The Gendered Spillover Effect of Young Children's Health on Human Capital: Evidence from Turkey

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Abstract

How health technology interacts with underlying cultural norms may have unanticipated consequences for development. I investigate a national vaccination campaign targeting under-five children in Turkey, and document gains in human capital among age-eligible children of both sexes but spillover effects that accrue exclusively to older girl siblings. These findings are consistent with predictions from a standard intrahousehold model of time allocation in the presence of gender norms regarding the division of household labor and suggest technologies and policies that improve the health of young children may have the added benefit of improving educational outcomes for their older sisters.

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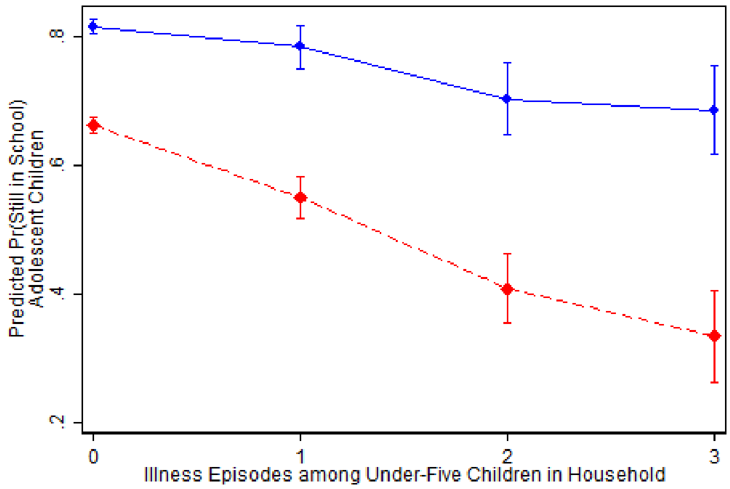
1 Introduction

How technologies are introduced and their interplay with existing cultural norms can have unanticipated consequences for development. This paper explores one such technology–immunizations, which have revolutionized the control of infectious disease in recent history. The target of most immunization campaigns are young children, and like other early childhood interventions, such campaigns may have important effects on other household members.[1] The spillover effects on non-treated children are unclear, and depend on parental preferences and household budget constraints.

The handful of empirical studies which have investigated similar questions focus on whether parents' investments reinforce or compensate for differential endowments.[2] However, early child health interventions operate within a cultural context of gender roles that typically place the burden of household activities on girls. Given such norms, sick young children in the household may differentially raise the opportunity of cost of an older girl child's schooling. Evidence consistent with such a mechanism is presented in Figure 1 which demonstrates that, for Turkish children 11 to 15 years of age, the gender gap in schooling increases in the number of illness episodes experienced by younger children in the household.[3]

FIGURE 1
Gender Schooling Gap and Child Illness



Notes: Data presented are from the Turkish Demographic and Health Surveys (1993 1998 and 2003) merging in the women's file which includes questions on illness episodes experienced by under-five children in the last two weeks with the household file which includes information on whether a member is still in school.

[1] See Almond and Currie (2011), Currie and Vogl (2013) and Glewwe and Miguel (2007) for reviews.

[2] For recent empirical studies on parental response to health investments see Yi, Heckman, Zhang, and Conti (2015), Parman (2013) and Adhvaryu and Nyshadham (2014). Ozier (2014) investigated spillover effects of deworming in Kenya on unborn children. Seminal theoretical contributions include Becker and Tomes (1979) and Behrman, Pollak, and Taubman (1982).

[3] A similar pattern is demonstrated when aggregating over Demographic and Health surveys around the world, conditional on household fixed effects (Alsan and Bendavid, 2015).

To address the endogeneity of investment in children's health, this paper exploits one of the most successful and largest mass vaccination campaigns in recent history–the Turkish National Immunization Campaign of 1985. The impetus for the campaign grew out of advancements in vaccine delivery and a long-standing personal relationship between the UNICEF director and the prime minister of Turkey with the stated goal of improving child survival. The campaign was unique in its sheer scale and the number of diseases that were included in the effort (measles, polio, as well as diphtheria pertussis and tetanus (DPT)). The logistical accomplishments of the campaign were unprecedented. Within three months 27 million vaccines had been administered; coverage for measles vaccine increased from 37 to 83 % nationwide and a similarly impressive jump was noted for DPT vaccination.

The empirical strategy adopted exploits heterogeneity in the precampaign prevalence of vaccine preventable illness to compare areas that experienced a relatively larger gain in coverage to areas that experienced a more modest increase. The strategy developed in the paper corrects for underreporting of vital events which is particularly severe in rural areas and presents an obstacle to impact evaluation in developing countries.[4] The greatest threat to the validity of the analysis is that vaccine preventable disease (VPD) prevalence is not randomly assigned. High VPD prevalence in the precampaign period could be correlated with low literacy and socioeconomic status more generally–and such areas could be on a different time path than areas with less prevalent disease. I provide evidence that VPD prevalence is not correlated with precampaign covariates prior to the rollout of the intervention conditional on other covariates. Placebo intervention dates for the campaign fails to produce similar results.

The campaign did not achieve its stated goal of reducing infant or child mortality. Reasons for the null effect are discussed, with the most likely one being that vaccine preventable illnesses were not a leading cause of mortality for this age group at the time. However, there were declines in disability and gains in schooling for age-eligible children as measured in their young adult life. A one standard deviation increase of vaccine preventable illness in the precampaign period was associated with approximately a 5% decline in disability, a 2.4 % increase in literacy and a 1.6 % increase in educational attainment. These findings are robust to a range of controls thought to influence children's health and education at the individual, household and local geographic level such as maternal literacy, family structure, father's occupation and health care supply. The results are not driven by mean reversion or a specific geographic subsample of the country. The effect of the campaign on disability for age-eligible children is similar for boys and girls, consistent with official reports on widespread vaccine dissemination, but educational returns are highest for girls who have younger siblings.[5]

[4] The UN estimates that only 65% of births and one-third of all deaths are recorded through civil registration throughout the world (Mikkelsen, Lopez, and Phillips, 2015).

[5] Vaccination of older siblings is protective for the health of younger children though the converse is not necessarily true, since older children typically have acquired natural immunity by school age.

To explore these gender-specific effects in more detail and isolate spillover effects, I examine the effect of the campaign on older siblings who were not targets of the campaign.[6] I find older sisters living with an age-eligible child improve their literacy and educational attainment, while older brothers do not. Data from the Demographic and Health Surveys (DHS) in Turkey and government enrollment statistics reveal where in the years of schooling distribution girls gained. The results show that more girls were induced to attend school on the extensive margin and to complete the "compulsory" education heavily subsidized by the state.

The results are interpreted within a model of the intrahousehold distribution of resources across progeny. In an environment where parents seek to maximize the expected earnings of their children, and the human capital of the youngest children require inputs of time, parents must choose how much time an older sibling may spend in school and how much time he/she spends performing childcare and other household activities. If there are lower returns to girls' schooling in the labor market, parents will demand less schooling for their daughters than their sons. Furthermore, if the opportunity cost of time in school increases more for girls than boys when a younger sibling is sick, due to a gendered division of labor in the home and substitutability between mother and older daughter (Rosenzweig, 1980), then illness shocks among young children will exacerbate the gender gap in education.

Several findings support the notion that opportunity costs and gender norms in household labor play a key role in the behavioral mechanism underpinning the empirical results. First, in the spillover sample, the differential gendered effect is increasing in the number of young children in the household (up to a point). Second, spillover effects are absent if there are no age-eligible children in the household.[7] Third, the gendered spillover effect is greater if the supply of maternal domestic time is limited by work outside the home, particularly in cotton fields. Fourth, the gendered spillover effect is absent among households with grandmothers, a potential substitute for a mothers' (and older girls') domestic time.

The model and the paper focus on time. Of course, less illness in a household also lowers medical expenditures and increases household income. Although primary schooling in Turkey was free, parents may simply prefer educating boys on average, thus marginal changes in income should affect daughters' education more than sons'. I argue the income channel is less plausible since the positive wealth shock to the household from reduced morbidity of an under-five child is small. Child illness episodes treated in the public sector are heavily subsidized but require time to travel, wait and stay with a child if hospitalized or follow instructions to care for the sick child at home.[8] Empirically, I do not find significant impacts

[6] I use the term "spillover" to refer to gains that are not directly related to receipt of the vaccine. Although older age children might also benefit from herd immunity –and this might be larger for girls than boys if they are tasked with childcare, this does not appear to be the main explanation for my findings given the U-shaped age pattern of vaccine preventable illness morbidity–discussed in detail below.

[7] This is similar to the finding in the age-eligible sample, which demonstrates gendered effects are absent if the child is likely the youngest in the family.

[8] In 1961, Turkey passed a law to socialize it's health service ("Statute of Socialization of Health Ser-

of the campaign on proxies for household wealth. The notion that time is a key determinant of child health in developing countries was highlighted in Miller and Urdinola (2010) and in the 1985 UNICEF State of the World's Children Report (UNICEF, 1985).[9]

This paper draws upon research at the intersection of infectious disease, children's health, gender and development. It contributes to the body of literature developed by Currie, Almond, Gertler and others emphasizing the importance of early childhood health for future well being. It provides an additional explanation for the rise of female schooling. Becker, Hubbard, and Murphy (2010) focus on female comparative advantage in noncognitive skills as the driving force. Pitt, Rosenzweig, and Hassan (2012) adapt the Roy model of occupation choice. In their model, health investments predict larger schooling gains for girl than boy children since health increases returns to labor in the brawn economy, increasing the opportunity cost of boys' schooling. This paper complements such an explanation, emphasizing how technological advances in child health will disproportionately impact the time budget of those primarily tasked with caring for them when they are ill. The paper also touches on debates about how to close the gender gap in developing countries. Much focus has been on the relative merits of gender-specific affirmative action policies and economic growth.[10] The findings herein point to improved child health as another potential policy tool.

The structure of the rest of the paper is as follows: section 2 describes the campaign and gendered patterns of time use, section 3 introduces the theoretical framework used to motivate and interpret the results, section 4 introduces the identification strategy and the data, section 5 presents the results section 6 discusses underlying biological pathways and competing explanations. Section 7 concludes.

2 Background

2.1 Turkish National Immunization Campaign

In 1980, Jim P. Grant became UNICEF director and shortly thereafter unveiled an initiative known as the child survival revolution which was based on four simple strategies: Growth

vices"). Socialization was defined as providing free services at the point of delivery (with the exception of the cost of drugs), and collecting premiums to pay for the services. The collection of premiums was never implemented, but health centers linked to hospitals for provision of primary care were established and staffed by doctors (recent medical graduates) who were assigned two years compulsory service after graduation (Fisek and Erdal, 1985; Topalli, 2015). Other mechanisms (e.g. epidemiologic spillovers and taste-based discrimination) are considered below but cannot sufficiently explain the spillover results.

[9] Although time may be less important in developed countries, there is still strong evidence of a gendered division of parental responsibility for childrens' health. According to a recent Kaiser Health Survey in the United States, 81% of mothers report they are responsible for assuring a child receives recommended care. Among working parents with children under 18 in the home, 39% of mothers (compared to 3% of fathers) report primary responsibility for taking care of children when they are sick (Kaiser Family Foundation, 2014).

[10] See Duflo (2012) for a review.

Monitoring, Oral Rehydration, Breastfeeding and Immunizations (GOBI).[11] As part of the revolution, Grant was searching for a low-resource country that would serve as a showcase for a successful mass immunization campaign. Grant sought out Turgut Özal, a colleague from his days at USAID, and a man who had subsequently gone on to become Turkey's prime minister. Özal agreed with the concept and the planning began. As described in a subsequent UNICEF report, the campaign "had a clear aim: to show that a large middle-income country with high infant mortality and barely average EPI coverage could inexpensively vaccinate at least 80 % of its children–despite barriers of weather, terrain, and population dispersion" (UNICEF, 1986, page 7).[12]

The campaign began with then Turkish President Kenan Evren vaccinating a baby in front of the press. This launched the first ten day campaign, with two more occurring before the end of the year. The campaign involved an impressive collaboration across sectors. Widespread media messages were conveyed by the press. Imams were given a prepared sermon to deliver from 54,000 mosques throughout the country on the Friday evening before campaign launch which quoted text on the importance of caring for children from the Quran.[13] "Not to miss one single child," became a national motto. Turkish Radio and Television donated free air time and an average of six articles were carried in the main national newspapers every day until the campaign's end. Healthcare workers (physicians and paramedicals) were trained and the cold chain infrastructure was bolstered with private and public donations. The target population precampaign was estimated at 5.1 million children between 0 and 60 months. There were over 45,000 vaccination stations aimed at being within a 10-15 minute travel time from each home. Health centers, mosques and schools as well as a few businesses served as vaccination sites.

[11] This section draws heavily on the following publications:
"Rapid Assessment: Turkish National Immunization Campaign of 1985" (UNICEF, 1986)., "Report of the Baseline Survey for the 1985 Turkish National Immunization Campaign" (Tunçbilek, Cerit, Unalan, Akadli, and Toros, 1985) and "The Vaccination Situation of Children Between 0-5 Years of Age After the Accelerated Vaccination Campaign and a Comparison with Pre-Campaign Results" (Tunçbilek, Ulusoy, Hancioglu, Unalan, Cerit, Uner, Toros, Akadli, Kulu, and Ayhan, 1986). Unfortunately, only the published results from the baseline survey are available and they are compared to the reconstructed variable in Appendix Figure B3.

[12] Other mass vaccination campaigns include Brazil (1980 to 1985), India (1985) and Burkina Faso (late 1984). However, the Brazil campaign only included polio vaccination; the India campaign was instituted by private doctors, and the Burkina Faso campaign also had a primary health care component. The 1985 Turkish campaign is therefore unique in its scale, number of different types of vaccines delivered, use of the public sector and focus on child health (Barron, Buch, Behr, and Crisp, 1987). Though other vaccination campaigns had been carried out in Turkey prior to 1985, they were not nearly as large scale or well coordinated, typically only serving small areas. Furthermore, to the extent such campaigns were delivered effectively (and I have no evidence to suggest they were), they will be incorporated into the baseline measure of VPD prevalence used in the empirical strategy. I thank Resul Cesur for the comment.

[13] See Appendix Figure B1 for photos of the campaign.

Table 1: Coverage of Eligible Population

Vaccine	*Age Group*	*Pre (%)*	*Post (%)*
DPT	2-11 months	28	92
&	12-59 months	52	94
OPV	total	47	94
	2-11months	12	72
Measles	12-59 months	40	84
	total	37	83

Notes: Data taken from "Rapid Assessment: UNICEF Report of the Turkish National Immunization Campaign" (UNICEF, 1986).

Table 1 reports increased vaccine coverage among the target population of children under 60 months before and after the campaign. Figure 2 plots health outcome measures over time. Panel A demonstrates a strong downward trend in child mortality that antedates the vaccination campaign and is in contrast to Appendix Figure B2 Panel A which shows a discontinuous drop in vaccine preventable deaths in 1985.[14] The decline in disability in Figure 2 Panel B occurs contemporaneous with the campaign.[15] [16]

[14] Results on mortality might be more impressive for the rollout of pneumococcal and rotavirus vaccination (since pneumonia and diarrhea are the leading causes of child mortality in developing countries). More recent research suggests the measles virus suppresses the immune system by attacking memory B cells and could leave a long lasting impact on the ability of individuals to fight many different types of infections (Mina, Metcalf, de Swart, Osterhaus, and Grenfell, 2015). The implication is that measles vaccination therefore protects against other common illnesses which would require childcare.

[15] Disability has a low mean (approximately 1% of the sample) in the census. It is important to note that, like the case fatality rate, disability from vaccine preventable illnesses is much lower than their incidence and overall morbidity. There is precedent for using disability in the census to measure the impact of infectious disease at the population level (Almond, 2006).

[16] Panel B demonstrates heaping on age. In the main analysis, the estimates use repeated cross sections that do not include 1980.

Figure 2: Health Effects of The Campaign

Notes: Data presented are from the Demographic and Health Survey (1993, 1998) and the Turkish Census (2000). Data from Panel A are plotted by Death Year, and Panel B are plotted by Birth Year.

2.2 Gender Norms in Turkey

This section seeks to provide context for the gender norms that existed and upon which the immunization campaign was superimposed to motivate the hypothesis that girls might have benefitted more in response to early child health interventions than boys. Patterns on time use by gender and beliefs about the relative benefits of educating girls are described.

2.2.1 Time Use

The first nationally representative time use survey in Turkey was performed in 2006. Although approximately 20 years after the intervention, the pattern produced below is relevant and was likely more pronounced at the time of the campaign. Figure 3 Panel A shows the time (in minutes) that are spent on household activities by age group and gender. The divergence in tasks begins early; with young women 15-24 spending much more time on household activities than their male peers. These results obtain when looking within households. A regression of time (in minutes) spent on household chores on gender and household fixed effects limited to never married individuals 15-24 years of age yields a coefficient of 169.19 significant at the 1% level. Within the same household, in 2006, girls spent almost three hours more on household activities than boys did on a typical day.

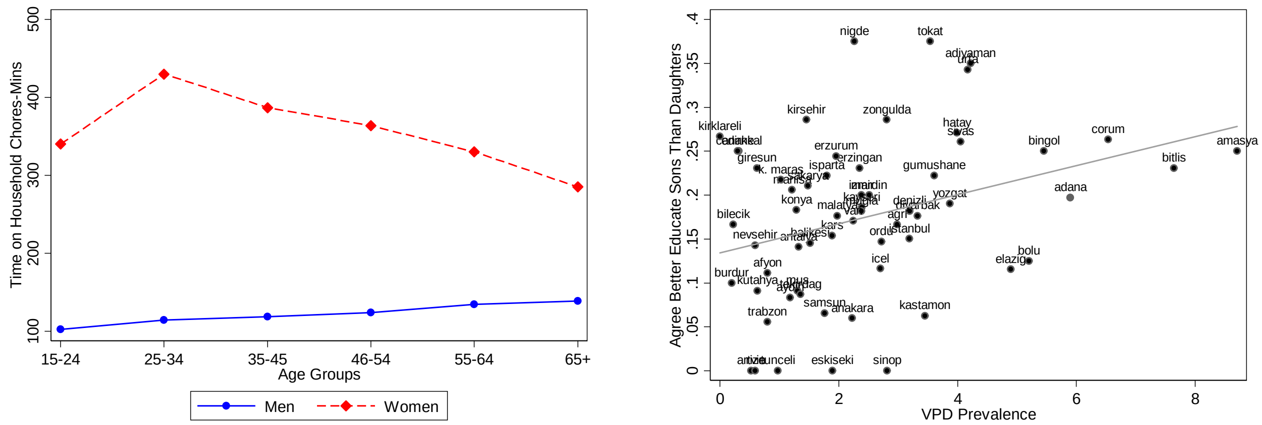
2.2.2 Beliefs about Education

Since the Kemalist Reforms, education was compulsory in Turkey and part of a larger aim to reduce the influence of religious education. According to Berkes (1998, p. 466), "the constitutional provision that every Turkish citizen had the right to free primary education and the subsequent educational laws making secular education compulsory to the age of twelve were active deterrents to the opening of religious schools in competition with the primary schools administered by the Ministry of Education." Despite this law, there may be parental preferences regarding child education by gender. The Demographic and Health Survey in 2008 asked women whether they agreed with this statement: "It is better to educate sons than daughters." I limit the sample to mothers born before 1968, so as to recreate the views of the population that would have had young kids at the time of the campaign. Caution should be used when interpreting the results given concerns about survival bias, demand bias and opinions shifting over time. There is heterogeneity in the proportion of mothers that admit to agreeing with this statement, close to zero in some provinces, and almost two-fifths in others. Figure 3 Panel B shows a robust positive correlation between where this view is more openly expressed and the precampaign prevalence of vaccine preventable disease. Together, these graphs provide support for the notion that girls were often tasked with childcare roles (or household chores when a mother is preoccupied with a sick child) and that girls' education was viewed as less important than boys', particularly in areas where the campaign should have had the greatest impact, as described below.

FIGURE 3: GENDERED TIME USE AND PARENTAL BELIEFS

A. Time Use by Age and Gender

B. Parental Beliefs about Education



Notes: Data plotted are from the 2006 Time Use Survey (Panel A) and the 2008 DHS (Panel B). Panel B displays the partial regression plot of an indicator variable for "agree with the statement, it is better to educate sons than daughters" on VPD prevalence.

3 Model of Intrahousehold Time Allocation in the Presence of Early Childhood Illness

In this section, I develop a simple model which seeks to interpret the empirical findings. Building on the work of Behrman, Pollak, and Taubman (1982), parents seek to maximize a parental welfare function that gives equal weight to each child and is additively separable in a vector of expected earnings (**E**) for each of their i children. Following Behrman, Pollak, and Taubman (1982) I ignore the sequential nature of the decisionmaking and view allocation as a one-period problem taking the number of children as a given.

To focus attention on the salient features of the applied work, I assume there are three children per household: an older schoolage boy and girl sibling and an under-five younger child. The expected earnings of each i child is a function of their time in school S (if age-eligible) and an early childhood health investment, H: $E_i = E(S_i, H_i)$. Health of young children are determined by their endowment at birth, e, which is complemented by investments of domestic time. For older schoolage children, the stock of health-related time investments when the child was under-five is fixed at H_o.[17] For any child i the expected earnings is therefore: $E_i = p(S_i, H_i)w_s$ where $p(\cdot)$ is the probability of earning the skilled wage and is strictly concave and monotonically increasing in both arguments. I assume the skilled wage is higher for males than female, $w_s^b \gg w_s^g$, which is in line with the data and determined by equilibrium in the labor market.[18] [19] I also assume that separate spheres start early, so that the outside option for the older girls' time, were she not in school, would be to perform domestic duties worth price of w_d whereas the older boy would work in agriculture for w_a.[20] This division of labor could be due to a comparative advantage males have in "brawn" Pitt, Rosenzweig, and Hassan (2012) or the historical use of the plow Alesina, Giuliano, and Nunn (2013).[21] The parents' choose schooling and child health investment to optimize future earnings subject to

[17] Complementarities between genetic endowments, early child investments and schooling are clearly important (Cunha and Heckman, 2007). However, the model does not need to assume that genetic endowments differ between the sexes or that parents place a higher welfare weight on boys versus girls to obtain the gender gap in schooling (equation 1). Behrman (1997) calls this form of parental preference "equal concern."

[18] Ilkkaracan and Selim (2007) review the literature on wage gap in Turkey and note that estimates vary widely, but data using official statistics show that women on average earn 60 % of men according to the hourly wage rate based on 1987 data.

[19] A simpler model whereby the labor market return to boys' education is higher than girls' predicts girls should be preferentially pulled out of school for *any* household income shock; whereas the model presented below distinguishes between agriculture and domestic shocks and assesses their varying effect on the gender gap in education. Empirical evidence suggests the type of shock does matter–Jensen (2000) shows that rainfall deviations have a larger (negative) effect on boys' education than girls in affected areas.

[20] In the United Nations Report "Legislative Reform on Child Domestic Labour: A Gender Analysis" it is estimated that 350 million children ages 5-17 are engaged in work, a large percentage in domestic service (UNICEF, 2008, page i). In addition, "Traditional gender roles have contributed to the assumption that women and girls make ideal domestic workers because they are subservient and meek. They are also expected to be well skilled at care giving, child rearing and house keeping, all activities considered to be an extension of the woman's natural role (UNICEF, 2008, page 3)." See work by Goldin (1992) for a discussion of the constancy in gender distinctions in the historical United States labor market.

[21] The model is a simplification, since girls often perform agricultural work as well, though all that is needed is relative specialization by girls and boys from an early stage. This assumption lines up with the data on gender and child labor in agriculture: boys are 37 percentage points more likely to be working in agriculture than girls, where girls are more likely to work in the service sector as well as "performing household chores within their own homes (International Labor Organization, 2016)."

the relevant constraints:

$$\begin{aligned}\max_{S_b S_g, H_y} U(E_i|v) &= \left[p(S_g, H_0)w_s^g\right] + \left[p(S_b, H_0)w_s^b\right] + \left[p(H_y)w_s^y\right] \\ s.t.\ Y + w_d D_g + w_a A_b &= p_s(S_g + S_b) + p_d H_y \\ T_g &= D_g + S_g,\ T_b = A_b + S_b\end{aligned}$$

where g, b, m, y index girl, boy, mother, and young child, respectively, T, S, D, A, H indicate total, schooling, domestic, agricultural and health investment time, w, p indicate prices and v indicates whether or not the child is ill. If the young child is healthy ($v = 1$), the mother inelastically supplies all her labor for chores which safeguard child health and such inputs are sufficient. However, if the young child is ill ($v = 0$), the mother's supply of time is not sufficient so that, $H_y = veD_m \quad +(1 - v)e(D_m + D_g)$.

Calculating full income and maximizing when $v = 1$ yields the following equilibrium condition which characterizes the gender gap in schooling:

$$p'(S_b) = \frac{w_s^g}{w_s^b}\frac{w_a + p_s}{w_d + p_s}p'(S_g). \tag{1}$$

The first term on the right hand side of this equation represents gender-based labor market discrimination and the second term reflects within household discrimination which readies girls for domestic work and boys for manual labor. Boys are predicted to be allocated more time in school than girls as long as the ratio of agriculture and domestic prices is less than that for skilled labor: $\frac{w_a+p_s}{w_d+p_s} < \frac{w_b}{w_g} \Rightarrow p'(S_g^*) > p'(S_b^*) \Leftrightarrow S_g^* < S_b^*$. Positive shocks to the local price for domestic work (due, for example, to increased demand in the setting of inelastic supply) widen the education gap whereas agricultural shocks reduce it.

If $v = 0$, the first order condition with respect to the education of the older boy is unchanged and reflects the trade-off between prices for agriculture and skill. However, for older sisters the marginal probability of schooling now must equal the ratio of shadow wages plus a term in the younger sibling: $ew_s^y p'(H_y)$. Thus schooling for girl children will be smaller when the young child is ill than if he is healthy widening the education gender gap.[22] Note that the gender of the younger child matters as well– since younger brothers have a higher skilled labor market return, this further reduces equilibrium girl education.[23]

4 Empirical Strategy and Data Construction

To identify the effect of the campaign on health and human capital, I employ a difference-in-differences (DD) estimator, using the approach described by Card (1992). I use available

[22]Since $p\prime(S_b) = \frac{w_s^g}{w_s^b}\frac{\lambda(w_a+p_s)}{ew_s^y p'(H_y)+\lambda(p_s+w_d)}p'(S_g) < \frac{w_s^g}{w_s^b}\frac{\lambda(w_a+p_s)}{\lambda(p_s+w_d)}p'(S_g)$

[23]See Appendix Figure B5 for evidence consistent with this effect.

health statistics to develop a baseline measure of the prevalence of vaccine prevalence illness at the local geographic level. The national immunization campaign then provides a treatment effect that varies depending on how high the burden of disease is prior to its introduction. Cohorts between 0 to 60 months at the time of the campaign (whose year of birth is between 1980 and 1986) are affected while cohorts born before that time are not directly affected as in a traditional DD framework. The grouped version of this estimator is as follows:

$$Outcome_{pt} = \alpha + \beta \left(VPD_p I_t^{post}\right) + \gamma I_t^{post} + \rho VPD_p + \mathbf{X}'_{pt}\Gamma + \varepsilon_{pt}, \tag{2}$$

where p denotes province and t denotes time. Equation 2 is used because demographic variables such as child mortality are only calculable at the provincial level. $\mathbf{X}_{pt}$ includes average maternal literacy, family size, log number of health personnel, professional status of father, fraction female and population density. I next turn to an estimating equation which analyzes outcomes at the individual level, i. This specification allows for the inclusion of individual level controls to increase precision, time-varying covariates measured at the province level that may be a source of omitted variable bias (Angrist and Pischke, 2009) and permits an investigation of differential response by gender. The estimating equation is:

$$Outcome_{ipt} = \alpha + \beta(VPD_p I_t^{post}) + \sum_c \gamma_c I_p^c + \sum_j \rho_j I_t^j + + \theta I_i^{girl} + \mathbf{X}'_{ipt}\Gamma + \varepsilon_{ipt}, \tag{3}$$

where I_p^c I_t^j and I_i^{girl} represent indicator variables for birth province, birth cohort and gender, respectively. β is the difference-in-differences estimate. $\mathbf{X}_{ipt}$ is a column vector of covariates that vary at the individual, household or birth province level and have been shown to influence children's health and human capital, such as maternal literacy, family size, father's occupation, sex composition of siblings and relationship to household head.[24] [25] I assess for a gendered impact of the vaccination campaign on health and human capital outcomes by interacting each covariate in the individual-level specification with an indicator

[24] Families with (more) girls might be larger if parents follow a son-biased stopping rule (see Clark (2000) and Barcellos, Carvalho, and Lleras-Muney (2014)). Appendix Figure B6 provides supportive evidence that such a rule was followed in Turkey in 1985. I include family size and sex composition of siblings in all regressions. However, unlike other important recent work on sibling rivalry which uses sibling gender or composition as the main treatment variable, gender is considered a mitigating factor in the analysis herein. The distribution of vaccine preventable illness interacted with campaign rollout is used for identification. Furthermore, the spillover analysis focuses on the impact of younger siblings on older siblings, which typically has less selection bias than estimating the impact of older siblings on younger siblings due to endogenous fertility (see Appendix Tables V and VI versus III and IV in Vogl (2013)). Nevertheless, the interpretation of gender-specific heterogeneity in response to the campaign would be unclear if the treatment effect was correlated with either fertility or sex-selection in the data. I find no evidence of this (see Appendix Table B4). That treatment is orthogonal to pregnancy outcomes conditional on covariates is useful to document since there was a loosening of abortion legislation in Turkey in 1983. (I thank Onur Altindag for the comment).

[25] Adding occupation of father and mother's literacy reduces my sample since some older children move out of the household. Including these parental characteristics allows a more direct comparision with the coefficients for the spillover effects in Table 7. Specifications that do not include parental characteristics can be found in Appendix Table B2.

for girl. In this specification, β_1 represents the difference-in-differences estimate for boys and β_2 is the differential impact of the campaign for girls versus boys. $\beta_1 + \beta_2$ is the estimate for girls:[26]

$$\begin{aligned} Outcome_{ipt} &= \alpha + \beta_1(VPD_p I_t^{post}) + \beta_2(VPD_p I_t^{post} I_i^{girl}) + \sum_c \gamma_c I_p^c + \sum_j \rho_j I_t^j \qquad (4) \\ &+\theta I_i^{girl} + \mathbf{X}'_{ipt}\Gamma + \left(I_i^{girl}\mathbf{X}'_{ipt}\right)\Psi + \sum_c \gamma_c^{girl}\left(I_i^{girl} I_p^c\right) + \sum_j \omega_j^{girl}\left(I_i^{girl} I_t^j\right) + \varepsilon_{ipt}. \end{aligned}$$

The inclusion of province of birth fixed effects absorb differences between provinces that might jointly determine a high baseline VPD prevalence and the accumulation of human capital. The individual level regressions include cohort fixed effects to control for any other national policies or events that would affect human capital outcomes in a specific year for children of a given age. The use of province of birth to assign treatment reduces concern about endogenous migration.

To assess for spillover effects of early child health on older siblings, equation 3 is modified by replacing I_t^{post} with $I_t^{postspillover}$ with the latter equal to one in census year 1990 for the cohort immediately older than the age-eligible population and zero for the same age-range in 1985. The sample includes children of household heads who were 11-15 years of age at the time of the 1985 and 1990 census and had younger siblings in the household. This age range is ideal since this group is young enough to still be residing with younger siblings who were targets of the campaign (enabling me to identify those indirectly affected) yet old enough to be ineligible for the campaign themselves. By 11 years of age, primary school should have been completed at this time in Turkey. Note that the design matrix for the spillover analysis also includes age rank (birth order for those children that are in the household). In addition, enrollment statistics at the province level were gathered from the Turkish Statistical Institute (1982) and are described further in Section 5.

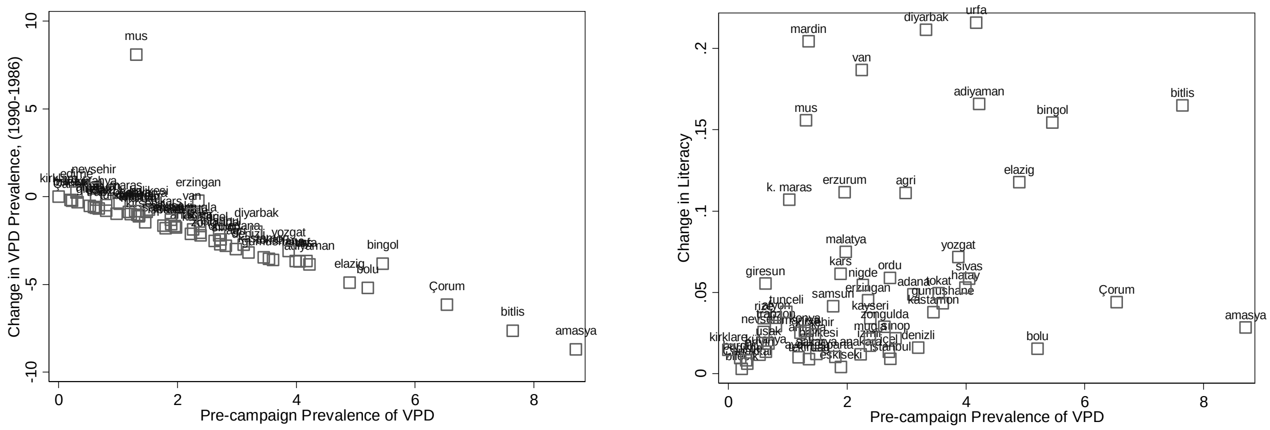
The estimation strategy compares health and human capital outcomes among individuals born in high versus low prevalence VPD provinces before and after the initiation of the immunization campaign. In order for the underlying variation in vaccine preventable illnesses to be useful as a natural experiment, it must be the case that the program had more of an impact in places where the prevalence of disease was higher. Reports immediately after the campaign support this idea: "The increases in vaccine percentages that the campaign has made possible, have been higher in rural areas and in regions where the percentages were lower before" (Tunçbilek, Ulusoy, Hancioglu, Unalan, Cerit, Uner, Toros, Akadli, Kulu, and Ayhan, 1986, page 36). This is reflected in the near total interruption of the targeted diseases in the years immediately following the campaign (Figure 4 Panel A).[27]

[26] Pooled models produce the same coefficients as separate regressions but are more efficient assuming the variance of the residuals is the same between sexes. Weighted least squares estimates that relax this assumption produce similar results (available on request) (Franzese and Kam, 2007).

[27] The method to construct the difference in VPD Prevalence over the period 1986 and 1990 and before

Figure 4: First Stage and Reduced Form

A. "First Stage" B. "Reduced Form"



Notes: Panel A data are taken from Ölüm Istatistikleri and plots the difference in VPD prevalence by province between the years 1990 and 1986 on the y-axis and the precampaign VPD prevalence in 1985 on the x-axis. Data from Panel B are from Turkish Censuses and plot the change in the proportion of the sample that is literate on the y-axis and the pre-campaign VPD prevalence on the x-axis. The Census samples include individuals 15-19 years of age and post-campaign is defined as those born between 1980 and 1986.

4.1 Constructing Disease Prevalence

To create a measure of prevalence of vaccine preventable diseases prior to the rollout of the campaign, I use the Turkish Mortality Statistics from 1977 to 1985 (Ölüm Istatistikleri). These data are collected annually and include number, cause and age of death at the province level as well as number of deaths at the district level. Using multiple years smooths out the epidemic nature of vaccine illnesses: $\overline{VPD\ deaths}_p = \frac{1}{9}\sum_{y=1977}^{y=1985} VPD\ deaths_p^y$.

One feature of statistics from low and middle-income countries is the underreporting of vital events to local authorities, particularly in rural areas. Although vital events may be underreported, population counts, enumerated by the federal census, are generally not as poorly measured. Since incidence and prevalence rates are normalized by population–the bias introduced by underreporting of vital events is exacerbated by the use of a federal source for the denominator and a local source for the numerator when attempting to construct a meaningful epidemiologic or demographic measure.[28] To address the problem of nonrandom

the campaign was as follows: first, I entered data on VPD mortality from Ölüm Istatistikleri, the vital statistics files used to create the pre-campaign prevalence data. These provincial level vital statistics were multiplied by a correction factor derived from the census to correct for under-reporting in remote areas and over-reporting in areas that are referral centers. The average number of deaths by province over the period 1986 to 1990 and 1977 to 1985 was calculated and the process for constructing prevalence from death data (using the case fatality rate and normalizing by children in 1985) was applied. For a detailed discussion of this process, see Section on Data Construction.

[28] Poorly recorded vital statistics are also problematic if using disease or death counts on the left-hand side, even with fixed effects for province, since reporting errors can change over time in ways that are correlated with health interventions or policies.

underreporting of vital events in the administrative data, I exploit a unique question in the 1985 Turkish census to construct a correction factor (CF). The 1985 enumerators asked women whether they had given birth in the last 12 months and whether that baby had survived.[29] Assuming that are no systematic differences between underreporting of infant deaths and deaths from vaccine preventable disease, this ratio can then be used to correct for underreporting in rural areas: $\frac{Infant\ Deaths^{census}_{p,1985}}{Infant\ Deaths^{istatiskleri}_{p,1985}} = CF_{p,1985}$.

The next step in constructing the prevalence of vaccine preventable disease from deaths is to use information on the case fatality rate (CFR). The CFR is the number of deaths divided by the number of cases of the disease, and can be used to scale up fatalities to represent infections at a particular point in time. One complicating feature is that the CFR may not be constant across space or demographic groups. For example, the CFR may be higher among those with compromised immune systems or with lack of access to healthcare. *A priori*, it's unclear whether the CFR would be higher or lower in more rural settings since the lack of vaccination and access to micronutrient supplementation might be offset by the avoidance of poor sanitation and compromised safe water supply issues that are associated with rapid urbanization.[30] The simplest approach is to assume a constant CFR across all geographic entities: $\overline{VPD\ cases_p} = \frac{\overline{VPD\ deaths_p} * CF_p}{CFR}$.[31] Prevalence at the province level is the number of cases divided by the at risk population (under-five children).[32] A map of VPD prevalence deciles across Turkey prior to the campaign is shown in Figure 5 below.[33]

[29] More often the census question asks about the number of children ever born and the number of children that have survived.

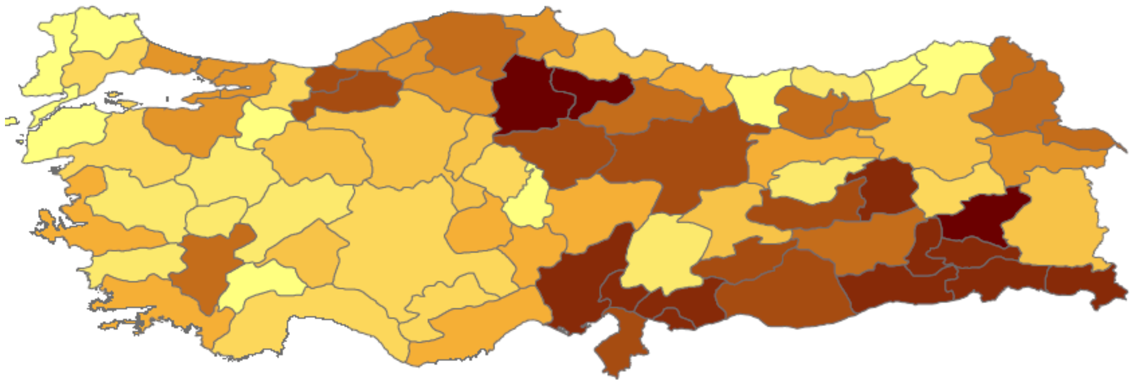
[30] See Alsan and Goldin (2015) for an historical analysis of the importance of safe water and sewerage for infant mortality reduction. It is most likely, however, that the CFR was higher in areas with the most to gain from the program. This would imply that the precampaign VPD is too low in such areas and understates the benefit of the campaign.

[31] Case fatality rates differ across vaccine preventable diseases; however, finding agreement on the number can be difficult. Since there is much more research on the CFR for measles, and since most of the deaths due to vaccine preventable illnesses are attributable to measles, I used the measles CFR estimate (Güriş, Bayazıt, Özdemirer, Buyurgan, Yalnız, Toprak, and Aycan, 2003).

[32] For five provinces that were historically linked and are represented as agglomerations of three or more distinct provinces in the data, I averaged over district cases (derived from the fraction of all provincial deaths in a district) in order to preserve heterogenity in disease risk. Findings are similar (though weaker) if this heterogenity is ignored.

[33] Mainly Kurdish provinces are dropped in robustness tests (Appendix Table B3).

Figure 5: Map of precampaign VPD Prevalence (deciles)



Notes: Map of VPD Prevalence in the precampaign period. See text for details of VPD construction. Darker shades indicate higher prevalence.

Micro-level data on human capital outcomes and other household level controls come from the 5 % Turkish census sample provided by Integrated Public Use Micro Sample (IPUMS) and the Turkish Statistical Institute (Minnesota Population Center, 2010). Census data are available for the years 1985, 1990 and 2000 and include data on literacy, educational attainment (less than primary, primary, secondary and university completed) and disability. To supplement these data, I also include data on years of schooling from the Demographic and Health Surveys (DHS) (ICF International, 2003, 1998, 1993) and data on school enrollment by gender from the Turkish Government. I merge individual observations from the censuses to the precampaign VPD prevalence. Provincial infant and child mortality rates are constructed from individual birth histories collected by the DHS. Time-varying provincial level data on healthcare access including number of health professionals are from the Turkish Statistical Abstract (Türkiye Īstatistik Yilliği) and are included in robustness checks (TurkStat, 1983, 1989).

The age-eligible sample in the main analysis includes individuals between 15 and 19 years old across two waves of census data, 1985 and 2000.[34] Any individual younger than 15 in 2000 would have been subject to a major education reform in Turkey and must be excluded.[35] Furthermore, vaccination continued (though at a diminished level) post-campaign potentially affecting younger cohorts. Disability is not available in the 1990 census. I restrict the analysis to children who are still living in their birth province to reduce measurement error (e.g. not knowing precisely when the child moved) associated with treatment assignment for the main analysis and make the same restriction for older siblings in the spillover analysis.[36] This

[34] Given the age-dependence of human capital accumulation, the analysis centers on children who are of the same age and uses repeated cross sections from 1985 and 2000.

[35] According to Kirdar, Tayfur, and Koç (2011, page 11): "The new compulsory schooling system affected children who started school at or after September 1993, we assume that children who were born in 1986 or later were bound by the policy." Note that the youngest child in my sample is born in 1985.

[36] For the spillover analysis, I assume that if older children are still living in their birth province then

reduces the sample by about 30 %–although results are quantitatively similar without this restriction. Summary statistics are provided in Appendix Table B1.

5 Results

5.1 Effects of the Campaign

The results of equation 2 are presented in Table 2. Consistent with Figure 2, there are no appreciable effects on the vaccination campaign on child or infant mortality in columns (4) and (5).[37] However, I find statistically significant gains for both disability and human capital accumulation at this level of aggregation (columns (1) to (3)). The coefficient on VPD prevalence is insignificant except for the outcome of disability and infant mortality which lends support for the identifying assumption that, in the absence of the campaign, groups with high and low vaccine preventable illness would have experienced similar changes in the outcome variables. Based on the low overall fatality rate from vaccine preventable disease in Turkey at this time, in retrospect, the results on mortality may not appear particularly surprising.

Table 2: Effects of The Campaign-Province-Level

Dependent Variable	Disabled	Literate	Educational Attainment	Log Child Mortality Rate	Log Infant Mortality Rate
	(1)	(2)	(3)	(4)	(5)
VPD Prevalence *Post	-0.0006**	0.0128**	0.0234**	0.0143	-0.0459
	(0.0003)	(0.0058)	(0.0111)	(0.0279)	(0.0400)
Post	0.0074***	-0.0151	0.0247	-0.2775**	-0.1646
	(0.0012)	(0.0170)	(0.0347)	(0.1378)	(0.1712)
VPD Prevalence	0.0005**	-0.0059	-0.0125	0.0028	0.0817**
	(0.0002)	(0.0044)	(0.0092)	(0.0366)	(0.0371)
Observations	122	122	122	120	117
R-squared	0.3769	0.7433	0.8240	0.2642	0.2778
Number Clusters	61	61	61	60	60

Notes: OLS estimates of Equation (1). Child mortality constructed using birth history data from DHS 1993 and 1998. Literacy, Disability, and Educational Attainment come from the Turkish Census. In addition to the variables shown (VPD prevalence, post and the interaction), the regression also controlled for population density, average mother's literacy, family size, father's professional status, fraction female and log of health personnel. Standard errors clustered at the province level. * ** *** represent significance at the 10, 5 and 1 percent level, respectively.

the household hasn't moved. This avoids having different younger children born in different provinces and introducing measurement error by choosing one of the younger children's birth provinces to assign VPD prevalence.

[37] Bloom, Canning, and Shenoy (2012) investigated the impact of vaccinations on human capital of treated children in the Phillipines and find effects on education but not height.

5.2 Threats to Identification

In order for the difference in difference estimate to be interpreted as a causal effect, it must be that VPD prevalence in the precampaign period is as good as randomly assigned conditional on covariates and places of varying precampaign VPD prevalence must be on parallel trends. Table 3 addresses the first claim. Column (1) presents summary statistics for the age-eligible province level sample used in Table 2. In column (2) I regress each covariate on VPD prevalence alone and in column (3) I include all other covariates in the analysis. Although precampaign VPD prevalence is positively associated with less human capital and larger families, once conditioning on covariates, VPD prevalence fails to predict most of the variables in the precampaign period, except for disability (the implicit first stage).

Table 3: Summary Statistics and balance

Province Characteristics in 1985 by VPD Prevalence			
Variable	All	VPD Prevalence	
		without controls	*with controls*
Disabled	0.012	0.0006***	0.0005**
	[0.003]	(0.0002)	(0.0002)
Literate	0.904	-0.0237**	0.001
	[0.116]	(0.0091)	(0.0032)
Educational Attainment	1.927	-0.0563***	0.0002
	[0.151]	(0.0207)	(0.0074)
Father Professional	0.158	-0.0023	0.0001
	[0.044]	(0.0023)	(0.0025)
Mom Literate	0.445	-0.0414***	-0.0056
	[0.187]	(0.0128)	(0.0067)
Family Size	6.263	0.2668***	0.0524
	[1.179]	(0.0833)	(0.0510)
Population Density	66.879	0.1630	0.5564
	[56.869]	(2.2169)	(2.0672)
Fraction Female	0.517	-0.0015	-0.0009
	[0.025]	(0.0017)	(0.0020)
Log Health Personnel	5.787	0.0114	0.0291
	[0.857]	(0.0509)	(0.0523)
Number Provinces	61	61	61

Notes: Column 1 reports average values for the 61 provinces with standard deviation in brackets. Columns 2 and 3 report coefficients from a single regression of indicated province characteristics in the pre-vaccination period on VPD prevalence. Column 3 adds controls described in Table 2. Robust standard errors are reported in parentheses. * ** *** represent significance at the 10, 5 and 1 percent level, respectively.

To address the concern about differential trends between places with more versus less disease at baseline, I perform a falsification test where I estimate equation 2 substituting the period 1970-1975 as the post-period of analysis and 1966 to 1970 as the pre-period. (Note that I cannot use 1975 to 1980 in a placebo post period for human capital outcomes due to spillover effects for older siblings demonstrated below).[38] The results are shown in Table 4–the interaction of placebo post and VPD prevalence is no longer a significant predictor of morbidity or human capital.

Table 4: Falsification Test-Province level

Dependent Variable	Disabled	Literate	Educational Attainment
	(1)	(2)	(3)
VPD Prevalence*Placebo Post	-0.0002	0.0024	0.0104
	(0.0002)	(0.0030)	-0.0079
Post	-0.0001	0.0393**	-0.3221***
	(0.0010)	(0.0156)	-0.0355
VPD Prevalence	0.0005***	0.0025	0.0004
	(0.0002)	(0.0026)	-0.0063
Observations	122	122	122
R-squared	0.3618	0.7901	0.8915
Number Clusters	61	61	61

Notes: OLS estimates of Equation (1) estimated on individuals born between 1966 and 1975. Placebo post is an indicator variable equal to one if the year of birth is greater than or equal to 1971. Literacy, Disability and Educational Attainment are from the Turkish Census. In addition to the variables shown (VPD prevalence, post and the interaction), the regression also controlled for population density, fraction female, average mother's literacy, family size, professional status of father and log of health personnel. Standard errors clustered at the province level. * ** *** represent significance at the 10, 5 and 1 percent level, respectively.

I next turn to estimating the impact of the campaign using micro-level data from individuals. These specifications allows for the inclusion of time-varying provincial level variables which may be a source of omitted variable bias such as mother's literacy, father's occupational status, family size, gender, age rank, fraction girl siblings and relationship to household head (LeVine and Rowe, 2009; Black and Devereux, 2011).[39] Table 5 reports results for three outcomes: disabled, literate and educational attainment. Columns (1) (3) (5) (7) and (9) estimate equation 3. A one standard deviation increase of vaccine preventable illness in the precampaign period was associated with approximately a 5% decline in disability, a 2.4 % increase in literacy and a 1.6 % increase in educational attainment using the coefficients from columns (1) (3) and (7), respectively. The low overall mean of disability in the population (about 1 %) likely reflects under-reporting. If this under-reporting is worse in areas that were heavily impacted by the campaign, areas with high VPD prevalence at baseline, this would weaken my ability to detect an effect of the campaign.

[38] This time period avoids contamination through spillover effects, although the late 1960s and early 1970s was a period of instability in Turkish history.

[39] Time-varying health care infrastructure is included as an additional control in Table 6.

Columns (2) (4) (6) (8) and (10) estimate equation 4 and formally test whether the marginal effect of the campaign differed for boys versus girls. For disability, the impact of the campaign for girls is indistinguishable of that for boys. Yet the marginal effect for girls is statistically significant. How could boys have similar health gains but smaller human capital gains from the campaign? There are a few possibilities. For instance, discrimination or higher returns to boys in the labor market could create a differential health threshold to educate boys versus girls (see discussion in Aldreman and Gertler (1997)). Another possibility is that girls are benefitting from the campaign through an additional channel that is not related to improved own health. Put differently, the estimates below might reflect both direct and spillover effects for girls, but mostly direct health benefits for boys. Note that vaccination continued for children born after 1985, and therefore these individuals likely benefitted from having healthier younger children in their household–a hypothesis this paper is focused on and is examined in detail below.[40] Tentative support for such a possibility is provided by the gender-family size interactions: larger families have a much more negative impact on girls' human capital than boys'.[41] Furthermore, for children that are identified as the youngest child in the family, based on age rank and number of siblings, the direct effects of the campaign are observed (columns (5) and (9)) but the gender-specific effects are absent (e.g. β_2 is not significant in columns (6) and (10)).[42]

A series of robustness checks are performed in Table 6 and in the Appendix. First, region-year fixed effects are included to control nonparametrically for any shocks to a region (Table 6, columns 1 and 2). Although literacy is no longer statistically significant; the point estimate is comparable to baseline. Second, I add birth province interacted with a linear trend for year of birth. Literacy retains significance and the expected sign, but disability flips signs and is significant at the 10% level.[43] Columns (5) and (6) include data on health professionals and the last two columns adjust for mean reversion. In Appendix Table B3 I assess robustness to restricting to only urban or rural areas and to dropping Kurdish areas. The estimates are not sensitive to these changes.

[40] Living in a household with vaccinated family members would also benefit young children's health.

[41] The point estimate of family size on literacy is -0.0015 (s.e. of 0.0003) whereas the interaction of girl with family size is -0.003 (s.e. of 0.0008).

[42] Likelihood of being the last child born in the family is also higher if a mother is older. Identifying youngest child using age rank and older age mother generates similar results.

[43] Interaction terms in nonlinear models are difficult to interpret as marginal effects (Buis, 2010) but result in statistically significant coefficient estimates of the same sign as the linear model presented above. Nonlinear models produce positive but insignificant coefficient estimates when linear trends in province and birth year are added and estimates are not statistically different with or without trends.

5.3 Spillovers to Older Siblings

5.3.1 Census Data

I next turn to elucidating whether the intervention had an impact on older siblings of children age-eligible for the intervention by using equations 3 and 4 and replacing I_t^{post} with $I_t^{postspillover}$ as described above. The results are reported in Table 7. Panel A reports OLS estimates for the outcome literate and Panel B reports the results for the outcome of educational attainment. I cannot test for spillover effects on disability since it was not reported in the 1990 census.

In column (1), the spillover difference-in-differences estimate is positive and significant and approximately 35% the size of the direct effect estimated in Table 5 column (3). Moving to specification (3) in column (2), these results are driven by β_2, the additional spillover effect for girls, since β_1 is small and not statistically significant. The differential spillover effect of the campaign on literacy for girls (0.0067) is significant at the 1 % level and the magnitude is approximately 75 % of the the differential impact for girls reported in Table 5 column (3). Panel (B) estimates reveal a similar pattern, with the spillover effect explaining much of the gender-specific age-eligible result.

The results imply the spillover benefits of young children's health on the human capital of older siblings in the household accrued exclusively to girls. To probe mechanisms which might explain such a pattern, I limit the analysis to a subsample of children whose mothers state they work outside the home. This widens this gender difference (column (3)) as does restricting to cotton-growing areas in column (4) of Panels (A) and (B).[44]

Other researchers have pointed out the importance of grandmothers for girls' health. Duflo (2003) finds that the anthropometrics of girl grandchildren living with grandmothers newly eligible for pension funds in South Africa improve substantially, whereas boys' health does not respond. Further, she finds no effect of living with a pension eligible grandfather on grandchild health. There is also anecdotal evidence that grandmothers assist mothers in rearing children and therefore may function as maternal substitutes, able to absorb the additional domestic tasks early child illness creates. Motivated by this evidence, I compare the gender-specific spillover effect of the campaign in households with a grandfather but no grandmother (column 5) and with a grandmother but no grandfather (column 6). When grandfathers are present, the spillover effects are larger in magnitude though imprecisely estimated due to the smaller sample size. In contrast, when grandmothers are present–the gender-specific spillover effect attenuates substantially, particularly compared to either when grandfathers are present or when mothers work outside the home. Column (7) in Panels (A) and (B) investigate heterogenous gender specific spillover effects among households with more than one but less than five young children in the household (these effects are also explored

[44] It is estimated that 80% of the workforce that is engaged in cotton harvesting in Turkey are women (International Trade Centre, 2011, p. 7).

non-parametically in Figure 6). In general, a higher number of younger siblings translates into a larger gendered spillover effect. Column (8) is included as a placebo test. If there are no young children in the household, spillover effects should be absent. This prediction is borne out in the data. Taken together, these results lend support to the notion that older sisters benefitted from the campaign and the mechanism is via their time allocation shifting from domestic work to education.

Table 5: Baseline estimates of the effects of the Campaign

Dependent Variable	Disabled		Literate				Educational Attainment			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline	*Gender Interacted*	*Baseline*	*Gender Interacted*	*Baseline-Youngest*	*Gender Interacted-Youngest*	*Baseline*	*Gender Interacted*	*Baseline-Youngest*	*Gender Interacted-Youngest*
VPD Prevalence*Post	-0.0004*	-0.0003	0.0139**	0.0102**	0.0085*	0.0075	0.0227**	0.0166*	0.0179*	0.0168
	(0.0002)	(0.0003)	(0.0057)	(0.0049)	(0.0049)	(0.0057)	(0.0101)	(0.0088)	(0.0091)	(0.0113)
VPD Prevalence *Post *Girl		-0.0002		0.0088**		0.0028		0.0155**		0.0053
		(0.0004)		(0.0039)		(0.0062)		(0.0071)		(0.0129)
Sum of Above		*-0.00056***		*0.0190***		*0.0103**		*0.0321***		*0.0221**
		(0.0003)		*(0.00770)*		*(0.006)*		*(0.0138)*		*(0.0114)*
Observations	342,197	342,197	342,096	342,096	21,688	21,688	341,969	341,969	21,685	21,685
Mean Dependent Variable	0.0126	0.0126	0.920	0.920	0.948	0.948	1.871	1.871	1.925	1.871
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. Clusters	61	61	61	61	61	61	61	61	61	61

Notes: OLS estimates of equation (2) reported in columns (1) (3) (5) (7) and (9). Province of birth and year of birth fixed effects included in every regression. Columns (2) (4) (6) (8) and (10) report results from equation (3), in which each explanatory variable is interacted with an indicator for girl. The sample includes individuals 15-19 in the 1985 and 2000 Censuses who would have been age-eligible for the campaign. Columns (5) (6) (9) and (10) restrict the sample to individuals who are most likely the youngest surviving sibling in the family (since they are the youngest in age rank in the household and have at least two older siblings). Individual characteristics in every specification include gender, family size, fraction of siblings that are female, age rank, relationship to household head, occupational status of the father, and an indicator for maternal literacy. Standard errors clustered at the province level. * ** *** represents significance at the 10, 5, and 1 percent level, respectively.

Table 6: Robustness checks

Dependent Variable	Disabled	Literate	Disabled	Literate	Disabled	Literate	Disabled	Literate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Region-Year FE		*Province*Linear YOB*		*Health Professionals*		*Mean Reversion*	
VPD Prevalence*Post	-0.0005**	0.0012	0.0022*	0.0144*	-0.0004*	0.0132**	-0.0004	0.0050**
	(0.0002)	(0.0025)	(0.0012)	(0.0073)	(0.0002)	(0.0053)	(0.0003)	(0.0023)
Observations	342,197	342,096	342,197	342,096	342,197	342,096	342,197	342,096
Mean of Dependent Variable	0.0126	0.920	0.0126	0.920	0.0126	0.920	0.0126	0.920
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. Clusters	61	61	61	61	61	61	61	61

Notes: OLS estimates of equation (2). Province of birth and year of birth fixed effects included in every regression. Individual characteristics in every specification include gender, family size, fraction of siblings that are female, age rank, relationship to household head, occupational status of the father, and an indicator for maternal literacy. The first two columns includes region –year of census fixed effects. Column (3) and (4) include province year of birth linear trends. Columns (5) and (6) add health professionals and (7) and (8) assess for robustness to mean reversion. Standard errors clustered at the province level. * ** *** represents significance at the 10, 5, and 1 percent level, respectively.

Table 7: Estimates of spillover effects of the Campaign

PANEL A: SPILLOVER EFFECTS ON LITERACY

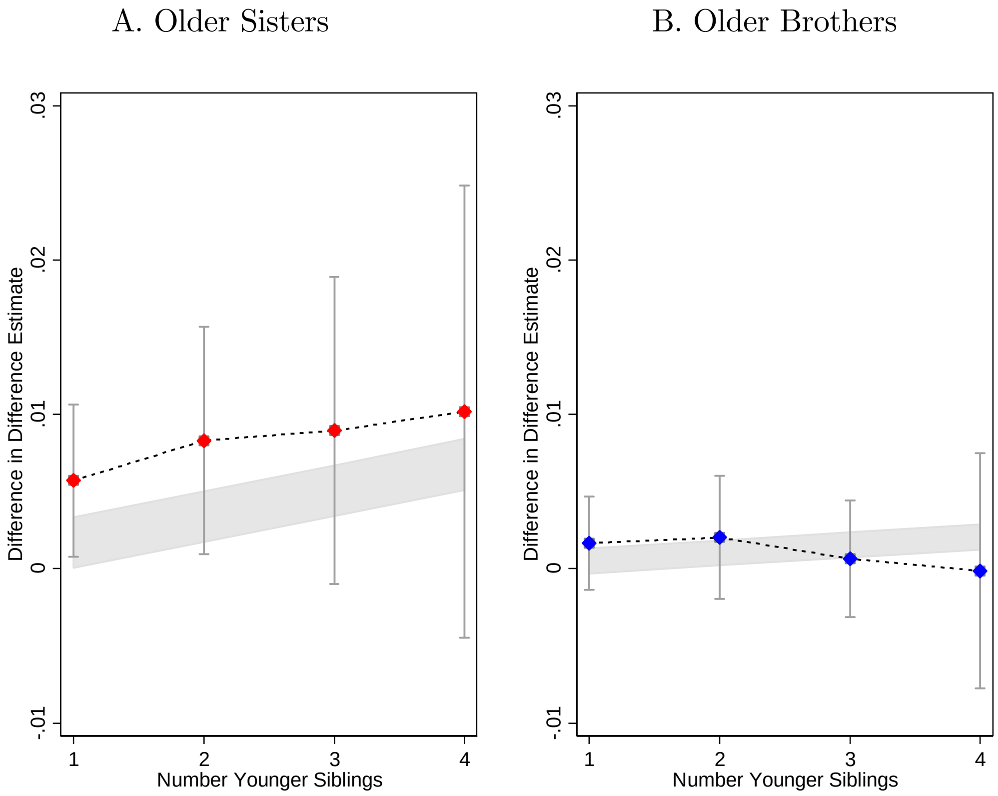
Sample	*Baseline*	*Gender Interacted*	*Mother Works Outside Home*	*Cotton Producing Area*	*Grandfather present*	*Grandmother present*	*>1 Younger Kids in HH*	*No Younger Kids in HH*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VPD Prevalence *PostSpillover	0.0052**	0.0022	0.0024	0.0015	0.0065	0.0051	0.0016	0.0032
	(0.0022)	(0.0015)	(0.0017)	(0.0022)	(0.0077)	(0.0033)	(0.0016)	(0.0023)
VPD Prevalence *PostSpillover*Girl		0.0067***	0.0081***	0.0094**	0.0126	0.0039	0.0079***	0.0028
		(0.0021)	(0.0024)	(0.0035)	(0.0120)	(0.0036)	(0.0026)	(0.0019)
Observations	254,831	254,831	128,443	130,250	2,427	19,074	130,499	144,615
Mean of Dependent Variable	0.909	0.909	0.872	0.894	0.911	0.910	0.889	0.954
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. Clusters	61	61	61	23	61	61	61	61

PANEL B: SPILLOVER EFFECTS ON EDUCATIONAL ATTAINMENT

VPD Prevalence *PostSpillover	0.0106**	0.0027	0.0022	0.0047	0.0188	0.0040	0.0030	0.0058
	(0.0045)	(0.0033)	(0.0034)	(0.0054)	(0.0195)	(0.0056)	(0.0034)	(0.0047)
VPD Prevalence *PostSpillover*Girl		0.0173***	0.0193***	0.0232***	0.0259	0.0067	0.0174***	0.0064
		(0.0045)	(0.0049)	(0.0069)	(0.0293)	(0.0075)	(0.0064)	(0.0044)
Observations	254,495	254,495	128,287	130,092	2,424	19,046	130,303	144,501
Mean of Dependent Variable	1.629	1.629	1.540	1.603	1.641	1.620	1.564	1.792
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. Clusters	61	61	61	23	61	61	61	61

Notes: OLS estimates of equation (2) reported in columns (1) of Panels (A) and (B) and equation (3) reported in the remaining columns where post spillover is substituted for post. In Panel (A) the outcome is literacy and in Panel (B) the outcome variable is educational attainment. The sample consists of children of household heads ages 11 to 15 who have a sibling under 10 in the household for the first 7 columns and the final columns is a placebo test where the sample consists of the same age children of household heads with no younger sibling in the household. Province of birth and year of birth fixed effects included in every regression. Individual characteristics refer to gender, occupational status of the father, family size, maternal literacy, age rank and fraction of siblings that are female. Columns (3) in Panels (A) and (B) estimate equation (3) on a subsample of children whose mother states she works outside the home (not necessarily for pay). Columns (4) in Panels (A) and (B) estimate equation (3) include children who live in cotton producing areas (>50^{th} percentile). Columns (5) in Panels (A) and (B) include households with a grandfather but no grandmother present. Columns (6) in Panels (A) and (B) include households with a grandmother but no grandfather. Columns (7) in Panels (A) and (B) include households with 2 to 4 young children in the household. Columns (8) in Panels (A) and (B) include households without young children. Standard errors clustered at the province level. * ** *** represents significance at the 10, 5, and 1 percent level, respectively.

Figure 6: Gendered Spillover Response



Notes: OLS estimates of equation (2) separately by gender and by number of children under-ten in the household. Figure represents the marginal spillover effect of the campaign for girls (Panel A) versus boys (Panel B). Plotted are the coefficients (points) and 95% confidence interval from each gender/child combination. The shaded area represents the 95% confidence interval of a parametric specification with number of children under-ten interacted with the treatment variable, conditional on number of children under-ten and estimated separately by gender.

Figure 6 plots the marginal spillover effect of the campaign on girls versus boys by the number of siblings under 10 years of age for the literacy outcome.[45] The results demonstrate a pattern consistent with Figure 1–namely, the benefits of mass dissemination of the vaccine technology were higher for girls than boys and this difference increased in the number of young potentially treated children in the household. A linear estimation of the same pattern is shaded and superimposed on the figure. However, this pattern holds only up to a point. The standard errors increase with increasing number of children since there is less mass in that part of the distribution. Including mothers with 5 or more children under 10 years of age in the graph (which represents <5% of the entire sample), erases the gains for literacy for girls though it is not statistically significant (point estimate 0.0001 (s.e. 0.006)), suggesting that as the number of children increases, whether they are healthy or not is less important than the overall number of children the older girl must help her mother maintain.

[45]This includes those directly vaccinated as part of the campaign (those 5-9 years old) as well as those who were vaccinated in the follow-up period (under-fives) who also benefitted from less vaccine preventable illness among their school age siblings (5-9 years years old).

5.3.2 Evidence from Demographic and Health Surveys

I supplement the spillover analysis using the household files from the DHS.[46] These data have number of years of education and harmonized education levels, which allows for an exploration of where in the years of schooling distribution the campaign may have had an effect. To do so I use the years of schooling variable, which has a range from 0 to 20 and derive from that those who have received no school, at least compulsory education (5) years and the years above the compulsory cutoff. Similar to the main results, I include those who remain in province of birth or childhood to reduce measurement error in treatment assignment. I compare individuals born between 1971 and 1980 in the 2008 DHS to those born between 1961 to 1970 in the 1998 DHS (ages 28 to 37). This treatment group was chosen since these individuals would have been just outside the age eligible window for vaccination at the time of the campaign. I define the spillover and control cohort over a longer period of time than the census because of the smaller overall sample size and because there is more measurement error in the definition of treatment in the DHS since I cannot recreate sibship structure during the campaign.[47]

Table 8 estimates equation 4. According to the estimates, a one standard deviation increase in VPD prevalence (˜1.6) in these data is predicted to increase years of schooling by approximately 0.10 years of education, or 1.6 % of the sample mean. Moving across the columns, the results suggest that women are induced to engage in school (on the extensive margin) and complete at least compulsory education as a result of the campaign. On the other hand, there is no compelling evidence the campaign had a spillover impact on years of education beyond the compulsory cutoff.

[46] The female file has somewhat richer data than the household file (e.g. anthropometrics) but is only for ever married women in most years except 1998.

[47] Having two censuses five years apart is particularly advantageous for examining spillover effects. The spillover cohorts across the censuses (1970-1974 for the control and 1975-1979 for the treatment) can be fairly close in time and age. The DHS corroborates the census findings while providing a finer outcome measure than in the census.

Table 8: Evidence from the DHS

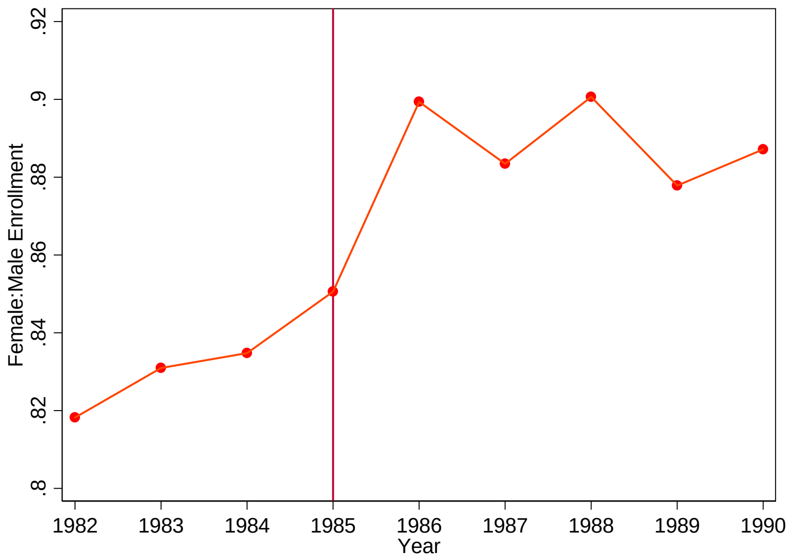
Dependent Variable	Years Schooling	No Education	Compulsory Education	Additional Years
	(1)	(2)	(3)	(4)
VPD Prevalence*PostSpillover	-0.0989	-0.0107	0.0096	-0.2686
	(0.0792)	(0.0066)	(0.0064)	(0.1614)
VPD Prevalence *PostSpillover*Girl	0.1627***	-0.0243**	0.0194*	0.0763
	(0.0573)	(0.0099)	(0.0108)	(0.1198)
Mean Dependent Variable	6.55	0.105	0.86	4.07
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes
Birth Province Fixed Effects	Yes	Yes	Yes	Yes
Observations	8,363	8,367	8,367	8,363
No. Clusters	61	61	61	61

Notes: OLS estimates of Equation (2) using various waves of the DHS household files. Data from men and women are used to evaluate spillover effects. The "treatment group" includes individuals between 1971 and 1980 and the control includes those born between 1961 to 1970. All regressions include year of birth fixed effects, year of birth fixed effects and their interaction with female as well as an indicator variable for female. Standard errors clustered on the birth province level.
* ** *** represents significance at the 10, 5, and 1 percent level, respectively.

5.3.3 Enrollment Statistics

Enrollment numbers by gender, grade and year are available from the National Education Statistics of Formal Education collected by the Turkish Government. I examine how the ratio of gender parity in primary level five enrollment (corresponding to children age 11) changes over time. Children in this age range would have been eligible caretakers for sick children if parental time inputs were insufficient yet should not have been direct recipients of the vaccines. I regress the enrollment ratio of girls and boys on the interaction of baseline vaccine preventable disease and a post dummy for 1985 (as in equation 2) as well as province and year fixed effects. Figure 7 shows how the ratio evolves over time. The results from this regression yield a point estimate 0.020 and a standard error of 0.008.

Figure 7: Enrollment Ratio By Gender



Notes: Ratio of female to male enrollment in primary school grade 5. Children at this grade are approximately 11 years of age and the youngest (11 in 1990) would have been on the cusp of eligibility for the campaign. Data are taken from the National Education Statistics of Turkish Government.

5.4 Alternative Explanations for Gendered Spillover Effects

There are several competing theories that might explain the gendered effects on health and human capital presented above. First, poor health is a negative income shock for a household. When children are sick less often, and assuming girls' schooling is more income elastic than boys', parents who would not educate girl children in lean times may now have the resources to do so. However, evidence supporting the income mechanism is scant. To start, most families in the 1993 Turkish DHS treated children with low-cost medical therapies (e.g. antibiotics and oral rehydration therapy (ORT)) or home remedies for common child ailments (respiratory and diarrheal symptoms). For more serious manifestations of disease that are more costly to treat, over 90% of hospitalizations for pneumonia and dehydration took place in the heavily subsidized public sector. Yet the time costs to care for sick young children are not trivial as described below. Empirically, the campaign does not improve household wealth in the DHS or affect the professional status of either parent in the census (see Appendix Table B6).

Taste-based discrimination provides another competing explanation for the results. A convenient way to model such discrimination is to assume that there is a higher health threshold to educate girls than boys or to assume that families place higher weights on boy children.[48] Indeed, Appendix Table B5 demonstrates the effect of disability on literacy is

[48] See Alesina and Ferrara (2014) for a model of different threshold effects applied to judicial racial discrimination. In the extreme, it could be that girls will only be educated if they are not disabled but boys will always be educated despite disability.

more negative for girls than boys and this could be a possible reason for the gendered direct effects of the campaign demonstrated in Tables 5 and 6. Although, taste-based discrimination would reinforce these findings (or potentially explain the gendered division of intrahousehold production), on its own, it fails to predict spillover benefits accruing only to older sisters.

Epidemiological spillovers are the most likely alternative explanation for my results. If older sisters are spending a substantial amount of time with younger siblings, they would also receive the greatest health benefits from the reduction in contagious disease once those young children are vaccinated. Although difficult to disprove, since the 1990 census does not include disability, it must be recognized that the epidemiological hypothesis nests the theory I develop above, namely, that older sisters are doing much more caretaking which places them at heightened risk. However, given the U-shaped pattern of morbidity from infectious diseases–with school-age children typically having mild manifestations and most school-aged kids already possessing immunity via vaccination or direct disease exposure, the health benefits of the campaign for this population would have been limited.[49]

5.5 The Burden of Under-Five Sickness and the Protective Effect of Immunizations

For the mechanism outlined above to be plausible, it must be that children under-five are sick either acutely but frequently or chronically; that such sickness leads to health-seeking and caretaking behaviors which place increasing demands on a mother's time, that daughters are viewed as substitute mothers and that sickness can be interrupted by targeted policies which improve child health, such as a vaccine campaign. According to the 1993 Turkish DHS, approximately 51% of children under-five had one or more illness episodes in the two week interval preceding the interview. These illness episodes included diarrhea, fever and cough. To assess the correlation between vaccination status and illness, I regressed an indicator for any illness in the last two weeks on gender of child, age of child and number of vaccines received. The vaccines included were those distributed during the campaign: DPT, measles and polio, as well as BCG (Bacille Calmette Guerin), a vaccination against tuberculosis. Children under-five were 2 percentage points less likely to experience an illness in the last two weeks for each additional vaccine they had received (coefficient of -0.024 and standard error of 0.004). Sex and age of child were also statistically significant, with older age and girl

[49] For example, the age-specific complication rate of measles (which is the most prevalent and well documented of all vaccine preventable illnesses) demonstrates a stark U-shaped pattern, with infants and young toddlers having the highest complication rate (41.4%) compared to those in the 10-19 year old range (12.8%) or older adults (34.4%) (Orenstein, Perry, and Halsey, 2004). Measles is so highly contagious that most middle school age children would have already been naturally exposed, and exposure to naturally occuring measles virus is considered to confer lifelong immunity (Centers for Disease Control and Prevention, 2013).

sex suggestive of a protective effect.[50] Based on these results, a child who was fully vaccinated during the campaign had a 17 percentage point reduction in acute illness episodes.

Not all illness episodes require trips to the doctor. Among children with episodes of cough or fever in the last two weeks, 62% received some treatment and 35% received medical treatment. For episodes of diarrhea, 75% of children received treatment though only 25% received medical treatment. However, it's important to note that many effective interventions are time-intensive. ORT for diarrhea is one such example. Infants and young children must be fed the solution every few minutes.[51]

In addition to acute illness, vaccine preventable illnesses can rarely result in chronic disease with ongoing caregiving needs. Paralysis from polio is perhaps the most well-known. It is estimated that 1 in 4 people become symptomatic with polio virus though only 1 in 200 will be paralyzed and only 2 to 10% of those with paralysis die due to difficulty breathing (Centers for Disease Control and Prevention, 2015). Measles can lead to a severe pneumonia and, in 1 of every 1000 children, an encephalitis that can result in deafness, brain damage and intellectual disability. Hypoxia and ensuing brain sequelae can also rarely occur from the violent cough associated with pertussis.

Other studies have found evidence consistent with the notion that girls step in to perform housekeeping and childcare chores when a mother is absent. Gertler, Levine, and Ames (2004) using data from Indonesia, found that although daughters in general were not more likely than sons to drop out of school if a parent died, daughters with younger siblings were more likely to do so. They relate this finding to ethnographic literature in Indonesia which places the burden of household duties on older girls. Such norms are also prevalent in Turkey, especially during the time of the campaign: According to Fernea (1995, p. 263), "Young girls help their mothers with the housework and take care of younger siblings." Thus the interaction of norms, technology and biology can give plausibly explain the gender-specific spillover effect observed in the analysis.

6 Policy Implications and Concluding Remarks

Several studies in economics have documented unintended consequences of technological fixes for public health problems (Field, Glennerster, and Hussam, 2011; Lakdawalla, Sood, and Goldman, 2006). This article investigated the impact of the Turkish National Immunization Campaign on health and human capital through the lens of cultural norms and incorporating disease dynamics. The campaign was prompted by innovation in vaccine development and delivery and was instituted with broad-based political and religious support. Vaccination

[50] Assessing which vaccines are most protective is beyond the scope of the current paper. Please see discussion above on the potential cross-protective effects of measles vaccination against other illnesses.

[51] Approximately 7.8% of all children under-five had visited a hospital for treatment. If a child is hospitalized, many developing countries rely on mothers to provide inpatient nursing, including meal preparation, medication administration and laundry.

distribution was near universal but occurred in an environment where gender roles were concretized early.

Although the documented gains in vaccine coverage for under-five children were impressive, I find no evidence that the intended reduction in infant mortality was realized. The impacts on disability and human capital were significant and the latter effect was not limited to the targeted population: older sisters of age-eligible recipients also benefitted relative to older brothers. The results were interpreted within a model of intrahousehold allocation of scarce time resources and specialization. Gender-specific spillover effects increased in the number of younger siblings and if the mother worked outside the home and were absent in the presence of grandmothers and in the absence of young children–providing empirical support for the time use mechanism. Although other forces for convergence could have been at play, the pattern of accentuation and attenuation of gendered spillover effects as the time budget of mothers tighten and slacken, respectively, is striking and its interpretation is consistent with the gendered division of household tasks commonly observed in microdata from low- and middle-income countries. The observation that girls gained compulsory education, but nothing more, points to interactions between education and health policy in Turkey.

As child survival continues to increase in developing countries, emphasis will gradually shift from decreasing mortality to reducing morbidity. The spillover effects of the campaign on the human capital of older girl siblings suggests that individuals most often tasked with caring for young children when they are ill will also disproportionately benefit from their health improvement. These unanticipated outcomes provide yet another reason to look beyond mortality to other outcomes (namely, education and gender equity) when modeling or assessing the full impact of the broad-based distribution of early childhood health technologies in low-and middle-income countries. [52]

[52] A comparative cost effectiveness calculation of under-five vaccination on schooling is provided in Appendix C.

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7 Appendices

7.1 Appendix A: Data Sources and Variable Definitions

Age Rank: The order of age for individuals from the same mother in the household, who are children of the household head. This is given the value of 96 (missing) for individual observations in the main analysis of direct effects who are usually defined as "other relatives".

Fraction Girls: Siblings identified as individuals from the same mother in the household, who are children of the household head. Those who identify the same mother are the denominator, and number of those identified who are girls form the numerator. This is given the value of 96 (missing) for individual observations in the main analysis of direct effects who are usually defined as "other relatives".

Birth Province: This variable is obtained through a question on the Turkish Census

Child Mortality Rate: This variable is calculated at the province level using the Turkish Demographic and Health Surveys from 1993 and 1998 and is defined as the total number of deaths of children between 1 and 5 divided by the total number of children born during that period. This ratio is then multiplied by 1000.

Cotton: 1985 production data on cotton and cottonseed from the Agricultural Structure and Production Dataset published by the Prime Ministry State Institute of Statistics, Turkey. For each province, total production in tons was entered and divided by the hectares. Provinces with high cotton production were defined as those above the median.

Disabled: Disabled is ascertained through a question on the Turkish Census (though is not available in 1990) and is an indicator variable equal to one if the person is physically disabled. The definition of a person having a disability is as follows: "DISABLE indicates whether the person reported a disability of any kind (Minnesota Population Center, 2010)."

Education Years: Education in years is a variable in the Turkish DHS.

Education Level: Level of education completed. This question was asked of individuals 6 and above who are literate. Illiterate individuals were recoded as 0, unknown and not in universe recoded as missing (unless latter is due to illiteracy and then assumed to be 0).

Health Personnel by Province: Data on the number of practitioners and (public and private) hospitals by province and year are available from Turkish Statistical Abstract (Türkiye Istatistik Yilligi). The natural log of health personnel are included in robustness tests.

Infant Mortality Rate: This variable is calculated at the province level using the Turkish Demographic and Health Surveys from 1993 and 1998 and is defined as the total number of deaths of infants (children under the age of one) divided by the total number of births. This ratio is then multiplied by 1000.

Literate: Literate is ascertained through a question on the Turkish Census and is an indicator variable equal to one if the person is literate. According to the original Turkish census forms, the definition of person who is literate : "LIT indicates whether or not the respondent could read and write in the Turkish language. A person is typically considered literate if he or she can both read and write. All other persons are illiterate, including those who can either read or write but cannot do both (Minnesota Population Center, 2010)."

Mother Literate: This variable is also ascertained through a question on the Turkish Census and is an indicator variable equal to one if the individual's mother was literate.

Mother Works: This is an indicator variable equal to one if the employment status of mother was "at work" and zero otherwise.

Urban: Urban-rural status in an unharmonized variable in the Turkish Census and is an indicator variable equal to one if the dwelling is part of city in Census year 1990.

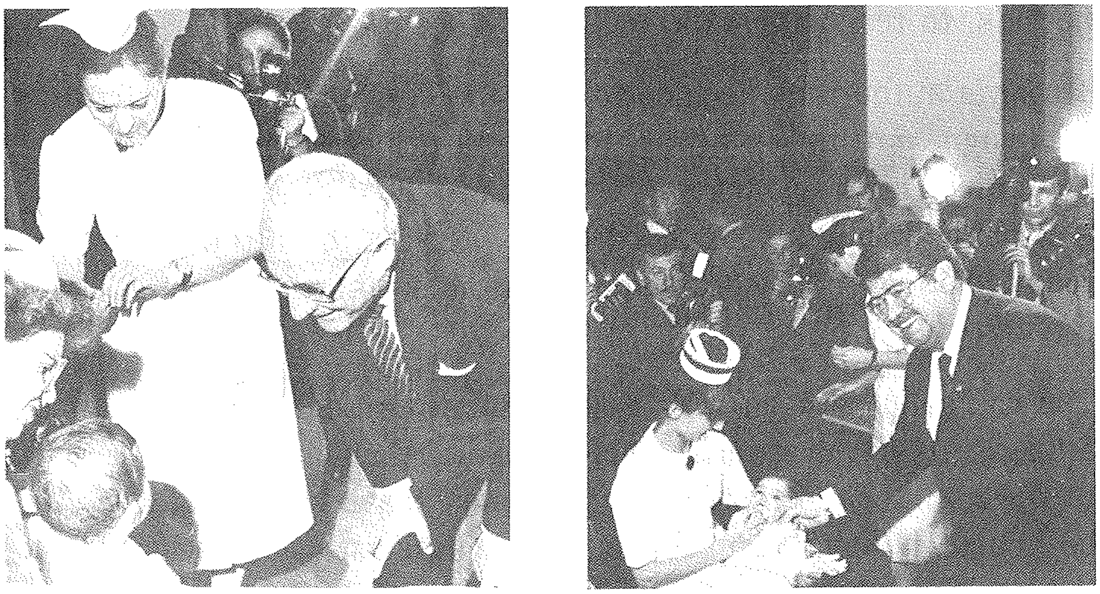
Vaccine Preventable Disease Prevalence: Please see Section 5 for a detailed description of the derivation. Vaccine preventable deaths include diphtheria, pertussis, polio and measles. These data are taken from Turkish Mortality Statistics (Ölüm Istatistikleri) over the years 1977 to 1985. The average of these values at the province level is multiplied by the correction factor, divided by the case fatality rate and then the number of cases is divided by the under-five population calculated from the 1985 Turkish census.

Ratio of Enrollment: Ratio of girls to boys enrolled in primary grade 5 available in the National Education Statistics. It is the sum of children that completed or repeated grade 5, by sex.

Year of Birth: This variable is calculated as year of survey minus age.

7.2 Appendix B: Additional Figures and Tables

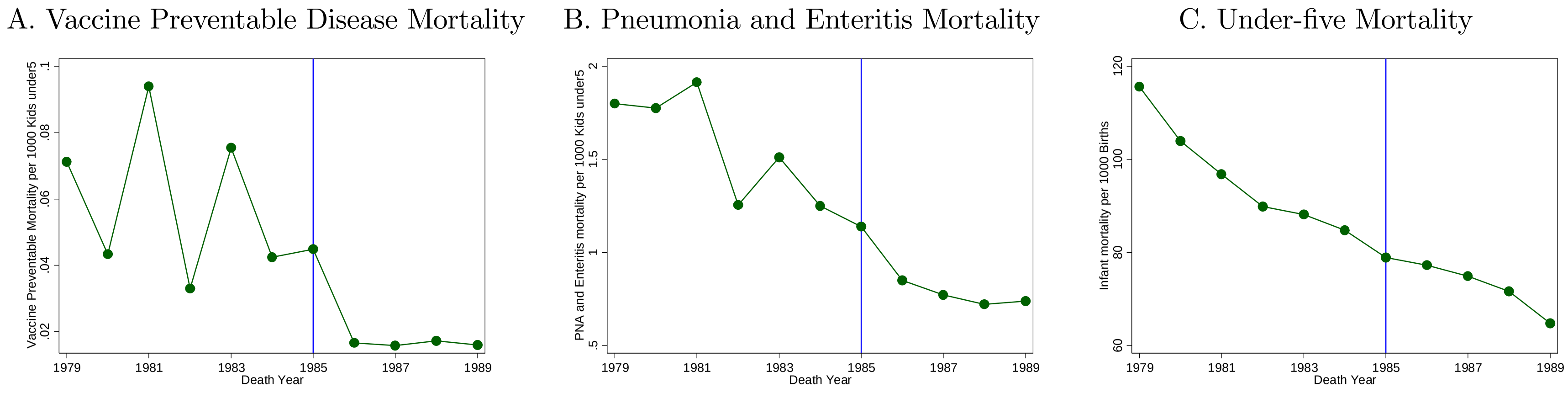
Appendix Figure b1: The Strategy of Mass Vaccination



President Evren and Premier Özal lead the campaign.

Notes: Photos from Black (1996)

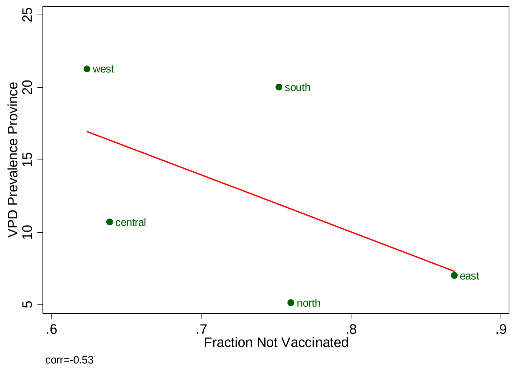
Appendix Figure B2: Cause of Death and Infant mortality



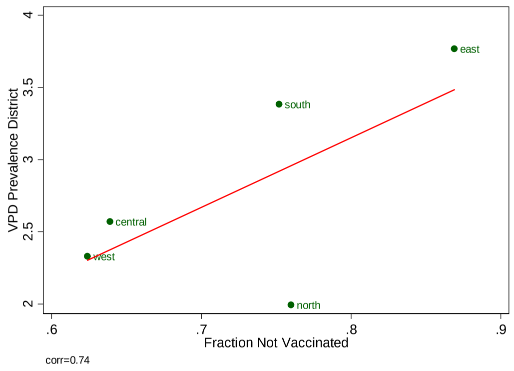
Notes: Figure plots the time series of diseases from the vital statistics (Panel A and B) and under-five mortality from the DHS (Panel C).

Appendix Figure B3: measures of the Burden from VPD

A. Uncorrected



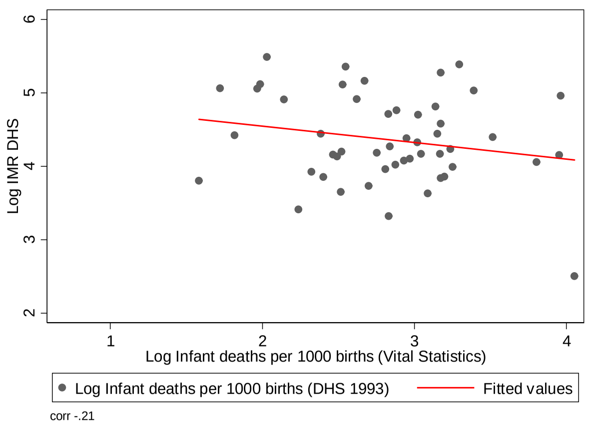
B. Corrected



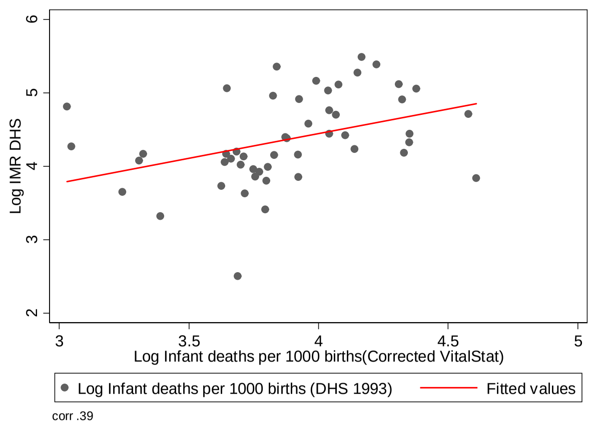
Notes: Figure plots the correlation between VPD prevalence regional percent unvaccinated in 1985. VPD prevalence based on the author's calculation. Data on percent vaccinated are from the published results of a baseline survey (Tuncibelik (1985)). Finer geographic variation from the survey not available.

Appendix Figure B4: measures of Infant Mortality

A. Uncorrected

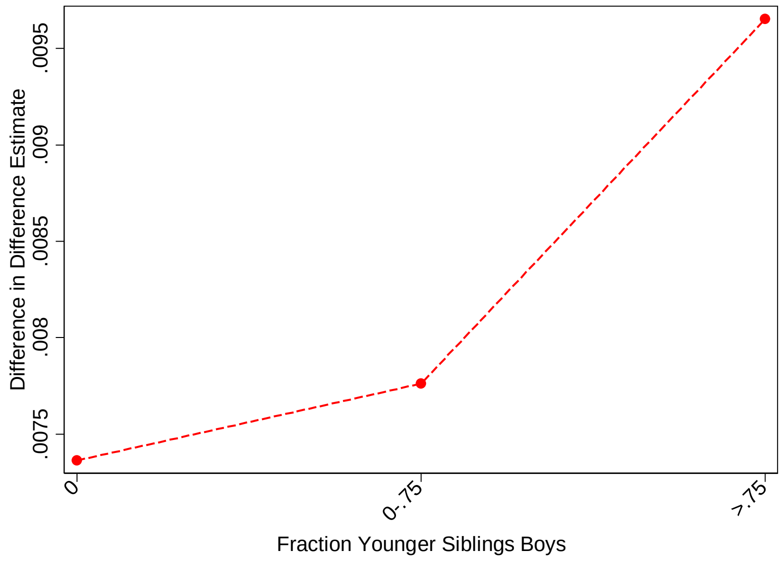


B. Corrected



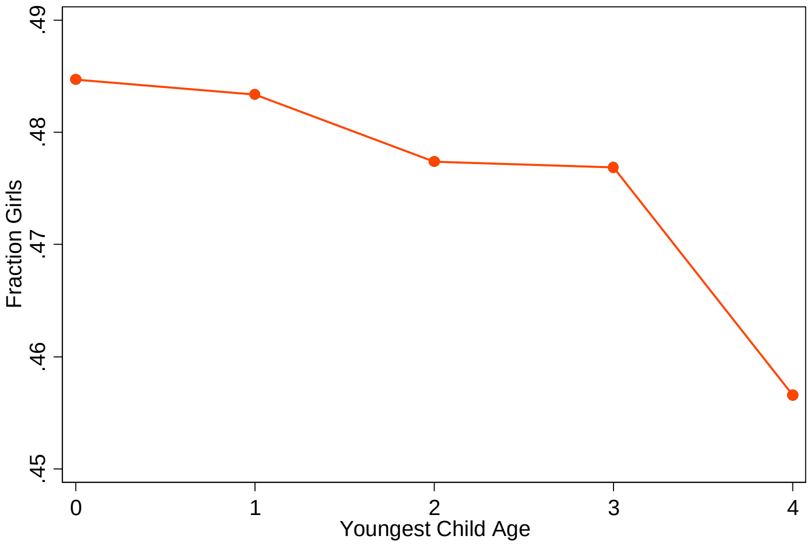
Notes: Data presented are from the Demographic and Health Survey (1993 1998) Ölüm Istatistikleri, and the Turkish Census (1985). Data from Panel A demonstrate the correlation between Infant Mortality and Vital Statistics IMR without the correction for under-reporting. Data from Panel B demonstrate the same relationship after applying the correction factor. See text for details on correction factor construction.

Appendix Figure B5: Sex Younger Siblings



Notes: OLS estimates separately for girls by fraction of children under-ten in the household who are boys. Standard errors clustered at the province level. Estimates for older brothers are much noiser and difficult to graph on the same y-axis as older sisters but do not show the same pattern.

Appendix Figure B6:
Fraction girls by youngest child age



Notes: Mean of the fraction girls by youngest child age from the Turkish Census 1985.

Table B1: Summary Statistics

variable name	mean	standard deviation
year of birth	1976.47	7.538
year	1993.36	7.45
age	16.89	1.407
famsize	5.90	3.416
less	0.11	0.318
literate	0.94	0.246
disabled	0.01	0.113
gender	0.51	0.50
mother literate	0.58	0.49
vpd prevalence	2.82	1.61
ln total health personnel	6.97	1.29
Demographic and Health Survey		
ln under-five mortality	4.66	0.50
ln infant mortality rate	4.50	0.53
Spillover		
year of birth	1974.71	2.87
year	1987.52	2.50
age	12.81	1.39
famsize	7.35	2.59
literate	0.92	0.28
less than primary	0.25	0.43
gender	0.51	0.50
mother literate	0.51	0.50

TABLE B2: ROBUSTNESS-DROP PARENTAL CHARACTERISTICS

Dependent Variable	Disabled		Literate		Educational Attainment	
	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	*Gender Interacted*	*Baseline*	*Gender Interacted*	*Baseline*	*Gender Interacted*
VPD Prevalence*Post	-0.0003	-0.0003	0.0147**	0.0103**	0.0082**	0.0059*
	(0.0002)	(0.0003)	(0.0060)	(0.0050)	(0.0040)	(0.0034)
VPD Prevalence *Post *Girl		-0.0000		0.0090**		0.0053
		(0.0003)		(0.0036)		(0.0032)
Observations	476,178	476,178	475,975	475,975	475,809	475,809
R-squared	0.0017	0.0019	0.1558	0.1899	0.2179	0.2326
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Birth Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	No	No
No. Clusters	61	61	61	61	61	61

Notes: OLS estimates of equation (2) reported in columns (1) (3) and (5). Province of birth and year of birth fixed effects included in every regression. Columns (2) (4) and (6) reports results from specification (3), in which each explanatory variable is interacted with an indicator for girl. Standard errors clustered at the province level. * ** *** represents significance at the 10, 5, and 1 percent level, respectively.

Table B3: Estimation on Geographic Subsamples

Dependent Variable	Disabled	Literate	Disabled	Literate	Disabled	Literate
	(1)	(2)	(3)	(4)	(5)	(6)
	Urban		*Rural*		*Drop Kurdish Areas*	
VPD Prevalence*Post	-0.0002	0.0162*	-0.0007*	0.0098	-0.0006**	0.0079*
	(0.0003)	(0.0088)	(0.0003)	(0.0064)	(0.0002)	(0.0042)
Observations	233,414	233,357	108,783	108,739	311,695	311,606
R-squared	0.0023	0.1493	0.0026	0.1726	0.0022	0.1095
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Birth Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
No. Clusters	33	33	28	28	56	56

Notes: OLS estimates of equation (2) reported on different geographic subsamples, including urban only (as classified in the 1990 census) rural only (the complement of urban). Kurdish are primarily in the Southeast ("Turkish Kurdistan") and includes the provinces of Agri, Batman, Bitlis, Mardin Hakkari, Siirt, Simak, Van and Diyabaker. * ** *** represent significance at the 10, 5 and 1 percent level, respectively.

TABLE B4: FERTILITY OUTCOMES

Dependent Variable	Birth		Girl Baby	
	(1)	(2)	(3)	(4)
VPD Prevalence *Post	0.0023	0.0023	-0.0028	-0.0028
	(0.0022)	(0.0022)	(0.006)	(0.006)
Observations	61,793	61,793	9,341	9,341
R-squared	0.0134	0.0183	0.081	0.008
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Maternal Characteristics	No	Yes	No	Yes
No. Clusters	58	58	58	58

Notes: OLS estimates on a panel of births from 1980 to 1990 constructed from the 1993 and 1998 DHS. All regressions include province fixed effects and year of birth fixed effects as in equation 2. In columns (3) and (4) the outcome is the gender of the baby conditional on a birth. The second and fourth columns add controls for maternal literacy and maternal age. Standard errors are clustered at the province level. * ** *** represent significance at the 10, 5 and 1 percent level, respectively.

Table B5: Effect of Disability on Literacy

Dependent Variable	Literate	
	Boys	*Girls*
Disabled	-0.3031***	-0.3400***
	(0.0100)	(0.0145)
Observations	175,348	166,748
R-squared	0.1222	0.2428
Year of Birth Fixed Effects	Yes	Yes
Province FE	Yes	Yes
Individual Characteristics	Yes	Yes
No. Clusters	61	61

Notes: OLS estimates of literacy on disability All regressions include birth province fixed effects and year of birth fixed effects. Standard errors are clustered at the province level. * ** *** represent significance at the 10, 5 and 1 percent level, respectively.

Table B6: Effect on occupation and Wealth

Dependent Variable	Professional Status Father		Professional Status Mother		Wealth Index
Sample	Direct	Spillover	Direct	Spillover	DHS
	(1)	(2)	(3)	(4)	(5)
VPD Prevalence *Post	0.0017	0.0549	-0.0004	-0.0020	0.0236
	(0.0025)	(0.1767)	(0.0031)	(0.0014)	(0.0270)
Observations	234,800	254,916	275,715	161,301	2,413
R-squared	0.0661	0.5266	0.0756	0.3062	0.1999
Year of Birth Fixed Effects	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Maternal Characteristics	Yes	No	Yes	No	No
No. Clusters	61	61	61	61	61

Notes: OLS estimates. Sample and outcome are provided in column headings. Column 5 uses the DHS sample described in Table 7. Occupational status of the father and mother were considered high and equal to one if they reported an occupation as a legislator, professional, clerk, technician or service worker. Agricultural workers and crafts/trades as well as plan and machine operators and elementary workers were considered unskilled. Wealth refers to the DHS wealth index constructed using principal component analysis and categorized into quintiles. Estimation with an ordered logit (not shown) also fails to produce statistically significant results. * ** *** represent significance at the 10, 5 and 1 percent level, respectively.

7.3 Appendix C: Comparative Cost Effectiveness

The costs of the campaign (including personnel and capital costs), were approximately 30 million USD, of which approximately 2.2 million USD was provided by agencies other than the Turkish government. The campaign distributed 27 million vaccinations, thus a cost of slightly more than a dollar per vaccine delivered. The reduction in mortality appears negligible. Given that the program affected approximately 3.2 million under-five children, and assuming half those children had older school-age sisters, the cost per student for one increase in grade level was approximately 300 USD (primary school level had about 6 years of schooling at this time). This can be compared to other programs such as informing parents on higher returns to education for children (20.7 additional years of schooling per 100 USD spent) deworming through primary schools (13.9 years per 100 USD spent), free primary school uniforms (0.71 year per 100 USD) and merit scholarships for girls (0.27 years per 100 USD). Statistics from J-PAL (2015).

7.4 Appendix References

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