The nutritional cost of beef bans in India[1]

Aparajita Dasgupta[2] Farhan Majid[3] Wafa Hakim Orman[4]

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Abstract

Beef is a rich source of heme iron and one of its cheapest sources in India. We use the state-level rollout of beef possession and sale bans as a natural experiment to study the health consequences of formalizing a religious restriction as law. Leveraging the intertemporal and spatial variation in these bans we invoke a triple difference-in-differences estimation framework and compare women's hemoglobin levels in groups that traditionally eat beef—Muslims, Christians, and lower-caste Hindus—with those in groups that do not. We find that bans reduce women's hemoglobin in beef-eating communities by 3 mg/dl and increase severe anemia by 27 percent.

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[2] Department of Economics, Ashoka University. Email: aparajita.dasgupta@ashoka.edu.in

[3] IMPAQ International, Columbia, MD 21044, USA. Email: fmajid@impaqint.com

[4] Department of Economics, Accounting, & Finance, University of Alabama in Huntsville, Huntsville, AL 35899. Email: wafa.orman@uah.edu.

Diet is a fundamental determinant of human health but identifying the effects of dietary norms is empirically challenging because individuals who follow certain cultural norms may be different in various unobservable ways from those who do not. Cultural practices are also persistent over time; therefore, it is harder to econometrically exploit the time variation in cultural practices. Furthermore, there may be bundling—people may collectively follow a wide array of dietary norms—and so isolating the effects of a specific dietary norm can be difficult.

In this paper we make use of a natural experiment arising from state regulations that ban the sale or possession of beef—to study the effects of beef bans on women's health. The primary outcome of interest in our study is anemia, among Indian women, in their prime reproductive age. We hypothesize that bans on the possession or sale of beef—one of the cheapest sources of iron—lead to an increase in the rate of anemia among women in groups that traditionally consume beef. We find that these bans are associated with lower hemoglobin and a higher incidence of moderate and severe anemia.

Our study contributes to a deeper understanding of how state regulation or favoritism in religious markets may shape population health and development. By showing that policy has the power to affect anemia, our paper contributes to the larger debate over policies to reduce anemia. Furthermore, our analysis contributes to the larger debate on links between the consumption of red meat in a developing country and health, which has not seen much analysis in a causal framework (Johnston et al. 2019).

Our work is broadly related to the literature on the role and development of institutions (Glaeser and Shleifer 2002; La Porta et al. 1997; Acemoglu and Johnson 2005; La Porta, Lopez-de-Silanes, and Shleifer 2008). Our work is also close to recent work on Ramadan fasting and its unintended costs on society (Almond and

Mazumder 2011; Campante and Yanagizawa-Drott 2015; van Ewijk 2015; Majid 2015); how the cultural norms of Indian migrants generate nutritional costs (Atkin 2013); and the effects of the relaxations of the Catholic Church's prohibition on meat consumption on Fridays (Bell 1968).

I. Background

Many major world religions forbid the consumption of certain types of food.[5] The Hindu faith reveres cows as sacred. Most Indian religious and ethnic groups—Jains, Sikhs, and upper-caste Hindus—prohibit the consumption of beef. Since India won independence from the British in 1947, several states have banned cattle slaughter. Most of these bans were enacted between 1950 and 1980. At present, cow slaughter is banned in twenty of the twenty-nine states and, since the 1980s, legislation has focused on increasing the strictness of these bans—some states have banned the *possession or sale* of beef in addition to banning the slaughter of cows.

Beef is one of the richest sources of dietary iron, however. In India it is cheaper than chicken, goat meat, mutton, or pork, and it is also one of the *cheapest* sources of iron in the diets of groups that traditionally consume beef—Muslims, Christians, and lower-caste Hindus (also known as Dalits or Scheduled Castes). The iron in beef is part of a molecule called heme, which the human body absorbs more readily than other forms of iron, such as those present in

[5]Judaism prescribes a strict set of rules, called Kashrut, regarding what may and may not be eaten. Islam has similar laws, dividing foods into haram (forbidden) and halal (permitted). For over a thousand years, the Catholic Church required its members to abstain from meat on Fridays (Bell 1968). Hindu sacred texts prescribe the avoidance of beef consumption. 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 (Ambedkar 1948). Some Hindus apply the concept of ahimsa (non-violence) to their diet; they consider vegetarianism as ideal and practice forms of vegetarianism.

plant-based diets.[6] Indian foods are not typically fortified with iron. The population has little access to iron supplements. Wheat and rice, which dominate the normal Indian diet, inhibit the absorption of iron (Deaton and Drèze 2009). Poor absorption of iron results in iron deficiency, the leading cause of anemia.

Iron-deficiency anemia can cause fatigue, impair cognition, and lower work capacity, particularly among women of reproductive age, who experience excessive blood loss during menstruation, pregnancy, and childbirth. Anemia affects a third of the world's population (Chaparro et al. 2019). Its prevalence is highest in sub-Saharan Africa and South Asia, across all age groups. About 18 percent of pregnant women in the US are iron-deficient, and nearly 20 percent of Black and Mexican American women suffer from iron-deficiency anemia. India has the highest prevalence of anemia in the world (Stevens et al. 2013) and the largest number of anemic women; about 300 million women, or half of all Indian women, suffer from anemia (Balarajan et al. 2013). Iron-deficiency anemia is estimated to cause 40 percent of maternal deaths in India, directly or indirectly, and lead to a 6-percent loss in GDP per capita (Anand et al. 2014). To address the high burden of anemia, the World Health Assembly set the target of reducing anemia by half among women of reproductive age by 2025 relative to 2010 levels. The Sustainable Development Goals (SDG) aim to reduce the different forms of malnutrition, including anemia.

The literature on evaluating the success of interventions that intend to reduce anemia is sizable. Two strategies are commonly used to combat iron deficiency: iron supplementation and food fortification. Iron supplements are effective (Thomas et al. 2006; Chong et al. 2016) but they are expensive and suffer from poor compliance, especially among the low-income population (Diosady et al. 2019). In contrast, food fortification is an inexpensive

[6]The rate of absorption of a given iron content is higher for red meat (15–40 percent) than vegetarian diets (1–15 percent). Dietitians recommend that vegetarians consume ~80 percent more dietary iron than meat eaters.

intervention but programs, which rarely reach the poorest consistently, have shown mixed results (Banerjee, Barnhardt, and Duflo 2018; Karemer et al. 2020). Iron-deficiency anemia is a major public health challenge in India, but the role of iron and folic acid intervention in addressing its burden is limited, find Rai et al. (2018); instead, the study suggests that dietary diversification may potentially address iron-deficiency anemia.

The literature on the importance of religion and culture in economics is growing (Pande and Udry 2005; Guiso, Sapienza, and Zingales 2006; Fernández 2011; Alesina and Giuliano 2015; Iyer 2016; Page and Pande 2018; Kuran 2018; Roland 2020), as is the literature on the role of economic costs in social identity, as manifested through food choices (Atkin et al. 2021), and in the context of health or development (Jayachandran and Pande 2017; Becker and Woessmann 2011; Fruehwirth, Iyer, and Zhang 2019). But this line of work has not been studied at the micro or individual level—to the best of our knowledge—nor has it been studied how state favoritism of religion may have health or nutritional costs. By exploiting a unique natural experiment, we examine how the beef ban affects women of reproductive age in a country with a high incidence of anemia.

II. Data and Empirical framework

We collect and assemble legislation from 26 Indian states in both Hindi and English, along with federal documents, to compile a historical state-level panel data set on legislation banning the slaughter of cattle and the sale or possession of beef.

A Beef Bans

We compile a rich panel data set on cattle slaughter, and on the ban on the sale and possession of beef, between 1950 and 2016 by state and month-year (for the historical context of the bans, and for the details of the construction of the data set, please see the Data Appendix). Focusing on the more recent laws enables us to identify the contemporaneous variations between 1998 and 2016, our sample period, in a unique natural experiment. Intertemporal and spatial variations in these laws enable us to compare the hemoglobin levels of women in groups that consume beef with those in groups that do not consume beef, invoking a triple difference-in-differences estimation framework.

We use the relevant subsets of the period based on the availability of biomarker data from the Demographic and Health Survey (DHS)—nationally representative household surveys 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).

We use the data on beef consumption from the National Sample Survey (NSS) to study the mechanisms through changes in the consumption patterns of beef, and of some of its close substitutes, using the seven thick rounds of consumption expenditure from the NSS from 1983 to 2012.

Figure 1: State-level variation in beef bans, 1998–2015

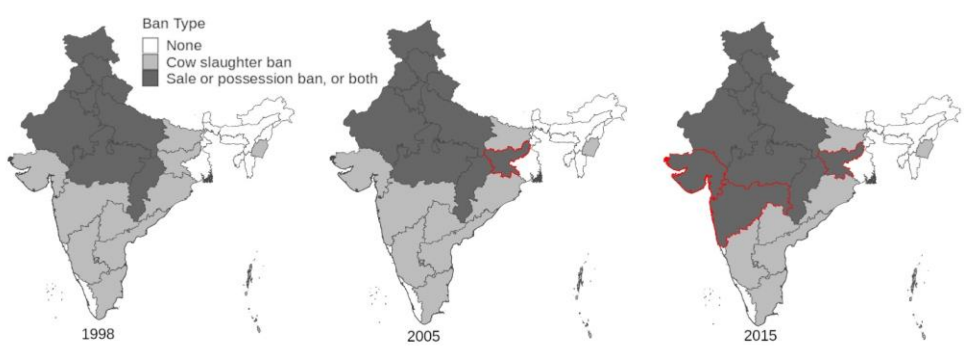

Figure 1 maps the status of state-level laws on slaughter bans and beef bans in 1998, 2005, and 2015. We focus on the period between 1998 and 2015 because biomarker data in the DHS is available only for this period. States that ban cow slaughter are colored medium gray; states that ban the possession or sale of beef are colored dark gray. If there were changes in the bans between 1998 and 2015—as in Jharkhand (2005), Gujarat (2011), and Maharashtra (2015)—the state boundaries are colored red. There was spatial variation, and increases, in beef bans over time during our sample period, and we exploit these for our triple difference framework.

Moreover, since bans by themselves may not be exogenous, we devise a variety of identification strategies to get a sense of the causal effect of beef bans. For instance, we look at state-level bans on the sale or possession of beef over time and compare the effects on groups that traditionally consume beef (Muslims, Christians, and lower-caste Hindus) relative to groups that traditionally do not consume beef (Sikhs, Jains, and upper-caste Hindus) using a triple difference-in-differences model.

Our model controls for the effects of the beef bans as well as cow slaughter, and their interactions with a dummy for the beef-consuming group, along with fixed effects for state, year, state × year, state × beef-consuming group, and year × beef-consuming group. The controls allow our estimates to be robust to a wide variety of unobservable heterogeneity that could potentially bias our estimates, including time-invariant and time-varying changes specific to states that banned beef. We harmonize the variation in bans with individual-level biomarker data on measures of anemia using data from the DHS from 1998 to 2016.

Our triple difference-in-differences model studies the effects of the ban on the possession or sale of beef on groups that consume beef relative to groups that do not. Our model controls for the effects of ban on cow slaughter as well as on the possession or sale of beef and their interactions with a dummy for the beef-consuming group along with fixed effects for state, year, state × year, state × beef-consuming group, and year × beef-consuming group. This allows our estimates to be robust to a wide variety of unobservable heterogeneity that could potentially bias our estimates, including time invariant and time varying changes specific to states that rolled beef possession/sale bans.

B Hemoglobin (Biomarker) Data

To estimate the impact of the ban on cattle slaughter on health outcomes, we use all three rounds of the DHS that have data on hemoglobin—the 1998–2000, 2005–06, and 2015–16 rounds. The DHS asks women about their birth history and socioeconomic background, among other topics, and provides hemoglobin (Hg) data for women aged 15–49 years at the time of interview.

Our primary outcomes are hemoglobin, moderate anemia (Hg<=109 g/L), and severe anemia (Hg<80 g/L).[7] We drop missing values and outliers in hemoglobin (Hg<40 or Hg >180) for the analysis. We drop all pregnant women and those smoking cigarettes from our sample as these conditions and behaviors affect the measurement of hemoglobin. We use information on religion and caste to clean the data further, dropping Buddhist, Jewish, Zoroastrian, and Donyi Polo respondents, because their numbers are very small.[8] We also drop respondents with “no religion” and observations with missing values. We harmonize this ban variation with individual level biomarker data on measures of anemia, using the Demographic and Health Surveys (DHS) 1998–2016.

[7] We follow WHO guidelines in defining our anemia cutoffs. For more information see USAID (2017).

[8] Our key estimates are robust even if we do not drop these minority groups.

During the period between 1998 and 2000, the DHS collected data only on ever-married women. Therefore, to keep our analysis consistent, we restrict our analysis on data from all DHS rounds to only ever-married women. Our exposure is a dummy variable indicating a beef ban in a given state in a particular year. 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. The groups that do not traditionally consume beef—Jains, Sikhs, and upper-caste Hindus—serve as placebos because we do not expect these groups to be affected by the beef bans.

Our estimates will be biased downward to the extent that individuals in our non-beef-consuming communities consume beef. The variation in bans by community and by the variation by state and time constitute a triple difference-in-difference-in-difference model. We account for potential confounding by controlling for individual and household characteristics likely to influence the relationship between beef bans and measures of anemia.

We include in our robustness analyses women's covariates including women's age, age squared, years of schooling attainment, total number of kids, height, household wealth index[9] dummies, and urban residence. To address migration-related concerns, we include controls for whether one is a resident and for years lived in one current residence.

C Consumption and Price Data

[9]To account for household socioeconomic status, we controlled for quintiles of the DHS wealth index, which is based on ownership of specific assets (e.g., radio and television), environmental conditions, and housing characteristics (e.g., materials used for housing construction and sanitation facilities), and constructed using a method developed by Filmer and Pritchett (2001).

To study the impact of bans on beef consumption, we use data from the thick rounds of the NSS between 1983 and 2012**:** the 38th round (1983), 43rd round (1987–88), 50th round (1993–94), 55th round (1999–2000), 61st round (2004–05), 66th round (2009–10), and 68th round (2011–12).

The NSS records household purchases of 169 food products, including beef and red meat. The surveys cover all the states of India. Together these surveys contain over 500,000 observations. As some states split between this time, to estimate the correct states, we define the state classification as per the latest round of the NSS for all states. We exclude Jammu and Kashmir from our analysis[10] and drop the top 1 percent of the observations for each NSS round for the monthly per capita expenditure (MPCE) as outliers. Ban exposure is a dummy variable indicating a beef ban in a given state in a particular year. The beef consumer group and the control group are defined as in the previous section.

Our key outcome of interest from the NSS is beef consumption. Accurate measurement may be a concern, as people may underreport consumption, given the taboo several religions associate with consuming beef. To address this problem, we follow the NSS practice and we do not distinguish between cow meat and buffalo meat in our measure of beef. Only Bihar and Chhattisgarh ban the slaughter of buffalo.

[10]Jammu and Kashmir is a Muslim-majority state but before independence the king issued an edict that banned the slaughter of cows. That edict is in force, and so we drop Jammu and Kashmir.

D Identification Strategy

We exploit a unique natural experiment arising from—state regulations that ban the sale or possession of beef—to examine the impact of these regulations on women's health. We look at state-level bans on the sale or possession of beef over time and compare the effects on groups that traditionally consume beef (Muslims, Christians, and lower-caste Hindus) relative to groups that traditionally do not consume beef (Sikhs, Jains, and upper-caste Hindus) using a triple difference-in-differences model.

To estimate the effects of restrictions in the availability of beef, our preferred difference-in-difference-in-differences (DDD) specification of interest is

$Y_{ihst} = \beta_1$ (sale or possession $ban_{s,t}$ x beef $consumer_{ist}$) + β_2 sale or possession $ban_{s,t}$ + β_3 beef $consumer_{ist}$ + $\beta_4$cow slaughter $ban_{s,t}$ + β_5 (cow slaughter $ban_{s,t}$ × beef $consumer_{ist}$) + $year_t$ + $state_s$ + $year_t$ × $state_s$ + $year_t$ × beef $consumer_{ist}$ + $state_s$ × beef $consumer_{ist}$ + U_{ihst} (1)

where Y is the outcome of interest (e.g., Hg levels) for woman i belonging to household h, in state s and observed in year t.

Our DDD model flexibly controls for sale or possession $ban_{s,t}$ (beef sale bans or beef possession bans), beef consumer fixed effects (Beef $consumer_i$), cow slaughter bans (cow slaughter $ban_{s,t}$), interactions of cow slaughter bans with beef consumer fixed effects (cow slaughter $ban_{s,t}$ × beef $consumer_i$), state fixed effects ($state_s$), year fixed effects ($year_t$), state and year fixed effects interactions ($year_t$ x $state_s$,), state specific beef consumer fixed effects ($state_s$ x beef $consumer_{ist}$) and beef consumer group specific year fixed effects ($year_t$ x beef $consumer_i$).

β_1 is the parameter of interest as it measures the impact of exposure to a ban on the sale or possession of beef in a given state relative to states where the sale or possession of beef is not banned) for women observed in year t belonging to the beef-eating group—Muslims, Dalits, and Christians—compared to those from non-beef-eating groups (Sikhs, Jains, and upper-caste Hindus).

We merge the DHS data with the beef ban data for the corresponding time period: 1998–2016. The sample is restricted to women in their prime reproductive age (15–35 years). Standard errors are clustered by state, and we also report wild-bootstrap p values that are clustered at the state level to adjust for smaller numbers of clusters (about 30 states in our data).[11]

Our identification strategy allows us to control for unobserved states by time fixed effects. The time trends in states with bans are potentially different from those in states without bans. By comparing the differences in outcomes for beef-consuming groups from non-beef-consuming groups within states over time, we can isolate the differential impact of beef bans. Moreover, by controlling for the effects of cow slaughter bans and their interactions with the beef dummy, we can look at the intensive margin effects that beef possession or sale bans have over and above any effects from cow slaughter bans. This allows us to control for unobservables specific to beef-consuming groups and to states with cow slaughter bans.

We estimate and difference the raw means of groups exposed to bans on the possession or sale of beef and groups that are not by time (post-ban and pre-ban) and type (consumer versus non-consumer of beef) (Table S2 in the Appendix).

Even without controlling for fixed effects or other covariates, the descriptive means for the triple difference suggest that—especially among beef consumers and for those in states that ban the

[11]We also experimented with clustering by state and five-year intervals, state and ten-year intervals, state, and beef consumer dummy as well as without clustering at all. In general, our estimates from the wild bootstrap p values were the most conservative of all, and the other estimates were very close to our estimates that clustered at the state level without wild bootstrap clustering. The estimates from other clustering procedures are available upon request.

possession or sale of beef—bans are associated with lower hemoglobin and a higher incidence of moderate and severe anemia.

III Results and Discussion

Our results from the econometric models test and confirm the key insights (Table 1). Column (1) show results for our triple differences model from Equation (1). We find that exposure to bans on the sale or possession of beef reduces hemoglobin levels by 1.232 g/L. These results are significant at 0.1 percent level with standard errors clustered by state.

Table 1: Effects of Sale or possession Bans on hemoglobin, moderate and severe anemia

	(1) Hemoglobin	(2) Moderate Anemia	(3) Severe Anemia
Sale or possession ban X Treated	-1.232*** (0.316)	0.0237*** (0.00585)	0.00624** (0.00189)
Bootstrapped p value	0.0717	0.0599	0.0892
Observations	532472	532472	532472
Mean of Dep. Variable	117.5	0.273	0.0234
SD	16.24	0.445	0.151

Note: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We also report the wild-bootstrap p-values at the state level. The values yield estimates that are significant at the 7 percent level of significance. Column (2) shows estimates for the same model as (1) except with moderate anemia, using the World Health Organization (WHO) cutoff of hemoglobin (< 11) as the dependent variable. We find that exposure to sale or possession bans increases the likelihood of being moderately or severely anemic by 2.37 percentage points. As a percentage of mean the effect is ~ 8.9%. These results are significant at 0.1 percent level with standard errors clustered by state.

Table 1 also reports the wild bootstrap p values at the state level and yields estimates that are significant at the 6 percent level of significance. Column (3) shows estimates for the same model as (1) except with severe anemia, using the WHO cutoff of hemoglobin < 8, as the dependent variable. We find that exposure to sale or possession bans increases the likelihood of being severely anemic by ~0.6 percentage points. As a percentage of the mean this effect is large at ~26.7%. These results are significant at 1 percent level with standard errors clustered by state. Table 1 also reports the wild bootstrap p values at the state level and yields estimates that are significant at the 9 percent level of significance.

Our data shows that about 25 percent of those we define as "beef consumers" consume beef whereas fewer than 1 percent of the "non-beef-consumers" consume any cow or buffalo meat. The MPCE of beef consumption is similar—approximately INR 6.0 per month among beef consumers but INR 0.1 per month among non-beef-consumers. In contrast, beef consumers spend INR 17.1 per month on red meat overall and non-beef-consumers spend INR 4.84 per month. Thus, beef represents about 25 percent of the total expenditure of beef consumers on red meat and 2 percent of non-beef-consumers.

The average level of hemoglobin, at 117.50, is below the anemia threshold (120 g/L), indicating that the problem is severe and that anemia is a public health issue (Table S1 in the Appendix). About 27 percent of women suffer from moderate or severe anemia and 2.3 percent are severely anemic (< 80 g/L). We limit our sample to women aged 15–35, their prime reproductive age. Within this group, the average age of women is 25 years, 31 percent reside in urban areas, the majority are residents, and the number of years at the current residence averages 12. On average, women have about 7.3 years of education and 1.42 children. About 36 percent of the female respondents belong to beef-consuming religious minorities and 55 percent live under a beef ban.

There is also a significant variation in beef bans within states over time that our triple difference model will take advantage of: ~0.13 standard deviation (SD) out of 0.50 overall SD (~27%) of all variation is within state variations. The effects differ by group. We find that beef bans lead to a reduction in hemoglobin of 1.23 gram per litre (g/L) among the beef-consuming group relative to the non-beef-consuming group. The probability of being moderately or severely anemic is 2.37 percentage points higher, which is about 9 percent higher as a percentage of the mean. The probability of being severely anemic is about 27 percentage points higher as a percentage of the mean. Therefore, the beef ban affects public health in general and women's health in particular.

A Robustness to alternate covariates

Table 1A (in the Appendix) presents the results from our models including the following covariates: age, age squared, years of schooling attainment, total number of kids, height, household wealth index dummies, and urban residence. Our results include controls for whether one is a resident and, to address selective migration-related concerns, the number of years lived in one current residence. Furthermore, we include controls for survey month fixed effects and its interactions with survey year and states as well as beef-eating groups, to flexibly control for any seasonality. The results show that our estimates from Table 1 remain robust.

Table 1B (in the Appendix) shows the estimates of Equation 1, except that we do not control for cow slaughter bans and their interactions with beef consumer dummy. This allows us to assess how sensitive our results in Table 1 are to controls for cow slaughter bans and in their interactions with beef consumer dummy. Table 1B reaffirms that the results of Table 1 are robust.

B Event Study Analysis

Goodman-Bacon (2021) has concerns over the time-varying heterogeneity of DDD models of the type in Equation 1. Standard difference-in-differences (DD) papers are not able to control for state × year fixed effects. We do, but concerns might remain regarding heterogeneity in treatment dynamics linked to beef consumers within states over time.

One way to address these concerns is to estimate a dynamic DDD model or an event study that flexibly allows for treatment effects to vary over time, following guidelines for conducting event studies that are well identified, as in Borusyak and Jaravel (2017). In our case, the time difference between surveys is not even; and given there are only three rounds of data, though collected over seven calendar years, one should be careful about interpreting results from our event study. Nonetheless, if we do find consistent results, it will be reassuring.

Pre-trends/Leads

Table 1C (in the Appendix[12]) shows the estimates of the pre-trends from running a dynamic DDD model/event study following the recommendations in Borusyak and Jaravel (2017). The estimates suggest that hemoglobin levels were *higher* among beef-eating minorities than among non-beef-eating groups in states with intense beef bans versus those states without such bans *before* the bans were introduced. However, the wild-bootstrap clustering adjusted p-values suggest that none of the pre-trend estimates have a p-value at or below 10 percent level of significance.

[12] Event study tables in the appendix are available upon request.

Semi-dynamic/Lagged Effects

Table 1D (in the Appendix) shows the estimates of the semi-dynamic DDD specification to study dynamics of treatment effect responses. Our estimates in Table 1 are broadly comparable and remain robust.

C Natural Experiment from State Splits

The state of Bihar was split in 2001 into two states: Bihar and Jharkhand. The pre-trends of the undivided state of Bihar in our 1998–99 survey were similar and it had not banned beef. After 2001, Jharkhand imposed an intense beef ban(possession and sale bans), but Bihar did not. We re-estimate our DDD model but we restrict our focus to Jharkhand and compare it to Bihar (Table 2). The results are similar to that in Table 1.

Table 2: Effects of Sale or possession Bans on hemoglobin, moderate and severe anemia in Jharkhand and Bihar

	(1) Hemoglobin	(2) Moderate Anemia	(3) Severe Anemia
Sale or possession ban X Treated	-1.972**	0.0476**	0.00700**
	(0.00918)	(0.000139)	(0.000105)
Observations	55732	55732	55732
Mean of Dep. Variable	114.0	0.339	0.0198
SD	14.43	0.473	0.139

Note: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

D Mechanisms

One mechanism through which a ban on the sale or possession of beef may potentially lead to an increase in anemia is through changes in its price or in the prices of its substitutes and complements.

We use the NSS data on consumption expenditure to examine the association between bans and prices (Table 3). We estimate a modified Equation (1) that drops all the interaction terms with the beef consumer dummy as well as the state ×year fixed effects to estimate a simple difference-in-differences (DD) version of Equation (1) because we expect the market price of beef to be constant across all types of religion and beef consumer.

Table 3 Outcome variable: Effect of beef sale or possession ban on prices

	(1) Beef price	(2) Mutton price	(3) Pork price
Sale or possession ban	2.064^{*}	5.238^{***}	4.964
	(1.167)	(1.825)	(4.276)
Bootstrapped p value	0.289	0.0864	0.713
Observations	302333	411639	267305
Mean of Dep. Variable	64.24	115.4	90.98
SD	36.89	78.38	42.62

Note: Imputed price at the household level * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$. Standard errors in parentheses

In absolute terms, beef is *cheaper* than mutton and pork. This is consistent with our hypothesis that banning the sale or possession of beef is harmful for women's health not only because beef is a good source of heme iron but also because it is a cheaper source of heme iron than other sources of red meat. Since Muslims typically do not consume pork, it is not a feasible substitute for most Muslims.

We find that banning the sale or possession of beef is associated with an increase in beef prices. The increase is not precisely estimated, however, because for prohibited goods missing data and measurement error may make studying own price effects a challenge, as shown by research in the US on alcohol bans during the Prohibition era (Dills, Jacobson, and Miron 2005) and on local smoking bans (Pakko 2005).

Banning the sale or possession of beef may affect both demand and supply, and the overall effects on prices can be ambiguous. We also find that bans induce some beef-consuming minorities to substitute mutton, leading to increased demand and spillover effects on, and therefore increases in, mutton prices.

Table 4 Outcome variable: Effect of beef sale or possession ban on meat consumption

	(1) Any Goatmeat	(2) Any Beef	(3) Any Pork
Sale or possession ban	-0.0353**	0.0197	0.00548
	(0.0147)	(0.0180)	(0.0137)
Bootstrapped p value	0.0988	0.300	0.786
Observations	572676	572676	572676
Mean of Dep. Variable	0.240	0.109	0.0459
SD	0.427	0.312	0.209

Standard errors in parentheses
Note: Meat consumption dummy at the household level
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

An event study model studies the effects of banning the sale or possession of beef on consumption (Tables 2A and 2B in the Appendix). We report wild-bootstrap clustering-adjusted p-values in square brackets. We find that bans reduce consumption (Table 4); there is no evidence of statistically significant pre-existing trends. We find that banning the sale or possession of beef is associated with relative increases in anemia among women in minority groups that traditionally consume beef: bans reduce women's hemoglobin and increase the incidence of severe anemia by as much as 27 percent in communities that traditionally eat beef.

Bans on the possession or sale of beef lead to a 1.23 g/L reduction in hemoglobin among the beef-consuming group relative to the non-beef-consuming group. The probability of being moderately or severely anemic is 2.37 percentage points higher, which is about 9 percent higher as a percentage of the mean. The probability of being severely anemic is about 27 percentage points higher as a percentage of the mean.

These results, taken together, suggest that our reduced form effects of beef sale or possession bans can be explained by increases in beef prices and reductions in beef consumption. And some households may have substituted beef with other forms of meat, like mutton; therefore, the effects of a ban on the sale or possession of beef on anemia may be biased downward. However, the overall magnitude of such effect is ambiguous because substitutes such as mutton are also more expensive sources of iron.

Our results highlight the role of institutional and cultural factors in shaping the high prevalence of anemia in India and the unintended health impacts of these bans on minorities well-being, and more broadly suggest that the importance of dietary restrictions and cultural factors in shaping population health and nutrition.

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Appendix

Table S1: Summary Statistics from DHS Data (1998−2016)

	Mean	**SD**	**Observations**
Hemoglobin	117.50	16.24007	532472
Moderate anemia	0.2727	.4453309	532472
Severe anemia	0.023355	.1510291	532472
Beef consumer	0.360137	.4800405	532472
Beef possession/sale ban	0.549464	.4975478	532472
Cow slaughter ban	0.830842	.3748919	532472
Years of schooling	7.321598	5.020915	532444
Total children ever born	1.426595	1.544556	532472
Age	24.68047	6.068756	532472
Urban	0.312982	.4637074	532472
Height (meters)	1.519747	.0591489	531268
Years in current residence	11.93275	8.215919	531785
Resident	0.954680	.2080047	532461
Wealth index	3.036402	1.393657	532472

Table S2: DDD In Means of Hemoglobin, Moderate and Severe Anemia

	States with Beef Possession/Sale Ban	States without Beef Possession/Sale Ban	Difference
PANEL A: Hemoglobin			
Beef Eating Groups			
Before	117.369	117.358	0.011
			(0.313)
After	116.615	119.83	−3.215
			(0.081)
Diff−in−Diff			−3.226
			(0.324)
Non− Beef Eating Groups			
Before	116.685	116.493	0.192
			(0.185)
After	117.277	117.314	−0.037
			(0.064)
Diff−in−Diff			−0.229
			(0.195)
DDD			**−2.997**
			(0.375)

<u>*PANEL B: Moderate Anemia*</u>			
Beef Eating Groups			
Before	0.293	0.279	0.014
			(0.008)
After	0.291	0.23	0.061
			(0.002)
Diff−in−Diff			0.047
			(0.009)
Non− Beef Eating Groups			
Before	0.302	0.291	0.011
			(0.005)
After	0.277	0.271	0.006
			(0.002)
Diff−in−Diff			−0.005
			(0.005)
DDD			**0.052**
			(0.01)

PANEL C: Severe Anemia			
Beef Eating Groups			
Before	0.034	0.031	0.004
			(0.003)
After	0.028	0.017	0.01
			(0.001)
Diff−in−Diff			0.006
			(0.003)
Non− Beef Eating Groups			
Before	0.037	0.031	0.006
			(0.002)
After	0.022	0.02	0.002
			(0.001)
Diff−in−Diff			−0.004
			(0.002)
DDD			**0.01**
			(0.003)

Note: Standard errors in parenthesis

Table 1A: Effects of Sale or possession Bans on hemoglobin, moderate and severe anemia with all controls

	(1) Hemoglobin	(2) Moderate Anemia	(3) Severe Anemia
Sale or possession ban# Treated	-1.459***	0.0251***	0.00837***
	(0.295)	(0.00539)	(0.00190)
Bootstrapped p value	0.0852	0.0375	0.0647
Observations	530544	530544	530544
Mean of Dep. Variable	117.5	0.273	0.0233
SD	16.23	0.445	0.151

Note: Standard errors in parentheses· * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Robustness exercise:

Table 1B: Effects of Sale or possession Bans without controls for Cow Slaughter Bans

	(1) Hemoglobin	(2) Moderate Anemia	(3) Severe Anemia
Sale or possession ban# Treated	-1.232*** (0.316)	0.0237*** (0.00585)	0.00624** (0.00189)
Bootstrapped p value	0.0717	0.0599	0.0892
Observations	532472	532472	532472
Mean of Dep. Variable	117.5	0.273	0.0234
SD	16.24	0.445	0.151

Note: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Data Appendix

Our database consists of state (month) year observations of cattle slaughter bans by state and (month) year, as set by policy between 1950 and 2016, of which we use data from 1983 to 2016.

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 of the Ministry of Agriculture, Government of India (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; we used that date 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, the existing law was applied in both states until a state passed its own separate legislation, and we coded the data accordingly. Three states were divided in 2000: Jharkhand was split from Bihar, Chhattisgarh from Madhya Pradesh, and Uttarakhand from Uttar Pradesh. When states were divided, the existing law was applied in both states until a state passed its own separate legislation, and we coded the data accordingly.

The earliest bans after independence were passed between 1950 and 1955, in West Bengal, Bombay, Uttar Pradesh, Bihar, Himachal Pradesh, and Punjab. From 1956 to 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 to 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. The three states formed in 2000 passed their own laws separate from the states they had been split from: Chhattisgarh in 2004, Jharkhand in 2005, and Uttarakhand in 2007.

Chhattisgarh 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.