Do "Beef Bans" Affect Women's Health? [1]

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ABSTRACT

This paper uses the state-level rollout of cattle slaughter bans in India as a natural experiment in beef availability around birth. We compile historical data on cattle slaughter ban legislation by state and harmonize it with household and individual level data on beef consumption (National Sample Surveys) and biomarkers (Demographic and Health Surveys). Using a difference-in-differences and event study design, we show that "beef bans" a) reduce beef consumption and women's hemoglobin in communities that traditionally eat beef in the short-term; b) early life exposure to cattle slaughter bans makes women 10% more likely to be anemic decades after birth. (JEL I12, J16, O15, O17, Z12)

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1. Introduction

Cattle slaughter is extremely controversial in India. The majority of Indian religious groups (upper caste Hindus, Sikhs, and Jains) traditionally prohibit beef consumption. In contrast, lower caste Hindus, Muslims, and Christians traditionally consume beef. Since independence from the British in 1947, an increasing number of states have rolled out bans on cattle slaughter so that the majority of Indian states– eighteen out of twenty-nine –currently ban cow slaughter. These bans are of great interest to economists. First, cattle slaughter bans are of intrinsic interest as they restrict the choice set for everyone, including those upper caste Hindus/Sikhs/Jains who may want to eat beef. Second, the reduction in supply of red meat may affect the consumption and welfare of marginalized populations belonging to lower caste Hindus, Muslims and Christians for whom beef traditionally has been a primary source of a natural source of iron and protein intake.

In this paper we first compile a rich panel data on cattle slaughter bans to document the prevalence and intensity of these bans across space and time. We then harmonize this data with household level consumption and individual level biomarker data to evaluate the short- and long-term effects of cattle slaughter bans around birth, a critical period of development, on beef consumption and health over the life course.

A large and growing literature has been studying the role of the first 1,000 days of life, and particularly the fetal period, in shaping life cycle health and skill formation (Almond & Currie 2011; Cunha & 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 & Hanson 2005).

Most papers explore rare and extreme shocks and have paid scarce attention to importance of dietary choices during early life (Almond & 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 contrast to prior work, this paper studies the long-term effect of disruptions in beef intake resulting from cow slaughter bans during early life on the next generation, particularly women of low socio-economic status (SES), who are more likely to be anemic to begin with due to lack of proper diet.

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

Beef is one of the best sources of dietary iron, with 18.8mg of iron per100 mg of edible portion. This is even higher than goat meat, another widely consumed source of red meat in India, which contains 2.5 mg of iron per 100 mg of edible portion.[1] The iron in beef is part of a molecule called heme, and the human body absorbs heme iron more readily than other forms of this mineral such as those present 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,

[1] See Gopalan et al. (1989) which presents the nutritional content in Indian dietary foods.

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).[2]

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–74.3% as opposed to 50.9% in Pakistan and 47% in Bangladesh (*Guidelines for Control of Iron Deficiency Anemia: National Iron+ Initiative* 2013*)*. 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. [3] [4]

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

[3]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)

[4]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 1998; Gopalan 1996). Genetic causes and poor hygiene that may lead

Furthermore, beef is one of the cheapest sources of heme-iron in Indian diets, and is cheaper than chicken, goat meat, mutton, or pork.[5] 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. While goat meat remains legal throughout the country and buffalo meat is available in most states, we expect the reduction in the supply of red meat due to cow slaughter bans to increase the prices for these and other substitutes. 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 investments, through the process of dynamic complementarity and self-productivity, we expect that the initial loss of iron during the fetal stage may be compounded to have large effects during adulthood (Cunha & Heckman 2007). For example, Costa Rican children who have iron deficiency in infancy have been found to suffer from poor performance in tasks in their childhood, 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 with a 37% increase in the likelihood of anemia in adulthood. Ewijk (2011) found that exposure to Ramadan beginning in the second trimester of pregnancy increased the likelihood of anemia by about 9 percentage points.

In our conceptual framework, we discuss two types of possible compensatory behavior. The first is during the prenatal stage, when women may substitute or add foods to their diets, which could provide the required levels of

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to infections and infestations are other contributing factors which may also interact with iron deficiency (Seshadri 2001).

[5] Price data is available upon request.

iron. The second behavior, which we are unable to test empirically, we discuss is the possibility of compensatory investments later in life. Red meat, including beef, is part of the typical diet for our treatment group– Muslims, Christians, and Hindus who are members of scheduled castes. Indian foods are not usually fortified with iron and the general population has very little access to iron supplements. Furthermore, the normal Indian diet is a cereal-dominated diet which may inhibit iron absorption (Deaton and Dreze 2009), and cow slaughter bans may have compounded the problem by banning a cheap and natural source of heme-based iron.

We hypothesize that for the individuals traditionally known for consuming beef-cattle slaughter ban variation across space and time should correspond to variation in early-life, and late-life health. Those who do not traditionally consume beef—upper caste Hindus, Jains, and Sikhs—serve as placebos, as we do not expect similar effects of cattle slaughter bans for these groups.

Our short-term (period based) analysis necessitates historical panel data on cattle slaughter bans with contemporaneous data on red meat consumption and hemoglobin. Our long-term (cohort based) analysis necessitates data 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. For cattle slaughter ban data, we construct our own policy panel dataset of state-year observations from 1950-2012 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/possession of beef, 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. For beef/red meat consumption, we gathered historical repeated cross sectional data from the National Sample Survey (NSS) from 1983-2012. For the biomarker data, we use hemoglobin data in the Demographic and Health Surveys (DHS).

We first study the *short-term* effects of cow slaughter bans on beef consumption using data from the NSS and women's hemoglobin from DHS. Our results show that beef consumption decreased for families exposed to cattle slaughter bans. Our results are robust to controlling for income which suggests that the effects of cattle slaughter bans are not driven by the potential loss of income for minorities such as Muslims, who traditionally work in the red meat industry.[6] Furthermore, we find that beef bans -of varying strictness- lead to lower hemoglobin levels among adult women.

We then study the *long-term* effects of exposure to cow slaughter bans around birth on hemoglobin and anemia. Since the consumption of red meat is a mitigating factor in the development of iron deficiency anemia for anemic populations, 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 should be higher. We find that overall, girls exposed to cattle slaughter bans in their year of birth have about 1 to 2 g/L 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 for women who have not completed primary schooling or who come from poorer families.

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 medical literature. Its focus on long-term effects allows us to look at effects of changes in consumption of beef and hence the

[6] We also studied effects on non-food expenditure and find no robust effects.

implied intake of iron on anemia levels decades after birth. Recent work has explored the effects of fasting during pregnancy on later life health (Almond & Mazumder 2011; van Ewijk 2011; Majid 2015). This work complements such work and explores how a ban on a specific food item—beef—impacts later life health in the beef-eating groups. Not much is known in economics or medicine about long-term causal effects of red meat consumption in pregnancy. 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 & Yanagizawa-Drott 2015), cattle slaughter bans represent a case of spillover of the religious practices of an influential majority on the choice set of minorities who don't traditionally follow the norms of the majority, in terms of dietary intake. Cattle slaughter ban variations allow us to study how the formalization of informal norms, present in the forms of taboos, customs and rituals for a particular group, affects societal welfare when they are imposed as legal restrictions on everyone. This is a topic of interest in the broader literature on culture and institutions on economic outcomes (North 2005; Grief 2006; Clingingsmith et al. 2009; Tabellinei 2010; Alesina & Giuliano 2015; Acemoglu & Jackson 2017; Barro and McCleary 2019). Here, we have a case where one can observe the process of formalization of informal norms at the population level and how it impacts societal welfare across generations. Given that anemia affects more than 50% of Indian women, our study is able to shed light on the cultural determinants of an important public policy issue.

Beyond consequentialist perspectives, one can argue that the study of legal bans on beef have intrinsic interest as well. It's not just about impact of bans on individual's welfare. But it is also very much about identity choice and the right to food (Sen 2001). In that sense this work contributes to recent work on social identity and economic outcomes (Atkin et al. 2019) by documenting the prevalence and intensity of bans on freedoms to consume food.

The rest of the paper is organized as follows: Section 2 describes the historical background of cow slaughter bans. Section 3 describes our conceptual framework. Section 4 describes the data and section 5 describes our empirical strategy. Section 6 shows results and section 7 concludes.

2. Historical background of cow slaughter bans

Cows have long been revered as sacred in the Hindu faith. The avoidance of beef consumption is valorised and regularly reinforced as one of the purest practicesin several sacred texts. The *Rig Veda*, the oldest Hindu scripture (composed between 1500 and 1200 BCE), describes cows as divine, sacred, and worthy of protection.[7] The earliest known reference to a legal ban on cow slaughter is an engraving on a stupa in Sanchi, Madhya Pradesh, dated to 412 CE, during the reign of Chandragupta II of the Gupta dynasty (photograph in Appendix B) (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).

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

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 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 and 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.

3. Conceptual framework

We first present a simplified static model to think about impact of cow slaughter bans on the food choices of pregnant women, their health, and utility in the spirit of Strauss and Thomas (2007). We then discuss the long-term impact of cow slaughter bans 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 taste and how their choices affect the health of their children. We abstract away from the full specification of the health function as in

Strauss & Thomas (2007), to focus on the relevant margin about beef consumption, without loss of generality. For our purposes, we 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 we set H as anemia during pregnancy. Dietary intake through food choices affects one's intake of iron—especially heme-based iron, which is more absorbable (Zijp et al. 2000).[8] Utility function of the mother is given by:

$$U = U (N_V, N_B ; H) \qquad (2)$$

For simplicity, we assume that income is exogenously given, so that there is no

[8] 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 & 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 (Narasinga 1981; 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 perhaps offers one explanation why vegetarians are more prone to iron deficiency than those who regularly consume red meat even in industrialized societies (West & Oastes 2008; Gibson & Ashwell 2003).

work and leisure constraint.[9] The budget constraint is given by:

$P_V N_V + P_B N_B = M$ (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, for example, due to habitual or historical consumption (Atkin 2016). 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, specifically, has some of the highest concentrations of heme-based iron, and is more easily absorbed than the non-heme iron in plant sources, beef may be thought of as a critical dietary input for

[9] 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 cow slaughter bans lower health outcomes, 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 & Thomas 2007).

heme-based iron, which is a key input for determining levels of anemia.[10][11] 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 explore the effect of bans, we now consider the case where the health and the utility function are both Cobb-Douglas. Cunha, Heckman, & 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 in fact not be unrealistic.

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:

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

[10] 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.

[11] 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).

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

The term in brackets is a term for the share of each good 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.[12]

Impact of cow slaughter bans

In this framework, as P_B rises with cow slaughter bans, beef consumption falls, which reduces the optimal intake of beef as well as the health stock which will be determined not only by the relative share of income spent on beef but also by the relative value of beef in the health production function. To the extent that beef consumption is not harmful to the health of pregnant women, we should expect that cow slaughter bans will reduce health in the form of hemoglobin levels of pregnant women. Note, however, that even if beef consumption is harmful to health of women, i.e. if $\gamma_B < 0$, then if other options which are accessible to pregnant women are even worse for health (though they give utility), we may still get a result that cow slaughter cow slaughter bans worsen health by making people more iron deficient. This theory is plausible in India, given that the typical Indian diet is known to be high in iron inhibitors such as tea and wheat, which are rich in tannins and phytates. These may potentially be consumed in higher amounts when there is no access to beef. In that case, the assumption is

[12]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.

that if γ_B <0 then γ_V <γ_B <0. So either γ_B >0 or, if γ_B < 0, then γ_V<γ_B <0 is necessary for cow slaughter bans to make health worse.[13]

3.2 Dynamic effects of bans on health:

Now consider the dynamic problem. We abstract away from the trade-off 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 in terms of anemia. Our framework is similar to some recent work, which studied effects of alcohol availability in utero on adult well-being in Sweden (Nilsson 2017), and inspired by the work of Cunha & Heckman (2007). For simplicity, suppose that there are only two childhood periods, T = 2, in the child's life cycle: one prenatal stage[14] (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:

$$h = A\left[\gamma(\bar{I}_1)^{\phi} + (1-\gamma){I_2}^{\phi}\right]^{1/\phi}$$

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

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[13] If prices of other goods also increase (general equilibrium effects), then the consumption of other goods which may be close substitutes for beef also increase, potentially leading to a double burden of cow slaughter bans on iron intake during critical periods of life. Another mechanism through which cow slaughter bans may potentially play a role is in terms of knowledge and subjective beliefs (Cunha et al. 2015). Mothers may not know the importance of heme-based iron 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 iron intake levels, leading to an on average lower intake of iron than would have been present if beef had been available and consumed.

[14]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.

multiplier, and

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

where μ is an exogenous negative shock which occurs due to cow slaughter bans in period 1. A key assumption in the framework (which is often not tested), is that $\mu + I_1 < 0$.[15] The elasticity of substitution is a measure of the substitutability of $\bar{I}_1$ and represents the degree of complementarity/substitutability. It determines how easy it is to compensate during the postnatal stage for low levels of investments in the prenatal stage due to a negative μ, i.e. a ban. 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, as $\varphi \rightarrow -\infty$, it is impossible to compensate for low prenatal investments in the postnatal period. Time around birth is a critical and 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

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[15] In the static framework before, we have argued why this is likely to be true in our case, whereby cow slaughter bans increase iron deficiency in mother-child dyad. We also provide evidence from the NSS in support of this assumption that cow slaughter bans do reduce beef intake, which leads to an overall reduction in diets rich in heme-iron. Furthermore, we explain the effects of substitutes (such as goat meat, and mutton, and spinach). Overall, we find that there is no change in spinach consumption but that there is some increase in goat meat and mutton consumption. However, consistent with this assumption, we find that the percentage of heme-iron available in goat meat and mutton is much smaller than that of beef (Gopalan et al. 1989).

time, which could have lifetime consequences that are difficult to remediate at later ages. "Dynamic complimentary" arises when stocks of health/skills acquired by the end of a given period (say, at birth) make investment in the 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 (for example, uptake of vaccinations) but also other types of skills such as cognitive skills, which may further reduce returns to parents' investing in nutrition and iron intake for these children, later in their lives (Banerjee & Majid 2018; Adhvaryu & Nyshadham 2016; Field et al. 2009). Second, "self-productivity" arises when lower stocks of skills (e.g. 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 (Balarajan et al. 2011). It also captures cross-effects: anemic women are more likely to be at risk of other diseases, and other diseases, in turn may make such women more likely to become anemic in adulthood. We expect the effects of bans to be primarily on women in their prime reproductive ages,[16] as the blood loss associated with menstruation is known to exacerbate iron deficiencies. In our data (see below), 51% of women are anemic, compared to only 8% of men.

4. Data

4.1 Cattle slaughter ban legislation

The database consists of state-(month) year observations of total cattle slaughter bans by state and (month) year, as set by policy between 1950 and 2012. The cattle slaughter ban data for this study was constructed by the authors

[16]Anemia can be caused by a lower intake of iron than what is already lost, which most often occurs among women in fertile ages.

from multiple sources. 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 altered accordingly 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 instances—the existing law was applied in both states until a state passed its own separate legislation, and we coded the data accordingly. Appendix D shows the dates when law was enacted for each state by type of ban.

Figure 1 depicts the status of state-level laws in 1959, 1979, 2000, and the present day. There is substantial spatial and temporal variation in bans that we will utilize for short-and long-term analysis of the bans. For example, the earliest bans after independence were passed between 1950 and 1955, in West Bengal, Bombay, Uttar Pradesh, Bihar, Himachal Pradesh, and Punjab. From 1956-1976, only Madhya Pradesh, Odisha, and Karnataka, and the union territories of Puducherry (then Pondicherry) and Andaman and Nicobar Islands passed new bans, while Gujarat, newly split from Bombay, amended its law to also prohibit the slaughter of bulls and bullocks. The period from 1976-1979 also saw bans imposed in Goa and Andhra Pradesh, and the union territories of Daman and Diu, and Dadra and Nagar Haveli, along with amendments to the existing laws in Gujarat and Himachal Pradesh. Gujarat now permitted the slaughter of bulls and bullocks with a fit-for-slaughter certificate, while Himachal Pradesh increased its maximum fines and prison sentence. No additional bans or amendments were passed between 1980 and 1994, but in 1994, Gujarat reinstated its ban on bull and bullock slaughter and Delhi passed a cow slaughter ban. In 1995, Rajasthan imposed a cow slaughter ban, while Goa lifted its ban, permitting cows to be slaughtered with a fit-for-slaughter certificate.

The next wave of legislative activity began in 2002, when Uttar Pradesh increased its fines and maximum prison sentence. In 2004, 2005, and 2007, the newly formed states of Chattisgarh, Jharkhand, and Uttarakhand respectively passed their own laws separate from the states they had been split from. Chattisgarh imposed a ban on bull and bullock slaughter, and increased the maximum fine. Jharkhand lifted the ban on buffalo slaughter but added bans on beef sale and possession, while also raising the maximum fine and both the maximum and minimum prison sentence. Uttarakhand imposed a ban on bull slaughter, and raised the maximum and minimum fines and prison sentence. In 2011, Gujarat reinstated its ban on bull slaughter. Finally, in 2015, Haryana imposed a ban on beef possession, Maharashtra banned bull slaughter, and both increased the minimum and maximum fines and prison sentences.

For our long-term analysis, when we study 15-49 year olds, we are able to utilize variation in legal bans from 1956 onwards, whereas for the short-term analysis with beef data, our estimates for cow slaughter bans are primarily driven by introduction of cow slaughter bans in Delhi (1994) and Rajasthan (1995). As Appendix D also shows, several states had enacted beef sale bans before 1983 (the time since when we have NSS data on consumption) which allows us to fully utilize variation from cow slaughter and beef sale bans for long-term analyses. In contrast, beef possession bans were mostly introduced much later, so that there is much more variation in beef possession bans for short term analysis (1983-2012) whereas beef sale bans (present before 1983) have more variation for allowing long-term analysis. Accordingly we will focus our presentation of results on beef sale bans in addition to cow slaughter bans for our analysis of long-term results and on beef possession (in addition to cow slaughter bans) for short term analysis.

4.2 National Sample Surveys

To study the impact of cattle slaughter bans on beef consumption, we collected data from the (thick) rounds of National Sample Survey between 1983-2012:[17] NSS (38^{th}, 43^{rd}, 50^{th}, 55^{th}, 61^{st}, 66^{th}, and 68^{th} rounds). The NSS is a rich set of surveys which record household purchases of 169 different food products, including beef and red meat consumption. The surveys cover all states of India, a country with many diverse food cultures across religious, caste, and ethno linguistic groups, which we will exploit in our identification strategy. Together these surveys contain over 500,000 observations for our analysis. 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 possession, or a ban on cow slaughter 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 comprises the communities in which beef eating is traditionally common—all Muslims,

[17] We use the seven thick rounds of NSS data precisely the 38th round (1983), 43rd round (1987-88), 50th round (1993-94), 55^{th} round (1999-2000), 61^{st} round (2004-05), 66^{th} round (2009-10) and 68^{th} round (2011-12).

Christians and scheduled caste Hindus. The control group is comprised of groups who do not traditionally eat beef—upper caste Hindus, Jains and Sikhs, who serve as placebos.

Figure 2 shows trends in beef consumption by treatment group/beef eating and ban status of states for poor samples (those in bottom half of marginal per capita consumption distribution). The figure clearly validates our choice of control group/non-beef eating groups whose mean values are close to zero in states with and without bans, whereas treatment groups have much higher positive means in states with and without bans. Furthermore, it is interesting to note that starting in the late 1990s/2000s (when Delhi and Rajasthan rolled out new cow slaughter bans) there is a widening gap driven by lower beef consumption for treatment groups in banned states relative to states that never had bans. In contrast there is convergence among control groups in late 2000s across states with and without bans.

Table S3a shows the proportions of various consumption items [18] including beef and buffalo meat by the treatment and control group. Here, we see that less than 1% of the control group consumes any cow or buffalo meat, and we believe this to be low enough for our purposes, showing the validity of our choice of control group. Table S3b contains the summary statistics of the same consumption proportions by the poor sample. We believe the extensive margin (whether or not someone consumes beef at all) is perhaps the more meaningful margin in case of a ban which is likely to shift people from eating beef to not eating beef at all.

4.3 Demographic and Health Surveys

To estimate the impact of cattle slaughter bans on health outcomes, we

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[18] Interestingly the treatment and control groups are comparable in goat meat consumption.

used the 2005-06 Indian Demographic and Health Surveys (DHS). The DHS are nationally representative household surveys conducted in low- and middle-income countries and are designed to collect health and socio-demographic 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.[19] 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 information to clean the data further, dropping Buddhist, Jewish, Zoroastrian, and Donyi Polo respondents. We also dropped 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.[20] Our exposure is a dummy variable indicating the presence of a legislative restriction on cattle slaughter in a

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[19] 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.

[20] 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.

given state in a particular year—a total ban on cow slaughter, or a ban on cow slaughter and a ban on the sale of beef, or a ban on exporting or transporting cows 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 aged 15-49 years at the time of interview, the DHS provides hemoglobin (Hg) data. Our primary outcome is 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, and economic well-being.

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. We also controlled for their partners' educational attainment and included a dummy indicating urban versus rural residence. Educational attainment was coded as follows: 0=no education; 1=incomplete primary; 2=complete primary; 3=incomplete secondary, 4=complete 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 &

Pritchett (2001; 1999). Tables S1 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 years for women and 31 for men, over 90% are married, and they have about two children 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 under 15% of them have education beyond high school. Over half of the respondents live in rural areas, and about 34% are currently working.

In Figure 3, we plot average hemoglobin levels over the life cycle for women in the two groups, in states with varying cattle slaughter bans. 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 that restrict cattle slaughter as opposed to states that do not.

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

5. Empirical strategies

5.1 Short-term effects on consumption

We first establish that cattle slaughter bans reduced beef intake during the years these bans were introduced. The analysis of long-terms effects of early life exposure often ignores this step, because of data limitations linking long-term analysis with short-term outcomes. To formally study the effects of cattle slaughter bans, we estimated the following differences-in-difference model:

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

where $I(Y_{i,c,s,t} > 0)$ is an indicator variable for consumption Y by person i, belonging to community c, in state s and time t. We control for dummies for bans, beef consuming community, state and year fixed effects, state specific time trends, and cluster the standard error at the state level. Our dependent variable is an indicator variable for consumption of any beef or buffalo meat.[21] Together with the variation by community, we have a triple difference-in-difference-in-difference model. We also estimate a similar triple difference specification as (1) but control for income levels (taking MPCE on all other goods as a proxy).[22]

5.2 Short-term effects on anemia

To examine the corresponding short-term effects of cattle slaughter bans on anemia we estimate the following reduced form equation:

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[21] 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.

[22] 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.

$$Y_{i,c,s,t} = \alpha + \beta_1 \text{Ban}_{c,s,,t} \text{ X Beef Consumer}_{c,s,t} + \beta_2 X_{i,c,s,t} + g(c, t) + U_{i,c,s,t} \quad (4b)$$

where Y is the outcome of interest (Hg levels) for woman i observed in year t from community c and state s. 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 s, at time t (for cohort t) for the treatment community—Muslims, Dalits, and Christians (beef consuming communities) compared to the control community (Hindus, Sikhs, and Jains). One advantage of studying anemia in the short term in addition to beef is that as beef consumption is self reported one may be concerned about reporting bias. However, given that hemoglobin is an objective measure (based on blood samples) it provides further corroborating that bans do indeed have "real" effects on welfare in the short-term.

5.2 Long-term effects on anemia

The following reduced form equation is used to model the long-term impact of cattle slaughter bans:

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

where Y is the outcome of interest (Hg levels, anemia incidence or height) for woman i born in year t belonging to mother m in state *s* and community *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 s at time t (for cohort t) for the treatment sample—Muslims, Dalits, and Christians (beef consuming communities) compared to the control group (Hindus, Sikhs, and Jains), controlling for dummies for bans and beef consuming communities. 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 $X_{i,m,c,s,t}$, 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 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(s,*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 unobservable characteristics 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 observed among less educated and poor women as not only may they 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.

6. Results

Short-term effects of bans on beef consumption

Table 1 shows the short-term effects of cow slaughter ban on the probability of beef consumption and expenditure for all sample and poor sample respectively. Cow slaughter bans are the most pervasive. Beef possession (sale) bans include bans on possession (sales) of beef in addition to cow slaughter bans. In our dataset (see Appendix D), beef possession bans have most variation for the time period 1983- onwards whereas beef sale bans had relatively less variation in this period. Hence, we may expect beef possession bans to be more reliable measure of measures in strictness of bans for the purposes of the short-term analysis.

Panel A shows effects on full sample, whereas Panel B shows effects of bans on poor sample (those whose consumption is less than the 50th percentile of per capita consumption expenditure in any given survey year). We find a statistically significant decline in consumption of any beef consumption in the treatment group. These effects are evident with cattle slaughter bans as well as beef possession bans (stricter bans) and are present in full sample as well as the poor sample.[23] Given that beef sale bans have relatively less variation post-1983, its not surprising that we don't find such effects in this period with beef sale bans. A potential threat to this identification can come if individuals are likely to under-report beef consumption during such bans or from social desirability bias. The NSSO has various mechanisms and checks in place to elicit the correct and impartial response from households.[24]Also, since the NSS reports consumption at

[23] We also found that the monthly per capita consumption expenditure for food items declines significantly for all during ban for our treatment group. However there is not a significant decline in non-food expenditure which perhaps suggests that this decline in beef consumption is not coming through an income effect. Results available upon request.

[24] Atkin et al. (2019) mentions that NSSO enumerators are sent to villages selected at random and survey 10 randomly selected households in that village. Additionally the NSSO randomizes

the household level and not individual level these may be an underestimate for beef consumption for women as typically they get a smaller share compared to men in a patriarchal society- who may also be less affected by bans if they are also more likely to eat outside the household.

Short-term effects of bans on hemoglobin

In addition to the DHS data from 2005-06, we have data on hemoglobin from two other rounds (1998-99 and 2015-16). We use this data to build survey month- year panel which we then merge with data on bans between 1998-99 and 2015-16. Although we are limited to more recent data, if there are significant effects, it supports the hypothesis that bans do indeed have first stage/short-term effects on an objective measure of wellbeing, which is unaffected by concerns about individuals under-reporting their true beef consumption out of fear of being punished in the presence of bans. Furthermore, it is often hypothesized that anemia is an acute condition so the measure may be responsive to immediate/short term changes as well. Table 2 shows that this is indeed the case. We find robust evidence that bans reduce hemoglobin in the short-term across three different types of bans with effects present among everyone as well as those belonging to low SES groups.

Long-term effects of bans

Table 3 shows the effects of two types of bans: cow slaughter bans and beef sale bans. In contrast to short-term analysis (which only had data from 1983-2012 from NSS or from 1998 to 2015 for DHS), the long-term analysis utilizes historic data starting 1956 to 1990. During this period many states introduced cow slaughter bans and beef sale bans for the first time so we have most variation for these two most prevalent bans. There are two models explored for each type of

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between two sets of survey teams, one hired by the NSSO headquarters and one by the state NSSO office to check for discrepancies.

treatment. The odd-numbered columns 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 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 indicates that our results are most applicable to relatively marginalized groups. As shown in Panel A, we find that both 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 years 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 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.

6.1 Alternative bans

Table 1A in the Appendix shows results for hemoglobin for the long-term analysis, but with three alternate bans: bull slaughter bans, buffalo slaughter bans, and beef possession bans.[25] There are very few states that have these laws in

[25] We also cumulated these different ban types to construct ban intensity and found the estimates are much bigger for higher ban intensity on consumption. Results available on request.

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.

6. 2 Alternative outcomes

In Tables 4 and 5, we explore samples and models as in Table 3, 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 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.

As a robustness check, we also tested the effect of the bans on height, a commonly used indicator of health and nutrition status. Results in Tables 2A and 3A show the effects of all five bans on adult height. Although there is some evidence for adverse effects for beef sale bans on height for women in the simple model, these are not present among the most marginalized groups. This is consistent with the conjecture that people are able to substitute alternative sources of protein in their diet (to which height is particularly sensitive), but unable to adequately do so for heme based iron sources given that beef represents a cheap source of heme iron for the beef eating communities and individuals, especially from less educated groups, may not be nutritionally aware about the loss of heme base iron (or its importance) in their diets. Our models for men in Panel B columns 3 show some evidence of a reduction in height in the vanilla model, but this result is not robust to the addition of covariates.

6.3 Putting the effect size into context

Although we are aware of no prior work studying long-term effects of red meat availability on anemia, we can compare our estimate from studies which has explored effects of fetal nutrition on adult anemia and those which provide iron supplements to adults for short-term effects. Ewijk (2011) found that exposure to Ramadan beginning in the second trimester of pregnancy increased the likelihood of anemia by about 9 percentage points. Exposure to Great Chinese Famine increased the likelihood of being anemic by 37 percentage points. The Work and Iron Status Evaluation (WISE) in Indonesia randomly assigned iron supplements to 17,000 Indonesian adults between 30 and 70. WISE found that low Hb women who received a treatment of 120 mg of iron every week for a year had an improvement of 0.2 g/dl which is almost twice the average effect for all female subjects. Our estimates of 1-2.3 g/L (0.1g/dl -0.23 g/dl) are broadly comparable.

6.4 Assessing robustness with an event study analysis

A. Dynamic short-term effects

The results from our above analysis of cattle slaughter bans on red meat consumption using NSS data documents changes in beef consumption due to presence of cattle slaughter in a triple differences framework. There are three reasons to explore alternative specifications for exposure to bans. First, the effects of bans may not be immediate and there maybe lagged effects. Second, one may be concerned about the existence of pre-trends in our analysis over and above inclusion of state specific linear time trends, discussed previously, which may potentially bias our interpretation of causal effects of bans. Third, one may also be interested in understanding what derives variation in our shown estimates and how sensitive our estimates are to inclusion and exclusion of additional group comparisons: To what extent does a double DiD deliver us results and how do these analyses compare with analysis with a fully statured model which can identify a quadruple differences-in difference model by effects of bans across states, time, treatment group and income (poor-to-rich).

To explore this, we estimate an event study model (Generalized DiD). The event study model allows us to explore the timing of cattle slaughter bans exposure more systematically and to evaluate the validity of the research design. In particular, these estimates allow us to explore nonparametrically the relationship between the time at which we first observe bans in our NSS data and the probability of consumption of beef.

We use a variant of model (4) with double differences in differences. Let k be the time at which the ban goes into effect in state *s*, as observed in our NSS data. Then our model is

$$I(Y_{i,s,t} > 0) = Ban_{s,} (t = k + j) + \beta_2 X_{i,s,t} + g(s, t) + U_{i,s,t} (6)$$

Instead of a single treatment effect, we have now also included m leads and q lags of the treatment effect. is the coefficient on the jth lead or lag. A test of the differences in differences assumption is = 0 ∀ j < 0, i.e. the coefficients on all leads of the treatment should be zero. [25]Moreover, treatment effects for j ≥ 0 may not be identical. For example, the effect of the treatment could accumulate over time, so that the effect of bans increases in j. g(s,t) includes terms of state, time, and state special linear time trends. In addition, we control for treatment group and for income (a dummy for per capita expenditures being below the 5th decile). Figure 4 shows results from the event study model with a double DiD and without restricting the sample to poor or treatment group. The dependent variable is an indicator variable for any beef consumption. On the X-axis, we have the leads and lags of ban effects relative to the base year when the ban was introduced for first time in the NSS survey year (T=0 is the base year, and is not shown). We focus on a balanced sample with three survey years observed before and after the bans were introduced.[26] The estimates are depicted with 90% confidence interval.[27] We find that bans reduce the probability of beef consumption by about 6 percentage points, with effects stabilizing thereafter, relative to pre-ban years when no significant effects were found. Figure 5 restricts the sample to the relatively poor and finds a similar story, but shows that the effects of the bans persist in all years after ban. Some of our pre-trend analysis shows positive effects, suggesting that, if anything, the estimates may be biased downwards. So far we have not restricted attention to the treatment sample. Figure 6 conducts a quadruple difference-in-difference where we compare differences in effects of bans across treatment and control groups in poor relative to the rich sample. The figure shows clear evidence that bans reduced beef consumption in post treatment years relative to pretreatment years. Interestingly, the effects appear with a lag (in T +2) and stabilize in magnitude after that (in T +3).[28] Overall, our estimate shows that bans reduce beef consumption and our estimates are robust to exclusion of treatment versus control as a third DiD, and robust to additional conclusion of a fourth difference (by income level) to target a high impact sample. Our estimates also

[26] For the time period under consideration, our estimates for event study for cow slaughter bans are driven by instruction of bans in Delhi and Rajasthan

[27] Results are still robust with 95% CI.

[28] Given the nature of our data, T+1 (and so on) refers to the next survey round data is available from. For instance, if T=0 in 2000, T+1 refers to 2004 round of NSS when the data was next collected and T+2 to 2009 round of the NSS.

show that effects of bans may show after a lag and can persist after the initial introduction. The persistent effects of bans makes more sense in our case also because the nature of the cow slaughter bans in Indian states is such that once they are made law, they are almost never rolled back. [29]

B. Dynamic long-term effects

So far, we have studied the statics and dynamics of the short-term effects of bans on beef consumption. Our results have shown that bans do indeed reduce beef consumption in a robust manner. We now turn to studying how timing of bans in early life affects anemia in the long-term. In general, the early life period from conception to age 5 is considered a critical period in shaping late life well-being. Our DDD model in (5) studies presence of a ban in the year of birth to estimate causal effects but does not tell us exactly when exposure to bans matter—do bans also matter at age 2-3 or can they also impact pregnancy outcome by impacting pre-pregnancy anemia levels of women? The biological and economic literature is not clear on when exposure to early life shocks matters the most, and identifying critical periods in human capital production function is an area where much needs to be learned. Furthermore, the nature of the study of our treatment groups is such that the bans turn on and do not turn off in most cases. Therefore, when a child is treated in their year of birth they are also treated after their birth year. Our DDD estimates, therefore, also reflect exposure beyond birth year, and exploring the timing of impacts may help in interpreting the magnitudes of the effects in (5).

We explore the timing of impacts using an event study model relevant to our cohort design used for long-term effects in (5) and for this we limit attention to our high-impact sample (women who are in their prime, ages 15-35, who have

[29] Goa is one exception, for instance, where bans were rolled back. Given the limited set(s) of states which rolled back, there wasn't much variation to apply for DDD model to evaluate rollback

not completed primary schooling as the treated group of beef eating communities). We limit our analysis to women, given that we found negligible effects of bans on men in our DDD analysis. Our approach for long-term analysis is similar to Hoynes et al. (2016), who study long-term effects of food stamps in US using a cohort design similar to ours where the food stamps also never turn off once they are turned on. Specifically, we allow for the impact of cow slaughter bans to vary with the age at ban introduction in their state of birth. For example, individuals born in 1980 in a state that implemented a cow slaughter ban in 1985 would have an event time of 5. They would have event time of −5 if a ban was implemented in their state in 1975 (and thus they were exposed during their entire childhood).

We estimate a version of model (5) where the treatment effect is replaced with a series of dummies based on two-year intervals of age at cow slaughter ban introduction (e.g., age -2 to -1, 0 to 1, 2 to 3, and so on) with those older than 5 years of age at time of ban serving as the base year. The end points are open brackets (5 or more years prior to birth on the left, age 6 or later on the right). We choose 6 or more years as omitted category to highlight the relative importance of bans in any time during early life and pre-conception relative to anytime after 5 years. The collapsing of years into bins of 2 or more helps reduce the collinearity between event time and birth year (Hoynes et al., 2016; Kline, 2012). We present results in Figure 7.[30] The figure is the reverse of a typical event study graph (as was shown for the short-term effects of cow slaughter bans) with negative "event time" signifying the case where a person was fully treated (i.e. the ban was in place in their state prior to birth). Further, treatment (exposure to the

[30] Following Hoynes et al. (2016) we show point estimates from our regressions. The confidence intervals for some values (those at the tail) are too large to see the overall pattern and hence the decision to show point estimates. Figures with confidence intervals are available upon request.

ban) increases as we move from the right (treated in later life) to the left (treated in early life). Finally, as we have said before, once the treatment turns on, it does not turn off.

While we do not have a strong prior assumption about the precise shape of the treatment effects, our hypothesis is that the effects of bans in early life (before the 6th birthday) should be more negative than if the bans were experienced later in life. Within the early childhood period, we expect the first 1,000 days of life to be particularly important, especially from conception to age 2. Our DDD estimation in (5) implicitly assumes that the time after birth may not matter as much, and would treat children both exposed to bans in year of birth but exposed in second year of life as controls. To the extent that the age 2-3 years also matters, our DDD may be biased downwards.

The results in Figure 7 are consistent with our hypothesis and encouraging for our research design. They show that relative to bans arriving after 5 years of age, bans in early life reduce hemoglobin among women in our high impact sample (the fact that most values are negative and below zero). Consistent with importance of ages 2-3 and before, bans at ages 4-5 have similar effects as those after age 5. The bans have generally lower values the further left one goes, suggesting early exposure matters more. The bans are most impactful in the year of birth, but also impactful, to a lesser extent, later at age 2-3. Interestingly, we observe that 2-3 years before birth we find a somewhat lesser effect of the bans instead of the effects flattening out. This may reflect the fact that those cases are not only exposed in utero but also exposed in a period relatively less critical than birth so that the average effects of exposure in those periods may be somewhat less.

7. Discussion & conclusion

Cow slaughter is an extremely sensitive issue in India, and religious sentiments are powerful enough that overturning these state-level bans is probably not feasible. However, the severity of anemia among Indian women as a public health issue and its dire consequences mean that alternative measures to supplement nutritional deficiencies, particularly for low-SES groups, are essential. Some studies show that 6% of GDP per capita is lost in India due to iron deficiency (Horton & Ross 2003).

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 & 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 compiling a new dataset on cattle slaughter bans in India to study the short and long-term effects of bans on consumption and health outcomes. We document that "beef bans" have increased in their prevalence and strictness overtime and there are very few cases of states rolling them back (e.g. Goa). This finding itself is not trivial in the sense that a legal ban reduces the right to certain food groups which may be an intrinsic part of someone's social identity. Given the enormous cultural and ethnic diversity in India- imposition of such legal bans affect the available choice set of an individual and the right to express her social identity through what they eat.

We find that beef bans reduce beef consumption for the Muslims, Christians and scheduled caste Hindus. Furthermore, we find that bans actually reduce hemoglobin among women in these communities in the short-term. Our analysis provides strong evidence of first stage effects from two different data sources (NSS and DHS) using a self reported (beef consumption) and a blood sample based (hemoglobin) measure. We further look at the effect of these disruptions during the perinatal period on the later life prevalence of anemia. Our analysis 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 those who have no schooling. The impact 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.

This paper not only helps us get a better understanding of cow slaughter bans, 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 origins hypothesis which focused on rare and extreme shocks such as famines and wars. Our event study analysis reveals that the effect of cattle slaughter bans are most pronounced for those of age 3 or less relative to those who experience these bans after 5 years of age, with the highest impact for those exposed around birth. These findings contribute to our understanding of critical periods in production of anemia later in life in a low income and anemic population of women.

Our analysis measures the reduced-form effect on anemia of exposure to cattle slaughter bans. Our estimates are arguably lower bounds if we take into account the small fraction of upper caste Hindus, Sikhs and Jains who also consume beef. Furthermore, there are possible general equilibrium effects coming from cross-price effects on related goods. For example, if the price of milk goes up during ban it can affect the control group in question resulting in attenuation bias in our long run health estimates. To the extent that people are able to substitute other nutritious foods for beef, our estimates of long-term effects on anemia may have been higher in the absence of such substitution patterns.

Future research needs to carefully study these general equilibrium effects and the nutritional content of any alternative diets. Our estimates of effects of beef intake may be biased as well, to the extent that the effects are driven by income changes. For instance all those working as butchers, or in the dairy or leather industries may be affected. To the extent that such general equilibrium effects also affect the non-beef eating communities, our estimates will not be biased. Furthermore, we are able to test directly for such effects by controlling for sector of work and income of households in our estimations, using household level data. Our estimates don't change with or without these controls, suggesting that income or sector of work is not driving the impact of bans on beef consumption. Nonetheless, exploring how cattle slaughter bans affect the market for cattle, how they affect consumption of different diets, and exploring the precise mechanisms through which early-life exposure to cattle slaughter mediates the long-term effects we document remain open questions for future research. An exciting path for research on the hemoglobin production function lies ahead with implications for our broader understanding of the complex links between early childhood, food, diets, socio-cultural norms, legislation, and well-being over the life course of individuals as well as the well-being of societies.

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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 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 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 S3a: Summary statistics for monthly per capita consumption

	Control	Treatment	Total
Beef	0.00649	0.246	0.109
	(0.0803)	(0.431)	(0.312)
Goat Meat	0.239	0.241	0.240
	(0.426)	(0.428)	(0.427)
Eggs	0.261	0.416	0.328
	(0.439)	(0.493)	(0.469)
Milk	0.791	0.628	0.721
	(0.406)	(0.483)	(0.448)
Dairy Products	0.346	0.247	0.304
	(0.476)	(0.431)	(0.460)
Spinach & Other Leafy	0.664	0.678	0.670
Vegetables	(0.472)	(0.467)	(0.470)
Pork	0.00684	0.0981	0.0459
	(0.0824)	(0.298)	(0.209)
Observations			572676

Note: The above shows mean followed by standard devotion in parenthesis. Treatment refers to beef eaters and control to non-beef eating groups. All variables are dummies of 1 if an individual consumes that any quantity of that food and 0 if they do not consume the food in question at all.

Table S3b: Summary statistics for monthly per capita consumption (Poor)

	Control	Treatment	Total
Beef	0.00642	0.216	0.117
	(0.0799)	(0.412)	(0.321)
Goat meat	0.197	0.196	0.196
	(0.398)	(0.397)	(0.397)
Eggs	0.195	0.339	0.271
	(0.396)	(0.474)	(0.444)
Milk	0.691	0.574	0.630
	(0.462)	(0.495)	(0.483)
Dairy product	0.202	0.159	0.180
	(0.402)	(0.366)	(0.384)
Palak	0.661	0.675	0.669
	(0.473)	(0.468)	(0.471)
Pork	0.00861	0.0560	0.0335
	(0.0924)	(0.230)	(0.180)
Observations			286266

Note: The above shows mean followed by standard devotion in parenthesis. Treatment refers to beef eaters and control to non-beef eating groups. All variables are dummies of 1 if an individual consumes that any quantity of that food and 0 if they do not consume the food in question at all. Sample restricted to poor households. Poor are defined as those who are in the lowest 50^{th} percentile of the per capita expenditure estimates in the survey round

Table 1.

Panel A: Short term Effects of Cow slaughter Ban on Consumption (for all)

VARIABLES	(1) Beef	(2) Beef	(3) Beef
Cow Slaughter Ban X Beef Consuming Group	-0.1131 (0.043)		
Beef Sale Ban X Beef Consumer Group		-0.0772 (0.058)	
Beef Possession Ban X Beef Consumer Group			-0.1499 (0.024)
Observations	572,676	572,676	572,676
R-squared	0.275	0.273	0.274

Panel B: Short term Effects of Cow slaughter Ban on Beef Consumption (poor sample)

Cow Slaughter Ban X Beef Consuming Group	-0.0747 (0.039)		
Beef Sale Ban X Beef Consumer Group		-0.0631 (0.057)	
Beef Possession Ban X Beef Consumer Group			-0.1485 (0.025)
Observations	286,266	286,266	286,266
R-squared	0.215	0.215	0.217

Notes: Robust standard errors in parentheses. The table shows results for effects of cattle slaughter ban, beef sale ban and beef possession on dummy for cow meat and buffalo meat consumption in for all sample and poor sample respectively. This dummy variable takes the value as 1 if the per capita consumption of beef (in kilograms) is greater than 0 and takes value as 0 if the per capita consumption of beef (in kilograms) is 0. The treatment group is all Muslims, all Christians, scheduled caste and scheduled tribes, while the control group is upper caste Hindus, Jains and Sikhs. 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 and 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. We have dropped the state Jammu and Kashmir from our analysis.

Table 2: Short-term effects of Bans on Hemoglobin

	(1)	(2)	(3)	(4)	(5)	(6)
	Hb	Hb	Hb	Hb	Hb	Hb
Cow Slaughter Ban X Beef Consumer	-1.607	-2.511				
	(0.536)	(0.939)				
Beef Sale Ban X Beef Consumer			-1.179	-1.042		
			(0.562)	(0.501)		
Beef Possession Ban X Beef Consumer					-1.120	-2.330
					(0.642)	(1.069)
Observations	776,719	132,644	615,743	99,534	309,333	50,521
R-squared	0.054	0.070	0.057	0.069	0.0620	0.0754

Note: Robust standard errors in parentheses. The table shows short-term contemporaneous results for effects on hemoglobin for women from pooled DHS sample (1998-99, 2005-06 and 2015-16 waves). This includes models from three different treatments: cow slaughter bans, beef sale bans and beef possession bans. The odd columns (1,3,5) show results for basic specification and estimates for difference in differences by treatment group and law, with state year and month fixed effects. The even columns control 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. The pooled DHS data for this purpose was taken from IPUMS to ensure comparability of regions and variables across survey rounds. Due to changes in state boundaries and definitions across survey years, it may be possible that banned and non-banned regions are combined into onto one region/state by IPUMS for purposes of harmonizing data across survey rounds. This led to some cases where IPUMS defined "state" had values of bans to be between 0 and 1 which we dropped for our analysis for consistency/ease of interpretation across analyses from other analyses in our paper. Results without dropping cases with bans between 0-1 values available upon request.

Table 3: Long term Effects of Cattle Slaughter Bans on Hemoglobin

Panel A: Women

	(1)	(2)	(3)	(4)
	Hb	Hb	Hb	Hb
Cow Slaughter Ban X Beef Consumer	-1.087 (0.579)	-1.540 (0.822)		
Beef Sale Ban X Beef Consumer			-1.260 (0.562)	-2.341 (0.501)
Observations	93,376	18,854	93,376	18,854
R-squared	0.039	0.069	0.039	0.069

Panel B: Men

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

Note: Robust standard errors in parentheses. 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 two different models from two different treatments: cow slaughter bans, and beef sale bans. The odd columns (1,3) show results for basic specification and estimates for difference-in-differences by treatment group and law, with state year and month fixed effects. In addition, even columns in Panel A (women) control 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. Sample is also restricted to fathers without education.

Table 4: Long term Effects of Cattle slaughter Bans on Likelihood of Being Anemic

Panel A: Women

	(1)	(2)	(3)	(4)
VARIABLES	Anemic	Anemic	Anemic	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)
Observations	93,376	18,854	93,376	18,854
R-squared	0.036	0.057	0.036	0.057

Panel B: Men

	(1)	(2)	(3)	(4)
VARIABLES	Anemic	Anemic	Anemic	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)
Observations	55,943	10,309	55,943	10,309
R-squared	0.018	0.042	0.018	0.042

Note: Robust standard errors in parentheses. 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 two different models from two different treatments: cow slaughter bans, and beef sale bans. The odd columns (1,3) 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. Sample is also restricted to fathers without education.

Table 5: Long term Effects of Cattle Slaughter Bans on Likelihood of Being Severely Anemic

Panel A: Women

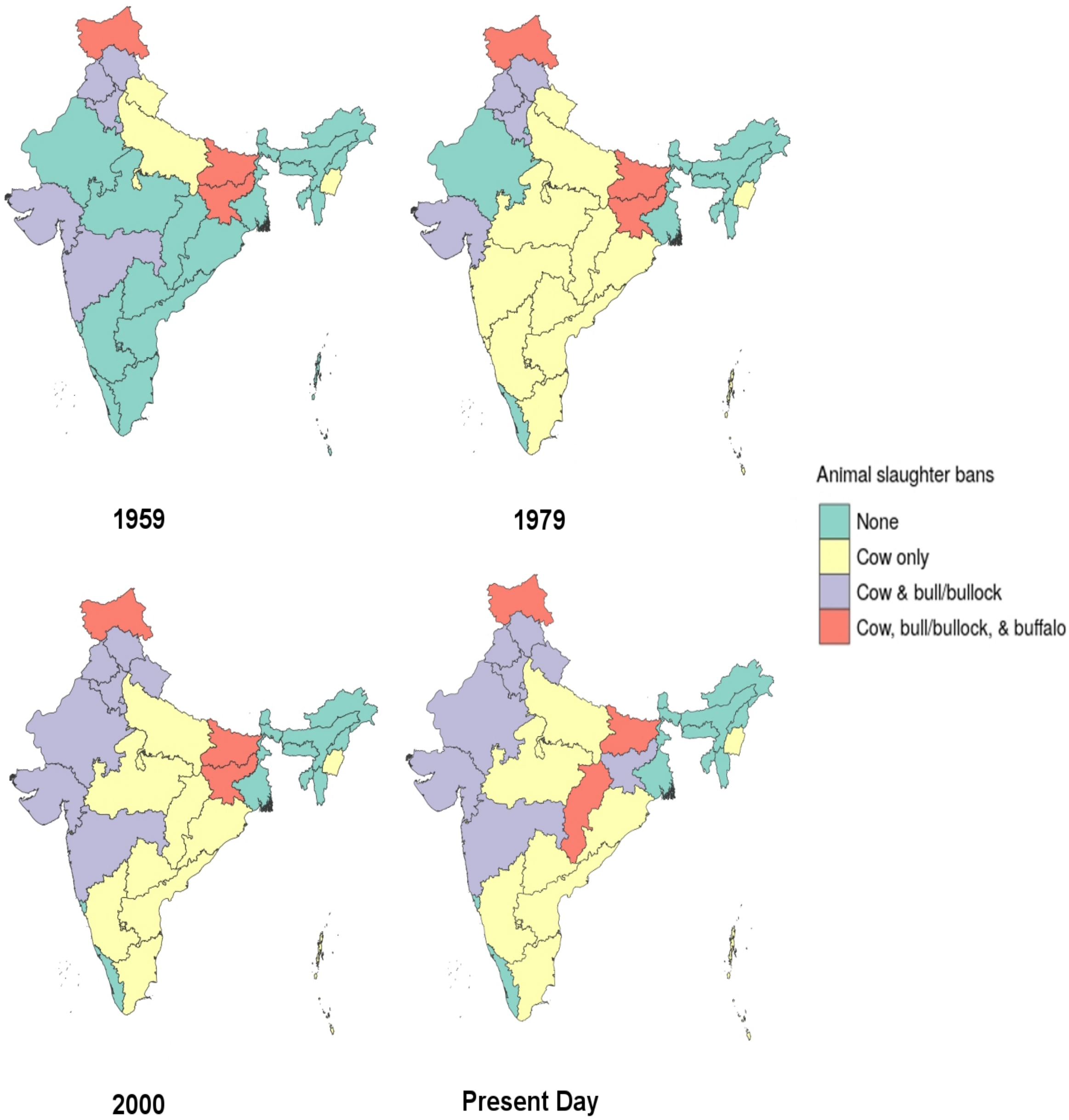
	(1)	(2)	(3)	(4)
VARIABLES	Severely Anemic	Severely Anemic	Severely Anemic	Severely Anemic
Cow Slaughter X	0.008	0.009		
Beef Consumer	(0.004)	(0.005)		
Beef Sale Ban X			0.006	0.006
Beef Consumer			(0.004)	(0.005)
Observations	93,376	18,854	93,376	18,854
R-squared	0.006	0.013	0.006	0.013

Panel B: Men

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

Note: Robust standard errors in parentheses. 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 two different models from two different treatments: cow slaughter bans and beef sale bans. The odd columns show results for basic specification and estimates for difference in differences by treatment group and law, with state year and month fixed effects. In addition, even columns in Panel A control 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. Sample is also restricted to fathers without education

FIGURES



1959
1979
2000
Present Day
Animal slaughter bans
None
Cow only
Cow & bull/bullock
Cow, bull/bullock, & buffalo

FIGURE 1: Summary of cattle slaughter bans as of January 1959, 1979, 2000, and present day (2012). Note: In 1959, Tamil Nadu permitted slaughter of cows if they were unproductive and had a "fit-for-slaughter" certificate. Source: Authors.

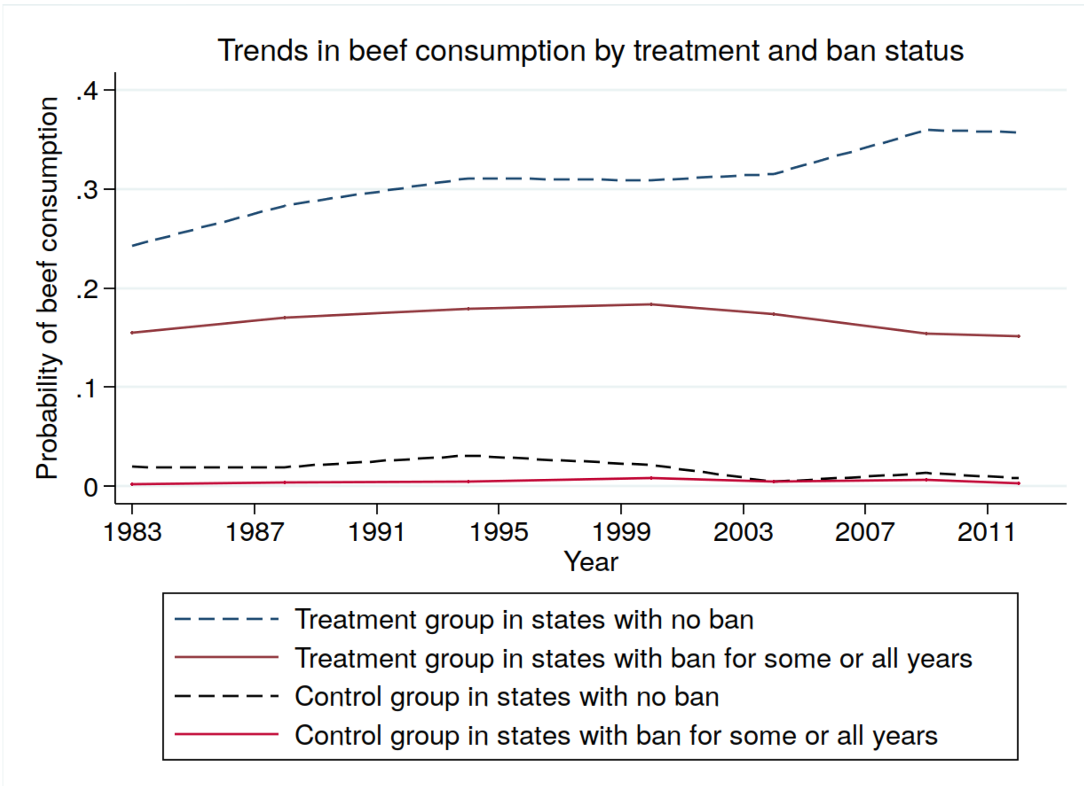


FIGURE 2: Trends in beef consumption for poor (those in below 5th decile of marginal per capita consumption). Source: Authors.

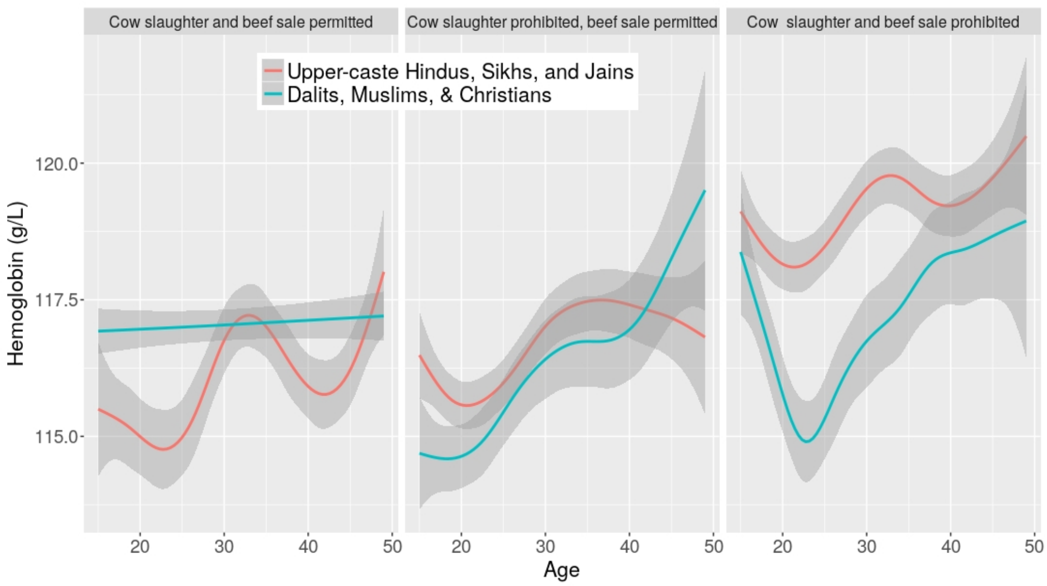


FIGURE 3 Average hemoglobin levels for women, by age, community, and presence of cattle slaughter restrictions in state of residence. Shaded area represents the 95% confidence interval. Source: Authors.

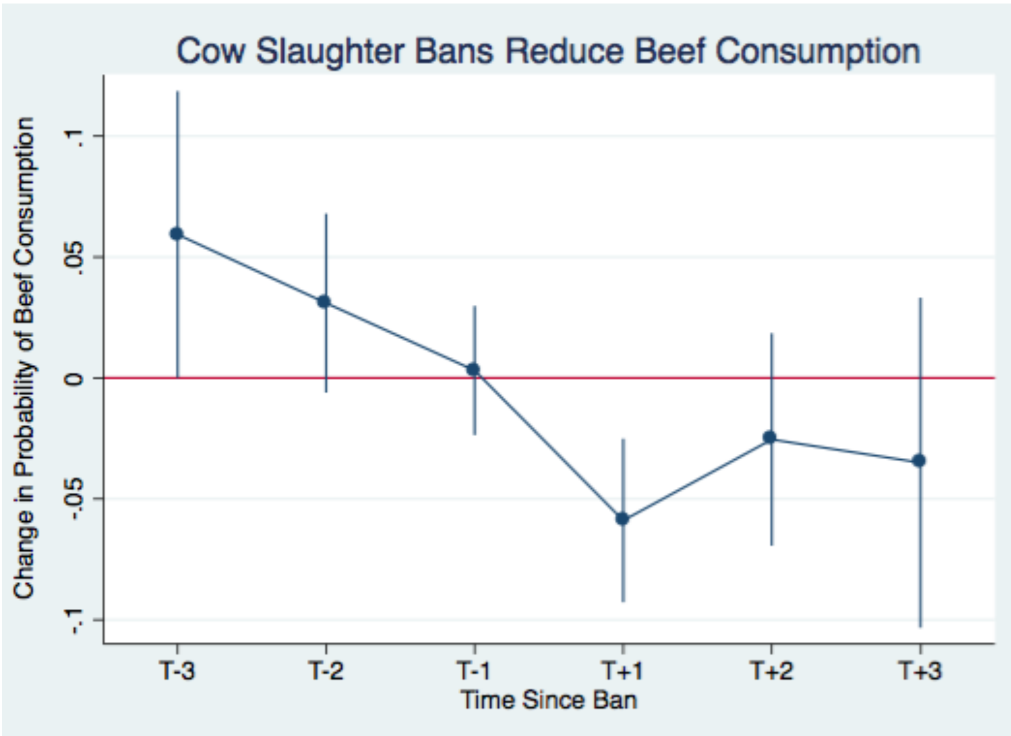


FIGURE 4: We show estimates of a double DID with state specific linear trends, but without restricting the sample to poor or treatment group. Dependent variable is a dummy for any beef consumption and on x-axis we have the leads and lags of ban effects relative to the base year when ban was introduced for first time (T=0 is the base year and is not shown) in the NSS survey year. We focus on a balanced sample with 3 survey years observed before and after the bans were introduced. The estimates show 90% confidence intervals. Source: Authors.

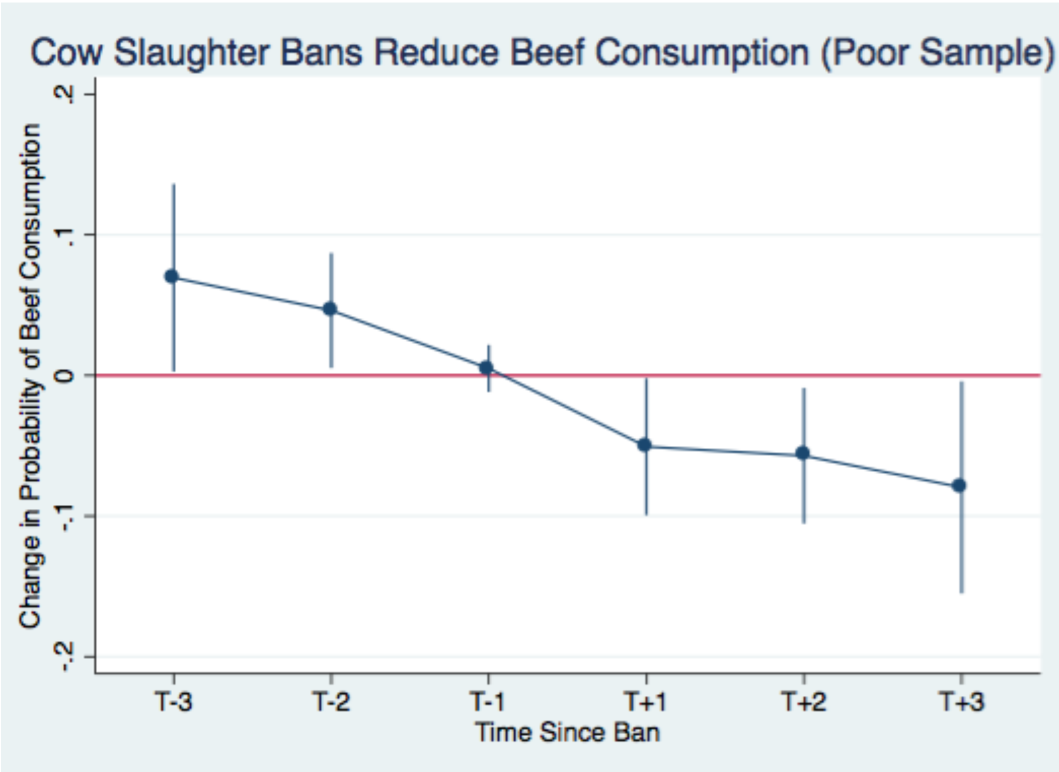


FIGURE 5: We show estimates of a double DID with state specific linear trends, restricting the sample to poor but without any restrictions on treatment group status. Dependent variable is a dummy for any beef consumption and on x-axis we have the leads and lags of ban effects relative to the base year when ban was introduced for first time in the NSS survey year (T=0 is the base year and is not shown). We focus on a balanced sample with three survey years observed before and after the bans were introduced. The estimates show 90% confidence intervals. Source: Authors.

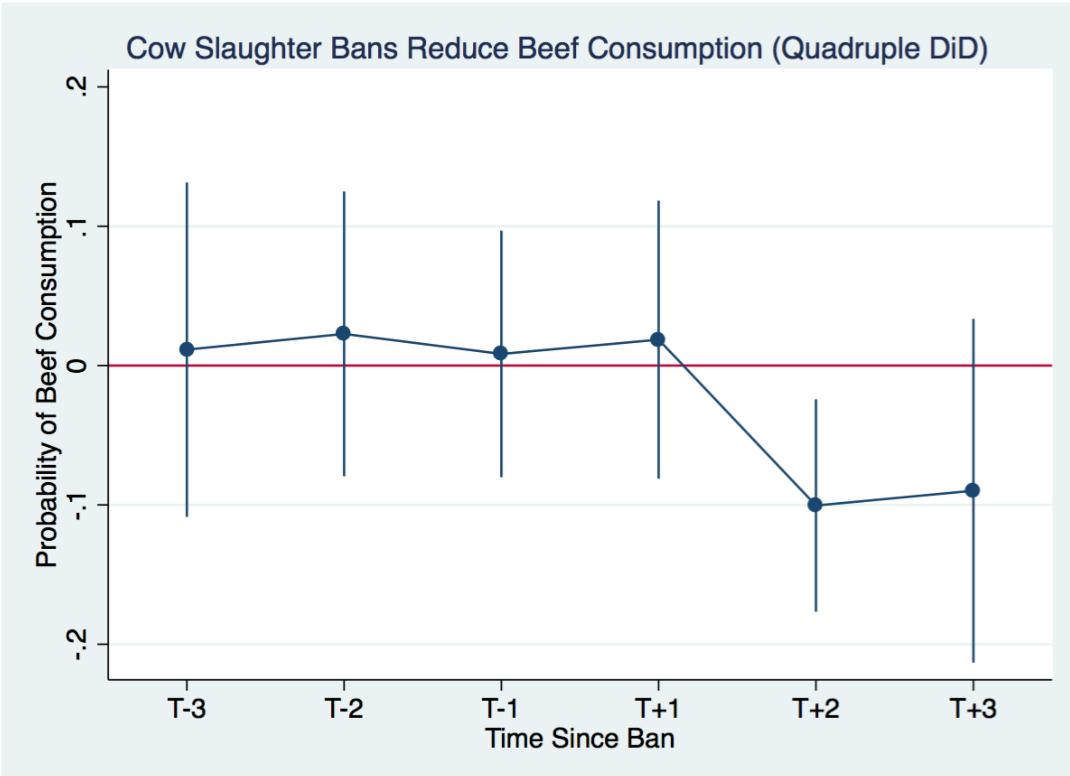


FIGURE 6: We show estimates of a quadruple DID with state specific linear trends. These models fully interact states with cow slaughter bans to those with no bans with event time, income (dummy for poor) and treatment/control group status. Dependent variable is a dummy for any beef consumption and on x-axis we have the leads and lags of ban effects relative to the base year when ban was introduced for first time (T=0 is the base year and is not shown) in the NSS survey year. We focus on a balanced sample with three survey years observed before and after the bans were introduced. The estimates show 90% confidence intervals. Source: Authors.

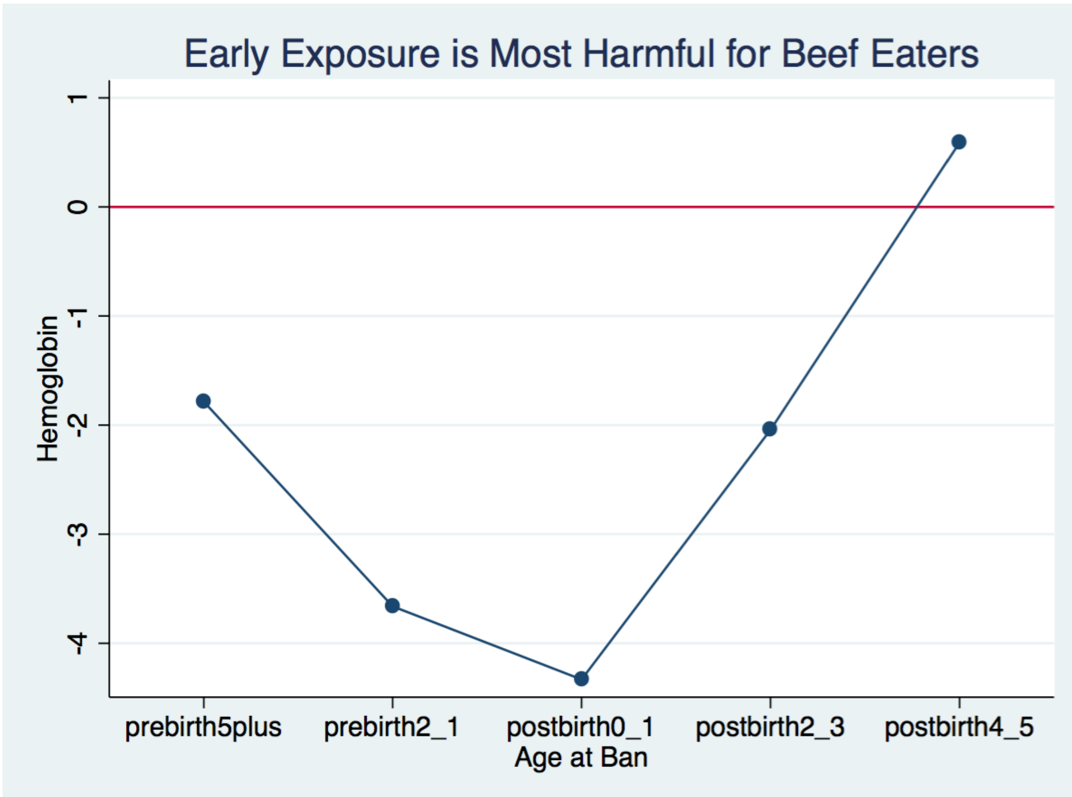


FIGURE 7: The figure plots coefficients from an event study analysis for long-term effects on hemoglobin. Event time is defined as age when cow slaughter bans are first introduced in one's state. We control for year of birth and state fixed defects, state specific time trends, age, age squared, urban, total births ever, whether currently pregnant, and dummies for the wealth index. In addition, the samples are restricted to those in prime age (15-35) and those with no education and those who are in treatment group/beef eating groups. Age groups older than 5 years are the reference category. Analysis is restricted to states which witness a new ban being introduced for the years in our sample and at least 7 years of data before and after bans in each state in our sample to allow for a balanced sample. See the text for further description of the model. Source: Authors.

For Online Publication

APPENDIX A: TABLES

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

Panel A: Women

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Hb	Hb	Hb	Hb	Hb	Hb
Bull Slaughter Ban X Beef Consumer	-0.895	-0.535				
	(0.584)	(0.886)				
Buffalo Slaughter Ban X Beef Consumer			-0.960	-0.418		
			(0.315)	(0.446)		
Beef Possession Ban X Beef Consumer					-1.325	-1.291
					(0.326)	(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

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Hb	Hb	Hb	Hb	Hb	Hb
Bull Slaughter Ban X Beef Consumer	-1.376	-1.492				
	(0.796)	(0.929)				
Buffalo Slaughter Ban X Beef Consumer			-2.892	-2.336		
			(0.389)	(0.881)		
Beef Possession Ban X Beef Consumer					0.562	0.280
					(1.107)	(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..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 two 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. In addition, even columns in Panel A (women) control 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. Sample is also restricted to fathers without education.

	(1)	(2)	(3)	(4)
VARIABLES	Height	Height	Height	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)
Observations	60,677	11,058	60,677	11,058
R-squared	0.071	0.085	0.071	0.085

Table 2A: Effects of Cattle Slaughter Bans on Adult Height

Panel A: Women

	(1)	(2)	(3)	(4)
VARIABLES	Height	Height	Height	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)
Observations	99,071	19,730	99,071	19,730
R-squared	0.054	0.079	0.053	0.079

Panel B: Men

Note: Robust standard errors in parentheses. 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 two different models from two different treatments: cow slaughter bans and beef sale bans. The odd columns 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. Sample is also restricted to fathers without education.

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

Panel A: Women

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Height	Height	Height	Height	Height	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

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Height	Height	Height	Height	Height	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. 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 two 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. In addition, even columns in Panel A (women) control 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. Sample is also 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 Dayanand Saraswati, the founder of the AryaSamaj, 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 against 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 the following: 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, which 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, which 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, and 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 withstand 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, 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.

APPENDIX D

State	Date law took effect	Cow slaughter ban	Bull slaughter ban	Buffalo slaughter ban	Beef sale ban	Beef possession ban
Andaman and Nicobar	1/25/1967	Yes	No	No	No	No
Andhra Pradesh	12/19/1976	Yes	No	No	No	No
Bihar	1/11/1956	Yes	Yes	Yes	No	No
Chandigarh	6/27/1956	Yes	Yes	No	Yes	No
Chhattisgarh	8/7/1959	Yes	No	No	Yes	Yes
Chhattisgarh	9/11/2006	Yes	Yes	Yes	No	Yes

Dadra and Nagar Haveli	6/21/1978	Yes	No	No	Yes	No
Daman and Diu	6/21/1978	Yes	No	No	Yes	No
Goa	6/21/1978	Yes	No	No	Yes	No
Goa	7/11/1996	No	No	No	No	No
Gujarat*	12/14/1954	Yes	Yes	No	No	No
Gujarat	5/6/1961	Yes	Yes	No	No	No
Gujarat	10/17/1979	Yes	No	No	No	No
Gujarat	3/15/1994	Yes	Yes	No	No	No
Gujarat	10/24/2011	Yes	Yes	No	No	No
Haryana	6/27/1956	Yes	Yes	No	Yes	No
Haryana	11/19/2015	Yes	Yes	No	Yes	Yes
Himachal Pradesh	6/27/1956	Yes	Yes	No	Yes	No
Himachal Pradesh	6/8/1979	Yes	Yes	No	Yes	No
Jharkhand	1/11/1956	Yes	Yes	Yes	No	No
Jharkhand	12/7/2005	Yes	Yes	No	Yes	Yes
Karnataka	8/14/1964	Yes	No	No	No	No
Madhya Pradesh	8/7/1959	Yes	No	No	Yes	Yes
Maharashtra*	12/14/1954	Yes	Yes	No	No	No
Maharashtra	3/1/1977	Yes	No	No	No	No
Maharashtra	3/4/2015	Yes	Yes	No	Yes	Yes
Manipur	1936	Yes	No	No	No	No
NCT of Delhi	4/15/1994	Yes	Yes	No	No	No
Odisha	2/2/1961	Yes	No	No	No	No
Puducherry	7/1/1969	Yes	No	No	Yes	Yes
Punjab	6/27/1956	Yes	Yes	No	Yes	No
Rajasthan	8/24/1995	Yes	Yes	No	Yes	Yes
Tamil Nadu	4/28/1958	No	No	No	No	No
Tamil Nadu	8/30/1976	Yes	No	No	No	No
Telangana	12/19/1976	Yes	No	No	No	No
Uttar Pradesh	1955	Yes	No	No	Yes	No
UttarPradesh**	11/12/2002	Yes	No	No	Yes	No
Uttarakhand	1955	Yes	No	No	Yes	No
Uttarakhand	11/12/2002	Yes	No	No	Yes	No
Uttarakhand	7/19/2007	Yes	Yes	No	Yes	No

Notes: * Refers to the Bombay Animal Preservation Act; ** New legislation increased penalties, States with no bans: Arunachal Pradesh, Assam, Kerala, Lakshadweep, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, West Bengal.