Effects of a large-scale alcohol ban on population-level alcohol intake, weight, blood pressure, blood glucose, and domestic violence in India: a quasi-experimental population-based study

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Summary

Background Globally, alcohol consumption is a leading risk factor for deaths and disability and a causal factor in over 200 diseases, injuries, and health conditions. In April 2016, the manufacture, transport, sale, and consumption of alcohol was banned in Bihar, a populous Indian state. We sought to estimate the impacts of this ban on health outcomes and domestic violence.

Methods Data from the Indian National Family Health Surveys (2005–06, 2015–16, 2019–21), Annual Health Survey (2013), and District Level Household Survey (2012), were used to conduct difference-in-differences (DID) analysis, comparing Bihar (n = 10,733 men, n = 88,188 women) and neighbouring states (n = 38,674 men, n = 284,820 women) before and after the ban. Outcomes included frequent (daily or weekly) alcohol consumption, underweight, obesity, hypertension, diabetes, and intimate partner violence. A triple difference model adding male–female interaction to the DID model was also estimated. Attributable averted cases were calculated to estimate the impact of the ban.

Findings Across all models, the ban led to reduced frequent alcohol consumption (DID: −7.1 percentage points (pp) (95% CI −9.6pp, −4.6pp), lower overweight/obesity (−5.6pp (−8.9, −2.2) among males, and reduced experiences of emotional (−4.8pp (−8.2pp, −1.4pp) and sexual (−5.5pp (−8.7pp, −2.3pp) violence among females. The ban prevented approximately 2.4 million cases of daily/weekly alcohol consumption and 1.8 million cases of overweight/obesity among males, and 2.1 million cases of intimate partner violence among females.

Interpretation Strict alcohol regulation policies may yield significant population level health benefits for frequent drinkers and many victims of intimate partner violence.

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Introduction

Globally, alcohol use has been found to be a leading risk factor for deaths and disability-adjusted life years (DALYs) and is a causal factor in more than 200 diseases, injuries, and other health conditions.[1,2] In 2016, alcohol consumption contributed to 5.3% of all deaths (~3 million) and 5.1% of the global burden of disease and injury.[2] A preponderance of evidence suggests that excessive drinking poses short-term health risks like injuries and violence, while long-term risks include cardiovascular and liver diseases, cancer, obesity, diabetes, and mental or neurodevelopmental disorders.[1,3] While some studies imply that low alcohol consumption may be protective, the recent GBD collaboration publications suggest that minimizing health loss requires zero or close to zero drinks per day for most population groups.[1,3] Moreover, alcohol dependence is linked to spousal violence, though the magnitude, specifics and covariates of such association remain in debate.[4] Studies published until 2012 were criticised for not being sufficiently empirically robust to support preventative policies.[5] In a recent report, the WHO recognised the need for further investigation, but treated alcohol intake as a factor "known to influence

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Research in context

Evidence before this study

Alcohol intake links to social problems and health outcomes including body weight, diabetes, and hypertension. While some studies suggest minimal intake is beneficial, and excessive alcohol increases mortality risks, the Global Burden of Diseases meta-analysis indicates that nearly zero daily drinks as optimal. Reduced alcohol intake has been linked to lower spousal violence, although uncertainty exist around the causal nature of these linkages.

We conducted a systematic review on alcohol bans and their effects on populations, analysing national strategies and global attitudes. We searched PubMed for articles published from 1993 to 2023, using combination of different search terms related to alcohol ban, health outcomes and intimate partner violence (IPV). Our search yielded 41 relevant articles from 1403. Currently, 10 countries have complete alcohol ban, and 20 have partial bans, but evidence on their effectiveness is limited to modifying alcohol consumption and addressing social problems. Two studies in India used difference-in-differences methods to link alcohol bans to reduced IPV or crime, while another finds evidence on reduced self-reported alcohol consumption following the ban, but no study assessed the effects of alcohol ban on health outcomes.

Added value of this study

This study is the first evaluation of the health consequences following the implementation of strict alcohol prohibition in Bihar, a state in India with a population of 130.7 million. Initiated in 2016, the prohibition offered a unique opportunity to examine its effects using quasi-experimental methods. The ban led to decreased daily/weekly alcohol intake, reduced bodyweight and high blood glucose among men, and lower sexual and emotional violence among women. The ban is estimated to prevent 2.4 million cases of daily/weekly alcohol consumption, 1.8 million cases of overweight/obesity among males, and over 2.1 million cases of IPV among females.

Implications of all the available evidence

Our findings align with existing evidence on benefits of reduced alcohol consumption and underscore the potential health and social advantages of strict alcohol regulation policies, despite cultural and economic challenges in their implementation.

violence against women and violence against children".[6] The harmful effects of alcohol consumption on morbidity outcomes are dependent on the total volume of alcohol consumed and pattern of drinking, among other background characteristics and existing diseases.[3,7] Worldwide, alcohol-related mortality rates are higher among men (7.7%) accompanied by higher alcohol consumption (19.4 L of pure alcohol per capita in 2016) compared to women (mortality rate of 2.6%; consumption of 7.0 L).[8] The evidence linking alcohol intake and disease burden suggests that policy measures should be adopted to curb excessive consumption.

The WHO Global Alcohol Action Plan seeks to reduce the harmful use of alcohol as a public health priority.[9] In 2016, 80 countries reported writing national alcohol related policies.[2] As of 2024, 10 countries worldwide have a total ban on alcohol. Historically, alcohol prohibition has been met with turbulent consequences. The US Prohibition Era of 1920–1933 has been touted as an example of stringent regulations, credited with the collapse of the brewery industry, development of black-market trade and corruption, unintended impetus towards normalization of drinking among women and youth, reduction in alcohol related harms in the short term but the effects dwindling after the subsequent repeal of the prohibition.[10,11]

Current alcohol policies are often less restrictive, focusing on specific regions, communities, culturally significant days, public drinking laws, advertising restrictions, licensing or age restrictions, and pricing measures like increased taxation, among others.[12] For instance, community-level interventions often focus on alcohol consumption, addressing immediate morbidity outcomes like accidents, social harm, and chronic diseases.[13] Pricing policies only had temporary effects on alcohol related mortality in Denmark, but had sharper impacts on deaths and hospitalizations among older drinkers in Finland.[14] Advertising bans also lead to a decrease alcohol consumption.[15] Evidence from Lithuania suggests that implementing comprehensive measures such as restrictions on alcohol marketing, increased taxation, and criminal charges against drunk driving has reduced mortality, cardiovascular diseases, and alcohol-related diseases among men.[16] More evidence from low-and-middle-income countries (LMICs) is needed to substantiate global culturally appropriate policy recommendations.

While alcohol use in India is less than the worldwide average, the country is observing an increasing trend in consumption.[17] Moreover, in India, a large proportion of alcohol consumption is undocumented.[2] India's 2019-21 National Family Health Survey (NFHS) estimates that 18.7% of men and 1.3% of women over the age of 15 years consume alcohol in India.[18] India has been experimenting with alcohol prohibition laws since its independence in 1947, with 13 instances of partial or complete prohibition on the sale and consumption of alcohol across different states of India between 1974 and

1997.[19] These include currently alcohol prohibited states of Gujarat, Mizoram, and Nagaland along with previously enforced states of Andhra Pradesh, Haryana, Kerala, Manipur, and Tamil Nadu (Supplementary Figure R1). However, many of these prohibition policies were enforced gradually, and in varying degrees, preventing rigorous assessment of impacts.[20] Among the few evaluations of these policies in India, evidence shows that the alcohol bans did lead to substantial reduction in drinking (40%), domestic violence (50%), and crimes against women (25%).[21]

The most recent case of alcohol prohibition was implemented in Bihar; one of India's most densely inhabited states, with a population over 130 million. The Bihar Prohibition and Excise Act brought about a near complete halt on the manufacture, transport, sale, and consumption of alcohol throughout the state in April 2016. Unlike earlier instances, Bihar's universal ban was launched almost overnight and enforced with strict intensity, making it an attractive natural experiment to estimate the true causal impacts of a strict alcohol restriction policy on health and domestic violence outcomes. Previous studies show significantly reduced alcohol intake, violent crimes, and intimate partner violence outcomes after the ban in Bihar.[22–24] However, these studies have largely ignored the health impacts of the ban on the population. We build on the recent work to identify the population health impacts of alcohol prohibition utilizing anthropometrics and biomarker data from the largest available health datasets in India. We use state representative data to quasi-experimentally assess the effect of the ban on 1) at least weekly alcohol intake; hypothesize second-order reductions on 2) body weight, 3) noncommunicable diseases such as diabetes and hypertension and 4) IPV experienced by women (Fig. 1a).

Methods

Data sources

We use individual and household level data from the Indian National Family Health Surveys (equivalent to Demographic Health Surveys in other countries) in 2005–06 (NFHS3), 2015–2016 (NFHS4) and 2019–2021 (NFHS5). These cross-sectional surveys follow a systematic, multi-stage stratified sampling design, covering all states/union territories in India. While NFHS3 is representative at the state level, NFHS4 and NFHS5 are representative at both state and district levels. We pooled data from the woman and man datasets. NFHS4 and 5 are used for difference-in-differences analyses, whereas NFHS3 is used to indirectly test the parallel trends assumption. Since NFHS3 did not collect data on blood pressure or blood glucose, we supplement these data

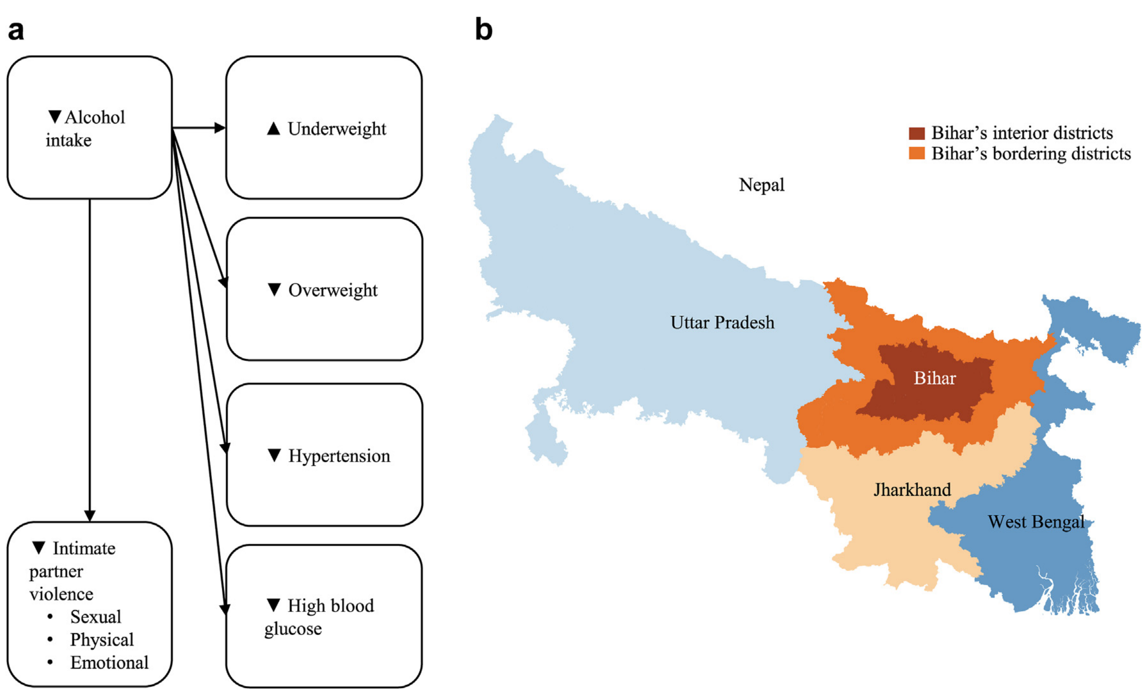

Fig. 1: **Pathways from alcohol consumption to health and intimate partner violence outcomes (a) and map of states and districts (b) included in the analysis**. Note: Bihar's bordering districts include districts bordering the states of Uttar Pradesh: West Champaran, Gopalganj, Siwan, Saran, Bhojpur, Buxar, Kaimur, and Rohtas; West Bengal: Kishnaganj, Purnia, and Katihar; and Jharkhand: Bhagalpur, Banka, Aurangabad, Gaya, Nawada, and Jamui; and the country Nepal: East Champaran, Sheohar, Sitamarhi, Madhubhani, Supul, and Araria.

using the 2012–13 Annual Health Survey (Bihar, Uttar Pradesh, Jharkhand) and the 2012–14 District Level Household Survey (West Bengal), both of which are representative at the state and district levels. The final analytical sample for Bihar included 10,733 men aged 15–54 years and 88,188 women aged 15–49 years (Supplemental Figure R2). The sample for Bihar's neighbouring states (Uttar Pradesh, Jharkhand, and West Bengal) included 38,674 men and 284,820 women.

Outcomes

'At least weekly alcohol intake' is a dummy variable taking the value one for individuals who reported consuming alcohol either "almost every day" or "about once a week" and zero otherwise. Health outcomes for men aged 15–54 years included underweight, overweight/obesity, hypertension, and high blood glucose. Underweight was defined as body mass index ≤18.5 kg/m^2.[25] Overweight/obesity was defined as body mass index ≥23 kg/m^2 per guidelines for Asian populations.[26] Hypertension was defined as average systolic blood pressure ≥140 or diastolic blood pressure ≥90 mmHg.[18,27] High blood glucose was defined as random blood glucose >140 mg/dl.[18,28]

The NFHS also provides information on domestic violence on 15 percent of households randomly selected for state modules. Domestic violence outcomes are calculated as binary indictors for women, if they report experiencing any form of emotional (humiliation, threats, insults), physical (pushing, arm twisting, slapping, punching, kicking, choking, attacks with objects and weapons), or sexual (forced sexual acts or intercourse) violence from their husband. Details of instruments and methods used to collect data on outcomes are described in Methods supplement 1.

Covariates

We include several individual-level covariates including age (years), education (years) and cigarettes or bidis smoked daily (number) and household-level covariates include urban residence (binary), access to health insurance (binary), family size (number), religion (Hindu, Muslim, Christian), caste (scheduled caste, scheduled tribe), below poverty line card (binary), and a wealth index (ranging from 1 to 5).[3,22] The wealth index was constructed using principal component analysis of 41 household assets and amenities performed after pooling the three waves of NFHS, enabling control for changes in absolute asset poverty.[29]

Difference-in-differences models

The prohibition was an electoral promise by Bihar's Chief Minister who pledged to purge alcoholism from the state while campaigning for the 2015 assembly elections. This pledge was in response to repeated complaints of domestic violence, public nuisance, and a demand for prohibition by women voters.[22] People were also encouraged to report cases of drinking to the police. Sudden statewide implementation along with strict imposition of penalties and punishments makes the ban a credible source of quasi-exogenous variation needed for natural experiments.

In the absence of randomized assignment (unrealistic at the population level) of individuals to treatment (i.e., exposure to alcohol restriction), we treated the ban as a natural (or quasi) experiment. However, because Bihar self-selected into introducing the alcohol ban, there may be unobservable state-specific factors that drove this decision-for instance, rampant alcohol consumption, or a demand from voters.[30] Such factors, however, are likely to be fixed or relatively invariant over the short-term.[31] Second, there may be time-varying factors that could bias estimates, such as the national implementation of awareness campaigns on alcohol or increase in income. The preferred method of controlling for both issues is using longitudinal data to estimate difference-in-differences (DID) models.[32] For DID analysis we considered Bihar as the treatment group and, Bihar's neighbouring states (Uttar Pradesh to the west, Jharkhand to the south, and West Bengal to the east) as the comparison group (Fig. 1b). The alcohol ban was also implemented just after the NFHS4 (2015–16) data were collected, giving us a credible baseline; NFHS5 serves as our endline. DID models provide average treatment effect estimates in our analyses. To determine the association between the alcohol ban and corresponding changes in health outcomes within Bihar, we estimated Equation 1 for person i, from household h in state s in year of survey t:

$$P(Y_{ihst}=1)=\beta_0+\beta_1 Bihar_s+\beta_2 Post_t+\beta_3 Bihar_s * Post_t + \sum_{j=4}^{J}\beta_j X_{jihst}+\epsilon_{ihst} \quad (1)$$

where $P(Y_{imhst}=1)$ denotes the probability that the outcome Y_{ihst} took on value 1. $Post_t$ is a time dummy that takes value 0 for data points obtained from NFHS4 (2015–16) and 1 for NFHS5 (2019–21). $Bihar_s$ is a treatment state dummy that takes value 0 for the comparison group and 1 for Bihar. β_3 (DID) represents the difference (control vs. Bihar) in the changes over time (2016–2021) or the average treatment effect. Details on the DID estimating equation are available in Methods supplement 2. Models were fit on individual level data using ordinary least squares using the Stata-18 'reg' function. Standard error estimates were robust and corrected for clustering at the district level. Regressions were estimated with sampling weights to provide representative estimates. All subsequent models followed similar estimating procedures.

Triple difference models

Less than one percent of the female population in Bihar, and neighbouring states consumed alcohol before the ban. Thus, the alcohol ban was expected to primarily affect alcohol consumption and health outcomes among men. This feature provides a third axis of comparison needed to implement a triple difference (DDD) model. Using females as an additional control for males is especially credible because unobservable time-varying within-state confounders are likely to be similar for both sexes. In other words, this model is useful for outcomes where there would be no direct impact of the ban on females. Since this model has two pre-post comparison groups, (1) Bihar vs. neighbouring states and (2) males vs. females, the DDD model is the unbiased difference between two DID models that may have been separately biased.[33] While both the DID and DDD models estimate the impact of the ban, they have different interpretations resulting from the more complex counterfactuals in the DDD model. We estimated Equation 2 for person i, from household h in state s in year of survey t:

$$P(Y_{ihst}=1)=\beta_0+\beta_1 Bihar_s+\beta_2 Post_t+\beta_3 Male_i + \beta_4 Bihar_s * Post_t + \beta_5 Bihar_s * Male_i + \beta_6 Male_i * Post_t + \beta_7 Bihar_s * Post_t * Male_i + \sum_{j=9}^{J} \beta_j X_{jihst} + \epsilon_{ihst} \quad (2)$$

Equation 2 is like Equation 1 but has four additional coefficients. $Male_i$ is a dummy that takes value 0 for female group and 1 for male. β_7 is the mean difference in change (2015–2020) in outcomes for Bihar's male compared to males from neighbouring states compared to the changes for Bihar's females compared to females from neighbouring states. β_7 is the DDD estimator and parameter of interest for our analysis. Details on the DDD estimating equation and interpretation are available in Methods supplement 3. Given the robustness of DDD over DID, our preferred estimates are DDD. The effects estimated by the DID and DDD models are intent-to-treat (ITT) estimates because our DID strategy models the potential exposure of the entire population of Bihar to the ban.[34]

Parallel trends

The main identifying assumption underlying DID validity is that the change in outcomes in control states is an unbiased estimate of the true counterfactual. Given that this assumption is not directly testable, we tested whether pre-ban time trends in Bihar and neighbouring states were similar. Like DID models, the underlying assumption for DDD models is that the relative outcome of females and males in the Bihar group trend in the same way as the relative outcome of females and males in the neighbouring states, in the absence of treatment.[33] Statistical tests for parallel trends are described in Methods supplement 4.

Additional analyses

In additional analyses, we first assess the population level impact of the ban in Bihar in 2023, estimating the number of cases of alcohol intake and obesity averted among males and cases of sexual and emotional violence averted among females. We calculate these estimates by multiplying coefficients related to these outcomes with the total number of males and females aged 15–49 in Bihar. Second, we examine the sensitivity of regression results to using different outcomes (daily alcohol intake, BMI, blood pressure and blood glucose) among males. Third, we change the comparison group to only Jharkhand for sensitivity analysis, as it was carved out of Bihar in 2000. Fourth, for outcomes where the parallel trends assumption was rejected, we supplemented DID models with controlled interrupted time series (CITS) models which project pre-2015 trends forward for both groups estimating a DID of slopes.[35] Lastly, to test sensitivity to reporting bias we compare the effects in Bihar's interior vs. border districts, expecting larger impacts in the interior areas due to reduced illegal import and cross-border alcohol consumption, even in the presence of underreporting. Refer to Methods supplement 5 for details on this section.

Results

Characteristics of treatment and control groups

In 2015–2016, 15.0% of males in Bihar consumed alcohol at least weekly, compared to 10.3% in neighbouring states (Table 1 and Supplementary Table R1). Among male drinkers in Bihar, 69.8% consumed alcohol from market sources (beer, wine, and hard liquor). Bihar had a larger population of Hindus, more individuals living in rural areas, and less education compared to its neighbouring states. Other covariates were similarly distributed in Bihar compared to neighbouring states. Similar findings were observed when comparing interior of Bihar to neighbouring states or comparing Bihar to Jharkhand.

Frequent alcohol intake

The parallel lines assumption for at least weekly alcohol intake among men was not rejected for both DID and DDD models (Fig. 2a and Supplementary Table R2). Before the ban, males in Bihar increased their frequent alcohol intake from 9.7% to 15.0%, while in neighbouring states, it increased from 7.2 to 10.3%. After the ban, these trends reversed, with at least weekly alcohol intake decreasing to 7.8% in Bihar, while in neighbouring states it continued to increase to 10.4%. Alcohol purchases from market sources also decreased and purchases from non-market sources increased in Bihar (Supplementary Figure R3). Despite the potential of the ban affecting females directly, at least weekly alcohol intake was virtually absent between 2005 and 2021 in both Bihar and neighbouring states, making them a de

	Bihar				Uttar Pradesh, Jharkhand, West Bengal			
	Female		Male		Female		Male	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Alcohol intake outcomes	N = 45,792		N = 5870		N = 144,159		N = 20,520	
At least weekly alcohol intake, %	0.2	[0.1, 0.2]	15.0	[13.9, 16.0]	0.4	[0.4, 0.5]	10.3	[9.7, 10.8]
Daily alcohol intake, %	0.1	[0.0, 0.1]	4.3	[3.7, 4.9]	0.1	[0.1, 0.1]	2.2	[2.0, 2.5]
Weekly alcohol intake, %	0.1	[0.1, 0.1]	10.7	[9.8, 11.5]	0.3	[0.3, 0.4]	8.1	[7.5, 8.6]
Monthly alcohol intake, %	0.1	[0.0, 0.1]	14.2	[13.2, 15.3]	0.3	[0.3, 0.3]	15.6	[15.0, 16.3]
No alcohol intake, %	99.8	[99.7, 99.8]	70.8	[69.5, 72.1]	99.2	[99.2, 99.3]	74.1	[73.3, 74.9]
Type of alcohol usually consumed by consumers	N = 123		N = 1779		N = 1627		N = 5398	
Non-market sources[a], %	52.8	[42.5, 63.0]	46.0	[43.3, 48.7]	76.4	[73.0, 79.7]	47.8	[46.0, 49.6]
Market sources[a], %	45.3	[35.0, 55.6]	69.8	[67.3, 72.2]	22.1	[18.9, 25.4]	65.6	[63.9, 67.2]
Health outcomes	N = 45,792[b]		N = 5870[b]		N = 144,159[b]		N = 20,520[b]	
Underweight[c], %	29.4	[29.0, 29.9]	24.8	[23.5, 26.1]	24.0	[23.8, 24.3]	23.6	[22.9, 24.4]
Overweight/obesity[c], %	20.5	[20.1, 20.9]	25.1	[23.8, 26.3]	28.5	[28.2, 28.8]	25.9	[25.1, 26.7]
Hypertension[c], %	6.6	[6.4, 6.9]	11.3	[10.4, 12.3]	9.3	[9.1, 9.5]	13.5	[12.8, 14.1]
High blood glucose[c], %	4.2	[4.0, 4.4]	7.4	[6.6, 8.2]	5.7	[5.5, 5.9]	9.1	[8.5, 9.7]
Intimate partner violence outcomes among women	N = 4044				N = 11,766			
Emotional violence[d], %	20.5	[19.0, 22.1]			13.0	[12.3, 13.8]		
Physical violence[d], %	41.4	[39.5, 43.3]			34.2	[33.1, 35.3]		
Sexual violence[d], %	13.8	[12.5, 15.2]			7.9	[7.3, 8.5]		
Covariates	N = 45,792		N = 5870		N = 144,159		N = 20,520	
Age, years	28.7	[28.6, 28.8]	30.8	[30.5, 31.1]	29.2	[29.1, 29.2]	31.3	[31.1, 31.5]
Education, years	4.6	[4.6, 4.7]	7.4	[7.3, 7.6]	6.3	[6.3, 6.3]	7.9	[7.8, 8.0]
Number of cigarettes or bidis smoked, number	0.1	[0.1, 0.1]	0.9	[0.8, 1.1]	0.0	[0.0, 0.1]	2.8	[2.7, 3.0]
Socio-economic status score (1–5), number	1.8	[1.7, 1.8]	1.9	[1.9, 1.9]	2.4	[2.4, 2.4]	2.5	[2.5, 2.5]
Urban, %	13.4	[13.1,13.8]	18.5	[17.3, 19.7]	28.3	[28.0, 28.6]	31.7	[30.8, 32.6]
Health insurance, %	12.6	[12.2, 12.9]	13.0	[12.1, 14.0]	15.8	[15.5, 16.1]	17.0	[16.2, 17.8]
Family size, number	6.3	[6.2, 6.3]	6.3	[6.2, 6.4]	5.9	[5.9, 5.9]	5.8	[5.7, 5.8]
Hindu, %	83.7	[83.3, 84.0]	84.7	[83.6, 85.8]	76.7	[76.4, 77.0]	78.2	[77.5, 79.0]
Muslim, %	16.2	[15.8, 16.6]	15.2	[14.1, 16.3]	20.9	[20.6, 21.2]	19.6	[18.9, 20.4]
Christian, %	0.0	[0.0, 0.1]	0.1	[0.0, 0.3]	0.5	[0.5, 0.6]	0.4	[0.3, 0.5]
Below Poverty Line card, %	55.4	[54.9, 55.9]	51.9	[50.5, 53.4]	30.4	[30.0, 30.7]	29.5	[28.7, 30.4]
Scheduled caste, %	19.2	[18.8, 19.6]	17.8	[16.7, 18.9]	23.4	[23.1, 23.7]	24.5	[23.7, 25.3]
Scheduled tribe, %	3.4	[3.2, 3.6]	2.4	[2.0, 2.9]	5.2	[5.0, 5.3]	5.6	[5.3, 6.0]

Note: All estimates from 2015 to 16 National Family Health Survey. Intimate partner violence outcomes are weighted using domestic violence weights, while all other outcomes and covariates are weighted using individual weights for males and females, respectively. [a]Type of alcohol usually consumed is asked only to those respondents who report consuming alcohol. Tadi Madi and country liquor are classified as non-market sources while beer, wine and hard liquor are classified as market sources. [b]Sample size is smaller for underweight at 45,225 females and 5769 males in Bihar, and 142,258 females and 20,039 males in the neighbouring states, hypertension at 44,880 females and 5758 males in Bihar, and 140,280 females and 19,849 males in the neighbouring states, and for diabetes at 45,274 females and 5781 males in Bihar, and 141,862 females and 20,014 males in the neighbouring states. [c]Underweight is defined as having a body mass index ≤18.5 kg/m^2, overweight/obesity is defined as having a body mass index ≥23 kg/m^2 as per the guidelines for Asian populations, hypertension is defined as having average systolic blood pressure ≥140 or diastolic blood pressure≥90 mmHg, and diabetes is classified as having blood glucose >140 mg/dl. [d]Intimate partner violence outcomes for women are binary indicators taking value one if they report experiencing from their husband emotional violence in the form of humiliation, threats, or insults, physical violence in the form of pushing, arm twisting, slapping, punching, kicking, choking, attacks with objects or weapons, and sexual violence in the form of forced sexual acts or intercourse.

Table 1: **Baseline summary statistics among men and women in Bihar vs. comparison states, 2015–2016.**

facto control group for men (Fig. 2b and d). The unadjusted model estimated a 7.3pp decrease in the prevalence of at least weekly alcohol intake among males in Bihar after the ban, compared to its neighbours ($p < 0.001$) (Fig. 2c and Supplementary Table R3). The fully adjusted model controlling for household and individual level controls also shows a 7.1pp decrease ($p < 0.001$) in alcohol intake among men. Treating females as a de facto control, similar findings were observed in the DDD (Supplementary Table R4).

Underweight, overweight and obesity

The parallel trends assumption was not rejected for underweight prevalence in both the DID and DDD models (Supplementary Table R2). For overweight/obesity the parallel trends assumption was not rejected in the DID model but was rejected in the DDD model. In 2015–16, the prevalence of underweight (24.8% vs. 23.6%) and overweight/obesity (25.1% vs. 25.9%) among males was similar in Bihar compared to neighbouring states, respectively (Fig. 3a and b). The DID

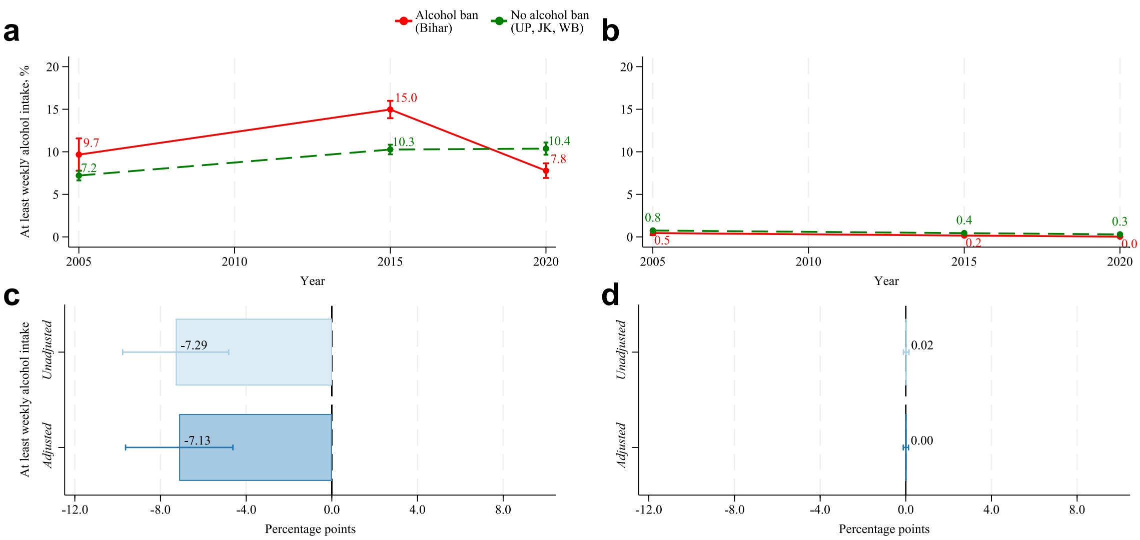

Fig. 2: **Pre-intervention trends (2005–16) and change (2015–21) in at least weekly alcohol intake**. Note: Similar pre-intervention trends among males (a) and females (b) in Bihar and neighbouring states (Uttar Pradesh, Jharkhand, and West Bengal) between 2005–06 and 2015–16. Coefficient plots are the estimated intent-to-treat effects for the difference-in-differences for males (c) and females (d), between 2015–16 and 2019–21, with robust standard errors clustered at district level. Adjusted model controls for age, urban residence, education, number of cigarettes/bidis smoked, health insurance, family size, religion, caste, below poverty line card, and household wealth characteristics. All estimates are from the NFHS and weighted using individual weights for males and females, respectively.

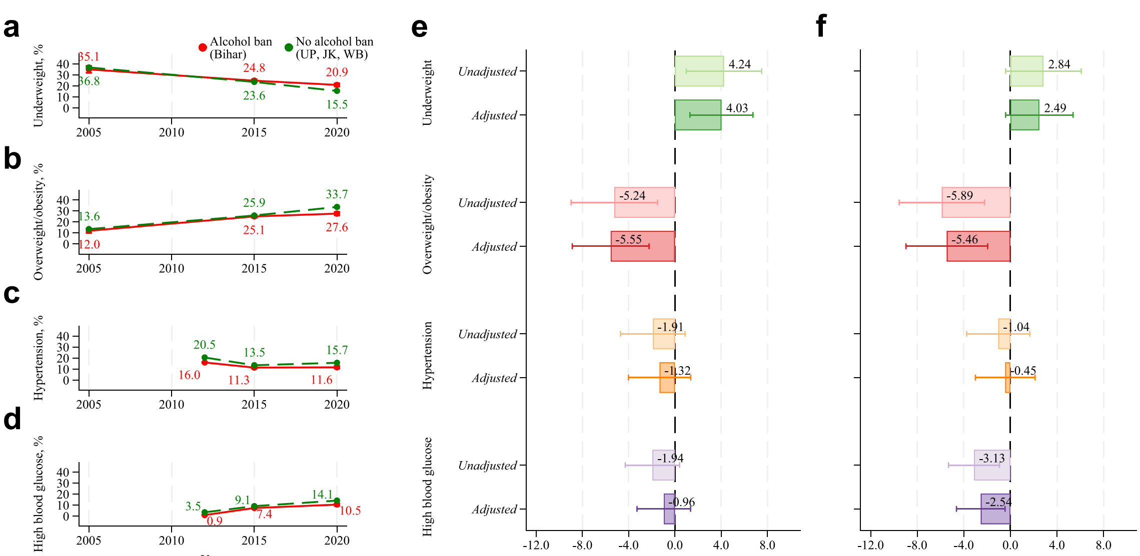

Fig. 3: **Pre-intervention trends (2005–16) and change (2015–2021) in health outcomes among males**. Note 1: Similar pre-intervention trends among males in Bihar and neighbouring states (Uttar Pradesh, Jharkhand, and West Bengal) in underweight (a), overweight/obesity (b), hypertension (c), and high blood glucose (d) between 2005–06 and 2015–16. Since the 2005-06 NFHS did not collect data on blood pressure and blood glucose, hypertension and high blood glucose estimates are supplemented with unweighted estimates from 2012 to 13 AHS and 2012–14 DLHS data. All other estimates are from the NFHS and weighted using individual weights for males. Note 2: Coefficient plots are the estimated intent-to-treat effects for the difference-in-differences model (e), and triple difference model (f), respectively, between 2015–16 and 2019–21, with robust standard errors, clustered at district level. Adjusted model controls for age, urban residence, education, number of cigarettes/bidis smoked, health insurance, family size, religion, caste, below poverty line card, and household wealth characteristics. All estimates are from the NFHS and weighted using individual weights for males.

model estimated a 4.0pp increase (p = 0.004) in underweight and 5.6pp (p = 0.001) decrease in overweight/obesity among males in Bihar, compared to the trend in neighbouring states (Fig. 3e). The DDD model estimated significant relative decline in overweight/obesity by 5.5pp (p = 0.002), but no significant increase in underweight (Fig. 3f).

Hypertension

Parallel trends assumption was rejected for hypertension prevalence among men in both DID and DDD models (Fig. 3c and Supplementary Table R2). The DID (−1.3pp) and DDD (−0.4pp) model showed that hypertension among males in Bihar reduced after the ban compared to the counterfactual, but the reduction was not statistically significant (p > 0.05) (Fig. 3e and f). The controlled interrupted time series models suggests that the ban may have resulted in a decrease in the prevalence of hypertension among males in Bihar, compared to the neighbouring states, with the difference in slopes being −0.9pp per year (p value = 0.010) (Supplementary Table R9).

High blood glucose

The parallel trends assumption for high blood glucose prevalence among men was not rejected for both DID and DDD models (Fig. 3d and Supplementary Table R2). Compared to the counterfactual, the DID (−1.0pp) and DDD (−2.5pp) models showed a decrease in high blood glucose prevalence among males in Bihar, but only the DDD coefficient was significant (p = 0.017) (Fig. 3e and f).

Intimate partner violence

Parallel trends assumption was not rejected for both emotional and sexual violence experienced by women in the DID models (Fig. 4a and c and Supplementary Table R2). However, physical violence experienced by women in Bihar declined between 2005 and 2015 (Fig. 4b). For women in Bihar, the DID model showed a relative decrease in emotional violence (4.8pp, p = 0.006) and sexual violence (5.5pp, p = 0.001) after the ban (Fig. 4d). There was no significant impact of the ban on physical violence faced by women in the DID and CITS models (Supplementary Table R9).

Additional analyses

We estimate that Bihar's alcohol ban prevented 2.4 million cases of frequent alcohol consumption, and 1.8 million cases of overweight/obesity among males, and 2.1 million cases of intimate partner violence compared to neighbouring states without a similar prohibition (Supplementary Table R5). For other outcomes, the analysis shows that the ban was associated with a −2.8pp (p < 0.001) reduction in daily drinking among men, significant coefficients for body mass index

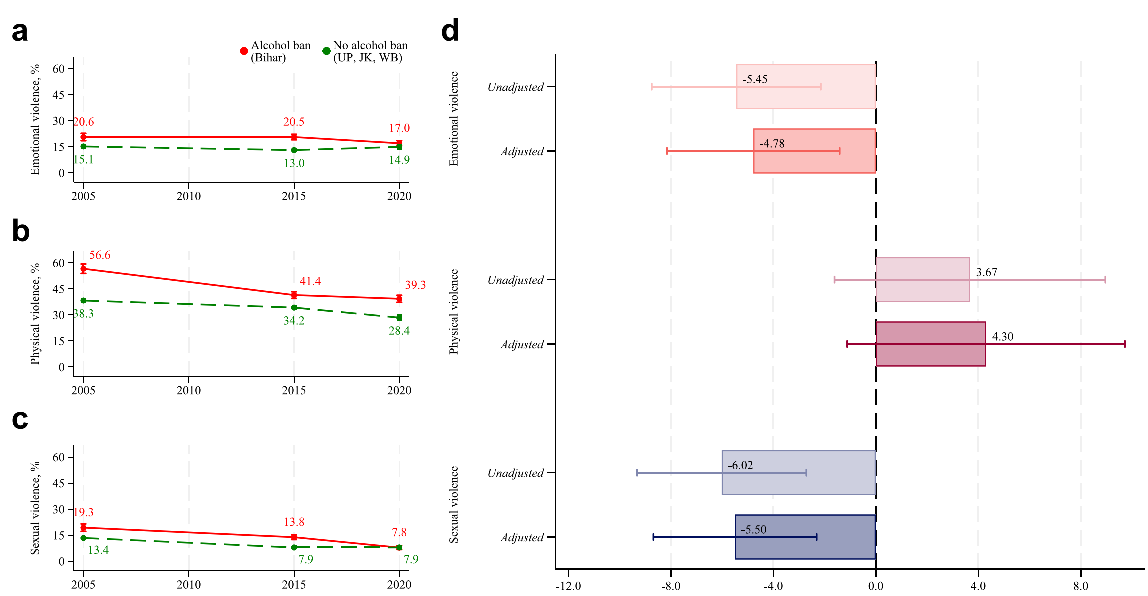

Fig. 4: **Pre-intervention trends (2005–16) and change (2015–2021) in intimate partner violence outcomes among females.** Note: Similar pre-intervention trends in females in Bihar and neighbouring states (Uttar Pradesh, Jharkhand, and West Bengal) in emotional violence (a), physical violence (b), and sexual violence (c), between 2005–06 and 2015–16. Coefficient plot (D) are the estimated intent-to-treat (ITT) effect for the difference-in-differences model (d), between 2015–16 and 2019–21, with robust standard errors, clustered at district level. Adjusted model controls for age, urban residence, education, number of cigarettes/bidis smoked, health insurance, family size, religion, caste, below poverty line card, and household wealth characteristics. All estimates are from the NFHS and weighted using domestic violence weights.

and blood glucose, but not blood pressure (Supplementary Table R6). The results were similar when using Jharkhand as the comparison group, with effects on at least weekly alcohol intake, underweight, and overweight/obesity among males (Supplementary Tables R7 and R8). The effects on hypertension and high blood glucose were not significant. The results for domestic violence were also similar, with a 4.6pp decrease in emotional violence and a 3.6pp decrease in sexual violence. The study also found larger effects in interior districts of Bihar, with at least weekly alcohol intake decreasing by nearly double in bordering districts compared to neighbouring states, indicating that reporting bias does not have a significant influence on the results (Supplementary Tables R10 and R11).

Discussion

To the best of our knowledge, this is the first evaluation of the health consequences of strict alcohol prohibition in a populous state in India. We found substantial population level benefits for males in Bihar in terms of lower frequent alcohol consumption, overweight/obesity, and diabetes, compared to neighbouring states. Additionally, women reported fewer cases of emotional and sexual violence from their intimate partners after the ban. We estimate that the ban prevented 2.4 million cases of frequent alcohol consumption, and 1.8 million cases of overweight/obesity among males, and 2.1 million cases of intimate partner violence compared to neighbouring states without a similar prohibition. Our estimates were robust to numerous additional analyses on alternate outcomes, varying exposure levels and counterfactuals. Our findings add to the global evidence on health impacts of alcohol consumption, particularly for LMICs.

Bihar's prohibition was built on the electoral promise of reducing IPV. According to the 2019-21 NFHS survey, 32% of ever-married women in India, 39% in Bihar, aged 18–49 years experienced physical, emotional, or sexual violence from their spouses in India as opposed to the 2018 global prevalence of 27%.[36] Studies in India have shown that odds of experiencing IPV is significantly higher among women whose husbands consume alcohol compared to women whose husbands do not consume alcohol.[37,38] A study using a difference-in-differences approach with geospatial data at sub-district levels, echoes our findings that women in Bihar were less likely to face intimate partner violence.[24] This study also finds evidence for reduced physical violence, and increased financial independence among women in Bihar. Evidence from other developing countries also suggests that alcohol abuse is strongly linked to IPV, and that a ban on alcohol sales during the COVID pandemic led to a reduction in hospitalizations due to sexual assault and a 19% reduction in weekly rape cases.[39,40] Alcohol abuse led aggressiveness may also lead to outcomes beyond IPV, such as increased mental health conditions among women such as anxiety and depression, and increased risk of maternal, and child mortality outcomes.[41,42] Our results suggest that strategies to curb alcohol consumption should be implemented synergistically with other evidence-based actions to address IPV.[38,43,44]

Per the Global Burden of Disease (GBD) 2019 rankings, alcohol is the second most important risk factor for deaths and disability for individuals aged 15–49 years in India.[45] Our results align with previous studies from India on the links between alcohol consumption as a modifiable risk factor for diabetes and hypertension among men in India.[46,47] Second-order effects identified in this study likely operate through mechanisms suggested in medical literature. Specifically, health benefits are realized through reductions in high alcohol intake leading to reductions in body weight via calorie deficits.[48] Reductions in blood glucose likely manifest through reduced insulin resistance and better pancreatic function among previous heavy users.[49] Reduced alcohol intake may also improve hypertension through improved nervous system functioning, arterial flow, and reduced cortisol level.[50] We estimated that alcohol ban prevented millions of cases of alcoholism and overweight/obesity, which have important implications for addressing non-communicable diseases such as hypertension and diabetes.

Our study has several strengths, including the use of large nationally representative, repeated cross-sectional series survey datasets that establish a temporal order such that exposure to the alcohol ban precedes the studied outcomes. The utilization of two sets of counterfactuals, one comparing Bihar to neighbouring states (DID), and another comparing, males to females, across neighbouring states and within Bihar (DDD), yielding directionally similar results lend confidence to the regression estimates. Our DID and DDD analytic approaches, in alignment with the parallel trends assumption being unrejected across most outcomes, account for plausible observed and unobserved confounders operating at state, household, and individual levels. Our synchronous evaluation of at least weekly alcohol intake and associated health outcomes offer a comprehensive assessment of whether and to what extent a mass reduction in alcohol consumption corresponds with downstream benefits in the population.

Our study is not without limitations. Firstly, owing to the nonrandomized nature of alcohol prohibition, confounding from unobserved factors that correspond with both exposure to treatment and alcohol consumption cannot be ruled out. Such factors would 1) only affect outcomes among men in Bihar, but not in comparison states (DID) or women in Bihar (DDD); and 2) not be accounted for by the control variables included in our analyses. For example, national food subsidies that may influence body mass may have been differentially rolled out across Indian states but would impact males and female similarly in Bihar. Our DDD models adjust for such confounders. Despite these controls, DID and DDD are based on assumptions that are only partially testable. Statistical analyses for parallel trends are only indirect because the true counterfactual can never be observed. Therefore, readers should interpret findings with caution. Secondly, because alcohol intake and IPV outcomes were self-reported, they may be subject to underreporting due to social desirability bias, memory recall, or fear of consequences. Specifically, underreporting of alcohol consumption in Bihar after the ban may bias our estimates on frequent alcohol intake away from the null. However, our analysis comparing bordering and interior districts of Bihar shows that respondents reported higher consumption if they had proximity or were likely to access alcohol brought in from neighbouring states. If underreporting became more pronounced in Bihar after the ban, we would likely not have detected differences between bordering and interior districts. Moreover, reports on alcohol consumption in Bihar after the ban also suggest large reductions in frequent alcohol intake among men.[51] Nonetheless we cannot negate proclivity towards undocumented alcohol consumption by frequent drinkers.[2]

Despite evidence for improvements in health outcomes, the sudden onset of the prohibition may have given rise to several complex ethical and health dilemmas not captured in the available data. These include risky withdrawal symptoms, increased prevalence of black-market trade in alcohol, and increased risk of substitution with other illicit substances.[22,52] Moreover, the population level impacts of the ban must be interpreted with a lens on the biology of addiction. In Bihar, little is known about the extent of alcohol use disorders characterized by compulsive heavy alcohol use and loss of control over alcohol intake.[53] Globally, such cases often have multiple substance use disorders. In the presence of a ban, these cases may resort to consuming illicitly procured stronger and more toxic forms of alcohol such as methanol or other substitutes.[54,55] Prohibition will also lead to a decrease in tax revenue, with uncounted effects. According to analysis on the state taxes, alcohol was the primary source of state excise duty, leading to an estimated loss of over USD375 million in 2016 alone.[56] Hence, we cannot recommend prohibition as a public health measure as it may lead to other expected or unexpected problems. However, it may be prudent to consider implementation of the five pronged WHO recommended SAFER technical package of restrictions on alcohol availability via licensing on sales, regulations on retail outlets, enforcement of legal minimum age of drinking and restriction on public drinking as more viable and evidence based alternative regulations.[57] Recent studies further suggest that targeting the heaviest drinkers is likely to be most effective to eliminate short-run alcohol related harms.[40] These studies indicate that the implementation of a statutory minimum unit price for alcohol may yield societal benefits, particularly for socioeconomically deprived communities.[40,58]

To conclude, the alcohol ban in Bihar curtailed alcohol consumption in men, leading to a decrease in overweight/obesity prevalence and a decline in women's experiences of emotional and sexual violence from their partners. These estimates will be valuable for future policy makers in India who may be considering similar bans in other Indian states. While we do not recommend outright bans as a practical and economically viable policy, our study combined with new evidence that no level of alcohol consumption is safe for humans suggests that stricter alcohol regulation policies may yield significant population level health benefits for frequent drinkers and benefits for victims of intimate partner violence. Further investigation is needed to understand potential benefits and fiscal implications of stricter alcohol regulation policies globally.

Contributors
S.C. conceived the idea, led overall synthesis, statistical analysis and wrote significant sections of the manuscript.

A.C. conducted the literature review, statistical analysis, prepared the tables and figures, and wrote significant sections of the manuscript.

S.S, A.K., and P.N. reviewed the analysis, results, contributed to the interpretations, and writing of the manuscript.

All authors read and approved the final version of the manuscript.

Data sharing statement
Data described in the article are open access and are available at https://www.idhsdata.org/idhs/. Code files can be made available on request.

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The authors declare no conflict of interest.

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Appendix A. Supplementary data
Supplementary data related to this article can be found at https://doi.org/10.1016/j.lansea.2024.100427.

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