine the long-term outcomes of children including the potential for catching up.

3.6. Conclusion

Inadequate nutrition is among the most severe outcomes of poverty related deprivations – it makes children vulnerable to illness/disease and impacts well-being throughout an individual's life. For a developing country, this translates into substantial loss of human capital and increased health costs. Policy interventions that target the critical window of the first 1000 days (since conception) are an effective means to reduce the prevalence of stunting. The findings of this paper suggest that there are considerable gains associated with even low value cash transfers if families have access to the cash during the prenatal period. Specifically, the supplemental income can reduce nutritional deprivation that a second or higher birth order child born in poverty is likely to experience.

Future research is needed to examine how household consumption patterns vary across birth order. Moreover, it is worth exploring whether relative to conditional cash transfers that more directly target nutritional shortfalls, there may be a learning period associated with the unconditional cash payments to families. If so, informational interventions may improve the effectiveness of such programs.

Chapter 4: Agriculture crop fires and respiratory health: Evidence using panel data from Pakistan

Abstract

Open field burning of agricultural crop residue (stubble) is a prominent source of anthropogenic air pollution in many developing countries. Evidence on the health impacts of this practice is limited and may prevent concrete policy action around the regulation of this practice. This paper uses remote sensing data to observe the short-term impact of high exposure to fire radiative power (FRP) on respiratory illness. Exposure to fires is measured within a spatial buffer using household and fire location geocoordinates and within a designated time frame leading up to the date of individual surveys. Results from fixed effects estimations suggest that individuals with the highest exposure are 1.355 times more likely to report incidence of respiratory illness.

4.1. Introduction

Exposure to ambient air pollution has been identified as a leading cause of respiratory illnesses - asthma, chronic obstructive pulmonary disease (copd), cough and difficulty in breathing (Rajak & Chattopadhyay, 2019; Cohen et al., 2017). The burden of disease is disproportionately higher for developing countries where the level of pollutants routinely exceeds the targets set by public health experts (Cohen et al., 2017; Ghosh et al., 2019). According to a WHO estimate, 90 percent of premature deaths attributed to ambient air pollution in 2015 occurred in low- and middle-income countries (WHO 2016). However, despite the significance of the agriculture sector in many of these countries, existing studies that examine health impacts of air pollution do so largely in the context of economic activity associated with industry, urbanization, and motorized travel (Mannucci & Franchini, 2017; Health Effects Institute, 2010). This paper explores whether the agricultural practice of crop residue burning impacts respiratory health.

Open field burning of agricultural crop residue (stubble) is prevalent in many developing countries (Cassou et al., 2018). It is a low-cost alternative to get rid of most post-harvest vegetative material and to prepare the fields for the next cropping season The burning of crop residue contributes to elevated levels of $PM_{2.5}$ – particles with an aerodynamic diameter equal to or less than 2.5 micrometers (He et al., 2020). These are considered to be more toxic than larger particles and pose a greater risk to health as they can be breathed deeply into the lung (Dockery et al., 1993). However, due to the seasonal patterns of these fires and limited availability of monitoring data on pollution, the health impacts of burning activity have not been well documented (Rajak & Chattopadhyay, 2019; He et al., 2020). Moreover, isolating the impact of fires from other economic factors that impact health is challenging for empirical analysis due to various endogeneity issues (Dominici et al., 2014). Recent studies have used satellite data to overcome some of these limitations (Rangel & Vogl, 2019) but to the best of my knowledge, have not capitalized on this data to examine the impact of fire exposure on individuals' respiratory health.

In this study I observe the short-term impact of high exposure to fire radiative power (FRP) on respiratory illness. I do this by matching three years of Moderate Resolution Imaging Spectroradiometer (MODIS) active fire data to micro level data from a household survey collected by the Oxford Policy Management in Pakistan. Exposure to fires is measured within a spatial buffer using household and fire location geocoordinates and within a designated time frame leading up to the date of individual surveys. Results suggest that individuals with the highest exposure are 1.355 times more likely to report incidence of respiratory illness. Robustness checks show that similar results are not present for other types of illness – thus validating that the underlying mechanism for the results is air pollution.

In the next section, I discuss the related literature to which this study contributes. I then proceed to discuss the data and subsequent empirical analysis including some sensitivity results. This is followed by a discussion and a brief conclusion.

4.2. Air pollution and health

Inhalable, fine and sulfate particles are a substantial environmental risk factor for mortality and morbidity (Cohen et al., 2017; Pope et al., 2009; Dockery et al., 1993). Premature deaths attributable to ambient air pollution may be caused by stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections (Schraufnagel et al., 2019; Cohen et al., 2017). The association between particulate matter and mortality was documented in the early nineties by the prominent Harvard Six Cities study that documented a significant impact on mortality rates even after controlling for various confounding factors (Dockery et al., 1993). In another study on pollution exposure across metropolitan areas in the U.S., Pope et al. (2009) found a 15% overall increase in life expectancy owing to a 10ug/m^3 average improvement in $PM_{2.5}$. They show that these improvements in life expectancy to hold for all populations regardless of behavioral, socioeconomic, or demographic conditions.

More recently, a number of studies have examined the impact of air pollution on health outcomes using remote sensing data on wind direction (Anderson, 2015; Rangel & Vogl, 2017; Deryugina et al., 2019). These studies have examined mortality rates (including from cardio-respiratory causes), often with an emphasis on urban sources of pollution. Anderson (2015) for instance captured the variation in pollution generated by wind patterns near major Los Angeles highways to show that a one standard deviation increase in downwind pollution exposure increases mortality among elderly individuals by 5 to 6 percent. Rangel and Vogl (2017) also exploit wind direction to examine effects of sugarcane residue burning in Sao Paulo, Brazil. The authors find that exposure to pollution during the gestation period has a strong negative effect on birthweight. While the adverse impact of air pollution on fetal and infant health is well documented by existing studies (Jayachandra, 2009; Currie et al., 2009; Currie et al., 2005), Rangel and Vogl (2017) provide the first causal examination of the agricultural practice of crop residue burning.

Extant literature from the atmospheric sciences provides considerable evidence that various types of biomass burning, including open field burning of crop residue, contribute to emissions of harmful air pollutants (Yin et al., 2017; Hayashi et al., 2014). Irfan et al. (2015) estimated the district level emission inventories of specific pollutants from straw burning in agricultural provinces of Pakistan. They show that the burning of straw contributes to various pollutants - CO, CO2, NOx, CH4, NH3, organic carbon – in a given year. Emissions from residue burning also result in elevated levels of particulate matter pollution with a recent study from China showing that 10 additional fires within a 50km radius led to a 4.79 micrometer increase in monthly fine particulate matter (He et al., 2020). Inhalation of these pollutants can lead to airflow obstruction which may be recurrent as in the case of asthma, or chronic such as the chronic obstructive pulmonary disease. Additionally, air pollution exposure can cause epithelial cell damage and increase the risk of lung infection and pneumonia (Neupane et al., 2010).

Fine particulate matter with a diameter of less than 10 micrometers and particularly $PM_{2.5}$ associated with fire pollution, accumulates in lung tissue and is a notable risk factor for respiratory disease and severity of infection. The detrimental health effects of short-term exposure to smoke have been documented by numerous studies. Sheldon & Sankaran (2017) document the transboundary impact of pollution from the Indonesian forest fires on polyclinic attendance in neighboring Singapore. The authors show that a one standard deviation increase in the radiative power of Indonesian fires increased the Pollution Standard Index in Singapore by 1.43 standard deviations and increased the polyclinic visits for acute respiratory tract infections by 0.67 standard deviation. Early studies on air pollution emissions from biomass burning in the United States have also documented deleterious impacts on respiratory health (Boopathy et al., 2002; Jacobs et al., 1997). More recently, Liu et al (2017) estimated the particulate matter directly attributable to wildfires and examined its impact on cardiovascular and respiratory hospital admissions among Medicare enrollees. They found that high levels of wildfire specific $PM_{2.5}$ exposure

for two consecutive days increased the risk of respiratory admissions during this period. The accessibility of air quality measures – particularly the availability of daily total $PM_{2.5}$ measurements allows of rich analysis that is often challenging for low-income countries.

Pollution monitoring stations are sparsely located in developing countries, making it difficult to fully capture specific health impacts. Still, some studies have documented an association between crop residue burning and respiratory health. Gupta (2019) provides epidemiological evidence that the health of school children in India is worse off during the seasonal spike in particulate matter from rice residue burning. For this study, real time monitoring data were collected over a three-year period along with spirometry tests to measure the physiological parameters of children. Similar results were found by Saggu et al., (2018) who noted a decline in lung function parameters of children during the crop burning period. In another study focusing on agricultural districts in India, Chakrabarti et al., (2019) show that the risk of acute respiratory illness was three times higher in district where there is intense crop residue burning activity. In terms of the disability adjusted life years lost per year, they find that eliminating the practice could avert a loss of 14.9 million (years) across three Indian states (Chakrabarti et al., 2019). In another study, Cancado et al. (2006), examined the impact of sugar cane burning for the city of Piracicaba, Brazil – where this practice accounted for 60% of the fine –mode aerosol mass. For a given year, they compared across periods of straw burning with non-burning periods to show that the daily hospital admittance of children and the elderly specifically due to respiratory disease went up at the time when sugar cane waste was burned.

The burning of crop residue in the Punjab region spanning northern India and eastern Pakistan leads to recurring formation of smog over the Indo Gangetic plain (IGP) and is a notable threat to air quality (Singh & Kaskaoutis, 2014). The scale at which burning activity takes place in Pakistan merits attention to the health impacts of this agricultural practice. The country relies heavily on agriculture – a sector that

accounts for over 18 percent of output and 39 percent of the employment. In a given year, most farmers plant two or more seasons of crops and burn the stubble to clear land between cropping cycles (Ahmed & Ahmed, 2013). Thus, fire activity can occur multiple times in a given year and is a potentially significant source of environmental pollution. Studies that have emphasized the risk to human health of unsustainable agricultural practices have focused on water pollution and pesticide runoff from agricultural land (Azizullah et al., 2011). Few studies have focused on similar evidence for agriculture activities that generate air pollution and consequently impact human health. For a developing country, where most households have limited options for avoidance behavior and poor access to health care services, the lack of concreate policy action regarding such pollution exposure can perpetuate existing health inequalities. This research addresses the fundamental but hitherto unexplored impact of agricultural crop fire exposure on respiratory health of individuals in Pakistan.

4.3. Data

The impact of fire exposure on reported illness is assessed using two datasets. The primary (panel) data is a large-scale survey collected by the Oxford Policy Management group which contains location information (geocoordinates) for each surveyed household. Approximately 8000 families were surveyed in a year leading to an overall sample of 23,902 households from the three years - 2011, 2013 and 2014. For every individual within the household, the survey reports on illness experienced within the past two months and gathers information on the most severe type of illness in this period. The survey was conducted in person by enumerators and therefore in addition to this information on health, the date on which each household was interviewed is also made available. This is essential for capturing temporal exposure to fire activity and is used as a source of additional variation across households. A timeline for the when the interviews took place in each year is provided in the appendix (Figure 1A). Finally, it is important to note that the survey

was conducted to evaluate a social insurance program[16] and is therefore disproportionally representative of a lower income segment of the population.

Data on fire/air pollution exposure was derived from Moderate-Resolution Imaging Spectroradiometer (MODIS) satellite data on active fires. MODIS, onboard the Aqua and Terra satellites, captures daily fire activity at a 1km resolution and provide information on the geographical coordinates of fires as well as their radiative power values. The data are publicly available at NASA's Fire Information for Resource Management System (FIRMS) website. For the purpose of this analysis, we only include fire events occurring over agricultural land. These were identified using land cover raster data available from the European Space/Climate Change Initiative (ESA/CCI) with a 300m spatial resolution. A fire event was identified as an agricultural fire if it was located in the 300 m pixel classified as cropland within the land cover classifications. The yearly average for the count of fires on cropped land is about 8073 fires[17].

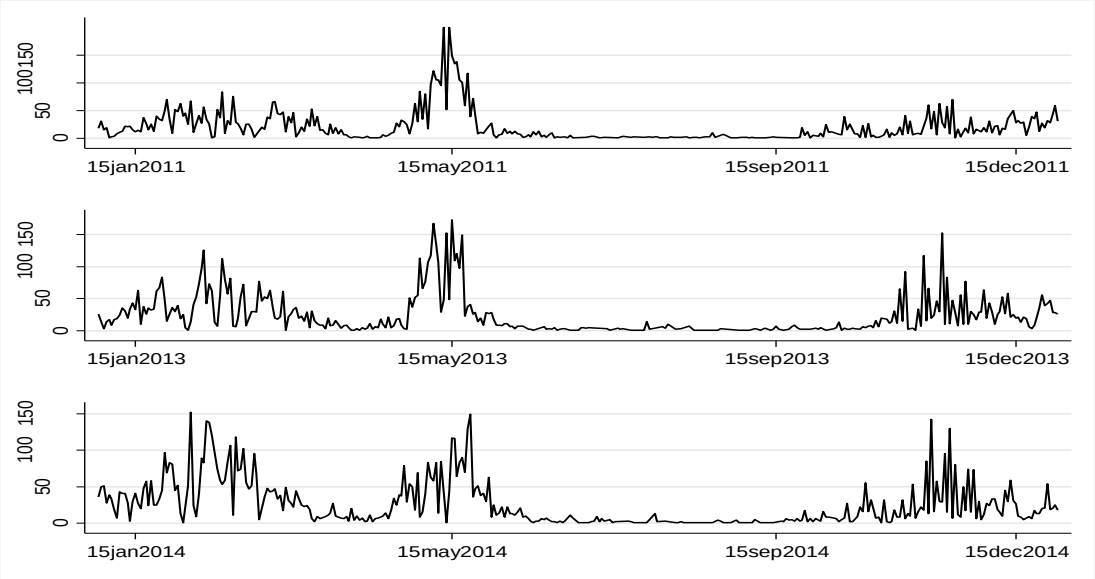
Figure 1 provides the temporal distribution of the fires for three years – 2011, 2013 and 2014. These years were selected in order to match fire data to available household survey – our source of information on health outcomes. In all years, we see that there is a spike in the number of fires per day in May - a period that corresponds to the post (wheat) harvest season when open field burning of fires takes place to clear the land for the next sowing season. The second harvest period occurs in October following which we see numerous fires in close temporal proximity in November, though the average daily count on most days in this period is not as high on most days. Fire activity is also high in the month of February – a period immediately after harvest of sugarcane[18].

[1616] Household survey data was collected for purposes of evaluating the Benazir Income Support program in Pakistan.

[17] The count of fires over agricultural land was 7254, 8058, and 8908 in 2011, 2013 and 2014 respectively.

[18] The harvest period can vary by a few weeks depending on the status of the crops and weather conditions.

Figure 4 1: Fires per day across the three years - 2011. 2013 & 2014



Fundamental to our understanding of the link between crop fires and respiratory health are the emission from fire activity. Therefore, we focus the analysis on the fire radiative power (FRP) which is the total energy released from the fire in Megawatts (MW) and serves as a better proxy for emissions than the count of fires. Information on the radiative power is recorded by the satellites for each fire observation. These values are calculated as the difference between apparent fire temperature (at the infrared 4-μm band) and the background temperature (Liu et. al. 2015).

Figure 2 presents the spatial distribution of fire radiative power following two major harvest seasons in the country. These maps use data on fire activity in two pre-monsoon months – April and May and two post monsoon months – October to November, roughly corresponding to the post-harvest periods of wheat and rice. For each year, the kernel density maps (using logged value of FRP) show the relative intensity of fires across different regions of the country. The northern Punjab districts of Hafizabad, Gujranwala and Sheikhupura have the greatest concentration of fire intensity. Additionally, in all years, the fire activity in terms of the total radiant energy being emitted is more intense during the pre-monsoon period. This is contrary to neighboring India where crop residue burning is concentrated in the

winter months (Abdurrahman et al., 2020; Miro et al., 2019). The difference is likely due to the higher total cultivation of wheat in Pakistan.

4.4. Analysis

To capture the health impacts of local air pollution from crop residue burning, we estimate the following logit fixed effects estimation:

$$1. \quad H_{it} = \beta_1(\textit{Exposure to crop fires})_{it} + \beta \mathbf{I}_t + \beta \mathbf{t}_i + \varepsilon_{it}$$

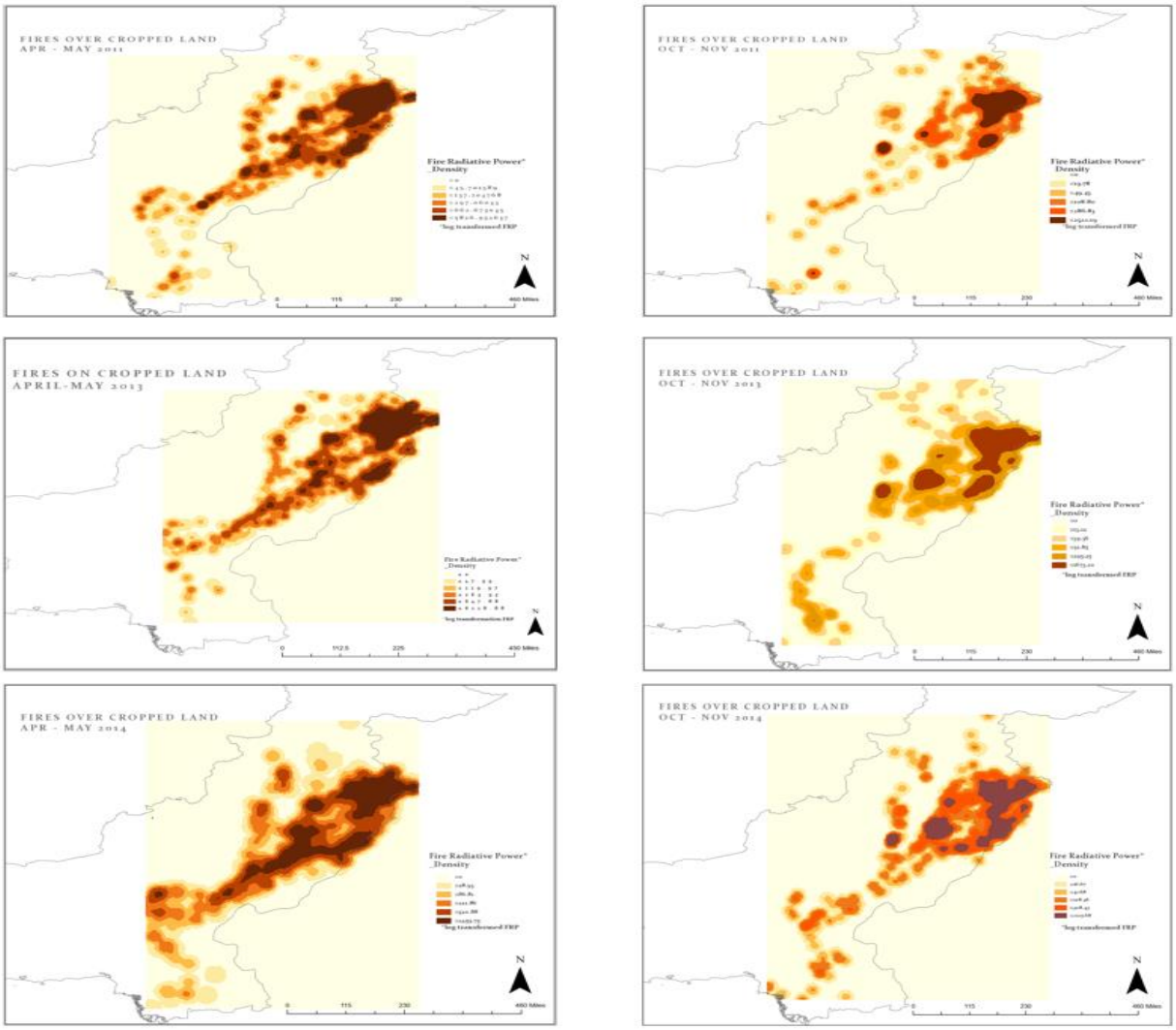
In the above equation, $H_{it} = 1$ if the individual has experienced respiratory illness in the 2 months prior to the interview (survey) and 0 otherwise. The variable for exposure to crop fires is constructed using the sum of fire radiative power from all fires that occurred in the 10 weeks leading up to the week of survey and within a given buffer radius of the household location. *I* and *t* are the household? and year fixed effects respectively, ε_{it} is the idiosyncratic error term clustered at the village level.

The dichotomous outcome variable was created using the following survey question: "*What was the most problematic type of illness or injury experienced in the last two months*?" It was asked only of individuals who in the preceding question had reported having experienced some illness in this period. Those respondents for whom respiratory illness or pneumonia (respiratory infection) was the most problematic illness, were coded as 1 and all others were given a value of zero. Due to the framing of this question, respiratory illnesses in the data are likely under-reported since individuals who suffer other more pressing health issues would not report problems related to respiratory health.

Then, to match the household survey with daily fire activity, we identify fires that occurred within a 10km radius of each household. This was done using the household geographical coordinates and the coordinate location of the fires. The fires were aggregated at the weekly level and for every household, and we match fires that occurred within the 10 weeks preceding the week of the interview. After

matching the two datasets – over time and across space, the variable for exposure was computed using the aggregated value of fire radiative power within the buffer radius. For each household, the value for this variable depended on the location of the household, the week of interview in each year, and the frequency (count) and intensity (FRP) of fires in the given period.

Figure 4.2: Spatial distribution of fire radiative power in the two post-harvest periods across three years – 2011. 2013 and 2014



In our data, we find significant provincial variation in the level of FRP exposure for households. Only 7.17% of the sample households in the province of KPK and 1.90% of in Baluchistan had any exposure to fires (Table 1). This is not surprising since agricultural activity and therefore crop fires are concentrated in the provinces of Punjab and Sindh

(Figure 2). The burning of wheat straw in these two provinces is a prominent source of pollutants (Irfan et al., 2015). It is important to note also that these two provinces account for 76% of the country's population.

Table 4.2: Sample of households across the four provinces

	Any Exposure		*No Exposure*	
	n	*%*	*n*	*%*
Punjab	*5,030*	57.34	*3,742*	42.66
Sindh	*1,738*	25.39	*5,108*	74.61
KPK	*394*	7.17	*5,103*	92.83
Baluchistan	*53*	1.90	*2,734*	98.10
Total	***7,215***	**30.19**	***16,687***	**69.81**

Note: Any exposure is non-zero exposure to fire radiative power within a 10km radius. Sample calculations based on three years of data with repeated sampling of households.

The regression analysis is consequently limited to the sample of households in the provinces of Punjab and Sindh. Even within this subsample, the distribution is highly skewed (see Appendix Figure 1A) so that the top quantile faces the most significant amount of exposure. To account for the skewed distribution of exposure in our overall sample we use three variations of the *exposure to crop fires* variable. First, we estimate the relationship between log FRP and incidence of respiratory illness. Next use a binary categorization of exposure where any positive exposure to FRP in the given time period is coded as 1 and 0 otherwise. Lastly, we estimate the model using a binary classification for high exposure i.e., the level of FRP exposure in the 4th quartile. For all three classifications of exposure, we estimate both individual and household fixed effects models.

A limitation in examining the impact of pollution on health outcomes is the potential for bias due to confounding factors (Dominici et al., 2014). An example of this for individual level analysis is the financial standing of a person whereby being well off may be associated with better health, but at the same time financial resources can dictate one's location in space i.e. relative proximity to a source of pollutant (in this

case, fires). The result of such spatial sorting if it does occur, would be that people who are closer to the fires are disproportionately poor. This may lead to an overestimation of the relationship between the variables of interest if low income individuals on average, have poorer health outcomes. In the absence of rich data, which is a frequent challenge for researchers in developing countries, it is difficult to adequately correct for such confounding factors. Since heterogeneity is to be expected even in low income families included in our sample, the current analysis uses panel fixed effect that controls for household level characteristics over the three years. By doing so, we are able to minimize the bias that may arise in our estimation due to confounding effects while also being able to control for time invariant traits that impact the incidence of respiratory illness for members of a household, beyond the impact of fire exposure. It is important to note however, that use of fixed effects in a logit model substantially reduces the sample size since it presents conditional estimates based on within individual (or within household) variation (Allison, 2009). The estimated conditional model excludes those individuals that have the same values of the explanatory variable across all three years. For purposes of comparison, estimates using Linear Probability Model (LPM) with the complete sample, are shown in the appendix.

Table 2 reports the odds ratios for the impact of exposure on respiratory illness (logit estimates are available in the appendix). Estimates for individual and household fixed effect models are reported for each classification of the explanatory variable. For each model, there is a positive association between FRP and respiratory illness. The relationship is not significant when we compare individuals with any exposure to those with none. A likely explanation for this is the substantial number of people with very low levels of exposure. However, high exposure i.e. within the fourth quartile makes individuals 1.355 times more likely to report incidence of respiratory illness. This result is based on individuals with differential exposure across years. In the household fixed effects models, individuals with the highest exposure are found to be 1.25 times more likely to report incidence of respiratory illness than others.

These results provide evidence that individuals with higher relative levels of exposure to emissions (radiative power) have a greater likelihood of respiratory illness.

Table 4.2: Effect on respiratory illness of FRP exposure in a 10km radius – Odds ratio estimates

	(1)		(2)		(3)	
Log FRP	1.177*	1.140**				
	(0.102)	(0.0749)				
Any exposure (=1)			1.141	1.117		
			(0.130)	(0.103)		
High Exposure - 4th Quartile					1.355**	1.259**
					(0.198)	(0.147)
Individual FE	✓		✓		✓	
Household FE		✓		✓		✓
Observations	746	7,414	2,541	21,500	2,541	21,500

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

These estimates account for the seasonal nature of fire activity since exposure is determined by the timing of fires as well as their spatial concentration. For each individual respondent, the chances of being in the topmost quartile is determined not just by location in space but also the timing of the interview. The results tell us that in the time that individuals are exposed to high levels of fire activity, there is a greater likelihood of them experiencing respiratory illness. Additionally, in Table 3, we show that this impact tends to decay as the distance to fires increases. If we estimate the above specification using a radius of 15 km, we find that the results weaken in significance and magnitude. The results are significant at the 90% confidence level for the household fixed effects estimates and suggest that individuals with the highest exposure to fires, are 1.24 times more likely to report incidence of respiratory illness, holding constant household factors.

Table 4.3: Effect on respiratory illness of FRP exposure in a10km and 15km radius – Odds ratio estimates				
	(1)		(2)	
	10km		**15km**	
High Exposure - 4th Quartile	1.355**	1.259**	1.244	1.249*
	(0.198)	(0.147)	(0.175)	(0.155)
Individual FE	✓		✓	
Household FE		✓		✓
Observations	2,541	21,500	2,541	21,500

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.4.1. Sensitivity analysis

To test the validity of the theoretical mechanism in the main results, I estimate the model using three alternative health outcomes – typhoid, kidney disease, and injury. Holding constant underlying characteristics, these outcomes should not be associated with high exposure to FRP from crop fires. Similar to the variable of interest i.e. respiratory illness, these are coded as binary outcomes with a value of 1 if the specific illness or injury is reported as the most pressing health outcome over the two months period preceding the survey, 0 otherwise. As mentioned earlier, only the most pressing health concern has been reported so categories of illnesses are mutually exclusive.

Table 3 reports the odds ratio based on these alternative specifications. The results are insignificant (even at 90 percent confidence interval) indicating that the incidence of these three outcomes is not impacted by high exposure to fire radiative power. Since short term exposure to suspended particles is unlikely to impact health outcomes like typhoid or kidney disease or result in injuries[19], these results provide

[19] The haze created from suspended particles has been linked to increased risk of accidents (injury), but this impact may be better captured in an analysis restricted to the winter months since that is the time when meteorological conditions interact with the pollution particles to reduce visibility.

some confirmation that the underlying causal mechanism through which high exposure to fire radiative power impacts respiratory health is air pollution.

Table 4.4: Effect on other illness/injury of FRP exposure in a 10km radius – Odds ratio estimates

	(1)		(2)		(3)	
	Typhoid		**Kidney disease**		**Injury**	
High Exposure - 4th Quartile	1.280	1.239	1.094	1.053	1.044	0.991
	(0.268)	(0.241)	(0.264)	(0.231)	(0.125)	(0.114)
Individual FE	✓		✓		✓	
Household FE		✓		✓		✓
Observations	1,180	9,167	1,373	11,506	3,325	25,742

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

4.5. Discussion

This paper examines the impact of open field fires on the respiratory health of individuals. It attempts to overcome current data limitations pertaining to air pollution during periods of crop residue burning by using proximity-based measures of fire exposure across households. Results of the conditional fixed effect model suggest that during periods of high exposure to fire radiative power, individuals are more likely to experience respiratory illness. Consistent with our theoretical understanding of the impacts of air pollution on respiratory health, we show that the results are not spurious since we do not find any association between our measure of exposure and other illnesses. These findings are also consistent with earlier empirical evidence on the impact of fire-based pollution on human health (Sheldon & Sankaran, 2017; Chagas et al., 2014).

In our analysis, variation in household level exposure depends on the timing of the interview as well as household proximity to the location of the fire. Using MODIS satellite data, we show that the count of fire is the highest in the month of May, which is the period after wheat has been harvested across the country. This differs

from the patterns of agricultural crop residue burning in neighboring India where the burning of rice stubble leads to high fire activity in the winter months of October – November (Miro et al., 2019). The fire radiative power in this period appears to be spatially concentrated in the northeastern districts of the Punjab province. However, the use of fixed effects in our logistic model allows us to capture the impact of experiencing differing individual and household level exposure across years.

There are limitations to this analysis that can be addressed in future research. While the household data are rich in terms of the spatial coverage and geocoded information, the outcome measure of respiratory illness relies on reports of most severe illness in the given time period. Therefore, the actual illness incidence is likely underreported by individuals that may be suffering from chronic illness or disease that exceeds in severity relative to any respiratory illness. The impact of exposure can be higher for such individuals and the impact may therefore be underestimated in the current study. Another constraint due to the existing data is that it is not possible to observe heterogeneous effects from factors such as indoor pollution exposure e.g., due to type of energy source used by the family or by individual health behaviors e.g. smoking. The current analysis does not measure the impact of such factors on respiratory health. However, to the extent that we expect these to be constant across a four-year time period, and to not systematically differ (on average) across groups with high and low exposure, the exclusion of these does not bias our main results as they will be picked up within fixed effects.

Individual level outcomes are examined for households in Punjab and Sindh provinces of Pakistan. These two provinces are dominated by agricultural activities including extensive cultivation of wheat, rice, sugarcane and cotton. For farmers, stubble burning offers the ease of crop rotation and a low-cost option to clear the straw that is left behind after mechanized forms of harvesting (Gupta, 2012). Its contribution to the atmospheric pollution and impact on human health is often overlooked due to the episodic nature of the fires (Irfan et al., 2015). Political will for

effective legislation and financially feasible alternatives to these practices are needed to incentivize a change in behavior. Policies to incentivize a reduction in burning include subsidizing technology for better residue management practices and strengthening the commercial markets for residue which is of substantial economic value. Moreover, agricultural extension services should highlight the potential decrease in productivity of agricultural land (Mandal, et al., 2004) caused by stubble burning as well as the benefits of incorporating residue into the soil.

4.6. Conclusion

This paper examines open field burning of crop residue and its impact on respiratory health in Pakistan. Due to the seasonal nature of fire activity and current data limitations, there is a lack of rigorous evidence on the health impacts of this practice in Pakistan. Public concern is often limited to the burning of rice stubble in the winter months, when smoke from these fires interacts which the meteorological conditions to result in smog (Gautam et al., 2007). This paper primarily observes exposure to fire radiative power associated with burning of wheat residue and reports a negative impacts respiratory health.

While existing studies have documented the substantial health gains from reduction in this source of pollution (Schraufnagel et al., 2019), further empirical research may be needed to motivate policy action. Future research should examine heterogeneous impacts across socio-demographic groups using more detailed data on health outcomes. Remote sensing data presents an opportunity to overcome some of the data limitations faced by researchers in developing countries. Data on wind directed can be incorporated to examine exogenous variation in exposure to pollution for further estimation of causal impacts.

Chapter 5: Conclusion

5.1. Overview

Improving the health outcomes of low-income populations remains a significant challenge for most developing countries. There is a cyclical nature to health challenges whereby a shortage of resources leads to sub-optimal healthcare spending, and subsequently, poor health outcomes result in reduced economic productivity and lower income over time. Moreover, health seeking behavior is skewed in that individuals and households may incur substantial out-of-pocket health expenditure on remedial health care and emergency curative services (Banerjee et al., 2015; Dupas, 2011), but there is seemingly less emphasis on avoidance behavior and prevention (Kremer & Glennerster, 2011). If circumstances arise, where the consequences of not seeking medical care are severe and immediate, the resulting health expenditures can be catastrophic for poor households. Such events exacerbate the depths of poverty for households that have poor accessibility to financial markets and limited options for borrowing or insurance.

Consequently, certain government programs that address market failures to mitigate the effects of poverty on health outcomes are gaining traction. These include programs like subsidized public health insurance that allow households to smooth consumption over episodes of unexpected illness, and supplemental income for low-income families to meet health and nutrition needs. The recent decade has seen increased public consensus around the need for a comprehensive social protection agenda that has the potential to improve the health of the most vulnerable people. However, despite political momentum around these initiatives, there is still limited academic evidence on the behavioral responses of beneficiary households within low-and middle-income countries (Dupas & Miguel, 2016). This work, in part, contributes towards that gap in evidence by examining outcomes associated with two national social assistance programs in Pakistan. The observed health outcomes

i.e., maternal health and child nutrition are of particular importance in the country-specific context but have significance for most developing countries.

Identifying market failure and achieving a consensus around its resolution can also be a challenge in the formulation of successful health policies. The current research discusses a third example where an unregulated market failure (i.e., pollution) continues to impact the health of vulnerable population. In contrast to the redistributive programs discussed earlier, public initiatives that actively seek a change in behavior are more likely to be met with resistance particularly if there is a transaction cost to that change. In such instances, adequate mechanisms and dispersal of information may be needed to protect the health and wellbeing of sub-populations. It must also be noted that the development agenda in low-income countries is often dictated by donor funding and a global impetus for reform. In contrast, health challenges with a more localized context, may see slower policy change even in instances of stark market failure.

The remaining chapter discusses the findings and policy implications corresponding to the three broach research questions addressed in this dissertation. It ends with limitations of the current analysis and suggestions for future research.

5.2. Research Findings

5.2.1. *Research Question 1: What is the impact of public health insurance on the use of maternal health services?*

Key Findings

The analysis in Chapter 2 provides evidence of success of Pakistan's Prime Minister National Health Program in reaching intended low-income beneficiaries and in improving the utilization of maternal health services. Districts where the program was introduced, saw improvement in two keys measures of safe motherhood practices – hospital birth and skilled attendance at birth. However, these results were driven largely by the urban sub-sample as our results did not show a significant

improvement in use of maternal health for rural areas. This confirms previous works in the literature showing that the improved utilization effect is attenuated among vulnerable insurance beneficiaries living in remote and under-catered areas (Fiestas et al., 2019; Grogger, et al., 2015).

In addition, data on mothers with multiple children was used from a cross-sectional survey to construct child level data with mother-fixed effect in order to observe the probability of having a birth certificate if the child is born after the introduction of the program. Thus, in addition to investigating the health-related effects of participation, this paper looks beyond utilization to find a positive spillover effect that insurance could have on a document that is arguably the foundation of civic rights.

Policy Implications

By encouraging households to seek diagnosis and care, well designed public health insurance can prevent inefficiencies in the health system. Self-diagnosis of treatment induces the risk of patients never getting proper treatment and results is wastage of resources on ineffective and incorrect treatment. This is also true in the case of maternal healthcare where seeking obstetric care in a timely manner can reduce complications related to childbirth. Given our findings on (increased) utilization, enabling access to quality healthcare through programs such as the PMNHP can incentivize behavior change which may extend to seeking preventative care.

While overall findings can be viewed as a measure of success for program implementation, the results also highlight the significance of supply side infrastructural constraints that limit the effectiveness of a such a demand side policy. To improve access to quality healthcare by low-income families, the government of Pakistan has focused on empaneling private sector hospitals as part of the insurance program. As a result, the program became more accessible for urban population where larger private hospitals operate. Rural areas catered to primarily by government infrastructure, and with limited geographical access to (empaneled)

hospitals would therefore be less likely to see program benefits – as is evidenced by the findings. Thus, while on the face of it, programs such as subsidized/free insurance may be important instruments for universal healthcare, some characteristics within the policy design can make them exclusionary. Unless these issues are addressed in a timely manner, the structure of the program can potentially exacerbate rural-urban inequities.

5.2.2. *Research Question 2: Does exposure to supplemental income during prenatal period improve the anthropometric trajectory of a child?*

Key Findings

Ch 3 examines the impact of in-utero exposure to the Benazir Income Support Program (BISP) - an unconditional cash transfer program in Pakistan. Data indicates an alarmingly high prevalence of stunting and underweight children from low-income families. While we do not find evidence of improved child nutrition in the overall sample, household that received supplemental income during all or for most of the prenatal period of a child's life, saw an improvement in anthropometric outcomes. Height for age z-scores improved for all children and weight for age z-scores were higher for female children with in-utero program exposure compared to other girls in the same age group. Significantly, birth order is found to be a key factor in the impact of the program. Results indicate better outcomes for second born children with magnitude of impact being even greater for the third (and higher order) child.

Policy Implications

Cash transfer programs are perhaps the most widely implemented developmental policy across low-and middle-income countries. Despite their success on many fronts (including improvement in education outcomes, reduction in child labor and increase in access to preventative healthcare) there is no consistent evidence on children's nutritional status as measured by anthropometric outcomes. The findings of chapter 3 have two major implications. First, the timing of the cash transfer

program matters and providing supplemental income to pregnant women may lead to sustainable improvements in height for age. Second, the marginal impact of such transfers is greater for populations with high fertility rate. Government funding for nutrition-related programs in Pakistan is much lower than the average for developing countries (IFPRI, 2016). The limited funds may be well-utilized by targeting pregnant women to overcome potential shortfalls occurring in utero.

Earlier studies have noted that cash transfers may not be sufficient and that critical behavior changes are necessary for more sustainable improvements in nutritional outcomes (Manley et al., 2013). Knowledge of behaviors such as good feeding practices (linked to the experience of a previous birth) may be a possible mechanism driving the association between unconditional cash transfers and anthropometric outcomes. This, in turn, underscores the value of combining transfer payments with informational interventions targeted to low-income families.

5.2.3. *Research Question 3: What is the health impact of exposure to pollution from the unregulated burning of agriculture crop residue?*

Key Findings

Analysis of satellite data for Pakistan suggests geographical and temporal variation in fire activity across the country. The peak in the number of fires over cropped land occurs in May – a period that follows the harvest of wheat in the country. Media reports suggest that public awareness of the problem of agricultural residue burning may be limited to the burning of rice stubble in the winter months (October-November) when atmospheric conditions interact with fire pollution to create smog. However, in this paper we document the health impacts of unregulated fire activity occurring predominantly during summer months. Based on the conservative estimates in our analysis, high exposure to radiative power leads to a 1.355 times increased likelihood of reporting illness.

Policy Implications

There are substantial health and productivity costs associated with poor environmental quality. According to a WHO estimate, 22 percent of all global deaths occur due to environmental factors and about two thirds of these deaths are attributable to noncommunicable diseases including respiratory illness (Pruss-Ustun et al., 2016). Moreover, certain population groups may be disproportionately impacted because they lack the resources to engage in avoidance behavior and in general have lower access to healthcare.

Agriculture fires used by farmers to clear lands of crop residue after harvest are widely prevalent with satellite data capturing about 8000 fire events in a given year for Pakistan. The external cost on society in the form of health impacts, requires government regulation of this practice. Current legislation around crop residue burning is weakly implemented possibly because there are limited alternatives available to farmers. Policies to incentivize a reduction in burning include subsidizing technology for better residue management practices and strengthening the commercial markets for residue which is of substantial economic value. Moreover, agricultural extension services should highlight the potential decrease in productivity of agricultural land (Mandal, et al., 2004) caused by stubble burning as well as the benefits of incorporating residue into the soil.

5.3. Limitations and Future direction

Experimental design is often the gold standard for impact assessment research. Due to the unavailability of such data, this research uses approaches such as the difference-in-difference and fixed effects specifications to either create counterfactual controls or to control for unobservable characteristics in order to overcome potential bias. The reliance on secondary data, however, limits the breath of analysis as not all questions and mechanisms related to the topic of interest can be suitably addressed with available information. This is a particular constraint for research in developing country contexts.

There are limitations to the analyses conducted in each of the three studies. In Chapter 2, a factor that limits the examination of the impact of health insurance is that available data does not allow for the identification of program beneficiaries at the household level. As a result, the analysis is carried out using the intent to treat impact at the district level. In Chapter 3, despite the availability of a rich panel data, anthropometric outcomes are not recorded for children above the age of five which restricts the sample size. Finally, in Chapter 4, available geocoded data on health outcomes is limited and a much richer analysis would be possible if hospital medical data were available. For such analysis, it is important also to examine differential effects across sub-populations through the lens of environmental justice which was not possible in the current analysis.

In the country specific context of Pakistan, future evaluations of the PMNHP and BISP can also explore how well the programs continue to meet broader objectives as well as possible spillovers. As more data are collected, research may examine more thoroughly the mechanism driving findings of this research. It is important for instance to examine the reasons why health care utilization did not improve for households in rural areas, and the channels that explain the birth order impacts of cash transfer programs. Additionally, health research using medical records at the village level would allow for more detailed and nuanced analysis of short- and long-term environmental impacts on well-being as well as the potential societal harm imposed by unregulated externalities.

More broadly, important questions pertaining to health outcomes in developing countries must be addressed by future research. While programs such as public health insurance are becoming increasingly popular, it is essential to examine how policies incentivizing demand for healthcare will impact overall quality of hospital services in resource constrained setting with limited health-system capacity. There is also a need to examine institutional constrains that may result in program benefits accruing unequally across sub-populations. Similarly, while there is now a large

body of evidence on cash transfer programs, further research is needed to examine the complementarities that must be present to enhance effectiveness of these initiatives. For instance, while the role of information has already been highlighted in academic literature with regards to underinvestment in healthcare (Dupas, 2011), its potential role in improving efficacy of developmental programs must be examined. Lastly, there is significant scope for research on health externalities – particularly with greater accessibility of remote sensing data. Global satellite data has opened many avenues for research in data scarce settings. Evidence on these important policy issues is critical as countries experiment with various approaches in making progress towards the 2030 development agenda outlined by the Sustainable Development Goals (SDGs).

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Appendix A

Appendix to Chapter 3

Figure 3. 1A: Percentage of households that started receiving BISP in a given year

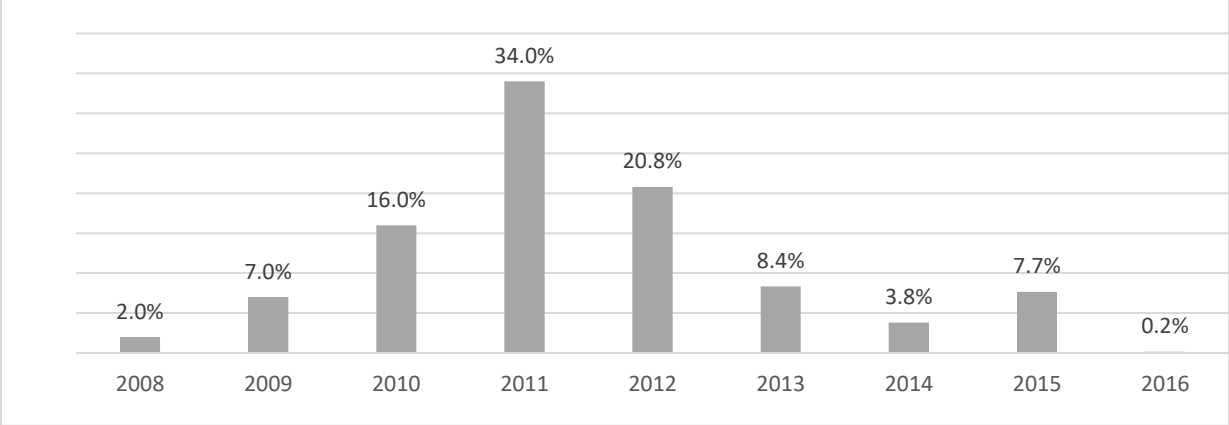


Table 3.1.A: Panel regression estimates: Impact of cash transfer on a child's anthropometry – months of exposure

	(1) HAZ	(2) HAZ	(3) WAZ	(4) WAZ
Months of Exposure	0.0005	0.0011	-0.001	-0.0007
	(0.002)	(0.002)	(0.002)	(0.001)
Program Exposure (=1)	0.079	0.0529	0.0295	0.022
	(0.073)	(0.0743)	(0.0563)	(0.056)
Female (=1)	0.039	0.072**	0.028	0.029
	(0.032)	(0.035)	(0.023)	(0.026)
Age	-0.035***	-0.036***	-0.014***	-0.015***
	(0.001)	(0.001)	(0.0007)	(0.0008)
Birth order	-0.156***	-0.209***	-0.155***	-0.189***
	(0.0309)	(0.034)	(0.019)	(0.022)
Recent illness (=1)	-0.0472	-0.0314	-0.0689***	-0.0612**
	(0.0319)	(0.0336)	(0.0230)	(0.0238)
Number of recipients	-0.0627	-0.0788	0.00129	0.00108
	(0.0486)	(0.0510)	(0.0356)	(0.0376)
Food Price Shock	-0.0526	-0.0742**	-0.0463*	-0.0309
	(0.036)	(0.037)	(0.025)	(0.025)
HH size	-0.00647	-0.0131	-0.0109	-0.0106
	(0.0119)	(0.0133)	(0.00909)	(0.00942)
Poverty Score	0.0125	0.00815	0.0132	-0.0009
	(0.0273)	(0.0262)	(0.0178)	(0.0158)
Year FE	✓	✓	✓	✓
Household FE	✓		✓	
Mother FE		✓		✓
Observations	16,185	14,796	17,302	15,840
R-squared	0.46	0.49	0.48	0.53

Household clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

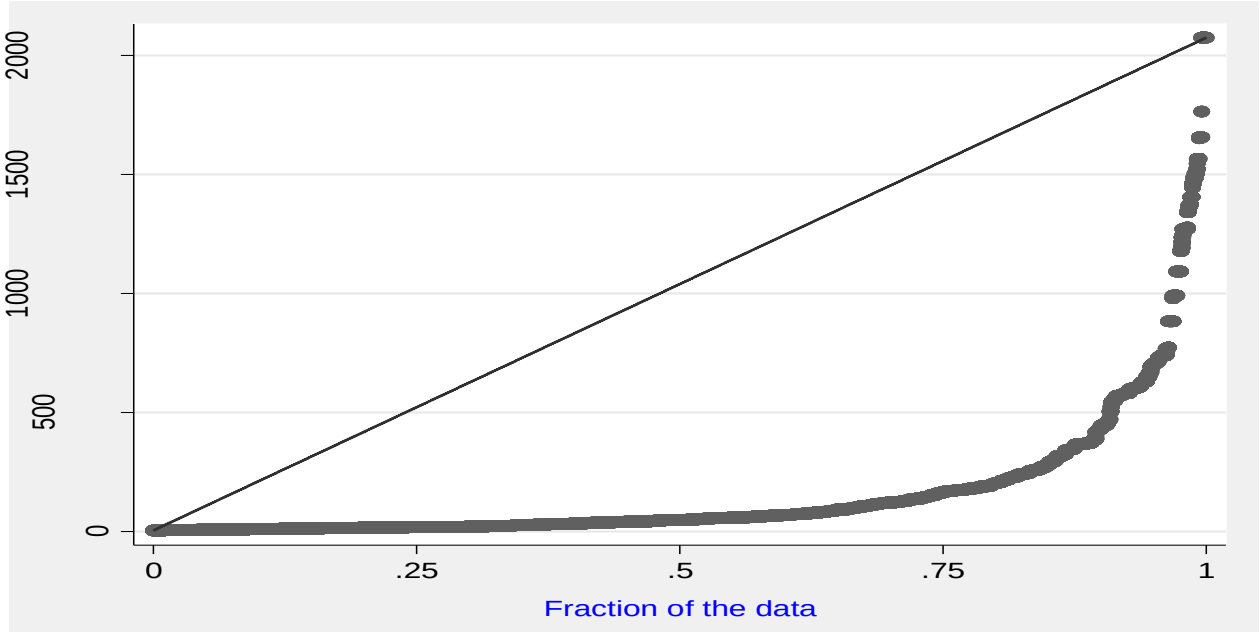
Appendix to Chapter 4.

Figure 4.1A: Timing of Survey in each year

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2011			x	x	x	x	x					
2013				x	x	x	x					
2014					x	x	x	x	x			

Note: The surveys were administered in person and for each interview the date and month was recorded by the enumerators.

Figure 4.2A: Distribution of FRP Exposure across quantiles



Note: The above figure shows the distribution of FRP exposure among those with positive exposure – based on the Punjab and Sindh subsample

Tables

Table 4.1A: Conditional logit estimates: Effect on respiratory illness of FRP in a 10km radius

	(1)		(2)		(3)	
	Respiratory illness					
Log FRP	0.163*	0.131**				
	(0.0866)	(0.0657)				
Any Exposure			0.132	0.110		
			(0.114)	(0.0927)		
High Exposure - 4th Quartile					0.304**	0.230**
					(0.146)	(0.117)
Individual FE	✓		✓		✓	
Household FE		✓		✓		✓
Observations	746	7,414	2,541	21,500	2,541	21,500

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.2A: Conditional logit estimates: Effect on other illness/injury of FRP in a 10km radius

	(1)		(2)		(3)	
	Typhoid		**Kidney disease**		**Injury**	
High Exposure - 4th Quartile	0.247	0.214	0.0902	0.0521	0.0430	-0.0087
	(0.209)	(0.194)	(0.241)	(0.219)	(0.120)	(0.115)
Individual FE	✓		✓		✓	
Household FE		✓		✓		✓
Observations	1,180	9,167	1,373	11,506	3,325	25,742

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.3A: Conditional logit estimates: Effect on respiratory illness in a 10km and 15km radius

	(1) **10km**		(2) **15km**	
High Exposure - 4th Quartile	0.304**	0.230**	0.219	0.222*
	(0.146)	(0.117)	(0.140)	(0.124)
Individual FE	✓		✓	
Household FE		✓		✓
Observations	2,541	21,500	2,541	21,500

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

LPM estimates

Table 4.1B: LPM estimates: Effect on respiratory illness of FRP in a 10km radius

	(1)	(2)	(3)	(4)	(5)	(6)
Log FRP	0.00102	0.00112				
	(0.000926)	(0.000840)				
Any Exposure			0.000867	0.00119		
			(0.000923)	(0.000909)		
High Exposure - 4th Quartile					0.00250*	0.00280**
					(0.00136)	(0.00134)
Individual FE	✓		✓		✓	
Household FE		✓		✓		✓
Observations	34,305	50,219	104,546	116,541	104,546	116,541
R-squared	0.55	0.09	0.48	0.075	0.48	0.075

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.2B: LPM estimates: Effect on other illness/injury of FRP in a 10km radius

	(1) **Typhoid**		(2) **Kidney disease**		(3) **Injury**	
High Exposure - 4th Quartile	0.000931	0.000847	-0.000306	-9.54e-05	0.000426	-0.000179
	(0.000868)	(0.000865)	(0.00111)	(0.00104)	(0.00128)	(0.00126)
Individual FE	✓		✓		✓	
Household FE		✓		✓		✓
Observations	104,546	116,541	104,546	116,541	104,546	116,541
R-squared	0.391	0.069	0.394	0.064	0.380	0.057

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.3B: LPM estimates: Effect on respiratory illness in a 10km and 15km radius

	(1)		(2)	
	10km		**15km**	
High Exposure - 4th Quartile	0.00250*	0.00280**	0.0016281	.0026108*
	(0.00136)	(0.00134)	(.0013231)	(.001333)
Individual FE	✓		✓	
Household FE		✓		✓
Observations	104,546	116,541	104,546	116,541
R-squared	0.48	0.075	0.48	0.075

The above models have been estimated using year fixed effects and village clustered standard errors. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1