Do cattle slaughter bans during early life affect anemia decades later?[1]

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ABSTRACT

Do cattle slaughter bans during early life affect anemia decades later? We exploit an ongoing natural experiment from the rollout of legislation banning cow slaughter across states in India to study the long-term effect of disruptions in red meat intake during pregnancy on the next generation. Reduced consumption of iron rich animal proteins is likely to be particularly harmful for pregnant women, who have a significantly greater need for iron. Indian women in particular may be most vulnerable, as over 50% of Indian women suffer from at least mild to moderate anemia. Using a triple difference-in-difference strategy which exploits variation across religious and caste groups which do and do not consume beef and time (cohort) variation in implementation of laws over more than 40 years from time of 1950s to 1990s in different states of India, we find that overall, women exposed to cow slaughter bans in their year of birth have lower levels of hemoglobin (Hb) and are up to 10% more likely to be anemic in their prime reproductive ages between 15 and 35, particularly those who have not completed primary schooling or who come from poorer families. We use data from a nationally representative survey—India's DHS 2005-2006—for this purpose. These impacts are evident in our triple difference-in-difference models and are robust to the inclusion of linear state specific time trends and an array of SES variables including own and partner's education and a wealth index. We find no similar effects for men. This is consistent with gender discrimination in parental investment in response to early life insults. For robustness we explore a range of similar policies likely to restrict red meat consumption: beef sale bans, beef possession bans, export of beef bans and buffalo/bull slaughter bans, which may restrict beef consumption among the beef consuming groups and find evidence in support of our findings. To explore early life mechanisms, we use data from the National Sample Survey (NSS) and find evidence of reduced red meat consumption. We rationalize these findings in the context of technologies of health formation over the life course. We conclude that cow slaughter bans can have long-term harmful effects, particularly for women of reproductive age among minorities which historically consume beef (scheduled caste Hindus, Christian and Muslims in particular). To the best of our knowledge, this is the first paper to document the long-term harmful health effects of cattle slaughter bans in India.

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1. Introduction

A large and growing literature has been studying the role of first 1000 days of life, and particularly the fetal period, in shaping life cycle health and skill formation (Almond and Currie, 2011; Cunha and Heckman, 2007).Restricted maternal nutrition during the period even before birth can lead to adaptive physiological responses that are beneficial for short term survival but scar the growth and development of vital organs leading to persistent long-term damage (Gluckman and Hanson, 2005).

Most papers exploit rare and extreme shocks and have paid scarce attention to importance of dietary choices during pregnancy (Almond and Mazumder 2011). Exceptions include some recent work on effects of prenatal alcohol availability (Nilsson 2017) and fasting during pregnancy, though the role of specific food choices is not well understood(Almond et al. 2017; Majid, 2015). In this paper we exploit an ongoing natural experiment from the rollout of legislation banning cattle slaughter across states in India to study the long-term effect of disruptions in red meat in take during pregnancy on the next generation, particularly those of low SES who are more likely to be anemic to begin with.

Cows are considered sacred in several religions that constitute the majority of the Indian population, and a majority of Indian states currently ban cow slaughter. The status of the cow is so high that "cow vigilantes" have been known to attack and killed people they suspect of trafficking in cattle intended for slaughter. Thirty-seven such attacks were reported in 2017 alone (A.A.K., 2018). These bans do not directly affect the majority of upper caste Hindus, Jains and Sikhs, who do not consume beef, but restrict its consumption for minorities for whom beef has been a natural source of protein and iron intake.

Red meat is one of the best sources of dietary iron. The iron in red meat is part of a molecule called heme, and the human body absorbs heme iron more readily than other forms of this mineral, say in plant based diets. As a result, anemia (especially severe anemia) is more common among populations with a diet low in animal proteins, and high in rice or in whole wheat, which are known to be high in phytates, thereby reducing the absorption of iron and causing mineral deficiency (Zijp et al., 2000). Among pregnant women, severe anemia has been shown to result in low birth weight and child mortality (Stoltzfus, 2001).[5]

India has among the world's highest incidence rates of iron-deficiency anemia—over 50% of Indian women suffer from at least mild to moderate anemia. It is estimated that anemia directly causes 20% of maternal deaths in India and indirectly accounts for another 20% (Rammohan et al, 2011; Ministry of Health and Family Welfare, 2013). Anand et al. (2014) discuss the extremely high incidence of iron-deficiency anemia in India even relative to Sub-Saharan African nations—barely 50% of cases of anemia in sub-Saharan Africa are attributable to iron deficiency, while over 70% of anemia cases among premenopausal women in India are. Anemia incidence in India is also significantly higher than in neighboring Pakistan and Bangladesh. Rammohan et al. (2011), who also use data from 2005-06 DHS surveys in India, find that anemia incidence is 11% lower among those who eat meat daily, and conclude that the high prevalence of vegetarianism (about a third of the population follows a strict vegetarian diet) combined with the lack of iron in popular Indian vegetarian foods contributes to the problem.[6][7]

We expect cattle slaughter bans to reduce the intake of beef, either directly or indirectly by reducing the supply and increasing relative prices for red meat. The reduced consumption of iron-rich animal protein is likely to be particularly harmful for pregnant women, who have a significantly greater need for iron (27 mg/day versus 18 mg/day otherwise). Anemic mothers may be more likely to give birth to anemic children. And in the absence of compensatory

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5 See Appendix C for more details about different types of anemia and their physiological determinants.

6 While vitamin C increases iron absorption, its consumption in the diet of most Indians is too low. Additionally, popular food items like tea and wheat bread contain tannins and phytates respectively, which inhibit iron absorption. Since iron in meat, poultry, and fish (heme iron) is more easily absorbed by the body than non-heme iron, found in plant foods, it is estimated that vegetarians need to increase their iron intake by 80% over omnivores. (Rammohanet. al., 2011)

7 The primary cause of anemia during pregnancy worldwide is nutritional iron deficiency, heightened by the physiologic demands of the fetus and maternal blood volume expansion during pregnancy (van den Broek N. 1998; Gopalan 1996). Genetic causes and poor hygiene that may lead to infections and infestations are other contributing factors which may also interact with iron deficiency (Seshadri 2001).

investments[8], through the process of dynamic complementarily and self-productivity, we expect that the initial loss in anemia during fetal stage may be compounded to have large effects during adulthood (Cunha and Heckman 2007)[9].We hypothesize that for the treated individuals- especially those traditionally known for consuming beef—Muslims, Christians, and members of scheduled castes—cattle slaughter ban variation across space and time should generate corresponding variation in early life, and hence late life health. Those who do not traditionally consume beef—upper caste Hindus, Jains and Sikhs—serve as placebos, since we should not expect any effect of cattle slaughter bans for these groups.

Our study has considerable data requirements. It necessitates information on cattle slaughter bans experienced by women several decades earlier, as well as detailed current information on adult outcomes on a blood sample based bio marker—hemoglobin—at a population level. We use information in the 2005-06 Demographic and Health Surveys (DHS) on an individual's year and state of birth, and link each individual in that survey to state- specific cattle slaughter bans for their birth year. For cattle slaughter ban data, we construct our own policy panel dataset of state year observations from 1950-2005 using data from the 2002 Report of the National Commission on Cattle, prepared for the Indian Ministry of Agriculture (Lodha, 2002) and the text of state legislation. We focus on cow slaughter bans, as well as additional legal restrictions imposed in some states, such as bans on the sale of beef, bans on the export of cows for slaughter, and bans on the slaughter of bulls/bullocks or water buffalo. This allows us to measure the effect of the strictness of a ban at the margin, since we expect that more restrictive legislation will lead to greater reductions in the supply of beef than only a ban on cow slaughter.

8 In our conceptual framework we discuss two types of possible compensatory behavior. One is during the prenatal stage- say to the extent that women can substitute for other diets, which can also provide there required levels of iron. And second, compensatory investments later in life. Our basic story is that red meat (beef) contains heme based iron which is a crucial input in pregnancy/infancy so that it does not have close and cheap substitutes in the presence of a beef ban. Indian foods are not usually fortified with iron and the access to iron supplements is very low at the population level. If anything, the normal diet is biased downwards those who inhibit iron abortion and the beef ban has made things worse by banning a cheap and natural source of heme based iron for those who consumed beefs at cheaper prices in the absence of bans.

9 For example, Coast Rican children who have iron deficiency in infancy have been found to suffer from poor performance in tasks in their childhood, even despite iron therapy later in life that corrects for their iron deficiency (Corapci et al. 2006). Shi et al (2013) find that fetal exposure to the Chinese famine from 1959-1961 was associated a 37% increase in the likelihood of anemia in adulthood

Since the consumption of red meat is a mitigating factor in the development of iron deficiency anemia, we hypothesize that in states with bans on cattle slaughter, which effectively restrict the supply of red meat for communities that would otherwise consume it, rates of anemia would be higher. We use data from the nationally representative DHS survey (2005-06) and find that overall, girls exposed to cattle slaughter bans in their year of birth have about1 to 2 g/L lower levels of hemoglobin (Hb) and are upto 10 % more likely to be anemic in their prime reproductive ages between 15 and 35, particularly for women who have not completed primary schooling or who come from poorer families.

To explore mechanisms, we complement our analysis of long-term effects with consumption data from the National Sample Survey (NSS) for first stage effects of cattle slaughter bans. Results show that beef consumption did indeed decrease for families exposed to cattle bans. We also test if beef bans lead to spillover effects on other food and non-food goods. Overall we find that the effects are driven by the extensive margin where people are more likely to not consume beef, despite the fact that there is less than 1:1 substitution into goat meat and mutton at the extensive margin. We find no effects on non-food items, which suggests that the mechanism is not one of wage/income effects from beef consumption but more specifically about reduced access to beef. We model these short and long-terms effects of beef bans in Section 3.

This paper makes some important contributions. To the best of our knowledge, it is the first paper to study the impact of cattle slaughter bans on *any* outcome in the economics or public health literatures. Its focus on long-term effects allows us to look at effects of changes in consumption of beef and hence the implied intake of iron on anemia levels 15 to 35 years after birth. Recent work has explored the effects of fasting during pregnancy on later life health (Almond and Mazumder 2011; van Ewijk 2011; Majid 2015). This work complements such work and explores the impact of a specific food item- beef- on later life health. Not much is known about long-term causal effects of red meat consumption in pregnancy in economics or medicine. We find evidence of significant adverse effects of cattle slaughter bans, especially among low SES groups who would otherwise have consumed beef. This work also informs the literature on the impact of religious institutions and norms on health and human capital formation (Iyer 2016). In contrast to studies of Ramadan exposure which primarily apply to Muslims (Almond et al. 2011; Majid 2015; Campante and Yanagizawa-Drott 2015), cattle slaughter bans represent a case of spillover of religious practices of an influential majority on choice set of minorities who don't traditionally follow similar norms of the majority in terms of dietary intake. Cattle slaughter bans also are different in that they represent how the formalization of informal norms in formal institutions affects societal welfare. This is a topic of interest in the broader literature on culture and institutions. Here, we have a case study where one can observe the process of formalization of informal norms at the population level and how it impacts societal welfare across generations (North 2005; Grief 2006; Tabellinei 2010; Alesina and Giuliano2015; Acemoglu and Jackson 2017).

The rest of the paper is organized as follows. Section 2 descries the historical background of cow slaughter bans. Section 3 describes the conceptual framework. Section 4 describes the data and empirical strategy. Second 5 shows results and section 6 discusses and concludes.

2 Historical background of cow slaughter bans

Cows have long been revered as sacred in the Hindu faith. The *Rig Veda*, the oldest Hindu scripture (composed between 1500 and 1200 BCE), describes cows as divine, sacred, and worthy of protection.[10] The earliest known reference to a legal ban on cow slaughter is an engraving on a stupa in Sanchi (photograph in Appendix B), Madhya Pradesh, dated to 412 CE, during the reign of Chandragupta II of the Gupta dynasty (Ambedkar, 1948).

Since the medieval era and the rule of North India by a series of Central Asian Muslim conquerors culminating with the Mughal Empire, cow slaughter has been alternately banned and permitted in different parts of India at different points in time—some Muslim rulers encouraged cow slaughter as a means of enforcing their authority, while others, like the Mughal emperors Akbar and Aurangzeb, prohibited it in the interests of communal harmony (Lodha, 2002). Under British rule, however, cow slaughter was legal and commonplace all over the country, and some anti-colonial uprisings and revivalist movements made cow slaughter bans a central issue (details in Appendix B).

When the Constitution of India was being drafted, after a significant debate during which both religious and economic concerns were raised, the issue was left to individual states, with the result that legislation on the issue of cattle slaughter varies significantly by state. Today, eighteen

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10 However, it also describes ritual cow and ox sacrifice in other sections—cows were to be sacrificed on special occasions *because* they were sacred.

of India’s twenty-nine states ban cattle slaughter to some extent, while eleven states, including Kerala, have no restrictions on cattle slaughter at all. Some, like Assam, permit cows to be slaughtered with a “fit-for-slaughter” certificate, issued if the cow is over a certain age or no longer productive. Still others, like Karnataka, prohibit cow slaughter entirely but allow bulls and oxen to be slaughtered under certain conditions. Others, like Punjab, prohibit the slaughter of cows, bulls, and oxen, but permit the slaughter of water buffalo. Finally, a few states like Chattisgarh also prohibit the slaughter of water buffalo. None of these bans—with the exception of Jammu & Kashmir and Manipur, which were princely states prior to Independence, and had already banned cow slaughter by royal decrees issued in 1932 and 1936, respectively—were in place at the time of Independence. Appendix B provides further legal background, including relevant Supreme Court cases. Figure 1 depicts the status of state-level laws in 1959, 1979, 2000, and the present day.

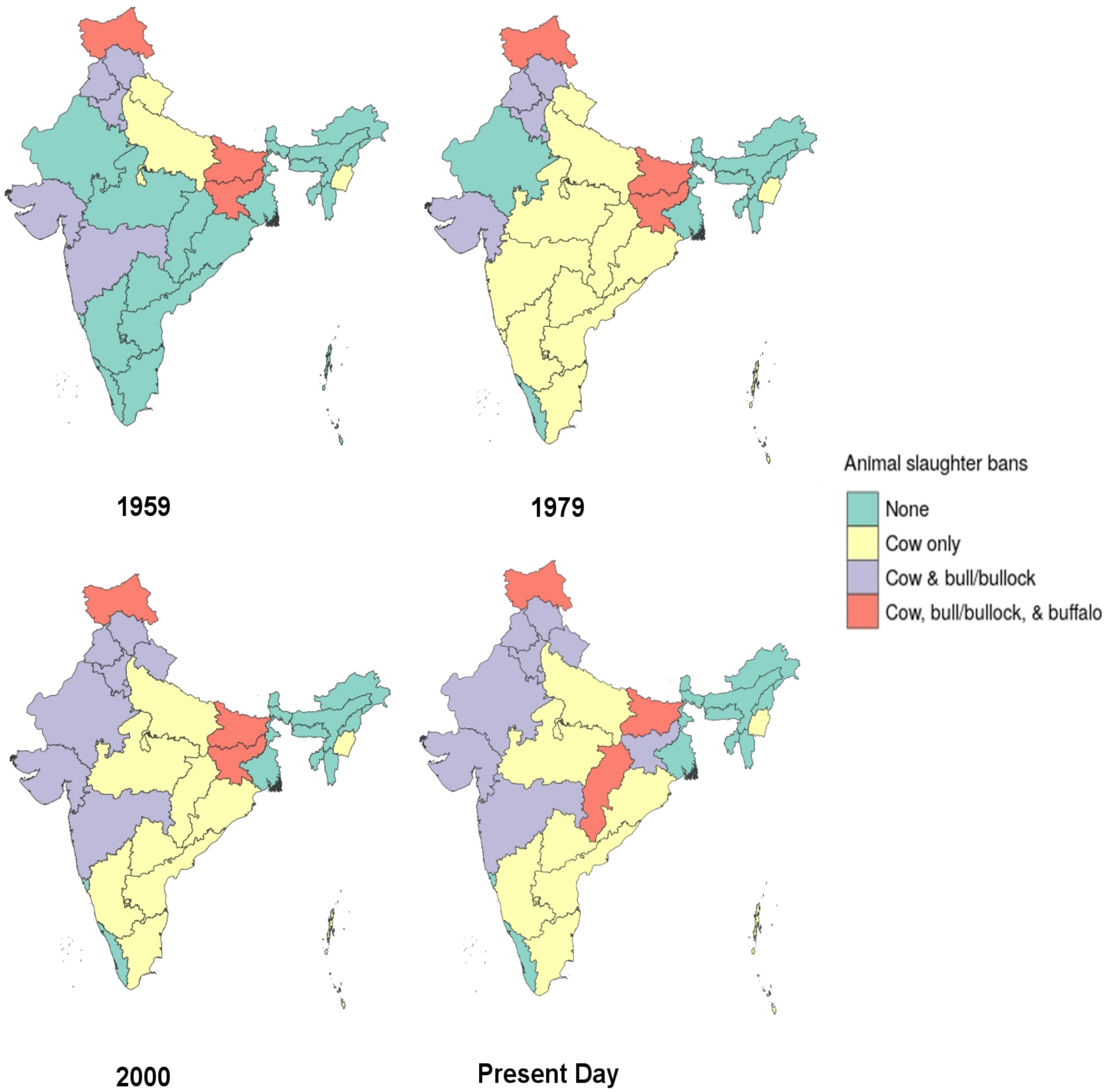

Figure 1: Summary of cattle slaughter bans as of January 1959, 1979, 2000, and present day. Note: In 1959, Tamil Nadu permitted slaughter of cows if they were unproductive and had a "fit-for-slaughter" certificate.

3. Conceptual Framework

We first present a simplified static model to think about impact of beef bans on the food choices of pregnant women, their health, and utility in thespirit of Strauss and Thomas (2007)and then discuss the long term impact by focusing on a dynamic technology of skill/health formation (Heckman 2006; Cunha and Heckman 2007; Cunha et al. 2010; Campbell et al. 2014)

3.1 Static Model

We assume that mothers make food choices- which have different nutritional values- based on both how they affect their utility /tastes but also based on how it affects the health of their child. We abstract away from the full specification of the health function as in Strauss and Thomas (2007), to focus on the relevant margin about beef consumption, without loss of generality. Assume there is only one child. Then the static health production function of the mother is given by:

$$H = H\ (N_{V,}N_B) \qquad (1)$$

where N_B is own quantity of beef consumed and N_V is own quantity of vegetarian diet consumed. One can think of N_V more generally as all other diets (goat meat, cereals etc without loss of generality), but to fix ideas we think of it as a vegetarian diet (e.g. spinach). H represents an array of measured health outcomes, but to fix ideas you can think of H as anemia during pregnancy. The basic idea then is that there dietary intake through food choices affects ones intake of iron- especially heme based iron, which is more absorbable (Zijp et al., 2000).[11]

Utility function of the mother is given by:

$$U = U\ (N_{V,}N_{B\ ;}H) \qquad (2)$$

[11] Heme is a biologically significant iron containing compound and a critical source of dietary iron. It was not until 1955 when absorption of heme-derived iron was established (West and Oastes 2008). Studies estimate that in Western societies, iron derived from heme sources such as myoglobin and hemoglobin make up two-thirds of the average person's total iron stores despite only constituting one-third of the iron that is actually ingested. (Narasinga1981; Bezwoda et al 1983; Carpenter et al 1992). So it's not just about iron content in a food, but content of heme based iron which is often not even reported in food products. This likely explains why vegetarians are more prone to iron deficiency than those who regularly consume red meat even in industrialized societies (West and Oastes 2008; Gibson and Ashwell 2003).

For simplicity, we assume that income is exogenously given, so that there is no work and leisure constraint[12]. The budget constraint is given by:

$$P_V N_V + P_B N_B = M \qquad (3)$$

Maximizing U (2) s.t (1) and (3) yields the following first order condition. We assume interior solutions for the following term:

$$\frac{\partial U}{\partial N_j} + \frac{\partial U}{\partial H}\frac{\partial H}{\partial N_j} = \lambda P_j$$

where j = { B,V}

The first order condition highlights that consumption of beef affects utility in two ways. There is the direct taste-based reason for people to consume beef, say, due to habits or a history of consumption (Atkin 2016).,or for purely taste based reasons. There is also an indirect effect through effects of beef on health. In this case, since heme-based iron is only present in meat, and beef has some of the highest concentrations of heme-based iron even compared to other meats, and is more easily absorbed than the non-heme iron in plant sources, beef may be thought of as a critical dietary input for heme-based iron, which itself is a key input for determining levels of anemia.[13][14]In our model above it is possible that the effect of beef consumption on health is non-linear, so that beef consumption only matters for health for people who are anemic and does not matter for those who are not anemic to start with.

To fix ideas, about effect of bans, we now consider the case where H and the Utility function are both Cobb-Douglas. Cunha, Heckman, and Schennach (2010) do not reject the Cobb-Douglas production function for cognitive skills at early stages of the life cycle, so this simpler formulation may still be not unrealistic.

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12 If we introduce labor income, we would have a term for labor supply and a budget constraint with an additional w.L where w is wage and L is hours worked. To the extent that beef bans lower health which affects either labor supply or wages, you can think of either of these two effects implying that the shadow price of beef will increase leading to further reductions in beef consumption (Strauss and Thomas 2007).

13 See Gopalan et al (1989) for a table on nutritional content in Indian foods. This data has been used by Atkin (2016) for studying caloric content in Indian food. Although heme content is not available in this data, there is data on iron contents. Beef (meal) for instance is reported to have 18.8 mg of iron per 100 gms of edible portions which is higher than any other item listed in meat and poultry category. Mutton (muscle) has 2.5 mg,whereas liver of sheep has 6.3 mg.

14 The demand for Complementary foods to contribute to heme based iron are very high and even breast milk contains little iron (Brown et al 1998).

In this case our Utility and Health functions will be given by:

$U = \alpha_B \log N_B + \alpha_v \log N_v + (1-\alpha_v - \alpha_B)\log H$

$H = \gamma_B \log N_B + \gamma_v \log N_v$

(3) is as before.

The solution to the optimization problem is given by:

$$N_B^* = \left[\frac{\left(\alpha_B + \frac{(1-\alpha_v-\alpha_B)\times\gamma_B}{H}\right)}{\alpha_v + \alpha_B + \frac{(1-\alpha_v-\alpha_B)}{H}}\right] \times \frac{M}{P_B}$$

$$N_v{}^* = \left[\frac{\left(\alpha_v + \frac{(1-\alpha_v-\alpha_B)\times\gamma_v}{H}\right)}{\alpha_v + \alpha_B + \frac{(1-\alpha_v-\alpha_B)}{H}}\right] \times \frac{M}{P_v}$$

The term in brackets is a term for the share of beef in utility (direct and indirect share through its contribution to health production and the utility value of the contribution to health function) relative to both goods. Interestingly the level of health also appears in this term.[15]

Impact of Beef bans

In this framework as P_B rises with beef bans, beef consumption falls, which reduces the optimal intake of beef as well as the health stock which will be determined by not only the relative share of income spend of beef but also by the relative value of beef in the health production function. To the extent that beef consumption is not harmful to health of pregnant women, we should expect that beef bans will reduce health /hemoglobin levels of pregnant women. Note, however, that even if beef consumption is harmful to health of women then γ_B<0 , if other options (which are accessible to pregnant women) are even worse for health though they give utility, then we may still get a situation that beef bans worsen health by making people

[15] Note that in the C-D case as income effects cancel out substitution effects from increase in beef prices, we have no cross price effects on demand for other goods.

even more iron deficient. This is plausible in the Indian context given that the typical Indian diet is known to be high in iron inhibitors such as tea and wheat, which is rich in phytates, so there may be substitution to goods which are iron inhibitors. In that case the assumption is that if γ_B<0 thenγ_v<γ_B<0. So either γ_B>0 or if γ_B< 0 then γ_v<γ_B<0 is necessary to for beef bans to make health worse off.[16]

3.2 Dynamic Effects of Bans on Health:

Now consider the dynamic problem. We abstract away from the tradeoff between utility and health value of beef and focus on the health production function to understand how fetal restrictions in beef availability end up affecting adult health/anemia. Our framework is similar to some recent work, which had studied effects of alcohol availability in utero on adult wellbeing in Sweden (Nilsson 2017) and inspired by the work of Cunha and Heckman (2007).

For simplicity suppose that there are only two childhood periods, T = 2, in the child's life cycle, one prenatal[17](t=1)and one postnatal stage (t = 2). The production technology for health we consider is a two period Constant Elasticity of Substitution (CES) function:

$$h = A\left[\gamma(\bar{\mathrm{I}}_1)^{\phi} + (1-\gamma)\mathrm{I}_2{}^{\phi}\right]^{1/\phi}$$

whereγ∈ [0, 1] and φ∈ (-∞, 1]. The share parameter (γ) is here a skill/health multiplier, and

$$\bar{\mathrm{I}}_1 = I_1 + \mu$$

Where μ is an exogenous negative shock which occurs due to beef bans in period 1. A key assumption in the framework (which is often not tested) is that $\mu + I_1 < 0$.[18] The elasticity of

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16 If prices of other goods also increases (general equilibrium effects), then the consumption of other goods which may be close substitutes for beef also increase leading to potentially double burden of beef bans on iron intake during critical period of life. Another mechanism through which beef bans may potentially play a role is in terms of knowledge- subjective beliefs (Cunha et al. 2015). Mothers may not know the importance of heme based for their own and their children's health. And the bans may make parents change their consumption bundle towards other goods so that they choose other goods (meats or vegetarian diet) randomly with respect to its iron intake levels leading to on average less intake of iron than was present in beef, leading to lower average intake of iron despite being able to increase consumption of other goods.

17 Strictly speaking in our empirical framework we study bans in year of birth, so period 1 should be year of birth and period 2, two years of birth and later.

18 In the static framework before, we have argued why this is likely to be true in our case whereby beef bans increase iron deficiency in mother-child died. We also provide evidence from NSS in support of this assumption that beef bans do increase reduce beef intake which leads to overall reduction in diets which in heme iron. Furthermore, we explain effects of substitutes (such as goat meat and mutton and spinach). Overall. We find that there is no

substitution, $1/(1-\varphi)$ is a measure of the sub-substitutability of $\bar{I}_1$and I_2; φ represents the degree of complementarity/sub- substitutability and determines how easy it is to compensate for low levels of investments (due to a negative $\mu i.eban$) in the prenatal stage during the postnatal stage.

When φ is small, it is difficult to compensate for low levels of prenatal investments ($\bar{I}_1$) during the postnatal period (I_2). When $\varphi = 1$, that is, $\bar{I}_1$and $I_2$are perfect substitutes, the timing of investments (pre- or postnatal period) is irrelevant for the level of human capital in adulthood. In the other extreme case, $\varphi \to -\infty$, it is impossible to compensate for low pre- natal investments in the postnatal period. Time around birth is a critical/highly sensitive period, so in the context of this paper, $\varphi< 0$ is likely the empirically relevant case for us. In this case, even a small adverse shock may result in large negative outcomes in the long run. The μ effect (bans) is carried over to the following period, and the combined effects of self-productivity and dynamic complementarities magnify its impact on human capital stock over time, which could have lasting lifetime consequences that are difficult to remediate at later ages.

"Dynamic complimentary" arise when stocks of health/skills acquired by the end of a given period (say at birth) make investment in next period (say post natal) more productive. Thus children who are born with iron deficiency may have lower returns to investments in not just nutrition and disease prevention (say uptake of vaccinations) but also other types of skills such as cognitive skills which may further reduce returns to investing in nutrition and iron intake of these kids for parents later in life(Adhvaryu and Nyshadham 2016; Field et al 2009;).Second, "self-productivity" arises when lower stocks of skills (say hemoglobin levels) in one period create lower stocks of skills (hemoglobin levels) in the next period (Hibbelein 2017: Iannotti et al 2006). This is consistent with epidemiological research which suggests that mothers who are anemic are more likely to give birth to children who are anemic too (Balarajan et al. 2011).It also has captures cross – effects, say more anemic women are more likely to be at risk of other disease and other disease in turn may make such women more likely to become anemic in adulthood.

An interesting finding in our paper is that the beef bans in first year of life generally have a larger effect for girls than for boys. Previous studies have documented son preference in India

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change in spinach consumption but there is some increase in goat meat /mutton. However, consistent with this assumption. We find that the percentage change in goat meat is much smaller than that for beef, which also has higher iron context than mutton in Indian diets (Gopalan et al 1989)

(Behrman and Deolalikar 1990; Jayachandran and Kuziemko 2011; Bharadwajand Lakdawala 2013). To the extent that returns to females are lower than men, even if boys and girls are equally unhealthy at birth, parents may decide to compensate for the disadvantage for boys early in life but not girls. One way to capture these findings in is to allow φ to vary by gender, with $\varphi_{boys} > \varphi_{girls}$. Under this parameterization, the elasticity of substitution across the prenatal and postnatal periods is higher for boys than for girls, implying that it is more difficult to remedy an early shock for girls than for boys. Via dynamic complementarities and self-productivity of skills an early shock could hence result in larger effects for women than for men.

4. Immediate impact of cow slaughter bans

We are interested in the long-term effects of cattle slaughter bans on anemia. However, we will first establish that cattle slaughter bans did indeed reduce beef intake during the years these bans were introduced. Often analysis of long-terms effects of early life exposure simply ignore this step, because of data limitations linking long-term measures with short term outcomes. To address this, we examine the first stage effects of cattle slaughter bans on consumption at the time the bans were introduced, studying the impact of cattle slaughter bans for traditional beef eaters versus the control group with the National Sample Survey data between 1983-2012 from (thick) rounds: NSS (38th, 43rd, 50th,55th, 61st,66th and 68th round). The NSS is a rich set of survey which record household purchases of 169 different food products ,including beef and red meat consumption. Over 240,000 households are surveyed in groups of 10 drawn from blocks of no more than 180 neighboring households within a village or city. The surveys cover all states of India, a country with many diverse food cultures across religious, caste, and ethnolinguistic groups which we will exploit in our identification strategy.

Together these surveys contain over 500,000 observations for our analysis[19] See Table S3, Panels A and B, for summary statistics on consumption by the treatment and control group. Note that the monthly consumption of beef and buffalo meat by the control group is zero, showing the validity of our choice of control group.

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[19] As some states split between this time, to estimate the correct states, we define the state classification as per the latest round of NSS for all states. We exclude the state "Jammu and Kashmir from our analysis and drop the top 1% of the observations for each NSS round for the MPCE (monthly per capita expenditure) because of outliers.

Our exposure is a dummy variable indicating the presence of a legislative restriction on cattle slaughter in a given state in a particular year—a total ban on cow slaughter, or a ban on cow slaughter and a ban on beef sale, or a ban on cow slaughter and a ban on cattle exports for the purposes of slaughter, or a ban on the slaughter of cows, bulls, and bullocks (see data section below for more details on the legislative data and identification strategy). Our treatment group, as defined in equation (4), comprises the communities in which beef-eating is traditionally common – all Muslims, Christians and scheduled caste Hindus. The control group comprises of groups who do not traditionally eat beef – upper caste Hindus, Jains and Sikhs, who serve as placebos. The bans vary by time and state.

The following reduced form equation was used to model the impact of cattle slaughter bans:

$$\mathrm{I}(Y_{\mathrm{i,c,t}} > 0) = \alpha + \beta_1 \mathrm{Ban}_{\mathrm{c,t}} \ \mathrm{X\ Beef\ Consumer}_{\mathrm{c,t}} + \beta_2 X_{\mathrm{i,c,t}} + g(c, t) + U_{\mathrm{i,c,t}} \quad (4)$$

where $I(Y_{i,c,t} > 0)$ is an indicator variable for consumption *Y* by person *i,* belonging to community *c,* in time *t.* We control for the state and year fixed effects, state specific time trends, Monthly Per Capita Expenditure excluding red meat beef and buffalo (MPCE) as a proxy for income and cluster the standard error at the state level. Our dependent variable is consumption of any beef/buffalo meat.[20] See Table S4 for summary statistics on this measure. Here, we see that 1% of the control group does consume cow or buffalo meat, but we believe this to be low enough for our purposes. We believe the extensive margin is perhaps the more meaningful margin in case of a ban where 88% of our sample does not consume any red meat and where bans are likely to shift people from eating beef to not eating at all.

Together with the variation by community, we have a triple difference-in-difference-in-difference model. We estimate a similar triple difference specification as (1) but control for income levels (taking MPCE on all other goods as a proxy).[21] Table 4 shows that a cattle

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20 NSS data does not separately ask for beef consumption in all rounds so we use this combined measure. This also has other advantages if we think people are less likely to report consuming beef-so that such questions allow one to ease some concerns regarding any potential reporting bias.

21 Controlling for income does not vary our results suggesting that our estimates are not biased by any general changes in income due to the bans.

slaughter ban significantly reduces the likelihood of any beef/ buffalo meat consumption for the treatment group by about 11 percentage points. In contrast, we find an 18 percentage point increase in goat meat consumption, which suggests substitution to an alternative red meat source.

5. Long-term Impact of Bans

5.1 Sample

The cattle slaughter ban data for this study was constructed by the authors from primary and secondary sources. The database consists of state-year observations of total cattle slaughter bans by state and year, as set by policy between 1950 and 2012. For the long-term effects we use policy data from 1950 till 1991, when the youngest respondents in our sample were born.The main source for the state-level data on cattle slaughter ban laws was the 2002 Report of the National Commission on Cattle, prepared for the Department of Animal Husbandry, Dairying, and Fisheries, a division of the Indian Ministry of Agriculture (Lodha, 2002).We examined individual state-level legislation to fill in the details of amendments and subsequent legislation. The date of publication in the State Gazette is the date a law formally comes into force in India, and that date was used as the date of the legislation. If a cattle slaughter ban was published in a given month in a year, that state was coded as having a ban from that month in that year onwards, for all subsequent years, unless the law was repealed or amended, in which case the coding was reversed from the year of the amendment. When states were divided—for example, the state of Bombay was divided into Maharashtra and Gujarat in 1960, and there are many such examples—the existing law was applied in both states until a state passed its own separate legislation, and we coded the data accordingly.

To estimate the impact of cattle slaughter bans on health outcomes, we used the 2005-06 Indian Demographic and Health Surveys (DHS). The DHS are nationally representative household surveys conducted in LMICs and are designed to collect health and sociodemographic information on women of reproductive age (15-49 years), men (usually aged 15-54 or 15-59), and children ever born (Corsi et al., 2012). The DHS asks women about their birth history, in addition to their socio-economic background, among other topics. Regarding birth history, information about date of birth (month and year) and child's gender is available for all births.

Data on hemoglobin levels is also collected, and measured in g/L, which is what we use. We implicitly assume that all respondents reside in the state of their birth.[22]

Our data set contains 103,198 observations on hemoglobin levels for women 15-49 years old, and 64,909 observations on hemoglobin levels for men ages 15-54, alive at the time of the interview, from the 2005-06 DHS survey. We used religion and caste data to clean the data further, dropping Buddhist, Jewish, Zoroastrian, and Donyi Polo respondents, those with no religion, and observations with missing values. Among Hindus, those belonging to scheduled tribes were dropped due to the tremendous heterogeneity between individual tribes. We also dropped the state of Jammu and Kashmir from the dataset[23].

5.2 Measures

Our exposure is a dummy variable indicating the presence of a legislative restriction on cattle slaughter in a given state in a particular year—a total ban on cow slaughter, or a ban on cow slaughter and a ban on beef sale, or a ban on cow slaughter and a ban on cattle exports for the purposes of slaughter, or a ban on the slaughter of cows, bulls, and bullocks. We interact this with a dummy for belonging to a community in which beef-eating is traditionally common—Muslims, Dalits (scheduled castes) and Christians. We expect the effects to be primarily centered on the groups whose diet would have been affected, compared to the groups who do not traditionally eat beef—upper-caste Hindus, Sikhs, and Jains—who serve as placebos. The bans vary by time and state. Together with the variation by community, we have a triple difference-in-difference-in-difference model.

For women 15-49 at the time of interview, the DHS provides hemoglobin (Hg) data. Our primary outcome was hemoglobin as well as measures of moderate (Hg<120 g/L) to severe anemia (Hg<80 g/L), which are widely regarded as an important measures of maternal health, nutrition as well as economic well-being**.**

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22 Munshi and Rosenzweig (2009) document extremely low spatial and marital mobility in India. See also Bhalotra (2008) who estimates that 86% of children born in 1970-97 in 15 major Indian states were born in the mother's current place of residence.

23 We drop Jammu and Kashmir, because it is a Muslim-majority state with a cow slaughter ban that was issued as an edict of the king prior to Independence, and we are unsure of the extent to which this ban is enforced—particularly since the king's edict contained no penalties or enforcement mechanism.

We account for potential confounding by controlling for individual and household characteristics posited to influence the relationship between cattle slaughter bans and Hg. Women's covariates included age, age squared, marital status, age at first marriage, whether currently pregnant, total number of children born, work status, and educational attainment; and their partner's covariates consisted of educational attainment. A dummy indicating urban versus rural residence was also included. Educational attainment was coded as follows: 0 –no education; 1- incomplete primary; 2-compete primary; 3-incomplete secondary, 4-secondary, and 5- higher education. To account for household SES, we controlled for quintiles of the DHS wealth index, which is based on ownership of specific assets (e.g. radio and television), environmental conditions, and housing characteristics (e.g., materials used for housing construction and sanitation facilities), and constructed using a method developed by Filmer and Pritchett (2001; 1999). TablesS1 and S2 contain the summary statistics of all the variables used for women and men respectively from the DHS.

We see that the average level of hemoglobin, at 117.06, is actually below the anemia threshold (120 g/L), indicating the severity of the problem as a public health issue. Table S1 also shows that about 51% of the respondents (who are all female) are anemic, and 3% are severely anemic (< 80 g/L). This is not true for the men in the DHS sample—the mean hemoglobin level is 143.4, 8% of them are anemic, and only 1% are severely anemic. The average age is 29.2 for women and 31 for men, over 90% are married, and they have about twochildren on average. About 5% of the female respondents were pregnant at the time of the survey, and we control for this in our regressions due to the negative effect of pregnancy on hemoglobin levels. About 30%of the women have no education at all, and just over 11% have education beyond high school. Meanwhile, only about 21% of their partners have no education, and just under15% of them have education beyond high school. Over half live in rural areas, and about 34% are currently working.

5.3 Empirical Strategy

The following reduced form equation was used to model the impact of cattle slaughter bans:

$$Y_{i,m,c,t} = \alpha + \beta_1 \text{Ban}_{c,t} \text{ X Beef Consumer}_{m,c,t} + \beta_2 X_{i,m,c,t} + g(c, t) + U_{i,m,c,t} \qquad (5)$$

where Y is the outcome of interest (either Hg levels or anemia incidence) for woman i born in year t belonging to mother m in state c. β_1 is the parameter of interest as it measures the impact of introduction of a total ban on cattle slaughter in a given state c, at time t (for cohort t) for the treatment sample—Muslims, Dalits, Christians (beef consuming communities) compared to the control group (Hindus, Sikhs, and Jains).Data on state and year specific bans was matched to the year of birth of each individual so that cohort variation in exposure to cattle slaughter bans around birth is exploited for identification of causal effects.

To deal with other factors that may confound the relation between cattle slaughter bans and the health outcome of interest (Hg or Anemia), we flexibly controlled for $X_{i,m,c,t}$, which is a vector containing individual and household characteristics. Our identification strategy exploits arguably exogenous timing of changes in rollout of bans with the timing of births. This suggests that our control group is not a different state, but individuals within the same state at different times and even within same time. We compare beef consuming groups (like Dalit) with control groups to estimate a triple difference in difference exploiting state, time and group variation in bans. We complement our identification strategy with controls for *g(c,t)*—state fixed effects and time trends (women's year of birth fixed effects).State fixed effects control for any time invariant differences between states that may bias the effects of cattle slaughter bans, whereas the year fixed effects control for unobservable changes in economic conditions over time. Furthermore, we also explore the role of time varying unobservables by including state specific time trends. In stratified models, we also examined heterogeneous effects of cattle slaughter bans by education level, age and economic background of the household (wealth quintiles).

We posit that these effects will be primarily among less educated and poor households as not only they may be more likely to be anemic but they are unable to make sufficient compensatory investments, compared to richer households who may be able to compensate for any early life nutritional loss with compensatory investments over their lifetime during prenatal or postnatal stages. We also posit that there will be stronger effects for girls than boys because parents are more likely to compensate for boys but not girls in Indian society as discussed in our conceptual framework as well.

6. Results

To begin with, we plot average hemoglobin levels over the life cycle for women in the two groups, in states with varying cattle slaughter bans, in Figure 2. We can see that hemoglobin levels appear to be higher for prime age women in traditionally beef-eating communities in states which do not restrict cattle slaughter as compared to states which do. Conversely, hemoglobin levels appear higher for women in non-beef-eating communities in states which restrict cattle slaughter as opposed to states which do not.

As an interesting aside, notice that the average hemoglobin level for either group almost never rises above the critical threshold for anemia, 120g/L. This is consistent with other estimates of an extremely high prevalence of anemia in Indian women across the board, and the mean of 117.06as shown in Table S1.

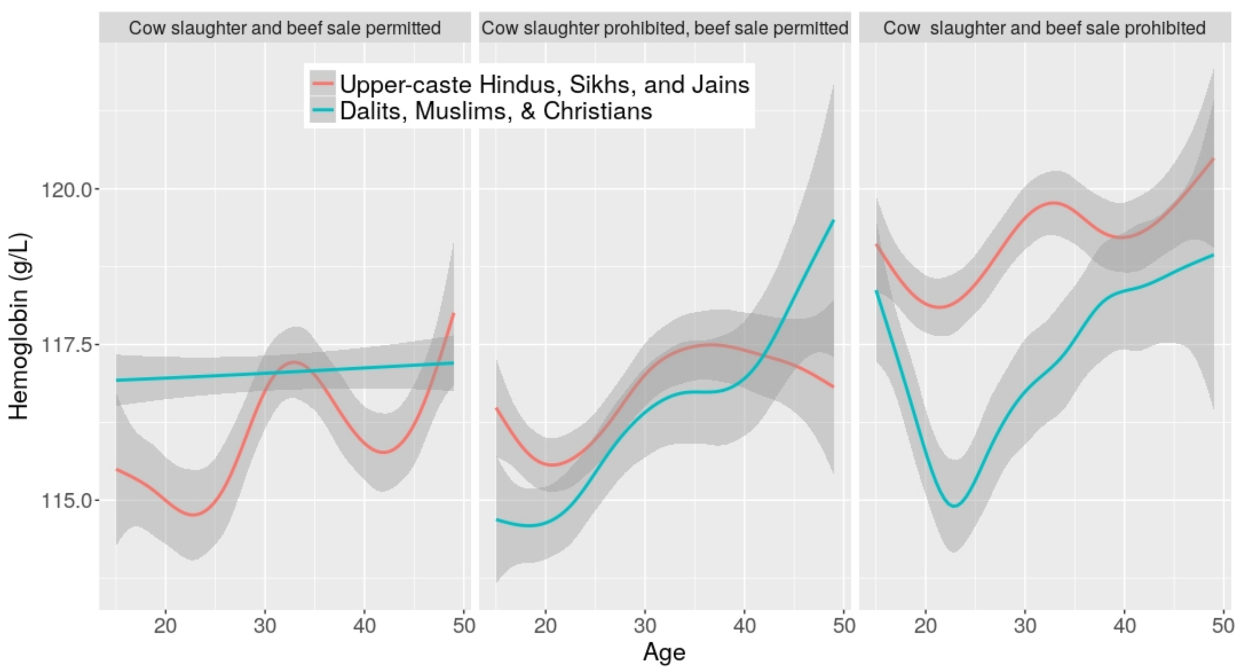

Figure 2: Average hemoglobin levels for women, by age, community, and presence of cattle slaughter restrictions in state of residence. Shaded area represents the 95% confidence interval.

We now turn our attention to the results of the model described in equation (1), summarized in Tables 1, 2, and 3. Table 1shows the effects of three types of bans, with varying levels of strictness. Cattle slaughter bans are the most pervasive. Beef sale bans in addition to cattle slaughter have bans on sales of beef. Export bans in addition to domestic beef bans prohibit the export of cattle for the purpose of slaughter or export of beef. There are two models explored for each type of treatment. The odd-numbered columns (1,3,5) show results for the basic specification with estimates for difference in differences by treatment group and law, with state year and month fixed effects, whereas the even-numbered columns (2, 4,6) control for a wide range of demographic and SES covariates, including state specific time trends (see table notes for details)and restricts attention to women without schooling in their prime age (15-35). Although the sample restriction to no schooling is restrictive, and decreases our sample size considerably, it emphasizes that our results are most applicable to relatively marginalized groups. We find that all three bans, around the time of births, reduce hemoglobin levels in women among the beef consuming groups in adulthood, with effects particularly strong for the most marginalized women in their prime ages of life when they are most likely to pass on some of these effects to the next generation. The effects vary in magnitude from ~1g/L to 2.3g/L.Panel B studies these effects on men. Interestingly, we do not find any effects of cattle slaughter restrictions on men for any of the models with respect to hemoglobin.

It is important to note that our control group in the models with beef sale bans and export bans includes states with cow slaughter bans but no additional restrictions. Ex ante, one might expect this to weaken our results, but the negative and significant coefficients on hemoglobin, and the positive and significant results on anemia and severe anemia, remain. We are able to measure the effects of stronger restrictions on the margin.

In Table 2 and 3, we explore samples and models as in Table 1, except that now we look at effects of cattle slaughter restrictions on the likelihood of being anemic and severely anemic (< 120 g/L and < 80 g/L respectively), using linear probability models. We find that cattle slaughter bans increase the probability of moderate anemia for women in the affected groups from 3 to 5 percentage points, and the probability of severe anemia by from around 0.3- 09 percentage points. In contrast, we do not find effects on moderate anemia for men, similar to the Hb results, though we do find evidence for effects on severe anemia for men, ranging from 0.3 to 0.9 percentage points.

Table 1A in the Appendix, shows results for hemoglobin but with three alternate bans: bull slaughter bans, buffalo slaughter bans, and beef possession bans. There are very few states which have these laws in addition to the bans we have already studied, so we recommend caution when drawing conclusions for India as a whole based on these results. Nonetheless, these laws may also contribute to reduced red meat availability for the beef eating groups, so we also studied them as part of our analysis. The results have the expected signs and magnitudes, especially for beef possession laws, which are similar to other laws, but we find the estimates are less precise in general. Interestingly, in contrast to earlier results, we find that some laws—buffalo slaughter bans in particular—have large and significant effects on men's hemoglobin level ranging from 2.4 to 2.9 g/L.

As a robustness check, we also tested their effects on height, a commonly used indicator of health and nutrition status. Results in tables 2A and 3A show the effects of all six bans on adult height. Although there is some evidence for adverse effects for beef sale bans and export bans on height for women in the vanilla model, these are not present among the most marginalized groups. We interpret this to suggest that people are able to substitute alternative sources of protein in their diet, but unable to adequately do so for iron sources. Our models for men in Panel B, columns 3 and 5 show some evidence of a reduction in height in the vanilla model, but this result is not robust to the addition of covariates.

7. Discussion and Conclusion

In 2012, the 65th World Health Assembly committed to halve anemia prevalence in women of reproductive age by 2025. An estimated 300 million Indian women, half of all Indian women, are known to suffer from anemia. Although much has been studied about iron supplements as well as deworming programs (Dupas and Miguel 2016), coverage for pregnant women remains low and scientists usually recommend diets rich in iron (Stevens et al. 2013). Food fortification programs are often recommended, though in India, coverage is low and success is mixed (Banerjee et al 2016).

In this context, this paper contributes by exploiting cattle slaughter bans in India to study the long-terms effects of an iron rich diet (beef) during the perinatal period on the later life prevalence of anemia. It finds that girls exposed to cattle slaughter bans in their year of birth have lower levels of hemoglobin (Hb) and are more likely to be anemic in their prime reproductive ages between 15 and 35, particularly for women who have no schooling. Theimpact of a cattle slaughter ban on hemoglobin levels is about 1-2.3 g/L. This is about one-tenth to one-fifth the effect of pregnancy, which tends to reduce hemoglobin levels by about 10 g/L across the board. These results are robust to the inclusion of bans of varying degrees of strictness, even as we compare them to a control group of states with cow slaughter bans and states with no restrictions on cattle slaughter.

We do not find any statistically significant effects of cattle slaughter bans on anemia and hemoglobin for men, in most of our models. We hypothesize that the difference in the results for men and women stems from the tradition prevalent in many Indian families wherein women eat only after the men and children in the family have eaten, and often do not receive as much nutrition as a result. Behrman (1988), Behrman and Deolalikar (1990) and Das Gupta (1987) also document large differences in childhood nutrition and mortality rates among boys and girls in India, resulting from systematic gender discrimination. Differential mortality rates by gender and cohort may also be driving some of our observed results.

Although we focus on the role of iron deficiency due to the reduced availability of red meat, other plausible mechanisms remain. There may be an income effect due to the reduced option value of cow ownership, changes in access to dairy products, and more. We intend to use additional waves of the DHS survey to increase sample size. These estimates also do not control for time-varying state-level economic data such as state GDP, unemployment rates, and access to health facilities, over and above what is captured by the state-specific time trends.

This paper not only helps us get a better understanding of iron rich diets, but builds up on recent research of the effects of fasting during pregnancy by exploring the role of nutritional deprivation of a particular food item (beef) during the perinatal period on later life outcomes. In doing so this work strengthens the argument that even moderate changes—those amenable to policy—can have long-term effects in contrast to earlier studies on the fetal origin hypothesis which focused on rare and extreme shocks such as famines and wars.

Cow slaughter is an extremely sensitive issue in India, and religious sentiments are powerful enough that overturning the ban is probably not feasible. However, the severity of anemia as a public health issue and its dire consequences mean that alternative measures to supplement nutritional deficiencies, particularly for low-SES groups, are essential. Deworming, iron supplementation and food fortification are some relatively cost-effective and simple solutions, with proven success if implemented appropriately (Dupas and Miguel, 2016; Zimmerman and Hurrell, 2007).Despite numerous government initiatives to provide iron supplementation—the 12x12 scheme, Integrated Child Development Services, National Nutrition Policy, the Mid-Day Meal Program (iron-enriched school lunches), Rajiv Gandhi Scheme for Girls Empowerment of Adolescent, the National Rural Health Mission, and many others, coverage remains low—barely 10% of women receive supplements, and only 7.6% of industrially milled wheat flour is fortified (Anand et al, 2014; Food Fortification Initiative).

Although this is beyond the scope of our paper, one possibility is to increase the fortification of popularly consumed cereals, and encouraging the consumption of iron-rich cereals like finger millet. The Public Distribution System (PDS, popularly called ration shops) remains the major source of nutrition for low-income families, and it focuses almost exclusively on wheat, rice, and sugar. Policy makers could work to ensure that all wheat and rice sold through the PDS is fortified with iron and folic acid; that finger millet and other inexpensive iron-rich foods are made available through the system; and that vitamin C supplementation is also prioritized and encouraged, as it increases the absorption of dietary iron. These measures may be combined with widespread education on the importance of consuming iron-rich foods, along with measures to increase their availability through the PDS.

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Table S1: Summary Statistics for Women

	Mean	Standard deviation	Min	Max
Hemoglobin	117.06	17.54	20.0	199
Anemic	0.51	0.50	0.0	1
Severely anemic	0.03	0.18	0.0	1
Height	1521.89	59.29	1003.0	1987
Treated	0.41	0.49	0.0	1
Total ban on cow slaughter	0.64	0.48	0.0	1
Beef sale ban	0.32	0.47	0.0	1
Beef export ban	0.42	0.49	0.0	1
Beef possession ban	0.08	0.26	0.0	1
Bull/bullock slaughter ban	0.18	0.39	0.0	1
Buffalo slaughter ban	0.06	0.24	0.0	1
Year	1976.11	9.51	1956	1991
Age	29.21	9.50	15.0	49
Currently work	0.34	0.47	0.0	1
Urban	0.47	0.50	0.0	1
Married	0.94	0.24	0.0	1
Age at first marriage	18.0	3.96	3.0	45
Number of children	2.06	2.04	0.0	16
Currently pregnant	0.05	0.21	0.0	1
N	103198			

Education	Number	Percent
No education	31102	30.14
Incomplete primary	7963	7.72
Complete primary	6951	6.74
Incomplete secondary	39406	38.18
Complete secondary	33215	32.19
Higher	11215	10.87
Total	103198	100.00
N	103198	

Partner's Education	Number	Percent
No education	16288	20.97
Incomplete primary	11747	15.13
Incomplete secondary	36551	47.06
Complete secondary	1628	2.10
Higher	11447	14.74
Total	77661	100.00
N	77661	

Wealth	Number	Percent
1	9625	9.33
2	14406	13.96
3	19840	19.23
4	26112	25.30
5	33215	32.19
Total	103198	100.00
N	103198	

Table S2: Summary Statistics for Men

	Mean	Standard deviation	Min	Max
Hemoglobin	143.39	18.26	22.0	199
Anemic	0.08	0.28	0.0	1
Severely anemic	0.01	0.08	0.0	1
Height	1645.69	69.00	800.0	1962
Treated	0.40	0.49	0.0	1
Total ban on cow slaughter	0.64	0.48	0.0	1
Beef sale ban	0.28	0.45	0.0	1
Beef export ban	0.37	0.48	0.0	1
Beef possession ban	0.05	0.21	0.0	1
Bull/bullock slaughter ban	0.13	0.34	0.0	1
Buffalo slaughter ban	0.03	0.17	0.0	1
Year	1974.37	10.79	1951.0	1991
Age	30.97	10.79	15.0	54
Currently work	0.83	0.37	0.0	1
Urban	0.53	0.50	0.0	1
Married	0.98	0.14	0.0	1
Age at first marriage	23.13	4.93	1.0	52
Number of children	1.69	2.04	0.0	19
N	64909			

Wealth	Number	Percent
1	5240	8.07
2	8831	13.61
3	13094	20.17
4	17357	26.74
5	20387	31.41
Total	64909	100.00
N	64909	

Table S3: Summary Statistics for consumption

Panel A: Monthly per capita consumption in Kg, Treatment group

	N**	Mean	C.V	10th %ile	25th %ile	50th %ile	75th %ile	90th %ile
Red Meat	275,517	0.27	1.79	0.00	0.00	0.00	0.38	0.80
- Cow Meat and Buffalo	275,517	0.14	2.63	0.00	0.00	0.00	0.00	0.25
- Goat Meat and Mutton	275,517	0.07	2.87	0.00	0.00	0.00	0.00	0.25
- Pork	275,517	0.05	4.00	0.00	0.00	0.00	0.00	0.07
Eggs (number of)	275,528	1.77	1.87	0.00	0.00	0.00	2.50	5.00
Other Non Vegetarian items	275,521	0.01	7.19	0.00	0.00	0.00	0.00	0.00
Spinach and other leafy vegetables	275,507	0.59	1.77	0.00	0.00	0.30	0.75	1.50
Milk (liters)								
Milk Products	275,541	2.84	1.40	0.00	0.00	1.67	4.00	7.50
	275,520	0.15	15.21	0.00	0.00	0.00	0.02	0.25

Panel B: Monthly per capita consumption in Kg, Control group

	N**	Mean	C.V	10th %ile	25th %ile	50th %ile	75th %ile	90th %ile
Red Meat	345,569	0.08	2.68	0.00	0.00	0.00	0.00	0.25
- Cow and Buffalo Meat	345,569	0.00	19.48	0.00	0.00	0.00	0.00	0.00
- Goat Meat and Mutton	345,569	0.07	2.70	0.00	0.00	0.00	0.00	0.25
- Pork	345,569	0.00	16.34	0.00	0.00	0.00	0.00	0.00
Eggs (number of)	345,560	1.26	2.54	0.00	0.00	0.00	1.09	4.00
Other Non Vegetarian items	345,568	0.01	10.53	0.00	0.00	0.00	0.00	0.00
Spinach and other leafy vegetables	345,569	0.51	1.52	0.00	0.00	0.30	0.67	1.25
Milk (liters)	345,547	5.75	1.18	0.00	1.00	3.75	7.50	15.00
Milk Products	345,570	0.27	6.10	0.00	0.00	0.00	0.14	0.50

**The outliers that have been dropped are top 1% of the households on the basis of their monthly per capita expenditure (MPCE)

Table S4: Summary Statistics for Monthly per capita consumption (Dummy*)

	Treatment Group			Control Group		
	Mean	Standard Deviation	C.V	Mean	Standard Deviation	C.V
Red Meat	0.50	0.50	1.00	0.24	0.43	1.77
- Cow and Buffalo Meat	0.25	0.43	1.75	0.01	0.08	12.59
- Goat Meat and Mutton	0.23	0.42	1.82	0.23	0.42	1.82
- Pork	0.10	0.30	2.99	0.01	0.08	12.04
Eggs	0.43	0.50	1.15	0.27	0.44	1.66
Other Non Vegetarian items	0.05	0.21	4.50	0.02	0.15	6.69
Spinach and other leafy vegetables	0.69	0.46	0.68	0.67	0.47	0.70
Milk	0.64	0.48	0.75	0.80	0.40	0.51
Milk Products	0.26	0.44	1.70	0.35	0.48	1.37
N**	275,545			345,575		

*Dummies have been created for each of the items, which takes value as 1 if consumption >0 and 0 if consumption=0
**The outliers that have been dropped are top 1% of the households on the basis of their monthly per capita expenditure (MPCE)

Table 1: Effects of Cow Slaughter, Beef Sale and Export Bans on Hemoglobin by Gender

Panel A: Women

	(1) Hb	(2) Hb	(3) Hb	(4) Hb	(5) Hb	(6) Hb
Cow Slaughter	-1.087*	-1.540*				
X Beef Consumer	(0.579)	(0.822)				
Beef Sale Ban			-1.260**	-2.341***		
X Beef Consumer			(0.562)	(0.501)		
Export Ban					-1.432**	-1.800**
X Beef Consumer					(0.534)	(0.683)
Observations	93,376	18,854	93,376	18,854	93,376	18,854
R-squared	0.039	0.069	0.039	0.069	0.040	0.069

Panel B: Men

VARIABLES	(1) Hb	(2) Hb	(3) Hb	(4) Hb	(5) Hb	(6) Hb
Cow Slaughter	0.721	1.050				
X Beef Consumer	(0.631)	(1.092)				
Beef Sale Ban			0.884	1.221		
X Beef Consumer			(0.697)	(0.946)		
Export Ban					0.790	0.579
X Beef Consumer					(0.630)	(1.009)
Observations	55,943	10,309	55,943	10,309	55,943	10,309
R-squared	0.058	0.077	0.058	0.077	0.058	0.077

Note: Robust standard errors in parentheses*** $p<0.01$, ** $p<0.05$, * $p<0.1$ .The table shows results for effects on Hemoglobin in Panel A for women and in Panel B for men (partners of women interviewed). Each Panel shows results from three different models from three different treatments: cow slaughter bans, beef sale bans, and beef export bans. The odd columns (1,3,5) show results for basic specification shows estimates for difference in differences by treatment group and law, with state year and month fixed effects. Even columns in Panel A (women) control in addition for: state specific time trends, age, age squared, urban, married, age at first marriage, total births ever, whether currently pregnant, currently working or not, and dummies for partners education and the wealth index. In addition the samples are restricted to those in their prime age (15-35) and those with no education. Even columns in Panel B control for age, age squared, whether currently working, urban, married, age at first marriage, total children and dummies for wealth index. In addition, sample is restricted to fathers without education.

Table 2: Effects of Cattle slaughter, Beef Sale and Export Bans on Likelihood of Being Anemic by Gender

Panel A: Women

VARIABLES	(1) Anemic	(2) Anemic	(3) Anemic	(4) Anemic	(5) Anemic	(6) Anemic
Cow Slaughter X Beef Consumer	0.027*	0.032*				
	(0.013)	(0.017)				
Beef Sale Ban X Beef Consumer			0.030**	0.053***		
			(0.014)	(0.012)		
Export Ban X Beef Consumer					0.035**	0.042***
					(0.013)	(0.014)
Observations	93,376	18,854	93,376	18,854	93,376	18,854
R-squared	0.036	0.057	0.036	0.057	0.036	0.057

Panel B: Men

VARIABLES	(1) Anemic	(2) Anemic	(3) Anemic	(4) Anemic	(5) Anemic	(6) Anemic
Cow Slaughter X Beef Consumer	0.000	0.008				
	(0.012)	(0.019)				
Beef Sale Ban X Beef Consumer			-0.007	-0.014		
			(0.010)	(0.015)		
Export Ban X Beef Consumer					-0.003	0.005
					(0.010)	(0.019)
Observations	55,943	10,309	55,943	10,309	55,943	10,309
R-squared	0.018	0.042	0.018	0.042	0.018	0.042

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1 .The table shows results for effects on Anemic status in Panel A for women and in Panel B for men (partners of women interviewed). Each Panel shows results from three different models from three different treatments: cow slaughter bans, beef sale bans, and beef export bans. The odd columns (1,3,5) show results for basic specification shows estimates for difference in differences by treatment group and law, with state year and month fixed effects. Even columns in Panel A (women) control in addition for: state specific time trends, age, age squared, urban, married, age at first marriage, total births ever, whether currently pregnant, currently working or not, and dummies for partners education and the wealth index. In addition the samples are restricted to those in their prime age (15-35) and those with no education. Even columns in Panel B control for age, age squared, whether currently working, urban, married, age at first marriage, total children and dummies for wealth index. In addition, sample is restricted to fathers without education.

Table 3: Effects of Cow Slaughter, Beef Sale and Export Bans on Likelihood of Being Severely Anemic by Gender

Panel A: Women

VARIABLES	(1) Severely Anemic	(2) Severely Anemic	(3) Severely Anemic	(4) Severely Anemic	(5) Severely Anemic	(6) Severely Anemic
Cow Slaughter X Beef Consumer	0.008**	0.009*				
	(0.004)	(0.005)				
Beef Sale Ban X Beef Consumer			0.006	0.006		
			(0.004)	(0.005)		
Export Ban X Beef Consumer					0.007**	0.009*
					(0.003)	(0.005)
Observations	93,376	18,854	93,376	18,854	93,376	18,854
R-squared	0.006	0.013	0.006	0.013	0.006	0.013

Panel B: Men

VARIABLES	(1) Severely Anemic	(2) Severely Anemic	(3) Severely Anemic	(4) Severely Anemic	(5) Severely Anemic	(6) Severely Anemic
Cow Slaughter X Beef Consumer	0.003**	0.005*				
	(0.001)	(0.003)				
Beef Sale Ban X Beef Consumer			0.002	0.009***		
			(0.001)	(0.003)		
Export Ban X Beef Consumer					0.003*	0.008**
					(0.002)	(0.003)
Observations	55,943	10,309	55,943	10,309	55,943	10,309
R-squared	0.003	0.014	0.003	0.014	0.003	0.014

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1 .The table shows results for effects on Severely Anemic status in Panel A for women and in Panel B for men (partners of women interviewed). Each Panel shows results from three different models from three different treatments: cow slaughter bans, beef sale bans, and beef export bans. The odd columns (1,3,5) show results for basic specification shows estimates for difference in differences by treatment group and law, with state year and month fixed effects. Even columns in Panel A (women) control in addition for: state specific time trends, age, age squared, urban, married, age at first marriage, total births ever, whether currently pregnant, currently working or not, and dummies for partners education and the wealth index. In addition the samples are restricted to those in their prime age (15-35) and those with no education. Even columns in Panel B control for age, age squared, whether currently working, urban, married, age at first marriage, total children and dummies for wealth index. In addition, sample is restricted to fathers without education.

Table 4: Effects of Cattle slaughter Ban on consumption

VARIABLES	(1) Beef Consumption	(2) Goat Meat and Mutton	(3) Food Expenditures	(4) Non-Food Expenditures
Cattle Slaughter X Beef Consumer	-0.109***	0.179**	-5.986	-14.163
	(0.045)	(0.054)	(17.992)	(35.786)
Observations	562,655	562,655	562,493	562,493

Notes: * p<0.00, ** p<0.01 and *** p<0.05.The table shows results for effects of cattle slaughter ban on cow meat and buffalo meat consumption in (1); goat meat and mutton in (2) for the regression specification mentioned above. The dependent variable in (1) and (2) is the dummy variable for the respective meat. This dummy variable takes the value as 1 if the per capita consumption of the respective meat (in kilograms) is greater than 0 and takes value as 0 if the per capita consumption of meat (in kilograms) is 0. (3) results for effects of cattle slaughter ban on monthly per capita expenditure of food items (in rupees) &(4) shows monthly per capita expenditure of non food items (in rupees). The food items include cereals and cereal substitutes, pulses and their products, milk and milk products, edible oil, egg, fish and meat, vegetables, fruits, sugar, salt and spices, beverages, refreshments and processed food. The non food items include pan, tobacco and intoxicants, fuel and light, clothing and footwear, education, medical, conveyance, other consumer services, miscellaneous good and entertainment, rent, taxes and cesses and durable goods.The cattle slaughter ban takes into account any kind of bans (Cow slaughter total ban, Bull slaughter ban or Buffalo slaughter ban). The treatment group is All Muslims, All Christians and Scheduled caste Hindus while the control group is Upper caste Hindus, Jains and Sikhs. Red meat consumption in the current set up includes cow and buffalo meat. To get the correct state (pseudo) fixed effects, we have constructed states Chhattisgarh, Jharkhand and Uttarakhand for the NSS rounds before the year 2000 using the state region and district codes. Similarly Goa and Daman & Diu have been separated for the NSS round before 1987. We have included in our specification the state specific time trends. We have used robust standard errors clustered at state level. Please be advised that we have dropped the state "Jammu and Kashmir" from our analysis. Also, top 1% of the observations for each NSS round for the MPCE (Monthly per capita expenditure in rupees) have also been dropped. Also, for (3) and (4) we have dropped the observations which showed the negative non food consumption expenditure (this is due to data minor errors in the first two thick rounds, i.e. 38th and 43rd).

APPENDIX A: TABLES

Table 1A: Effects of Bull Slaughter, Buffalo Slaughter and Export Bans on Hemoglobin by Gender

Panel A: Women

VARIABLES	(1) Hb	(2) Hb	(3) Hb	(4) Hb	(5) Hb	(6) Hb
Bull Slaughter X Beef Consumer	-0.895 (0.584)	-0.535 (0.886)				
Buffalo Slaughter X Beef Consumer			-0.960*** (0.315)	-0.418 (0.446)		
Beef Possess X Beef Consumer					-1.325*** (0.326)	-1.291* (0.669)
Observations	93,376	18,854	93,376	18,854	93,376	18,854
R-squared	0.039	0.068	0.039	0.068	0.039	0.068

Panel B: Men

VARIABLES	(1) Hb	(2) Hb	(3) Hb	(4) Hb	(5) Hb	(6) Hb
Bull Slaughter X Beef Consumer	-1.376* (0.796)	-1.492 (0.929)				
Buffalo Slaughter X Beef Consumer			-2.892*** (0.389)	-2.336** (0.881)		
Beef Possess X Beef Consumer					0.562 (1.107)	0.280 (2.664)
Observations	55,943	10,309	55,943	10,309	55,943	10,309
R-squared	0.058	0.077	0.058	0.077	0.058	0.077

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1 .The table shows results for effects on Hemoglobin status in Panel A for women and in Panel B for men (partners of women interviewed). Each Panel shows results from three different models from three different treatments: bull slaughter bans, buffalo slaughter bans, and beef possession bans. The odd columns (1,3,5) show results for basic specification shows estimates for difference in differences by treatment group and law, with state year and month fixed effects. Even columns in Panel A (women) control in addition for: state specific time trends, age, age squared, urban, married, age at first marriage, total births ever, whether currently pregnant, currently working or not, and dummies for partners education and the wealth index. In addition the samples are restricted to those in their prime age (15-35) and those with no education. Even columns in Panel B control for age, age squared, whether currently working, urban, married, age at first marriage, total children and dummies for wealth index. In addition, sample is restricted to fathers without education.

Table 2A: Effects of Cow Slaughter, Beef Sale and Export Bans on Adult Height by Gender

Panel A: Women

VARIABLES	(1) Height	(2) Height	(3) Height	(4) Height	(5) Height	(6) Height
Cow Slaughter X Beef Consumer	1.487	-1.341				
	(2.345)	(4.156)				
Beef Sale Ban X Beef Consumer			0.346	2.996		
			(2.635)	(3.165)		
Export Ban X Beef Consumer					-1.361	1.431
					(2.796)	(3.369)
Observations	99,071	19,730	99,071	19,730	99,071	19,730
R-squared	0.054	0.079	0.053	0.079	0.054	0.079

Panel B: Men

VARIABLES	(1) Height	(2) Height	(3) Height	(4) Height	(5) Height	(6) Height
Cow Slaughter X Beef Consumer	-1.632	0.169				
	(2.312)	(2.255)				
Beef Sale Ban X Beef Consumer			-3.864*	2.759		
			(1.985)	(2.471)		
Export Ban X Beef Consumer					-5.122**	0.749
					(2.073)	(2.664)
Observations	60,677	11,058	60,677	11,058	60,677	11,058
R-squared	0.071	0.085	0.071	0.085	0.071	0.085

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.
The table shows results for effects on adult height in Panel A for women and in Panel B for men (partners of women interviewed). Each Panel shows results from three different models from three different treatments: cow slaughter bans, beef sale bans, and beef export bans. The odd columns (1,3,5) show results for basic specification shows estimates for difference in differences by treatment group and law, with state year and month fixed effects. Even columns in Panel A (women) control in addition for: state specific time trends, age, age squared, urban, married, age at first marriage, total births ever, whether currently pregnant, currently working or not, and dummies for partners education and the wealth index. In addition the samples are restricted to those in their prime age (15-35) and those with no education. Even columns in Panel B control for age, age squared, whether currently working, urban, married, age at first marriage, total children and dummies for wealth index. In addition, sample is restricted to fathers without education.

Appendix Table 3A: Effects of Bull Slaughter, Buffalo Slaughter and Export Bans on Adult Height by Gender

Panel A: Women

VARIABLES	(1) Height	(2) Height	(3) Height	(4) Height	(5) Height	(6) Height
Bull Slaughter X Beef Consumer	-6.080*	-5.226*				
	(3.079)	(2.625)				
Buffalo Slaughter X Beef Consumer			-2.216	-3.568*		
			(2.241)	(1.937)		
Beef Possess X Beef Consumer					5.137	1.778
					(3.064)	(3.752)
Observations	99,071	19,730	99,071	19,730	99,071	19,730
R-squared	0.054	0.079	0.053	0.079	0.054	0.079

Panel B: Men

VARIABLES	(1) Height	(2) Height	(3) Height	(4) Height	(5) Height	(6) Height
Bull Slaughter X Beef Consumer	-5.479	0.382				
	(5.127)	(3.777)				
Buffalo Slaughter X Beef Consumer			-9.698**	-6.317***		
			(4.268)	(1.875)		
Beef Possess X Beef Consumer					1.724	-0.520
					(3.837)	(10.328)
Observations	60,677	11,058	60,677	11,058	60,677	11,058
R-squared	0.071	0.085	0.071	0.085	0.071	0.085

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1 .The table shows results for effects on adult height status in Panel A for women and in Panel B for men (partners of women interviewed). Each Panel shows results from three different models from three different treatments: bull slaughter bans, buffalo slaughter bans, and beef possession bans. The odd columns (1,3,5) show results for basic specification shows estimates for difference in differences by treatment group and law, with state year and month fixed effects. Even columns in Panel A (women) control in addition for: state specific time trends, age, age squared, urban, married, age at first marriage, total births ever, whether currently pregnant, currently working or not, and dummies for partners education and the wealth index. In addition the samples are restricted to those in their prime age (15-35) and those with no education. Even columns in Panel B control for age, age squared, whether currently working, urban, married, age at first marriage, total children and dummies for wealth index. In addition, sample is restricted to fathers without education.

Appendix B: Historical and legal background

Figure B1: Inscription on stupa at Sanchi, 412 CE

The 1870 Kuka revolt against British rule in Punjab by the Namdhari sect of Sikhs was partly driven by anger against widespread cow slaughter (Jha, 2002). The modern cow protection movement began with the publication of *Gocarunanidhi* by DayanandSaraswati, the founder of the Arya Samaj, a revivalist Hindu organization (Saraswati; Durga Prasad (translator), 1889). *Gocarunanidhi* is often considered the founding text of the cow protection movement (Adcock 2010), and in addition to religious arguments, it made numerous economic and "rationalist" arguments in favor of cow slaughter. For example, Saraswati argued that the milk from a dairy cow over its lifetime could feed many more people than the meat from that cow, and that the prevalence of cow slaughter since the Muslim invasions 700 years prior, and subsequent British rule, had raised the prices of dairy products. In the book, Saraswati also laid down instructions and descriptions of local cow protection councils, known as *GorakshiniSabhas*, which he had first founded in 1882.

After the Constitution was ratified in 1950, however, state boundaries still reflected the old British colonial state organization and existing or former princely states. In 1956, in response to popular demand, the States Reorganisation Act was passed, creating states based on linguistic boundaries. Nine of these newly reorganized states passed legislation banning or restricting cow slaughter by 1958.

In 1956, a group of butchers filed a lawsuit against the state of Bihar, contending that total bans on cow slaughter prevented them from earning their livelihoods and violated their religious rights as Muslims to slaughter cows on Eid-ul-Adha. In April 1958, the Supreme Court of India, in *Mohd. Hanif Qureshi v. State of Bihar* (1958 AIR 731, 1959 SCR 629) held that, firstly, cow slaughter was not a fundamental religious right, since other animals can be slaughtered to fulfill the religious requirement. However, states could not prohibit the slaughter of animals after they ceased to be economically productive, as this would not be in the public interest. After this decision, state laws prohibiting cow slaughter that were passed in the 1960s and 1970s tended to ban cow slaughter while permitting the slaughter of bulls and oxen that were old and could no longer work as draft animals.

The 1980s and 1990s saw numerous electoral victories for Hindu nationalist political parties like the BJP, which make cow protection a vital component of their electoral platform. Also, in 2005, the Supreme Court's decision in *State Of Gujarat v. Mirzapur Moti Kureshi Kassab* (2005(8) SCC 534) partially overturned the precedent established in *Qureishi*, making it easier for states to ban cow slaughter if they wish to do so.

APPENDIX C: Basic Primer on Anemia

Anemia is a condition that develops when your blood lacks enough healthy red blood cells or hemoglobin. Hemoglobin is a main part of red blood cells and binds oxygen. If you have too few or abnormal red blood cells, or your hemoglobin is abnormal or low, the cells in your body will not get enough oxygen.

Also, certain forms of anemia are hereditary and infants may be affected from the time of birth. Women in the childbearing years are particularly susceptible to iron-deficiency anemia because of the blood loss from menstruation and the increased blood supply demands during pregnancy. Older adults also may have a greater risk of developing anemia because of poor diet and other medical conditions. There are many types of anemia. All are very different in their causes and treatments. Iron-deficiency anemia, the most common type, is very treatable with diet changes and iron supplements. Some forms of anemia -- like the mild anemia that develops during pregnancy -- are even considered normal. However, some types of anemia may present lifelong health problems.

What Causes Anemia?

There are more than 400 types of anemia, which are divided into three groups: anemia caused by blood loss, anemia caused by decreased or faulty red blood cell production, anemia caused by destruction of red blood cells

Anemia Caused by Blood Loss

Red blood cells can be lost through bleeding, which often can occur slowly over a long period of time, and can go undetected. This kind of chronic bleeding commonly results from the following:

- Gastrointestinal conditions such as ulcers, hemorrhoids, gastritis (inflammation of the stomach), and cancer.
- Use of non-steroidal anti-inflammatory drugs (NSAIDs) such as aspirin or ibuprofen, which can cause ulcers and gastritis.
- Menstruation and childbirth in women, especially if menstrual bleeding is excessive and if there are multiple pregnancies

Anemia Caused by Decreased or Faulty Red Blood Cell Production

With this type of anemia, the body may produce too few blood cells or the blood cells may not function correctly. In either case, anemia can result. Red blood cells may be faulty or decreased due to abnormal red blood cells or a lack of minerals and vitamins needed for red blood cells to work properly. Conditions associated with these causes of anemia include the following: iron-deficiency anemia, vitamin deficiency, bone marrow and stem cell problems, and other health conditions

Iron-deficiency anemia occurs because of a lack of the mineral iron in the body. Bone marrow in the center of the bone needs iron to make hemoglobin, the part of the red blood cell that transports oxygen to the body's organs. Without adequate iron, the body cannot produce enough hemoglobin for red blood cells. Iron-deficiency anemia is caused by: an iron-poor diet, especially in infants, children, teens, vegans, and vegetarians; metabolic demands of pregnancy and breastfeeding that deplete a woman's iron stores, menstruation; frequent blood donation; endurance training; digestive conditions such as Crohn's disease or surgical removal of part of the stomach or small intestine; certain drugs, foods, and caffeinated drinks

Vitamin-deficiency anemia may occur when vitamin B12 and folate are deficient.
These two vitamins are needed to make red blood cells. Conditions leading to anemia caused by vitamin deficiency include:
Megaloblastic anemia: Vitamin B12 or folate or both are deficient.
Pernicious anemia: Poor vitamin B12 absorption caused by conditions such as Crohn's disease, an intestinal parasite infection, surgical removal of part of the stomach or intestine, or infection with HIV.
Dietary deficiency: Eating little or no meat may cause a lack of vitamin B12, while overcooking or eating too few vegetables may cause a folate deficiency.
Other causes of vitamin deficiency: pregnancy, certain medications, alcohol abuse, intestinal diseases such as celiac disease.

Bone marrow and stem cell problems may prevent the body from producing enough red blood cells. Some of the stem cells found in bone marrow develop into red blood cells. If stem cells are too few, defective, or replaced by other cells such as metastatic cancer cells, anemia may result. Anemia resulting from bone marrow or stem cell problems includes:

- Aplastic anemia occurs when there's a marked reduction in the number of stem cells or absence of these cells. Aplastic anemia can be inherited, can occur without apparent cause, or can occur when the bone marrow is injured by medications, radiation, chemotherapy, or infection.
- Thalassemia occurs when the red cells can't mature and grow properly. Thalassemia is an inherited condition that typically affects people of Mediterranean, African, Middle Eastern, and Southeast Asian descent. This condition can range in severity from mild to life threatening; the most severe form is called Cooley's anemia.

Lead exposure is toxic to the bone marrow, leading to fewer red blood cells. Lead poisoning occurs in adults from work-related exposure and in children who eat paint chips, for example. Improperly glazed pottery can also taint food and liquids with lead.

Anemia associated with other conditions usually occurs when there are too few hormones necessary for red blood cell production. Conditions causing this type of anemia include the following: advanced kidney disease, hypothyroidism, other chronic diseases, such as cancer, infection, lupus, diabetes, and rheumatoid arthritis, old age.

Anemia Caused by Destruction of Red Blood Cells

During early pregnancy, sufficient folic acid can help prevent the fetus from developing neural tube defects such as spina bifida.

When red blood cells are fragile and cannot with stand the routine stress of the circulatory system, they may rupture prematurely, causing hemolytic anemia. Hemolytic anemia can be present at birth or develop later. Sometimes there is no known cause, but some causes of hemolytic anemia may include: inherited conditions, such as thalassemia, stressors such as infections, drugs, snake or spider venom, or certain foods, toxins from advanced liver or kidney disease, inappropriate attack by the immune system (called hemolytic disease of the newborn when it occurs in the fetus of a pregnant woman), vascular grafts, prosthetic heart valves, tumors, severe burns, exposure to certain chemicals, severe hypertension, and clotting disorders. In rare cases, an enlarged spleen can trap red blood cells and destroy them before their circulating time is up.