The causal effect of iodised salt consumption on children's height in rural India

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Abstract

Height is often used as a proxy for human capital. Research has established that nutrition in early life is an important predictor of height. Less is known about what specific aspect of nutrition affects height. Medical evidence points to a mechanistic relationship between iodine deficiency and growth. This paper investigates whether the consumption of iodised salt improves height among children in rural India. I use 2SLS regression to circumvent concerns regarding the endogeneity of a household's availability of iodised salt and children's anthropometric status. I instrument for iodised salt consumption with the distance to the major salt producing state. Salt transported for longer distances is likely to be transported by rail rather than by road. Monitoring of iodised salt is only mandatory before and during rail transport. Therefore, distance serves as a proxy for the likelihood that the salt has been inspected for iodine, and thus iodised. I find that the availability of adequately iodised salt improves height-for-age by 0.664 Z-scores for children up to 1 year.

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Height is often used as a proxy for individuals' accumulated health stock, particularly in studies analysing data from developing countries (Lundborg et al., 2009; Alderman et al., 2006; Spears, 2012*a*; Hoddinott et al., 2013; Case, 2008; Glewwe and Edward A, 2007; Vogl, 2014). Existing research has established the importance of adequate nutritional intake in early life (Hoddinott et al., 2013). However, less is known about what specific aspect of undernutrition constitutes a potential driver of height, and thus health capital. This paper seeks to contribute to this knowledge gap by investigating the role of iodine intake on health capital.

Medical research suggests that iodine intake affects physiological processes involved in human growth (Zimmermann et al., 2007). It is therefore possible that the availability of iodised salt is a predictor of height among populations at risk for iodine deficiency. Mason et al. (2002) and Krämer et al. (2016) report positive associations between iodised salt availability and child growth among iodine deficient populations in low and middle income countries. Household consumption of iodised salt is likely to be correlated with omitted determinants of children's heights and contain measurement error. Simultaneity bias is also a potential threat to identification. The previous studies do not address these issuses and are therefore not able to estimate a causal impact of iodised salt consumption on growth. This paper adds to the literature by exploiting exogenous variation in the availability of iodised salt to estimate its effect on children's height-for-age Z-scores (HAZ), using a large household survey for rural India.

Despite a rapid economic growth, India has experienced slow improvements in child anthropometric outcomes (Deaton, 2009). 38% of all Indian children under five years old are stunted, meaning that their HAZ is below two standard deviations compared to a healthy reference population. One in three of all stunted children worldwide live in India (Menon et al., 2018). It is therefore of large policy relevance to understand the causes of short stature in India. Previous studies have found that open defecation (Hammer and Spears, 2016), inequality in human capital investment depending on birth order and gender (Jayachandran and Pande, 2017) and female nutritional deprivation reducing nutritional intake in utero (Osmani and Sen, 2003) are determinants of children's heights specific to the Indian context. Iodine intake is likely to be an additional predictor of height in India due to the high risk of iodine deficiency caused by the geography and diet (Pandav et al., 2003).

This paper uses exogenous variation in the regulation of iodised salt by state, prior to the nationwide mandatory USI. Around 80% of all salt in India is produced in Gujarat. Salt is then transported to other states either by rail or road. Previous studies such as Vir (2011), report a strong relationship between the proportion of salt transported by rail to a given state and the consumption of adequately iodised salt (≥ 15 μg iodine g/salt) per state. This can be explained by differences in regulation across transport modes. National law mandates the control of iodised salt prior to rail transport while monitoring is not mandatory for salt undergoing road transportation. Distance from the salt producing state dictates the cost-effectiveness of a given transportation mode. States far away from Gujarat are more likely to have their salt transported by rail and nearby states are more likely to import their salt by road. Therefore, following the implications from differences in monitoring across forms of transportation, states far from Gujarat are more likely to have a higher access to iodised salt compared to households residing in Gujarat or in nearby states.[1]

Therefore, I use distance to Gujarat per state as an instrumental variable (IV) for the access to adequately iodised salt in a two-stage-least-squares (TSLS) estimation. The IV results indicate that the consumption of adequately iodised salt at the household level improves children's height-for-age by 0.664 standard deviations and height by 1.845 cm, on average. The estimates are robust to the inclusion of covariates capturing infant and maternal health and nutrition status. I do not find any effects on weight-for-age Z-scores (WAZ). This is in line with the lack of a physiological relationship between thyroid hormones and adipose tissue among children. Additionally, the absence of an impact on weight also rules out the possibility that the main results are driven by an overall improvement in concurrent caloric availability. Specification checks show that the instrument is not systematically correlated with other determinants of child growth. The effect of the availability of adequately iodised salt on young children's height appears to be larger than the effects from other public policies. The results highlight the importance of access to adequate intake of micronutrients, such as iodine, for height and the overall accumulation of health capital.

This paper is structured as follows. I begin with reviewing the evidence on the relationship between iodine and human growth in Section 1. Subsequently, I describe the production and transport of salt in India in Section 2. The data and the IV strategy is described in Section 3. The econometric strategy is presented in Section 4. Descriptive statistics are provided in Section 5 and the results are shown and discussed in Section 6. The validity of the results is tested in Section 3.8 and concluding remarks are reported in Section 8.

1 Iodine and height

Iodine deficiency from conception and onwards increases the risk of reduced thyroid hormone production. It has long been observed that foetuses and newborns to mothers with

[1] Currently, the relationship between the mode of salt transport and the availability of adequately iodised salt is likely to be weaker due to nationwide mandatory USI. The latest nationwide survey, the 2015-2016 National Family Health Survey (NFHS) IV, points to a high consumption of salt containing some iodine across all states. However, it does not report the consumption of adequately iodised salt.

diseases characterised by thyroid problems have stunted growth, see Shields (2011).[2] Hypothyroidism, an illness where the thyroid gland does not produce enough thyroid hormone, is a well-recognised cause of short stature among children (Zimmermann et al., 2007). Delayed bone maturation is also observed in children with hypothyroidism (Robson et al., 2002). On the other hand, accelerated growth has been observed in children with hyperthyroidism. This is a condition where the thyroid gland produces excessive levels of thyroid hormones (Tarim, 2011).

Thyroid hormones are involved in many physiological processes which determine growth both in utero and postnatally (Zimmermann et al., 2007). Normal thyroid hormone levels are required for growth and development of the skeleton and peripheral tissues. Additionally, they are essential for the production and functioning of both growth hormone and insulin-like growth factors (Zimmermann et al., 2007; Robson et al., 2002). The relationship between thyroid hormones, such as thyroxin, and growth hormones and insulin-like growth factors has been observed across in-vivo and in-vitro animal studies (Ezzat et al., 1991; Samuels et al., 1989). Iodine supplementation of iodine deficient populations has been shown to increase insulin-like growth factors (Zimmermann et al., 2007).

In particular there seems to be a strong link between thyroid hormones and skeletal development (Robson et al., 2002). Thyroid hormones are needed for the expression of target genes to regulate skeletal development. The relationship is supported by animal studies and in-vitro studies among humans (Abu et al., 1997). There is no clear physiological relationship between thyroid hormones and soft tissue (Shields, 2011).

Despite the established biological pathways, there is limited evidence on the effect of iodine on prenatal and postnatal growth and the overall findings are mixed (Zimmermann et al., 2007; Farebrother et al., 2018). A review on the impact of iodine supplementation of women during preconception and pregnancy by Harding and De-Regil (2017) finds no impact of the two studies which measure the impact on birth weight. Harding and De-Regil (2017) conclude that their meta-analysis should be interpreted with caution due to the limited number of studies comprising of low-quality trials from populations with mild- to moderate iodine deficiency. The observations might therefore not be applicable to areas with moderate-to severe iodine deficiency which are common in many middle and low income countries. For instance, Zimmermann et al. (2007) find that iodine repletion improves thyroid hormone levels and somatic growth of children who are severely iodine deficient but not for those who are moderately iodine deficient.

Farebrother et al. (2018) conduct a systematic review of the effects of any form of iodine supplementation, including iodised salt, of pregnant women and children on prenatal and postnatal growth outcomes. The review consists of 18 studies and concludes that while

[2] Examples of such illnesses are Graves' disease, hypothyroidism, or thyroid hormone resistance (Shields, 2011)

postnatal iodine repletion may improve growth factors, they are uncertain whether it affects somatic growth. The authors also note that the quality of the overall evidence is low. Additionally, most of these studies do not capture a long time period of exposure to iodine supplementation. Additionally, the possible relative effects on growth in utero and postnatally have not been established (Farebrother et al., 2018).

Studies using cross-sectional data find positive associations between iodised salt availability and child anthropometric status. Mason et al. (2002) observe significant associations between iodised salt use and child growth in Bangladesh, India (Andhra Pradesh), Nepal, and Sri Lanka. In particular, they find positive associations for WAZ and mid-upper-arm circumference whereas the association with HAZ is weaker. However, the study only controls for a limited set of covariates and the effects are only reported for selected locations within the respective countries. Krämer et al. (2016) analyse the association between household unavailability of iodised salt and child growth across 46 low and middle income countries. They use 89 nationally representative, repeated, cross sectional demographic and health surveys (DHS) conducted between 1994 and 2012. The paper finds that the unavailability of iodised salt is associated with 3% higher odds of being stunted, 5% higher odds of being underweight and 9% higher odds of low birth weight. What is further interesting is that the sample for India is driving the associations for all outcomes except birth weight. When data from India is omitted from the analysis, only the association for low birth weight remains significant. It should also be noted that the main effects in Krämer et al. (2016) are not robust to the inclusion of covariates related to food intake.

The limited available cross-sectional evidence using survey data is likely to suffer from endogeneity issues such as omitted variable bias, measurement error regarding the duration of iodised salt use and retrospectively self-reported accounts of children's birth weights, and potential simultaneity bias. This study builds upon the extant literature by estimating a causal impact of adequately iodised salt on very young children's HAZ using a large nationwide survey for rural India. The endogeneity issues are circumvented by the application of IV regression.

2 The production and transport of salt in India

I use the distance to the major salt producing state of Gujarat as an instrument for the access to iodised salt. A lower consumption of iodised salt has been observed in Gujarat and states near Gujarat compared to states further away (Vir, 2011; Kaur et al., 2017; Sundaresan, 2009). The association between iodised salt availability and the proximity to salt producers is due to differential monitoring policies of salt transported by rail compared to road. Salt is more likely to be transported by rail if the salt producer is further away. Monitoring of iodised salt is only mandatory prior to rail, but not, road transport. In this section, I provide an overview of the Indian salt market with a focus on the production and export of salt from Gujarat. I emphasize the time period of 2005 and 2006 as the household data used for the analysis was collected during these years.

The most common type of salt in India stems from sea water evaporation.[3] The western coastal state of Gujarat has always been the largest producer and exporter of salt to the rest of India due to its long coast line and favourable climatic conditions for sea water brine evaporation. Salt production units in Gujarat are found in thirteen districts across the coastline and periphery of the salt marsh in the the Little Rann of Kutch (Saline Area Vitalization Enterprise Limited, 2005). During 2005-2006, Gujarat produced 77.5% of all salt consumed in India. Other salt producing states are Tamil Nadu, Rajasthan and Andhra Pradesh which produced 11.5%, 7.2% and 2.3% respectively of all salt in India in 2005-2006 (*Salt Commissioner India: Transport of salt by rail*, 2006).

The majority of all salt produced in India and Gujarat comes from the private sector. Data for 2003 indicates that 62% of salt manufacturers are large scale producers (plots of over 100 acres). As per Indian federal policy, all large salt manufacturers have to obtain licenses and register with the Salt Department. Manufacturers of salt for local use are exempted from this. The next largest category (27%) comprises of small producers who hold up to 10 acres of land. They do not require licenses and are not registered with the Salt Department. Thus, there is a substantial proportion of small scale and unregulated salt producers and traders in India (Saline Area Vitalization Enterprise Limited, 2005). The close proximity of salt producers and merchants in Gujarat has also helped them to form a strong lobby which influences the national supply and price of salt (Saline Area Vitalization Enterprise Limited, 2005).

2.1 Monitoring and movement of salt

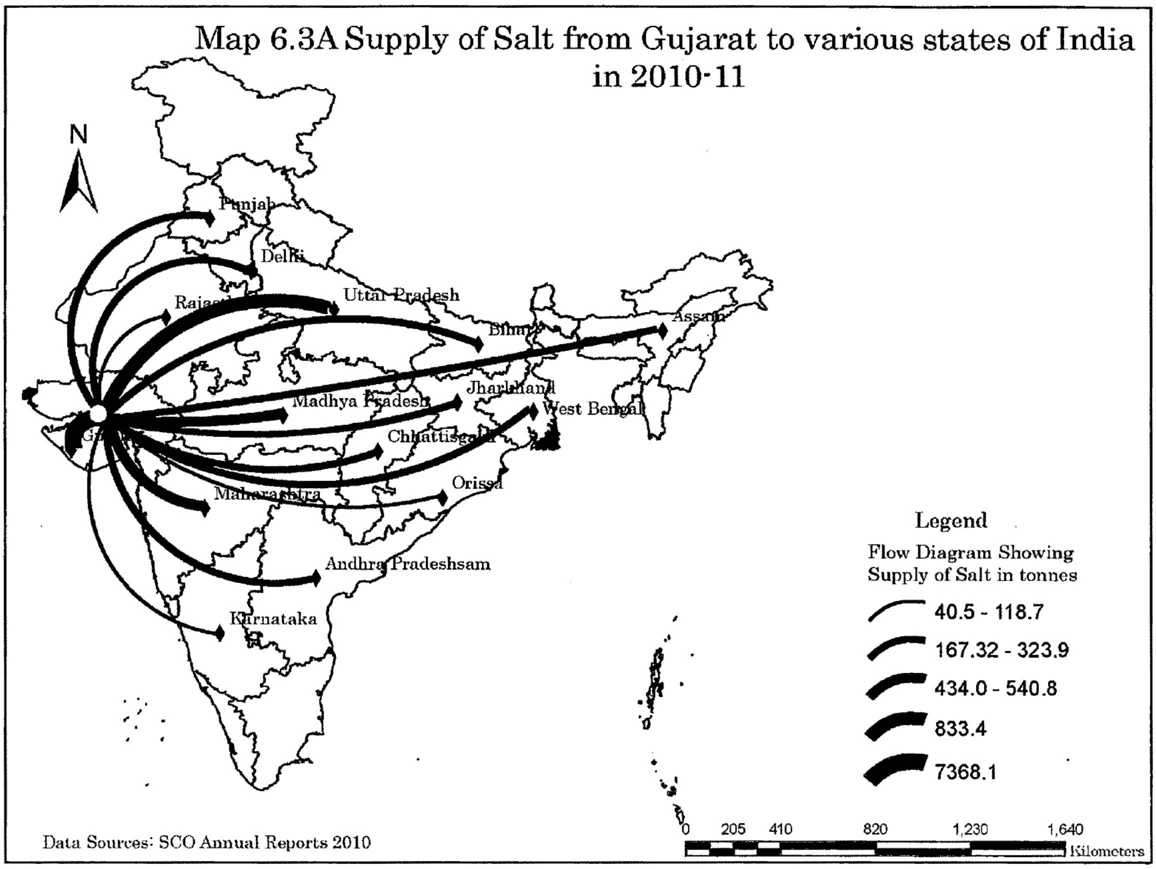
Salt production in Gujarat caters mainly to the eight north eastern States (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura), West Bengal, Bihar, Uttar Pradesh, Madhya Pradesh, Maharashtra, Goa, Rajasthan, Delhi, Jammu and Kashmir and Orissa (Vir, 2003). See Figure 1 for a visualisation of the size and destination of salt exported from Gujarat in 2010-2011 from the Salt Commissioner's Organisation, Department of Industrial Policy and Promotion (2011).[4] As seen from the figure, most Indian states import salt from Gujarat. The southern states import little

[3] Other types of salt production are inland salt from sub-soil ground water evaporation, lake salt from saline lakes and rock salt mining.

[4] I was not able to access comparable information for the time period of this study. Therefore, Figure 1 serves as an approximation of the export of salt from Gujarat during 2005-2006.

or no salt from Gujarat. This is due to their close proximity to the next largest salt producing state - Tamil Nadu.

Figure 1: Export of salt from Gujarat



This figure depicts the inter-state salt export flows from Gujarat across India in 2010-2011 from the Salt Commissioner's Organisation, Department of Industrial Policy and Promotion (2011).

In 2006, about 57% of salt for human consumption moved by rail and the rest by road (*Salt Commissioner's Organization*, 2016).[5] The mode of transport is determined by distance. It is more cost effective to use road transportation for shorter distances and rail transportation for longer distances (Vir, 2011, p.586). Sankar et al. (2006) observe that road transportation up to 1000 km appears to be more economical. A ban on the sale of non-iodised salt was implemented on the 17^{th} of May 2006. The analysis in this paper uses data just prior to its implementation. At this time, all states besides Gujarat and the small state of Arunachal Pradesh had a ban in place. These state level policies required that iodised salt should contain at least 15 μg iodine g/salt at the level of consumption. Therefore, the salt produced for export in Gujarat should be adequately iodised. On the other hand, salt produced both for domestic use and inter-state export in Tamil Nadu and Rajasthan should be adequately iodised.

[5] A marginal proportion of all salt is transported by sea.

Monitoring of iodised salt occurs at the level of production. Officials from the Salt Department test the iodine content of salt at iodisation plants (Pandav et al., 2003). However, control of iodised salt is restricted to major salt producers only and it is not being carried out in a systematic manner. Therefore, the many small producers who are not registered with the Salt Department are not monitored (Sundaresan, 2009). Thus, the control of iodised salt production is not sufficient to ensure adequate iodised salt supply, in particular from small producers.

Therefore, additional levels of monitoring play a key role. Salt rakes transported by rail undergo inspections from the Salt Department before it is loaded on the train. Only adequately iodised salt is given permission for transport. The control of salt transported by rail was implemented along the national "Iodine Deficiency Disorder Control programme" in 1973 (Kaur et al., 2017). Transportation of salt by rail also requires the registration of the producer which favours large salt producers for whom iodisation is less costly compared to smaller manufacturers (Kaur et al., 2017; Vir, 2011, p.586). For example, the north eastern states and West Bengal import their salt by rail and use a nominee system which consists of appointed traders who procure salt for the states. This system is biased in favour of large and registered salt producers who are more likely to produce adequately iodised salt (Vir, 2011, p.586).

On the other hand, there is no monitoring of salt transported by road. Therefore, small scale producers, who are less likely to comply with salt iodisation standards, often choose to transport their salt by road. Transportation by road also involves less capital compared to moving salt by rail which is further favourable for smaller producers (Kaur et al., 2017; Sundaresan, 2009).

In summary, a non-salt producing state is more likely to import salt by rail compared to road if it is further away from the salt producer. Due to mandatory monitoring of iodised salt transported by rail, a greater distance to Gujarat increases the likelihood of access to adequately iodised salt.

3 Data

The main data source for this study is India's version of the Demographic Health Survey, the 2005-2006 National Family and Health Survey (NFHS) III. This survey is representative for households with at least one eligible woman aged 15-49 at the state level (IIPS., 2007).[6] The survey consists of a rich variety of information, including household background characteristics, maternal and child health care utilisation and anthropometric

[6]The 2005-2006 NFHS III does not contain district level identifiers due to anonymity concerns in the collection of HIV information.

status.

Surveyors measure the lengths and heights of all children aged 0-59 months. Children under 24 months are measured lying down and older children are measured standing up. For consistency, I refer to the length of children measured lying down as height. Height-for-Age (HAZ) is defined as the difference between an individual's height and the mean height of a same-aged healthy reference population defined by the WHO in 2006, divided by the standard deviation of the reference population (de Onis, 2006). The calculated HAZ is provided in the NFHS. HAZ is frequently used as a measure for growth in developing countries including India, see for instance; Jayachandran and Pande (2017); Hammer and Spears (2016); Spears (2012*a*); Jain (2015). In particular it is thought to capture long term nutritional status and illness. The use of HAZ in the Indian context has further been discussed and validated by Tarozzi (2008). Additionally, I estimate the impact on height measured in cm and on the risk of being stunted. Stunting is defined as $\leq$ -2 HAZ and is thought to be a measure of severe long term nutritional deprivation.

The data contains information on objectively measured availability of adequately iodised salt at the household level. The NFHS surveyor measures the iodine content of the household's salt using a rapid-salt-testing kit. The survey reports the level of iodine available in the household in three categories; adequately iodised salt ($\geq$ 15 μg iodine g/salt), salt with some iodine or salt with no iodine. In the analysis, I omit the category referring to salt with an unknown level of iodine but below what is deemed adequate. This is due to the uncertainty regarding the dose-response relationship for the production and functioning of thyroid hormones.[7]

The analytical sample consists of rural households who were interviewed prior to May 2006 to reduce the risk that the access to adequately iodised salt is confounded by the implementation of the nationwide ban on non-iodised salt on the 17$^{\text{th}}$ of May 2006.

I further restrict the sample to households with children who are up to one year old at the time of the survey. This is because medical research indicates to that prenatal and early postnatal time periods are particularly sensitive for overall iodine intake (Zoeller and Rovet, 2004). However, it should be noted that there is no consensus regarding the role of thyroid hormones for growth in utero compared to postnatally or for various early postnatal time periods, see Farebrother et al. (2018). As we cannot assume that a household which was found to consume iodised salt during the interview also did so previously, restricting the analysis to very young children is more likely to capture the effect of iodised salt during a larger proportion of their lives compared to selecting older

[7]This also motivates the use of the 2005-2006 NFHS III for the analysis compared to the more recent 2015-2016 NFHS IV. The 2015-2016 NFHS IV only reports whether a household consumes iodised salt or not.

children for the analysis.[8] The analytical sample consists of children up to 12 months with non-missing information on HAZ in households who consume either adequately iodised salt or salt with no iodine. As the source of exogenous variation is determined by the state of residence, I further restrict the sample to households where the mother reports to have been living in the same area for at least one year.[9]

Lastly I merge in information on the state's distance to Gujarat. I use the GIS software QGIS to first locate the centroid per state as of the 2001 Indian Census. I subsequently calculate the distance from each state's centroid to the centroid of Gujarat.

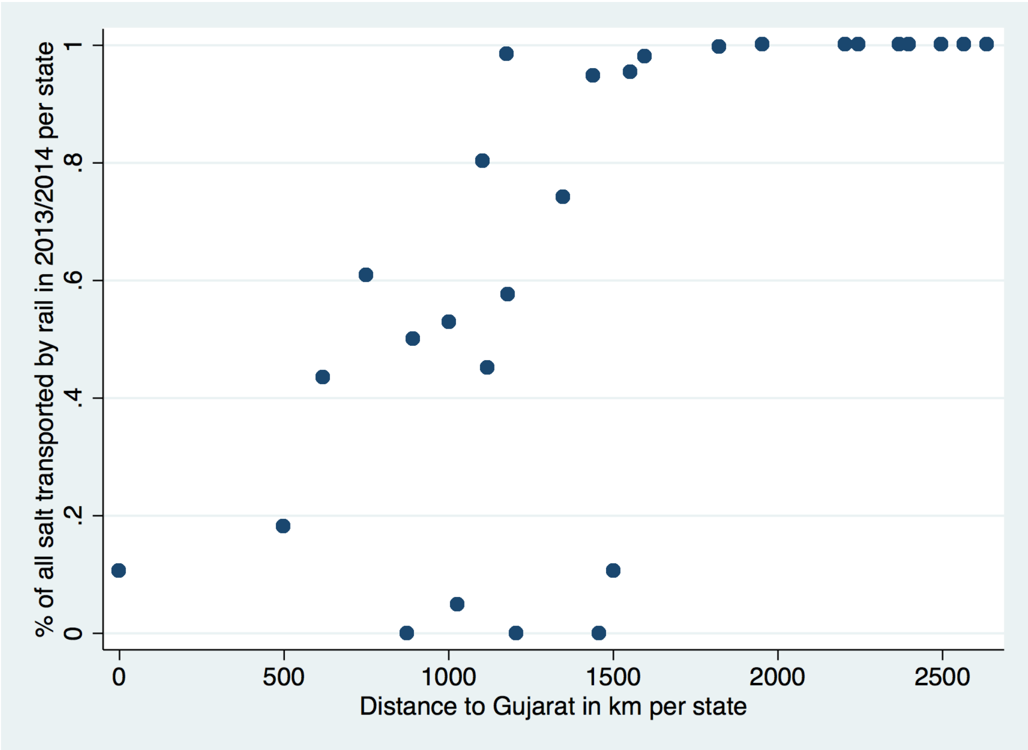
3.1 Definition of the instrumental variable

I start by investigating the relationship between the distance to Gujarat and the mode of transport per state. The earliest available information on the state-wise proportion of salt transport by rail compared to road is found in the 2013-2014 Salt Commissioner Annual Report, see Salt Commissioner's Organisation, Department of Industrial Policy and Promotion (2014). In Figure 2, I plot the relationship between the distance to Gujarat and the proportion of all salt transported by road compared to rail per state in 2013-2014. This figure serves as an approximation of the relationship during the 2005-2006 NFHS III. The report by Salt Commissioner's Organisation, Department of Industrial Policy and Promotion (2014) records that 26.5% of all salt in India in 2013-2014 moves by rail and 72.4% moves by road. This indicates an increase in the proportion of salt transported by road compared to the numbers reported for 2005-2006 by *Salt Commissioner's Organization* (2016). Therefore, the scatter plot in Figure 2 should be interpreted with caution. Nonetheless, the anticipated relationship between distance from Gujarat and rail transport remains. From Figure 2 we note that there is a strong and non-linear positive association between distance to Gujarat and the proportion of all salt transported by rail compared to road. A clear threshold appears around 1500 km. Almost all states located further away than 1500 km from Gujarat import their salt by rail.

[8]Estimating the effect of current iodised salt use on previous (and self-reported) anthropometric outcomes such as birth weight, would also introduce much uncertainty.

[9]Inter-state migration in India is very small, see Topalova (2005).

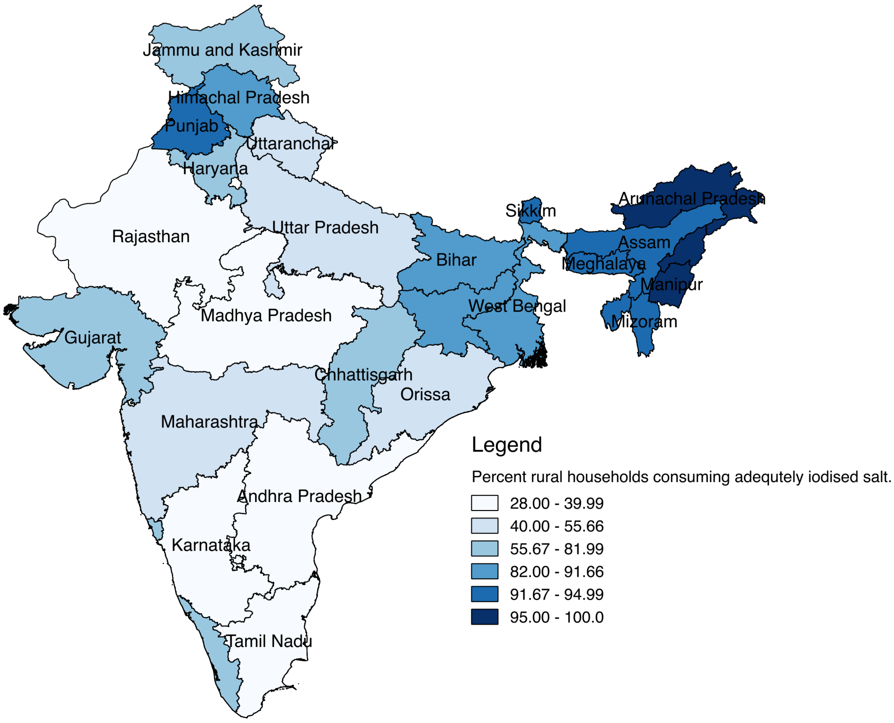
Figure 2: Distance to Gujarat and the proportion of salt transported by rail per state



This scatter plot shows the relationship between the distance to Gujarat from each state centroid and the proportion of all salt being transported by rail per state in 2013-2014. Information on the proportion of all salt transported by rail versus road is given by Salt Commissioner's Organisation, Department of Industrial Policy and Promotion (2014).

To inspect the spatial relationship between the proximity to Gujarat and access to iodised salt further, I have mapped the proportion of households consuming adequately iodised salt using the 2005-2006 NFHS III per state in Figure 3. From Figure 3 we observe a relationship between the coverage of adequately iodised salt per state and its distance from Gujarat. This map also highlights the relative efficacy of monitoring policies related to the transport of salt compared to state level policies. All states but Gujarat and Arunachal Pradesh had a ban on the sale and consumption of non-iodised salt during the years of the survey. We note that the coverage of adequately iodised salt was almost universal in Arunachal Pradesh where salt is likely to have been transported by rail despite the absence of a state level mandate. On the other hand, we observe that iodised salt use was low in states near Gujarat despite their state level bans on non-iodised salt.

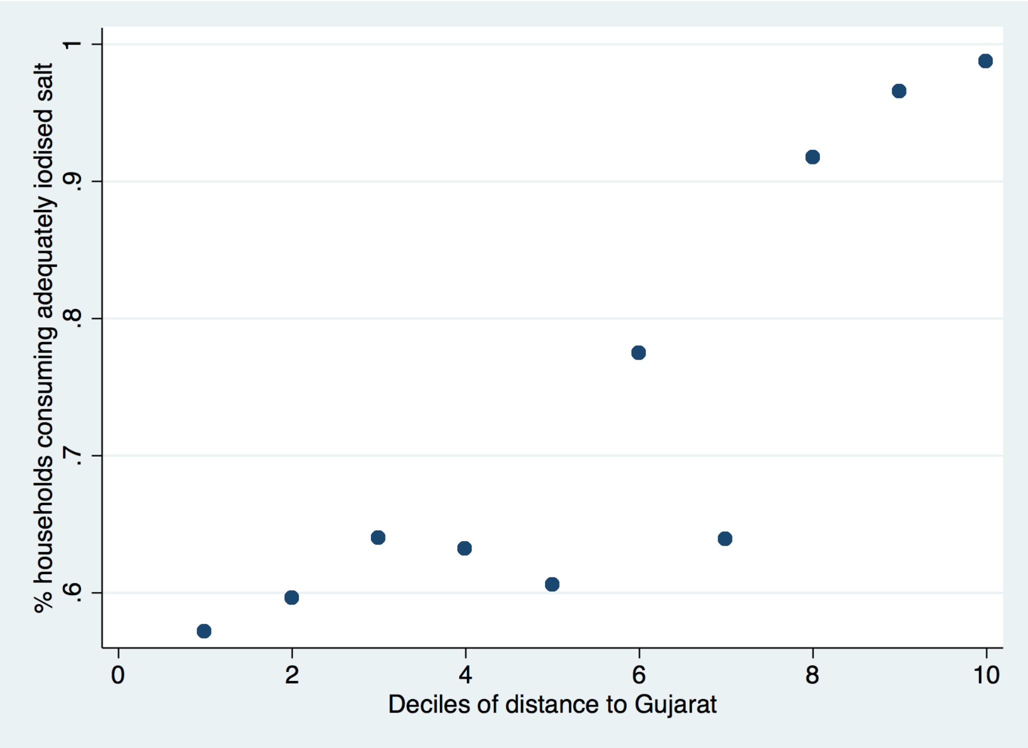
Figure 3: Iodised salt consumption per state in 2005-2006



This figure shows the percentage of rural households consuming adequately iodised salt per state based on data from the 2005-2006 NFHS III.

I use the distance to Gujarat per state to construct an instrumental variable for the availability of adequately iodised salt. Previous evidence from Vir (2011); Sankar et al. (2006) along with data presented in Figure 2 suggest a non-linear relationship between distance and the likelihood of rail transport. Therefore, I present the relationship between each decile of the distance distribution to Gujarat and the percentage of households consuming adequately iodised salt per state in the 2005-2006 NHFS III in Figure 4.

Figure 4: Iodised salt consumption per deciles of distance to Gujarat



This figure shows the percentage of rural households consuming adequately iodised salt per state from the 2005-2006 NFHS III in relation to the deciles of the distance distribution per state to Gujarat.

From Figure 4 we observe a large jump in the proportion of housholds consuming adequately iodised salt in the upper three deciles. I use this threshold to construct a binary instrumental variable. The instrumental variable takes value 1 if the state is in the upper three deciles of the distance distribution ($\geq$ 1553.558 km) from each state to Gujarat. The instrumental variable takes value 0 if the state is in the 7 lower deciles. The cut-off also corresponds well to the observed threshold of the relationship between distance and transport mode in Figure 2.

Moreover, I exclude states consuming a substantial proportion of salt not produced in Gujarat. I omit the two other salt exporting states from the analysis, Tamil Nadu and Rajasthan. As shown from Figure 1 we note that the southern states are less likely to consume salt from Gujarat due their close proximity to Tamil Nadu. Therefore, I exclude neighbouring states to Tamil Nadu from the main analysis.

4 Econometric specification

To start with, I estimate an OLS regression, specified in Equation 1.

$$\text{HAZ}_{is} = \alpha_0 + \beta \text{Iodised Salt}_{is} + \beta X_{is} + \mu_{is} \tag{1}$$

The outcome variable is HAZ for child i in state s. The independent variable of interest, *Iodised salt*, takes value 1 if the household was found to have adequately iodised salt and 0 if the salt had no iodine. X is a vector of covariates described below.

I account for any differences across regions by including regional dummies.[10] This is important due to large variation in both height and state governance across regions, see Deaton (2009).[11] Additionally, I control for any region-specific temporal variation, such as seasonal variation in the nutrition and disease environment, by adding year specific month of birth dummies interacted with region of residence. I further control for month of interview to remove any nationwide variation stemming from a potential increase in overall iodised salt coverage due to the notification of the federal ban in 2005 and subsequent anticipation of the implementation of the ban in May 2006.

The following state level variables are controlled for; GDP in 100 000 rupees per capita in 2004-2005 compiled by *National Institution for Transforming India, Government of India* (2006), health expenditure per capita in rupees in 2005-2006 found in Berman (2017), population density measured in 1000 inhabitants per km^2 calculated from the 2001 Indian Census. I also include a binary indicator variable for whether the state is an "Empowered Action Group" (EAG) state. This denotes that the state is socioeconomically backwards and has a higher priority of federal public health programmes such as the National Rural Health Mission (Kumar and Singh, 2016).[12] I partial out variation stemming from the institutional capacity, quality and efficiency in the delivery of public services by controlling for the proportion of institutional deliveries per state from the 2005-2006 NFHS III.[13]

I control for the number of goitre endemic areas in McCarrison (1915) per 100,000 population per state.[14] Accounting for known and longstanding goitre endemicity is likely to partial out any differences in state commitments to the eradication of iodine deficiency.

The following household covariates are included: the proportion of children aged 5 or younger, caste, religion, a dummy for whether the household's native tongue is Hindi,

[10]As the analytical sample omits states which import a large share of their salt from Tamil Nadu, the southern region is not included in the final sample. Therefore, five out of six regional dummies are included.

[11]Due to the high degree of multicollinearity between the instrumental variable and state, I am not able to include state level fixed effects.

[12]The following states are defined as EAG: Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttarakhand and Uttar Pradesh.

[13]I do not control for whether the specific child was delivered at a facility as this would decrease the sample size substantially.

[14]Please see Tafesse (2018) for a description and discussion of the constructed data set based on the map of goitre endemic areas in India in 1915 by McCarrison (1915).

wealth quintile,[15] and whether the household uses water from an unprotected water source. I control for the mother's educational attainment and mother's age as these variables often are shown to be strongly associated with children's human capital development Borooah (2005). Previous work by Spears (2012*b*) and Hammer and Spears (2016) emphasize the impact of sanitation on height. Therefore, I add an indicator variable denoting whether the mother practices open defecation.

The demand for iodised salt is likely to be positively related to other nutritional investments and availability. I reduce the risk for bias by accounting for the nutritional intake of the mother due to its impact on the nutritional availability for the child in utero and postnatally through breastfeeding. I control for whether the mother eats fish at least weekly. Fish is the most iodine rich food and thus the control variable captures dietary iodine availability. I further control for the incidence of other micronutrient deficiencies by accounting for the mother's anaemia status based on the haemoglobin test conducted by the DHS. The following categories are reported; no anaemia, mildly anaemic, moderately anaemic and severely anaemic.[16]

Moreover, health information and the ability to process such information is likely to affect the demand for iodised salt and other unobserved preventive health care investments. Therefore, I add controls for the mother's health knowledge. I generate a categorical variable for the mother's health knowledge based on her knowledge about tuberculosis (TBC), oral rehydration salt (ORS) and AIDS. The variable takes value 0 if the mother does not know about either category, 1 if she knows about one of the categories, 2 if she knows about two of the categories and 3 if she has knowledge about TBC, ORS and AIDS.

Finally, further child-specific covariates are incorporated in the specification. Dummy variables for whether the child is from a singleton or multiple birth are included as children from multiple births often are shorter than those from singleton births. I also control for birth dummies for birth order 1-5 and 6 and above as Borooah (2005) show that child order matter in explaining variations of child height in India. Additionally, I control for gender and the interaction of gender and birth order as Jayachandran and Pande (2017) find that gender specific birth order is an important predictor of children's heights in India. I also control for the current health status of the child by controlling for whether the child had diarrhoea, fever or cough within two weeks prior to the survey. Child health investment and the availability of health care services is accounted for by adding covariates

[15] DHS uses information on ownership of household items, dwelling characteristics, home construction materials and access to a bank or post office account to construct a composite wealth index based on principle component analysis. This score is then divided into quintiles ranking from 1 (poorest) to 5 (richest).

[16] I do not control for mother's height or weight as these outcomes might be directly affected by the availability of iodised salt.

for whether the child accessed any Integrated Child Development Services (ICDS). The ICDS provide health care, supplementary nutrition and pre-school services to children aged 0—6 years old (Jain, 2015).

I cluster the standard errors on the state level due to the federal nature of India and the IV being defined by state.

Even though I control for a large set of covariates, the OLS estimate of the impact of adequately iodised salt use on children's HAZ is at risk for bias. Iodised salt consumption is likely to be positively associated with unobserved characteristics related to health knowledge and preferences for investing in children's health. Omitted variable bias can therefore cause an upward bias in the coefficient of interest using OLS.

HAZ is a function of accumulated levels of health and nutrition, including the intake of iodine. The 2005-2006 NFHS III reports the current levels of iodine in the household's salt and there is a risk that the current use of iodised salt does not represent previous consumption. Therefore, the OLS specification might suffer from measurement error. Assuming that the measurement error is classical, i.e. that the measurement error has mean zero and is uncorrelated with the true dependent and independent variables and with the equation error, it is likely to bias the OLS estimate downwards. Lastly, there is a possibility of simultaneity bias as the consumption of iodised salt might depend on a child's characteristics. Therefore, I estimate a TSLS regression. The first stage is specified in Equation 2.

$$\text{Adequately Iodised Salt}_{is} = \alpha_0 + \gamma \text{Far}_s + \beta X_{is} + \mu_{is} \tag{2}$$

The instrumental variable *Far* is a binary variable which takes value 1 if the state's centroid is located far from Gujarat. Meaning that it is in the upper three deciles of the distance distribution from Gujarat. The variable takes value 0 if the household's state of residence is Gujarat or if the state is located in the lower 7 deciles of the distance distribution to Gujarat. X denotes the same set of covariates as in the OLS specification. The predicted estimates for *Adequately Iodised* salt are used in the second stage specified in Equation 3 below. The same set of covariates are included and standard errors are clustered at the state level.

$$\text{HAZ}_{is} = \alpha_0 + \delta \text{Adequately Iodised}_{is} + \beta X_{is} + \mu_{is} \tag{3}$$

5 Summary statistics

The means and standard deviations of various characteristics are shown for households who consume adequately iodised salt and for households who consume salt with nil iodine, respectively, in Table 1. The difference in means across the samples and accompanying t-statistics are provided in the last two columns of the table. We observe that children in households with adequately iodised salt have better anthropometric outcomes in terms of HAZ, height and WAZ, and a lower risk for stunting. We also note that the subsamples do not differ with reference to the health status of children or by mothers' anaemia status. In fact, children from households with non-iodised salt are more likely to use ICDS compared to child with access to adequately iodised salt. Households who consume adequately iodised salt are more likely to reside in states with higher rates of historical goitre endemicity. This can potentially be explained by larger state government commitments to eradicating iodine deficiency given that this is a prevalent and long standing problem.

The rationale for the use of IV regression is strengthened by observing that mothers in households with access to adequately iodised salt are more likely to have a better health knowledge and to consume fish more often. Furthermore, EAG state status and two important predictors of child nutritional status; maternal education and open defecation, also differ substantially across the samples. This systematic relationship suggests that the consumption of iodised salt could be potentially correlated with additional unobserved determinants of children's growth.

Table 1: Descriptive statistics by household consumption of adequately iodised salt

	Iodised Salt		Non-iodised salt		Difference	
	Mean	SD	Mean	SD	Difference	t-statistic
HAZ	-0.75	1.78	-1.22	1.70	-0.47***	(-6.57)
Stunted	0.22	0.42	0.31	0.46	0.09***	(4.83)
Height (cm)	64.74	6.69	63.75	6.61	-0.99***	(-3.60)
WAZ	-1.03	1.28	-1.50	1.23	-0.48***	(-9.15)
Age in months	6.45	3.40	6.59	3.39	0.15	(1.04)
Girl	0.48	0.50	0.54	0.50	0.06**	(2.67)
Singleton Birth	0.99	0.10	0.99	0.12	-0.00	(-0.77)
Birth Order	2.61	1.60	2.93	1.67	0.32***	(4.64)
Child used ICDS	0.32	0.46	0.38	0.49	0.06**	(3.13)
Child had diarrhoea recently	0.15	0.36	0.17	0.38	0.02	(1.30)
Child had fever recently	0.18	0.39	0.17	0.38	-0.01	(-0.53)
Child had cough recently	0.23	0.42	0.24	0.43	0.01	(0.47)
Mother's Age	25.28	5.46	24.98	5.43	-0.29	(-1.30)
Mother heard of AIDS	0.61	0.49	0.38	0.49	-0.23***	(-11.64)
Mother heard of ORS	0.74	0.44	0.67	0.47	-0.07***	(-3.55)
Mother heard of TBC	0.87	0.34	0.77	0.42	-0.10***	(-5.89)
Mother is anemic	0.63	0.48	0.64	0.48	0.02	(0.86)
Mother eats fish at least weekly	0.32	0.47	0.15	0.36	-0.17***	(-10.12)
Proportion of children under 5 in household	0.31	0.13	0.32	0.12	0.01	(1.12)
Unprotected water source	0.25	0.43	0.25	0.43	0.00	(0.19)
Mother practices open defecation	0.49	0.50	0.82	0.38	0.33***	(19.14)
Hindi	0.38	0.48	0.64	0.48	0.27***	(13.38)
Scheduled Caste	0.15	0.36	0.19	0.39	0.03*	(2.12)
Scheduled Tribe	0.25	0.43	0.22	0.41	-0.03	(-1.72)
Other Backward Caste	0.25	0.43	0.33	0.47	0.09***	(4.49)
Poor Household	0.43	0.50	0.60	0.49	0.17***	(8.43)
Mother has some education	0.63	0.48	0.41	0.49	-0.22***	(-10.86)
Hindu	0.60	0.49	0.82	0.38	0.22***	(12.84)
Muslim	0.14	0.35	0.12	0.33	-0.02	(-1.49)
Empowered action group state	0.39	0.49	0.66	0.47	0.27***	(13.68)
Central	0.07	0.26	0.25	0.43	0.18***	(10.95)
East	0.21	0.41	0.13	0.34	-0.08***	(-5.22)
North	0.27	0.44	0.42	0.49	0.14***	(7.25)
North East	0.37	0.48	0.04	0.20	-0.33***	(-26.16)
West	0.07	0.26	0.16	0.37	0.09***	(6.45)
Proportion institutional deliveries/state	0.84	0.09	0.84	0.10	-0.00	(-0.82)
State health expenditure * 1000 rupees/capita	0.03	0.02	0.02	0.02	-0.01***	(-14.19)
Historical goitre endemic locations/100 000 population per state	0.35	0.56	0.07	0.23	-0.28***	(-18.62)
State population (per 1000) density per km^2	0.33	0.28	0.37	0.23	0.04***	(4.30)
State GDP/capita (per 10000 rupees)	89.05	108.75	159.44	121.86	70.39***	(14.42)
Observations	2024		826		2850	

Next, I present the descriptive statistics for households in states near and far from Gujarat according to the definition of the IV indicator in Table 2. First we note that 93% of all households in states in the upper three deciles of the distance distribution were found to consume adequately iodised salt. The respective proportion is only 55% in Gujarat or nearby states. Children living far away from Gujarat have better anthropometric outcomes. The samples are balanced in terms of general child characteristics such as; gender, age, singleton birth status, birth status. Additionally, no statistically significant differences are found for whether the child had fever or cough recently, the proportion of children under 5 in the household, the proportion of muslims and the percentage of births delivered at a facility.

A clear difference in terms of health and nutrition between households in states near and far from Gujarat does not emerge. While mothers in states far away from Gujarat are more likely to have heard of AIDS and TBC, they are less likely to have heard of ORS. Households in states with closer proximity to the main salt exporting state are more likely to report a higher incidence of diarrhoea. They also report a higher utilisation of ICDS. It is not certain whether the higher use of ICDS reflects need or an improved access to health care services. Whilst nutritional intake, measured by the frequency of fish consumption, is better in states far from Gujarat, mothers in states near Gujarat are less likely to be anaemic. Other determinants of children's heights, such as the hygiene and sanitation environments, do not appear to vary consistently by IV assignment. Open defecation is higher in states nearer Gujarat while the proportion of households who access drinking water from an unprotected water source is lower. There does not seem to be a clear systematic relationship between predictors of height and IV status.

Table 2: Descriptive statistics by instrumental variable

	Near Gujarat		Far from Gujarat		Difference	
	Mean	SD	Mean	SD	Difference	t-statistic
Adequately Iodised Salt	0.55	0.50	0.93	0.26	-0.38***	(-26.27)
HAZ	-1.02	1.72	-0.71	1.82	-0.30***	(-4.49)
Stunted	0.27	0.44	0.22	0.41	0.05**	(2.99)
Height (cm)	64.15	6.62	64.87	6.74	-0.72**	(-2.83)
WAZ	-1.27	1.20	-1.01	1.38	-0.27***	(-5.30)
Age in months	6.46	3.37	6.53	3.43	-0.07	(-0.56)
Girl	0.49	0.50	0.51	0.50	-0.02	(-1.20)
Singleton Birth	0.99	0.10	0.98	0.12	0.01	(1.25)
Birth Order	2.67	1.57	2.76	1.70	-0.09	(-1.46)
Child used ICDS	0.39	0.49	0.25	0.43	0.15***	(8.42)
Child had diarrhoea recently	0.18	0.38	0.13	0.34	0.05***	(3.34)
Child had fever recently	0.17	0.38	0.19	0.39	-0.02	(-1.24)
Child had cough recently	0.22	0.42	0.25	0.43	-0.02	(-1.52)
Mother's Age	24.93	5.04	25.56	5.95	-0.63**	(-2.97)
Mother heard of AIDS	0.51	0.50	0.59	0.49	-0.09***	(-4.70)
Mother heard of ORS	0.74	0.44	0.69	0.46	0.05**	(3.03)
Mother heard of TBC	0.81	0.39	0.88	0.32	-0.07***	(-5.22)
Mother is anemic	0.60	0.49	0.69	0.46	-0.09***	(-4.77)
Mother eats fish at least weekly	0.14	0.35	0.46	0.50	-0.32***	(-18.99)
Proportion of children under 5 in household	0.31	0.13	0.32	0.13	-0.01	(-1.35)
Unprotected water source	0.19	0.39	0.33	0.47	-0.14***	(-7.91)
Mother practices open defecation	0.73	0.44	0.39	0.49	0.35***	(19.41)
Hindi	0.63	0.48	0.22	0.41	0.41***	(24.51)
Scheduled Caste	0.21	0.40	0.10	0.31	0.10***	(7.67)
Scheduled Tribe	0.15	0.36	0.37	0.48	-0.21***	(-12.84)
Other Backward Caste	0.32	0.47	0.21	0.41	0.11***	(6.84)
Poor Household	0.45	0.50	0.52	0.50	-0.07***	(-3.78)
Mother has some education	0.55	0.50	0.59	0.49	-0.04*	(-2.07)
Hindu	0.82	0.38	0.44	0.50	0.38***	(22.31)
Muslim	0.11	0.31	0.18	0.39	-0.07***	(-5.46)
Empowered action group state	0.57	0.50	0.34	0.47	0.23***	(12.48)
Central	0.22	0.41	0.00	0.00	0.22***	(21.30)
East	0.08	0.27	0.34	0.47	-0.27***	(-17.54)
North	0.54	0.50	0.00	0.00	0.54***	(44.09)
North East	0.00	0.00	0.66	0.47	-0.66***	(-47.93)
West	0.17	0.37	0.00	0.00	0.17***	(18.20)
Proportion institutional deliveries/state	0.83	0.10	0.86	0.06	-0.03***	(-8.42)
State health expenditure * 1000 rupees/capita	0.03	0.02	0.04	0.02	-0.01***	(-13.00)
Historical goitre endemic locations/100 000 population per state	0.11	0.22	0.49	0.67	-0.38***	(-18.84)
State population (per 1000) density per km^2	0.34	0.21	0.35	0.33	-0.02	(-1.71)
State GDP/capita (per 10000 rupees)	152.05	126.54	50.80	68.03	101.24***	(27.50)
Observations	1651		1199		2850	

6 Results

The regression results from the OLS specification (columns 1-2), first stage (columns 3-4), reduced form (5-6) and TSLS (columns 7-8) specifications are presented in Table 3. The OLS estimate shows that the availability of adequately iodised salt is associated with an increase by 0.156 height-for-age Z-scores after controlling for the full set of controls. Turning to the first stage in columns 3-4 we note that residing far from Gujarat increases the probability that a household consumes adequately iodised salt by 37.6 percentage points when no covariates are included and 55.2 percentage points after including the full set of controls. The corresponding Kleibergen-Paap F-statistic, shown at the bottom of Table 3 is 29.457 for the fully specified model and indicates that the instrument is not weak. The reduced form also show that the assignment of the IV is positively related to children's HAZ although it becomes statistically insignificant when the full set of covariates is included in column 6.

The TSLS result indicates that access to adequately iodised salt improves height-for-age by 0.664 standard deviations. The IV estimate is larger than the corresponding OLS coefficient, but we also note that the standard errors increase substantially from the OLS specification. The Durbin—Wu—Hausman test reveals that we fail to reject the null hypothesis that the consumption of adequately iodised salt is exogenous at the 1% level of statistical significance.

One would assume that any potential omitted characteristics which are positively related to the consumption of iodised salt, also have a positive effect on children's growth. Given this assumption, the risk for omitted variable bias could potentially cause OLS to be upward biased. As the IV results indicate that the OLS estimates were downward biased, OVB is not likely to have biased the OLS regressions significantly. This can potentially be explained by the inclusion of a rich set of covariates, particularly related to the nutritional environment and the mother's health practices and health knowledge.

Due to the increase in the coefficient of interest from the OLS to the IV estimations, the largest source of bias in the OLS specification is likely to be attenuation bias caused by measurement error. The risk for measurement error in the availability of adequately iodised salt is likely to stem from differences in current consumption of adequately iodised salt compared to previous consumption.[17] As HAZ is a function of current and past health and nutrition investments, one would ideally like to include information on past consumption of iodised salt in the analysis. As the IV is correlated with the consumption of adequately iodised salt but uncorrelated with the error term, IV regression identifies the true effect of adequately iodised salt consumption on HAZ.

[17] The bias is less likely to be caused by measurement error in the iodine content of the household's salt consumption at the time of the survey as the iodine content has been measured objectively.

Table 3: Effect on HAZ - OLS, first stage, reduced form and TSLS regressions.

	OLS		First Stage		Reduced Form		TSLS	
	(1) HAZ	(2) HAZ	(3) Adequately Iodised Salt	(4) Adequately Iodised Salt	(5) HAZ	(6) HAZ	(7) HAZ	(8) HAZ
Adequately Iodised Salt	0.467***	0.156*					0.805**	0.664*
	(0.105)	(0.082)					(0.389)	(0.364)
Far from Gujarat			0.376***	0.552***	0.303*	0.367		
			(0.054)	(0.102)	(0.164)	(0.239)		
Girl		0.184		-0.054		0.175		0.211*
		(0.124)		(0.032)		(0.124)		(0.115)
Child used ICDS		-0.048		0.039**		-0.035		-0.061
		(0.092)		(0.014)		(0.091)		(0.090)
Child had diarrhoea recently		-0.041		-0.004		-0.044		-0.041
		(0.069)		(0.020)		(0.069)		(0.066)
Child had fever recently		-0.057		0.006		-0.059		-0.063
		(0.082)		(0.022)		(0.081)		(0.076)
Child had cough recently		0.104		-0.026		0.100		0.118
		(0.102)		(0.029)		(0.100)		(0.098)
Mother mildly anaemic		-0.104		-0.015		-0.108		-0.099
		(0.087)		(0.023)		(0.087)		(0.081)
Mother moderately anaemic		-0.217***		0.002		-0.218***		-0.219***
		(0.074)		(0.026)		(0.074)		(0.072)
Mother severely anaemic		-0.348		0.046		-0.338		-0.369*
		(0.224)		(0.050)		(0.225)		(0.212)
Mother: Primary education		-0.164**		0.049		-0.157*		-0.189***
		(0.073)		(0.032)		(0.076)		(0.071)
Mother: Secondary education		0.113		0.046*		0.118		0.087
		(0.092)		(0.027)		(0.090)		(0.099)
Mother: Higher education		0.395*		0.058		0.391*		0.353*
		(0.200)		(0.051)		(0.199)		(0.205)
Mother eats fish at least weekly		-0.094		0.005		-0.084		-0.087
		(0.107)		(0.031)		(0.110)		(0.104)
Mother heard of one of ORS or TBC or AIDS		0.212		0.103***		0.227		0.159
		(0.139)		(0.030)		(0.138)		(0.145)
Mother heard of two out of ORS, TBC and AIDS		0.217		0.120***		0.238*		0.159
		(0.127)		(0.032)		(0.126)		(0.135)
Mother heard of ORS and TBC and AIDS		0.338**		0.126***		0.368**		0.284*
		(0.150)		(0.033)		(0.148)		(0.154)
Unprotected water source		-0.046		-0.049***		-0.063		-0.031
		(0.067)		(0.017)		(0.065)		(0.067)
Mother practices open defecation		-0.050		-0.034		-0.053		-0.030
		(0.100)		(0.025)		(0.100)		(0.096)
Poorer		-0.268**		0.042*		-0.262**		-0.289***
		(0.118)		(0.023)		(0.117)		(0.111)
Middle		0.080		0.028		0.085		0.067
		(0.119)		(0.029)		(0.120)		(0.107)
Richer		0.199		0.120***		0.223		0.144
		(0.133)		(0.040)		(0.133)		(0.115)
Richest		0.523**		0.192***		0.556***		0.429**
		(0.189)		(0.053)		(0.186)		(0.168)
Constant	-1.222***	-3.560***	0.552***	0.901***	-1.018***	-3.439***	-1.462***	-4.038***
	(0.088)	(0.857)	(0.051)	(0.276)	(0.087)	(0.900)	(0.267)	(0.856)
Kleibergen-Paap F-statistic					-		48.058	29.457
Observations	2850	2476	2850	2476	2850	2476	2850	2476
R^2	0.014	0.158	0.168	0.312	0.007	0.158	0.007	0.145

Notes: The outcome variable is HAZ. The consumption of adequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in the IV regressions in columns 7 and 8. The covariates included in columns 2, 4, 6 and 8 are described in subsection 4 but are not shown due to space restrictions. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

The increase in HAZ is supported by an observed increase in raw height measured in cm. I estimate the effect on height while controlling for age in months. The regression results are presented in Table 4. From column 6 we note that the IV results show that the access to adequately iodised salt increases height by 1.845 cm for children up to 12 months.

Even though access to iodised salt has a negative effect on the risk of being stunted, both the OLS and IV estimates are not significant at a conventional level of statistical significance after including all controls, see Table 8 in the Appendix. This possibly implies that access to iodised salt does not greatly improve height for children who have experienced severe long term nutritional deprivation.

Iodine is hypothesized to have a positive effect on somatic growth as thyroid hormones are needed to regulate skeletal development (Abu et al., 1997). According to Shields (2011), very little research has looked into the impact of thyroid hormone on foetal or infant adiposity as the biological relationship is less clear. A clinical trial of 5-15 year old children in Tibet with Kashin-Beck disease who received intramuscular iodised oil finds that iodine supplementation increased HAZ-scores, whereas WAZ-scores decreased, see Moreno-Reyes et al. (2003).[18] Therefore, one would not readily expect a positive effect of iodised salt on children's weights.

I analyse the impact of adequately iodised salt access on children's WAZ by estimating similar OLS and IV equations specified previously. I restrict the analysis to the sample of children used in the main regressions. From Table 9 in the Appendix we do not observe a positive effect of iodised salt on WAZ from the OLS results nor the IV results after controlling for all covariates. The absence of an effect on children's weights indicates that an overall increase in current nutritional intake, nor associated omitted characteristics, are unlikely to be driving the overall results on HAZ.

[18]The children were part of a selenium supplementation trial where a randomized group received intramuscular iodized oil before being further randomly assigned to receive selenium or placebo.

Table 4: Effect on height - OLS, reduced form and TSLS regressions.

	OLS		Reduced Form		TSLS	
	(1)	(2)	(3)	(4)	(5)	(6)
Adequately Iodised Salt	0.986***	0.478**			1.910	1.845***
	(0.314)	(0.185)			(1.288)	(0.709)
Far from Gujarat			0.719	1.035*		
			(0.517)	(0.508)		
Girl		-1.350***		-1.379***		-1.280***
		(0.268)		(0.272)		(0.234)
Child used ICDS		0.078		0.115		0.043
		(0.188)		(0.187)		(0.184)
Child had diarrhoea recently		0.003		-0.006		0.002
		(0.159)		(0.158)		(0.156)
Child had fever recently		-0.042		-0.048		-0.058
		(0.184)		(0.184)		(0.171)
Child had cough recently		0.309		0.298		0.346
		(0.240)		(0.238)		(0.234)
Mother mildly anaemic		-0.311		-0.325		-0.298*
		(0.192)		(0.193)		(0.179)
Mother moderately anaemic		-0.575***		-0.578***		-0.581***
		(0.154)		(0.154)		(0.156)
Mother severely anaemic		-1.219**		-1.191**		-1.277***
		(0.495)		(0.494)		(0.477)
Mother: Primary education		-0.340*		-0.316*		-0.406**
		(0.170)		(0.179)		(0.166)
Mother: Secondary education		0.330		0.345		0.259
		(0.236)		(0.230)		(0.242)
Mother: Higher education		1.041**		1.030**		0.923*
		(0.477)		(0.473)		(0.473)
Mother eats fish at least weekly		-0.297		-0.269		-0.278
		(0.236)		(0.239)		(0.234)
Mother heard of one of ORS or TBC or AIDS		0.234		0.279		0.088
		(0.393)		(0.390)		(0.402)
Mother heard of two out of ORS, TBC and AIDS		0.324		0.385		0.163
		(0.336)		(0.337)		(0.339)
Mother heard of ORS and TBC and AIDS		0.529		0.616		0.381
		(0.369)		(0.368)		(0.366)
Unprotected water source		-0.208		-0.258*		-0.166
		(0.137)		(0.137)		(0.130)
Mother practices open defecation		-0.216		-0.227		-0.165
		(0.251)		(0.251)		(0.245)
Poorer		-0.566**		-0.548**		-0.625**
		(0.257)		(0.252)		(0.249)
Middle		0.235		0.249		0.198
		(0.245)		(0.247)		(0.227)
Richer		0.400		0.471		0.249
		(0.314)		(0.312)		(0.296)
Richest		1.299***		1.398***		1.042**
		(0.438)		(0.426)		(0.412)
Constant	63.752***	44.363***	64.150***	43.968***	63.097***	41.863***
	(0.329)	(11.685)	(0.384)	(11.546)	(1.023)	(12.421)
Observations	2850	2477	2850	2477	2850	2477
R^2	0.004	0.691	0.003	0.690	0.001	0.684

Notes: The outcome variable is height measured in cm. The consumption of adequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in the IV regressions in columns 5 and 6. The covariates included in columns 2, 4, and 6 are described in subsection 4 but are not shown due to space restrictions. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

6.1 Heterogeneous effects

Next, I estimate the effect for separate age groups of children aged 0-6 months, 7-12 months, 13-18 months and 19-24 months. The results are presented in Table 5. We note that the effect of adequately iodised salt availability on HAZ is biggest for children up to 6 months. The IV estimate for children between 6 and 12 months is positive but not statistically significant. The effects for the older age categories are not statistically significant across both OLS and IV specifications. The results can possibly be interpreted as the impact of iodised salt availability being largest for very young children. However, medical research has not established the relative importance of access to iodine for linear growth of different age groups (Farebrother et al., 2018).

In the main regressions, I have controlled for the number of historical goitre endemic areas per population per state. This is to account for the naturally occurring risk for iodine deficiency per state and for any unobserved state level differences in public policy aiming to reduce known and long standing iodine deficiency. Intuitively the effect of iodised salt on HAZ should be larger for children at higher risk for iodine deficiency. To investigate whether the effect differs according to the risk for iodine deficiency, I estimate the main regressions for two sub samples separately; children residing in states in the upper three quartiles of the state-goitre distribution, and children from states in the three lower quartiles of the state-goitre distribution.[19] In line with the expectations, we observe a larger effect on HAZ in states with a higher risk for iodine deficiency. Children from states in the second and higher quartile of the historical state-goitre endemicity distribution experienced an improvement of height-for-age by 1.45 standard deviations.

The medical literature concerning the importance of thyroid hormones, and thus iodine for populations at risk for deficiency, does not observe consistent gender differences. Due to the differential impact of iodised salt on cognitive test scores shown in Tafesse (2018), I also estimate the effect of access to iodised salt on HAZ for boys and girls separately. The regression results are provided in Table 10 in the Appendix. Even though the IV coefficient appears to be somewhat larger for girls, see column (2) in Table 10, the treatment effect for boys and girls is not statistically significantly different from each other.

[19] I am not able to investigate the effect for mutually exclusive groups in the state-goitre distribution. States with high historical goitre endemicity are likely to be further away from Gujarat which leaves insufficient variation in the IV assignment indicator.

Table 5: Effect on HAZ - OLS and TSLS regressions for separate age groups

	0-6 Months		7-12 Months		13-18 Months		19-24 Months	
	(1) OLS	(2) TSLS	(3) OLS	(4) TSLS	(5) OLS	(6) TSLS	(7) OLS	(8) TSLS
Adequately Iodised Salt	0.265	1.232**	0.070	0.251	0.101	-0.199	0.054	-0.044
	(0.191)	(0.568)	(0.077)	(0.261)	(0.103)	(0.462)	(0.134)	(0.489)
Girl	0.076	0.111	0.239**	0.238**	0.267	0.284*	0.113	0.115
	(0.228)	(0.192)	(0.111)	(0.106)	(0.161)	(0.163)	(0.154)	(0.144)
Child used ICDS	-0.067	-0.104	0.094	0.096	0.211**	0.203**	-0.084	-0.085
	(0.125)	(0.116)	(0.081)	(0.078)	(0.088)	(0.088)	(0.114)	(0.107)
Child had diarrhoea recently	-0.289**	-0.327***	-0.031	-0.029	-0.259***	-0.258***	-0.213	-0.215
	(0.123)	(0.118)	(0.080)	(0.074)	(0.084)	(0.081)	(0.152)	(0.140)
Child had fever recently	0.069	0.054	-0.031	-0.026	0.193	0.174	0.117	0.120
	(0.137)	(0.127)	(0.074)	(0.072)	(0.119)	(0.124)	(0.163)	(0.149)
Child had cough recently	0.197	0.289*	0.008	0.005	-0.103	-0.094	-0.047	-0.052
	(0.163)	(0.159)	(0.067)	(0.063)	(0.102)	(0.102)	(0.140)	(0.124)
Mother mildly anaemic	-0.139	-0.156	-0.026	-0.022	-0.013	-0.017	0.139	0.137
	(0.111)	(0.105)	(0.064)	(0.060)	(0.096)	(0.091)	(0.116)	(0.106)
Mother moderately anaemic	-0.112	-0.115	-0.211**	-0.210**	-0.083	-0.087	0.088	0.089
	(0.147)	(0.134)	(0.095)	(0.090)	(0.107)	(0.105)	(0.139)	(0.129)
Mother severely anaemic	-0.213	-0.271	-0.207	-0.210	0.018	0.006	-0.383	-0.375
	(0.410)	(0.399)	(0.162)	(0.153)	(0.273)	(0.265)	(0.356)	(0.325)
Mother: Primary education	-0.047	-0.074	-0.088	-0.089	-0.107	-0.119	0.003	0.005
	(0.121)	(0.113)	(0.066)	(0.063)	(0.126)	(0.114)	(0.131)	(0.121)
Mother: Secondary education	0.095	0.041	0.034	0.027	-0.169	-0.165	0.175	0.177
	(0.155)	(0.157)	(0.120)	(0.115)	(0.199)	(0.185)	(0.159)	(0.150)
Mother: Higher education	0.171	0.016	0.407*	0.398**	0.109	0.139	0.928***	0.938***
	(0.288)	(0.289)	(0.198)	(0.184)	(0.224)	(0.202)	(0.210)	(0.214)
Mother eats fish at least weekly	-0.101	-0.091	-0.055	-0.056	-0.179	-0.179	-0.023	-0.027
	(0.148)	(0.154)	(0.109)	(0.102)	(0.151)	(0.143)	(0.126)	(0.122)
Mother heard of one of ORS or TBC or AIDS	0.372*	0.298	0.178	0.167	0.188	0.186	0.023	0.038
	(0.203)	(0.191)	(0.107)	(0.103)	(0.171)	(0.154)	(0.143)	(0.149)
Mother heard of two out of ORS, TBC and AIDS	0.317*	0.214	0.196*	0.185*	0.221	0.222	-0.101	-0.088
	(0.154)	(0.148)	(0.105)	(0.101)	(0.160)	(0.142)	(0.170)	(0.166)
Mother heard of ORS and TBC and AIDS	0.450**	0.385**	0.361***	0.343***	0.476**	0.499***	0.067	0.084
	(0.208)	(0.191)	(0.112)	(0.111)	(0.217)	(0.190)	(0.170)	(0.153)
Unprotected water source	-0.109	-0.080	0.046	0.054	0.133	0.114	0.249	0.245*
	(0.108)	(0.106)	(0.090)	(0.085)	(0.116)	(0.120)	(0.156)	(0.141)
Mother practices open defecation	0.263	0.316**	-0.186*	-0.177*	-0.096	-0.117	-0.077	-0.081
	(0.163)	(0.153)	(0.096)	(0.091)	(0.137)	(0.125)	(0.122)	(0.116)
Poorer	-0.303	-0.330*	0.027	0.020	0.253*	0.271**	0.264**	0.271**
	(0.185)	(0.183)	(0.106)	(0.101)	(0.142)	(0.138)	(0.118)	(0.121)
Middle	0.111	0.067	0.193**	0.185**	0.284**	0.316**	0.318**	0.323**
	(0.173)	(0.178)	(0.090)	(0.086)	(0.134)	(0.135)	(0.140)	(0.139)
Richer	0.255	0.172	0.260*	0.240*	0.351*	0.396**	0.579***	0.590***
	(0.234)	(0.223)	(0.149)	(0.141)	(0.180)	(0.173)	(0.198)	(0.184)
Richest	0.539	0.397	0.633***	0.597***	0.668**	0.741***	0.626***	0.643***
	(0.317)	(0.300)	(0.201)	(0.201)	(0.252)	(0.274)	(0.204)	(0.195)
Constant	-2.890***	-3.448***	-4.456***	-4.638***	-4.638***	-4.219***	-5.589***	-5.535***
	(0.991)	(0.798)	(0.736)	(0.715)	(1.139)	(1.144)	(1.335)	(1.392)
Observations	1241	1241	2804	2804	1351	1351	1150	1150
R^2	0.162	0.119	0.210	0.208	0.215	0.210	0.213	0.212

Notes: The outcome variable is HAZ. The regressions are estimated separately for children in different age categories. The consumption of adequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in the IV regressions shown in columns 2, 4, 6 and 8. The covariates included in all specifications are described in subsection 4 but are not shown due to space restrictions. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, ***

Table 6: Effect on HAZ - OLS and TSLS by historical goitre endemicity

	Higher historical goitre endemicity		Low historical goitre endemicity	
	(1) OLS	(2) TSLS	(3) OLS	(4) TSLS
Adequately Iodised Salt	0.222**	1.126**	0.143	0.832***
	(0.081)	(0.448)	(0.087)	(0.265)
Girl	0.338***	0.351***	0.126	0.169
	(0.079)	(0.082)	(0.150)	(0.112)
Child used ICDS	-0.106	-0.138	-0.002	-0.027
	(0.109)	(0.112)	(0.114)	(0.109)
Child had diarrhoea recently	-0.016	-0.027	-0.024	-0.044
	(0.085)	(0.083)	(0.070)	(0.062)
Child had fever recently	-0.078	-0.084	-0.030	-0.021
	(0.090)	(0.085)	(0.105)	(0.093)
Child had cough recently	0.143	0.175	0.118	0.133
	(0.118)	(0.114)	(0.119)	(0.120)
Mother mildly anaemic	-0.036	-0.028	-0.050	-0.036
	(0.091)	(0.084)	(0.107)	(0.098)
Mother moderately anaemic	-0.223**	-0.244***	-0.202***	-0.221***
	(0.083)	(0.088)	(0.061)	(0.059)
Mother severely anaemic	-0.219	-0.245	-0.403	-0.416
	(0.256)	(0.238)	(0.292)	(0.271)
Mother: Primary education	-0.155*	-0.209**	-0.024	-0.075
	(0.084)	(0.083)	(0.079)	(0.082)
Mother: Secondary education	0.071	0.011	0.153	0.130
	(0.114)	(0.114)	(0.116)	(0.121)
Mother: Higher education	0.502*	0.446*	0.594*	0.559*
	(0.240)	(0.231)	(0.310)	(0.320)
Mother eats fish at least weekly	-0.094	-0.099	-0.201	-0.227
	(0.128)	(0.122)	(0.146)	(0.139)
Mother heard of one of ORS or TBC or AIDS	0.175	0.098	0.153	0.090
	(0.148)	(0.167)	(0.160)	(0.154)
Mother heard of two out of ORS, TBC and AIDS	0.190	0.110	0.156	0.084
	(0.132)	(0.143)	(0.142)	(0.126)
Mother heard of ORS and TBC and AIDS	0.280	0.199	0.207	0.150
	(0.172)	(0.181)	(0.156)	(0.135)
Unprotected water source	-0.025	0.007	-0.051	-0.016
	(0.083)	(0.077)	(0.088)	(0.075)
Mother practices open defecation	-0.057	-0.003	0.017	0.036
	(0.128)	(0.126)	(0.128)	(0.127)
Poorer	-0.316**	-0.347***	-0.203*	-0.231**
	(0.118)	(0.110)	(0.106)	(0.095)
Middle	0.171	0.159	0.011	-0.002
	(0.148)	(0.141)	(0.133)	(0.117)
Richer	0.336*	0.251	0.060	-0.046
	(0.174)	(0.161)	(0.131)	(0.103)
Richest	0.572**	0.439**	0.683***	0.506***
	(0.234)	(0.204)	(0.117)	(0.114)
Constant	-2.848***	-3.585***	-4.576***	-5.343***
	(0.969)	(0.789)	(0.676)	(0.674)
Kleibergen-Paap F-statistic		80.735		62.945
Observations	2005	2005	1675	1675
R^2	0.178	0.143	0.163	0.132

The outcome variable is HAZ. The regressions are estimated separately for children in states in the upper three quartiles of the state-goitre distribution (columns 1-2), and children from states in the three lower quartiles of the state-goitre distribution (columns 3-4). The consumption of adequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in the IV regressions shown in columns 2, 4 and 6. The covariates included in all specifications are described in subsection 4 but are not shown due to space restrictions. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, ***

6.2 Characteristics of compliers

The Local Average Treatment Effect (LATE) theorem says that IV regression estimates the average causal effect of treatment on the sub-population of compliers. The external validity from the IV results is stronger if the compliant subpopulation is similar to other populations of interest (Angrist and Pischke, 2009, pp.150). Next, I investigate whether the LATE is driven by a specific subpopulation being induced to comply with the assignment who would have not otherwise been treated. I investigate the likelihood of compliers consisting of households with certain characteristics. Following Angrist and Pischke (2009), I provide the relative likelihood of a complier of a certain characteristic as given by the ratio of the first stage for a given group to the overall first stage.

The overall first stage is 0.376 and provided in column 3 in Table 3. The relative likelihood of compliance is provided in column 3 in Table 7. While positive relative likelihoods are observed for most characteristics related to worse socio-economic status and overall access to adequate nutrition, we note that poor households, households using unprotected water sources and households where the mother has little health knowledge, are particularly more likely to comply with the IV. Households where mothers have some education are less likely to be compliers. This suggests that the complier sub-population consist of worse off households who could be more likely to benefit from added iodine due to a lower overall nutritional intake. In addition to the threat of measurement error in the OLS, the larger estimates from the IV regression compared to OLS can be explained by potentially higher gains for the groups who are more likely to comply relative to the general population.[20]

Table 7: Complier characteristics

Characteristic	Overall proportion with characteristic (1)	First stage for characteristic (2)	Relative first stage (3)
Poor (<third wealth quintile)	0.586	0.489	1.300
Unprotected water source	0.247	0.459	1.220
Open defecation	0.586	0.386	1.025
Mother has anaemia	0.631	0.388	1.030
Mother eats fish weekly or more often	0.272	0.342	0.909
Mother has not heard of TBC, ORS or AIDS	0.075	0.540	1.434
Mother has some education	0.566	0.310	0.824

6.3 Selection effects

Previous studies suggest that iodine supplementation of iodine deficient populations can potentially improve fertility and reduce infant mortality (Zimmermann, 2012). If access

[20] In the absence of omitted variables and measurement error biases, OLS estimates approximate average effects for everyone.

to adequately iodised salt improves fertility and child survival, the effects on HAZ are possibly underestimated following the survival of "marginal" children.

Therefore, I investigate the effect of adequately iodised salt consumption on the probability of a child dying within the first year of birth, and on the number of children the mother has given birth to during the past 3 years. I estimate similar regressions as specified in Equations 1 and 3, but I exclude child specific covariates observed after birth.

The effect on infant mortality is analysed for the sample of all births from 2001 up to one year prior to the year and month of interview. I am not able to restrict the sample to births occurring within 12 months prior to the survey as this would potentially lead to right-censoring, meaning that the survival status of the child might not be known at the time of the analysis. Therefore, I include earlier births who were conceived during the absence of the nationwide ban on non-iodised salt.[21] The IV results point to a small and negative but statistically insignificant effect on infant mortality, see Table 12. Additionally, a reduced form regression of the IV on infant mortality does not find an effect, see column 5 in Table 15.

7 Validity checks

In the main regressions I have focused on the differential effect of access to adequately iodised salt compared to salt with no iodine, on height. As we do not know the iodine content of salt categorised as containing some iodine but below what is deemed adequate, we are unsure about its implications for children's growth. However, given that it contains less iodine than adequately iodised salt, the consumption of inadequately iodised salt should have a smaller impact on HAZ, if any.

As a robustness check I estimate the effect of inadequately iodised salt compared to non-iodised salt, on HAZ, otherwise following Equations 1 - 3. The regression results are presented in Table 11 in the Appendix. The IV is associated with a decreased likelihood of consuming salt with some iodine, see columns 3 and 4. The Kleibergen-Paap F-statistic is 47.186 which indicates that the instrument is not weak. This is in line with only adequately iodised salt being given permission for rail transport. Moreover, no significant relationship between inadequately iodised salt and HAZ is observed across both OLS and IV.

Third, I test whether the instrument is systematically correlated with changes in other determinants of height. I run reduced form placebo regressions where I stepwise estimate

[21] I do not include children born during the initial central ban on non-iodised salt in 1998-2000. This is due to the fact that Gujarat was also covered by this ban which makes the instrument less likely to be relevant prior to 2000.

the effect of the instrument on the variables previously used as covariates. I restrict the analysis to the household-, mother- and child specific covariates that were not balanced at baseline. A correlation between the instrument and the changes in other factors affecting growth positively would indicate a potential violation of the exclusion restriction. The reduced-form estimations do not just underline the validity of the instrument. They also shed light on other potential mechanisms by which the instrument might work through.

From Table 13 in the Appendix we note that the assignment status of the IV is associated with a higher risk of using water from an unprotected water source, lower maternal age, reduced health knowledge, less frequent consumption of fish and lower use of ICDS. Turning to more direct predictors of children's nutritional and health status, such as; whether the child received vitamin A supplementation, iron supplementation, deworming drugs, anaemia status and retrospectively reported birth weight, does not reveal positive associations with residing far from Gujarat, see Table 14 in Appendix **??**. All coefficients are statistically insignificant besides the effect on deworming which points to a negative relationship with the IV.

Additionally, the IV is not positively correlated with pregnancy related variables. Reduced form placebo regressions show that mothers in states far from Gujarat are less likely to give birth at a health facility and complete fewer ANC visits, see Table 15 in the Appendix. Moreover, no statistically significant effects are found on months of breastfeeding nor taking iron supplementation during pregnancy.

The IV is not systematically correlated with observed factors improving children's heights. This reduces potential worries about the IV not satisfying the exclusion restriction. However, the reduced form placebo regressions show that those with positive IV assignment status are marginally worse off in terms of some determinants of nutrition and health. The main results might therefore be picking up a treatment effect specific to those with a higher capacity to benefit from iodised salt due to otherwise lower health investments after controlling for all covariates. This was also highlighted in the discussion of the LATE.

8 Conclusion

This paper shows that the access to adequately iodised salt has a large effect on height-for-age Z-scores (HAZ) for children up to 1 year in rural India. I use exogenous variation in the availability of adequately iodised salt stemming from differences in the feasibility of monitoring of iodised salt depending on the distance from the major salt producing state in India.

The IV estimates point to an improved height-for-age by 0.664 Z-scores and increased height by 1.845 cm. The findings contribute to the mixed and limited scope of evidence from trials on iodine supplementation and somatic growth. Moreover, it improves upon the empirical strategy used in cross-sectional studies assessing the impact of iodised salt on children's growth, which do not address endogeneity concerns.

The effects on HAZ are largest for younger children, aged 0-6 months. This contributes further to an understanding of possibly particularly sensitive time periods of iodine intake for health. No effect is found on weight which is consistent with the lack of an established physiological relationship between iodine supplementation and soft tissue in children.

The effects from this study are bigger than the effects from other public health programmes on HAZ in India. Hammer and Spears (2016) find that a village sanitation intervention improves height-for-age by 0.3 standard deviations and Jain (2015) finds that supplementary daily feeding of girls up to 2 years improves height-for-age by 0.4 standard deviations. The large treatments effects from this study can potentially be explained by the sub-population of compliers. The compliers are more likely to be households who are socio-economically worse off. Children from such households may have a higher propensity to benefit form added iodine. Nonetheless, I show that access to adequately iodised salt plays a large role in improving health capital by reducing the prevalence of short stature in India.

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A Appendix

Table 8: Effect on stunting (≤-2 HAZ) - OLS, reduced form and IV regressions.

	OLS		Reduced Form		IV	
	(1)	(2)	(3)	(4)	(5)	(6)
Adequately Iodised Salt	-0.090***	-0.037			-0.128*	-0.070
	(0.024)	(0.023)			(0.069)	(0.071)
Far from Gujarat			-0.048	-0.039		
			(0.028)	(0.046)		
Girl		-0.045		-0.043		-0.047*
		(0.027)		(0.027)		(0.024)
Child used ICDS		0.008		0.006		0.009
		(0.022)		(0.022)		(0.021)
Child had diarrhoea recently		-0.001		-0.000		-0.001
		(0.030)		(0.031)		(0.029)
Child had fever recently		0.008		0.008		0.009
		(0.026)		(0.026)		(0.024)
Child had cough recently		-0.006		-0.005		-0.007
		(0.016)		(0.016)		(0.015)
Mother mildly anaemic		-0.013		-0.012		-0.013
		(0.023)		(0.023)		(0.021)
Mother moderately anaemic		0.016		0.016		0.016
		(0.025)		(0.025)		(0.024)
Mother severely anaemic		0.043		0.041		0.044
		(0.079)		(0.079)		(0.075)
Mother: Primary education		0.038*		0.036		0.039**
		(0.021)		(0.021)		(0.019)
Mother: Secondary education		-0.040		-0.041		-0.038
		(0.026)		(0.026)		(0.024)
Mother: Higher education		-0.103*		-0.105**		-0.101**
		(0.050)		(0.050)		(0.047)
Mother eats fish at least weekly		0.042		0.041		0.041*
		(0.025)		(0.025)		(0.023)
Mother heard of one of ORS or TBC or AIDS		-0.038		-0.042		-0.034
		(0.031)		(0.030)		(0.032)
Mother heard of two out of ORS, TBC and AIDS		-0.040		-0.045		-0.036
		(0.032)		(0.032)		(0.033)
Mother heard of ORS and TBC and AIDS		-0.092**		-0.098***		-0.089***
		(0.033)		(0.034)		(0.033)
Unprotected water source		-0.017		-0.015		-0.018
		(0.018)		(0.018)		(0.017)
Mother practices open defecation		0.009		0.010		0.008
		(0.025)		(0.025)		(0.024)
Poorer		0.039		0.037		0.040
		(0.035)		(0.035)		(0.033)
Middle		-0.036		-0.038		-0.036
		(0.025)		(0.025)		(0.023)
Richer		-0.059*		-0.063*		-0.055*
		(0.033)		(0.033)		(0.030)
Richest		-0.105**		-0.113**		-0.099***
		(0.040)		(0.040)		(0.037)
Observations	2850	2477	2850	2477	2850	2477
R^2	0.009	0.135	0.003	0.134	0.007	0.134

Notes: The outcome variable is the probability of stunting. The consumption of adequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in the IV regressions in columns 5 and 6. The covariates included in columns 2, 4 and 6 are described in subsection 4 but are not shown due to space restrictions. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 9: Effect on WAZ, - OLS and IV regressions.

	OLS		IV	
	(1) WAZ	(2) WAZ	(3) WAZ	(4) WAZ
Adequately Iodised Salt	0.475***	0.043	0.706	-0.418
	(0.104)	(0.050)	(0.461)	(0.292)
Girl		-0.056		-0.111
		(0.072)		(0.070)
Child used ICDS		-0.092*		-0.038
		(0.049)		(0.075)
Child had diarrhoea recently		-0.101*		-0.088*
		(0.049)		(0.046)
Child had fever recently		-0.183**		-0.160**
		(0.074)		(0.071)
Child had cough recently		0.104		0.019
		(0.063)		(0.074)
Mother mildly anaemic		-0.089**		-0.013
		(0.042)		(0.039)
Mother moderately anaemic		-0.207***		-0.096*
		(0.055)		(0.056)
Mother severely anaemic		-0.388***		-0.311**
		(0.128)		(0.154)
Mother: Primary education		-0.029		0.035
		(0.075)		(0.076)
Mother: Secondary education		0.122*		0.022
		(0.065)		(0.080)
Mother: Higher education		0.264**		-0.001
		(0.119)		(0.122)
Mother eats fish at least weekly		-0.020		0.057
		(0.050)		(0.079)
Mother heard of one of ORS or TBC or AIDS		0.155*		0.187*
		(0.088)		(0.101)
Mother heard of two out of ORS, TBC and AIDS		0.206***		0.219**
		(0.072)		(0.101)
Mother heard of ORS and TBC and AIDS		0.324***		0.284***
		(0.090)		(0.099)
Unprotected water source		0.048		0.118
		(0.051)		(0.073)
Mother practices open defecation		-0.046		-0.077
		(0.084)		(0.081)
Poorer		-0.068		0.140**
		(0.084)		(0.067)
Middle		0.166*		0.160**
		(0.086)		(0.079)
Richer		0.249**		0.199**
		(0.099)		(0.084)
Richest		0.418***		0.205*
		(0.140)		(0.111)
Constant	-1.501***	-3.770***	-1.665***	-1.196***
	(0.068)	(0.446)	(0.279)	(0.415)
Observations	2784	2420	2784	2420
R^2	0.028	0.347	0.022	0.143

Notes: The outcome variable is WAZ. The consumption of adequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in columns 3 and 4. The covariates included in columns 2 and 4 are described in subsection 4 but are not shown due to space restrictions. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 10: Effect on HAZ - OLS and TSLS regressions for girls and boys separately

	Girls		Boys	
	(1) OLS	(2) TSLS	(3) OLS	(4) TSLS
Adequately Iodised Salt	0.090	0.762*	0.192*	0.632*
	(0.180)	(0.439)	(0.101)	(0.362)
Child used ICDS	-0.064	-0.073	-0.076	-0.087
	(0.105)	(0.101)	(0.144)	(0.135)
Child had diarrhoea recently	-0.046	-0.031	0.024	0.014
	(0.133)	(0.120)	(0.135)	(0.123)
Child had fever recently	0.107	0.122	-0.151	-0.171*
	(0.141)	(0.124)	(0.096)	(0.091)
Child had cough recently	-0.057	-0.016	0.179	0.182
	(0.126)	(0.105)	(0.158)	(0.151)
Mother mildly anaemic	-0.110	-0.091	-0.108	-0.104
	(0.129)	(0.114)	(0.106)	(0.095)
Mother moderately anaemic	-0.120	-0.087	-0.240***	-0.266***
	(0.157)	(0.140)	(0.083)	(0.078)
Mother severely anaemic	-0.399	-0.483*	-0.315	-0.308
	(0.292)	(0.261)	(0.302)	(0.270)
Mother: Primary education	-0.119	-0.155	-0.151	-0.172
	(0.123)	(0.110)	(0.156)	(0.143)
Mother: Secondary education	0.284*	0.238	-0.037	-0.050
	(0.164)	(0.156)	(0.108)	(0.103)
Mother: Higher education	0.837*	0.724*	0.099	0.102
	(0.409)	(0.391)	(0.269)	(0.248)
Mother eats fish at least weekly	-0.027	0.003	-0.256*	-0.259**
	(0.104)	(0.111)	(0.124)	(0.113)
Mother heard of one of ORS or TBC or AIDS	0.356	0.302	0.049	-0.010
	(0.215)	(0.206)	(0.196)	(0.197)
Mother heard of two out of ORS, TBC and AIDS	0.375	0.318	0.107	0.036
	(0.225)	(0.220)	(0.197)	(0.199)
Mother heard of ORS and TBC and AIDS	0.453*	0.391*	0.306	0.250
	(0.250)	(0.237)	(0.208)	(0.190)
Unprotected water source	-0.174	-0.141	0.025	0.023
	(0.108)	(0.098)	(0.108)	(0.100)
Mother practices open defecation	-0.065	-0.059	0.058	0.088
	(0.152)	(0.135)	(0.156)	(0.153)
Poorer	-0.245	-0.250	-0.289**	-0.329***
	(0.206)	(0.201)	(0.129)	(0.119)
Middle	0.018	0.019	0.123	0.090
	(0.185)	(0.184)	(0.206)	(0.191)
Richer	0.124	0.048	0.275*	0.221*
	(0.196)	(0.183)	(0.143)	(0.128)
Richest	0.479*	0.344	0.634***	0.549***
	(0.234)	(0.210)	(0.189)	(0.165)
Constant	-3.487**	-3.975***	-2.668**	-3.272***
	(1.622)	(1.435)	(1.038)	(1.173)
Kleibergen-Paap F-statistic		22.650		24.805
Observations	1216	1216	1261	1261
R^2	0.199	0.176	0.189	0.181

The outcome variable is HAZ estimated separately for girls (columns 1-2) and boys (columns 3-4). The consumption of adequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in the IV regressions in the IV regressions in columns 2 and 4. The covariates included in all specifications are described in subsection 4 but are not shown due to space restrictions. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 11: Effect of salt with some iodine on HAZ - OLS, first stage, reduced form and IV regressions.

	OLS		First Stage		Reduced Form		IV	
	(1) HAZ	(2) HAZ	(3) Adequately Iodised Salt	(4) Adequately Iodised Salt	(5) HAZ	(6) HAZ	(7) HAZ	(8) HAZ
Inadequately iodised salt	-0.093	-0.019					-0.401	-0.602
	(0.090)	(0.064)					(0.359)	(0.488)
Far from Gujarat			-0.348***	-0.380***	0.140	0.229		
			(0.056)	(0.055)	(0.131)	(0.212)		
Girl		0.100		0.061		0.100		0.136
		(0.197)		(0.039)		(0.197)		(0.170)
Child used ICDS		0.046		-0.059**		0.054		0.019
		(0.135)		(0.021)		(0.133)		(0.127)
Child had diarrhoea recently		0.052		-0.025		0.051		0.036
		(0.066)		(0.025)		(0.067)		(0.072)
Child had fever recently		-0.135		-0.008		-0.136		-0.141
		(0.118)		(0.023)		(0.118)		(0.109)
Child had cough recently		0.183*		0.067**		0.179*		0.219**
		(0.090)		(0.030)		(0.087)		(0.105)
Mother mildly anaemic		-0.096		0.000		-0.098		-0.098
		(0.156)		(0.022)		(0.156)		(0.152)
Mother moderately anaemic		-0.116		0.017		-0.119		-0.108
		(0.100)		(0.024)		(0.100)		(0.097)
Mother severely anaemic		0.030		0.094		0.030		0.087
		(0.257)		(0.071)		(0.256)		(0.232)
Mother: Primary education		0.005		0.007		0.004		0.008
		(0.151)		(0.034)		(0.151)		(0.138)
Mother: Secondary education		0.107		-0.006		0.107		0.103
		(0.109)		(0.024)		(0.109)		(0.100)
Mother: Higher education		0.574		0.034		0.556		0.576
		(0.365)		(0.101)		(0.362)		(0.364)
Mother eats fish at least weekly		0.022		0.004		0.032		0.035
		(0.163)		(0.031)		(0.167)		(0.154)
Mother heard of one of ORS or TBC or AIDS		-0.035		-0.010		-0.037		-0.043
		(0.168)		(0.047)		(0.168)		(0.167)
Mother heard of two out of ORS, TBC and AIDS		0.025		-0.028		0.026		0.009
		(0.176)		(0.048)		(0.177)		(0.174)
Mother heard of ORS and TBC and AIDS		0.062		-0.020		0.074		0.062
		(0.172)		(0.047)		(0.171)		(0.174)
Unprotected water source		-0.018		0.064*		-0.027		0.012
		(0.065)		(0.036)		(0.062)		(0.065)
Mother practices open defecation		-0.042		0.016		-0.037		-0.027
		(0.135)		(0.048)		(0.135)		(0.143)
Poorer		0.179		0.002		0.178		0.179
		(0.182)		(0.028)		(0.182)		(0.172)
Middle		0.167		0.077**		0.165		0.211
		(0.145)		(0.033)		(0.146)		(0.148)
Richer		0.327*		0.055		0.326*		0.360**
		(0.188)		(0.058)		(0.188)		(0.168)
Richest		1.010***		0.094		1.016***		1.073***
		(0.233)		(0.066)		(0.237)		(0.255)
Constant	-1.035***	-5.906***	1.505***	2.309***	-1.205***	-5.990***	-0.601	-4.599***
	(0.120)	(1.084)	(0.052)	(0.190)	(0.068)	(1.048)	(0.510)	(1.548)
Kleibergen-Paap F-statistic					-		38.632	47.186
Observations	2011	1825	2011	1825	2011	1825	2011	1825
R^2	0.001	0.140	0.099	0.204	0.001	0.141	-0.007	0.118

Notes: The outcome is HAZ. The consumption of inadequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in the IV regressions in column 7 and 8. The covariates included in specifications 2, 4, 6 and 8 are described in subsection 4 but are not shown due to space restrictions. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 12: Effect on fertility and infant mortality - OLS and IV regressions

	Fertility		Infant Mortality	
	(1) OLS	(2) IV	(3) OLS	(4) IV
Adequately Iodised Salt	0.011	0.056	-0.005	-0.055
	(0.018)	(0.069)	(0.008)	(0.041)
Mother mildly anaemic	-0.008	-0.008	0.014	0.013
	(0.016)	(0.015)	(0.010)	(0.009)
Mother moderately anaemic	0.018	0.018	0.006	0.006
	(0.023)	(0.022)	(0.006)	(0.006)
Mother severely anaemic	0.080*	0.078*	0.053***	0.055***
	(0.046)	(0.044)	(0.016)	(0.016)
Mother: Primary education	-0.000	-0.002	0.006	0.008
	(0.031)	(0.029)	(0.012)	(0.011)
Mother: Secondary education	0.007	0.005	-0.012	-0.008
	(0.034)	(0.033)	(0.009)	(0.009)
Mother: Higher education	0.053	0.048	0.008	0.013
	(0.047)	(0.046)	(0.031)	(0.030)
Mother eats fish at least weekly	-0.032	-0.031	0.013*	0.014**
	(0.023)	(0.022)	(0.006)	(0.006)
Mother heard of one of ORS or TBC or AIDS	0.061	0.056	0.002	0.004
	(0.048)	(0.044)	(0.022)	(0.022)
Mother heard of two out of ORS, TBC and AIDS	0.063	0.058	0.002	0.005
	(0.049)	(0.044)	(0.028)	(0.028)
Mother heard of ORS and TBC and AIDS	0.063	0.059	-0.006	-0.001
	(0.041)	(0.037)	(0.026)	(0.025)
Unprotected water source	0.063**	0.065***	0.023**	0.019**
	(0.024)	(0.023)	(0.008)	(0.008)
Mother practices open defecation	0.014	0.015	0.003	0.003
	(0.027)	(0.027)	(0.012)	(0.011)
Poorer	0.007	0.005	0.000	0.003
	(0.029)	(0.028)	(0.007)	(0.007)
Middle	0.062**	0.060**	0.008	0.011
	(0.029)	(0.028)	(0.011)	(0.011)
Richer	0.024	0.019	-0.024***	-0.017**
	(0.033)	(0.033)	(0.006)	(0.008)
Richest	-0.062	-0.070	-0.054***	-0.042**
	(0.052)	(0.050)	(0.014)	(0.020)
Kleibergen-Paap F-statistic		37.871		100.835
Observations	2482	2482	3395	3395
R^2	0.218	0.217	0.128	0.120

Notes: The outcome variable in columns 1-2 is the number of children a woman has given birth to during the past 3 years prior to the survey. The outcome for specifications shown in colmns 3-4 is infant mortality - the likelihood that a child, conditional on being born at least one year prior to the survey, dying within one year of birth. The OLS regressions are shown in columns 1 and 3 and IV regressions are displayed in columns 2 and 4. The consumption of adequately iodised salt is instrumented with the indicator variable for residing far from Gujarat in the IV regressions. The covariates included in all specifications are described in subsection 4 but are not shown due to space restrictions. Child level covariates are not included in columns 1-2 and postnatal child variables are not included in columns 3-4. The omitted reference categories for the covariates displayed in the table are: mother has no anaemia, mother has no education, mother has not heard of ORS, TBC or AIDS and poorest wealth quintile. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 13: Reduced form placebo regressions: Variables previously used as covariates

	(1) Mother practices open defecation	(2) Unprotected water source	(3) Mother's level of health knowledge	(4) Mother's Age	(5) Mother eats fish at least weekly	(6) Mother has some education	(7) Mother's anemia status	(8) Child had diarrhoea recently	(9) Child used ICD
Far from Gujarat	-0.043	0.305***	-0.491***	-1.364**	-0.247**	0.036	0.062	0.071	-0.263***
	(0.067)	(0.092)	(0.091)	(0.618)	(0.097)	(0.043)	(0.126)	(0.045)	(0.089)
Constant	1.383***	-0.427**	1.689***	15.697***	0.521**	0.395***	0.948**	0.399*	1.321***
	(0.147)	(0.205)	(0.363)	(1.479)	(0.205)	(0.136)	(0.353)	(0.201)	(0.242)
Observations	2476	2476	2476	2476	2476	2476	2476	2476	2476
R^2	0.532	0.239	0.408	0.579	0.422	0.449	0.107	0.117	0.233

Notes: This table shows the reduced form placebo regressions with the outcomes being variables previously used as covariates in the main regressions. The covariates included in all specifications are described in subsection 4 but are not shown due to space restrictions. Robust standard errors are clustered on state and shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 14: Reduced form placebo regressions: Child health

	(1) Child received vitamin A-supplementation	(2) Child received iron supplementation	(3) Ever received vaccination	(4) Child has anaemia	(5) Birth Weight
Far from Gujarat	0.010	-0.079***	0.029	-0.093	-0.674
	(0.053)	(0.024)	(0.072)	(0.060)	(136.661)
Constant	1.124***	0.084	1.271***	1.040***	1894.675***
	(0.179)	(0.082)	(0.207)	(0.134)	(638.536)
Observations	2427	2469	1256	1300	756
R^2	0.263	0.106	0.373	0.151	0.259

Notes: This table shows the reduced form placebo regressions for child health related outcomes. The covariates included in all specifications are described in subsection 4 but are not shown due to space restrictions. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 15: Reduced form placebo regressions: Pregnancy related outcomes

	(1) Birth at facility	(2) Number of ANC visits	(3) Iron supplementation during pregnancy	(4) Months of breastfeeding	(5) Infant Mortality
Far from Gujarat	-0.140**	-2.462*	0.075	0.128	0.018
	(0.053)	(1.271)	(0.116)	(0.275)	(0.012)
Child used ICDS	-0.108**	-0.190	0.080*	0.075	
	(0.044)	(0.252)	(0.040)	(0.153)	
Child had diarrhoea recently	-0.011	-0.507	-0.061	0.008	
	(0.039)	(0.359)	(0.038)	(0.145)	
Child had fever recently	-0.000	-0.096	0.072	-0.200	
	(0.045)	(0.342)	(0.048)	(0.157)	
Child had cough recently	0.059**	0.191	0.039	-0.012	
	(0.026)	(0.381)	(0.030)	(0.139)	
Mother mildly anaemic	-0.076*	0.104	-0.017	0.114	0.003
	(0.039)	(0.231)	(0.033)	(0.104)	(0.008)
Mother moderately anaemic	-0.038	-0.408	-0.046	-0.095	0.022
	(0.055)	(0.274)	(0.041)	(0.155)	(0.014)
Mother severely anaemic	0.035	-2.000	-0.018	-0.820	0.053*
	(0.088)	(1.326)	(0.172)	(0.528)	(0.027)
Mother: Primary education	0.011	-0.277	-0.021	0.110	0.006
	(0.070)	(0.221)	(0.048)	(0.208)	(0.013)
Mother: Secondary education	0.004	0.338	0.099*	0.426	-0.013
	(0.062)	(0.410)	(0.051)	(0.259)	(0.011)
Mother: Higher education	-0.029	-0.202	0.151**	0.655**	-0.031
	(0.077)	(0.650)	(0.060)	(0.308)	(0.024)
Mother eats fish at least weekly	-0.001	0.052	0.037	0.062	-0.001
	(0.037)	(0.397)	(0.041)	(0.105)	(0.007)
Mother heard of one of ORS or TBC or AIDS	0.221**	0.644	0.305*	0.692	0.002
	(0.106)	(0.762)	(0.156)	(0.541)	(0.012)
Mother heard of two out of ORS, TBC and AIDS	0.209**	0.899	0.258*	0.709	-0.004
	(0.094)	(0.866)	(0.135)	(0.472)	(0.012)
Mother heard of ORS and TBC and AIDS	0.194**	1.223	0.338**	0.795	-0.008
	(0.091)	(0.896)	(0.122)	(0.469)	(0.014)
Unprotected water source	-0.038	0.303	-0.076**	0.067	-0.002
	(0.031)	(0.322)	(0.031)	(0.059)	(0.010)
Mother practices open defecation	-0.122**	0.034	-0.042	0.140	0.011
	(0.047)	(0.425)	(0.030)	(0.129)	(0.013)
Poorer	0.255***	0.633	-0.018	0.040	0.010
	(0.065)	(0.525)	(0.055)	(0.130)	(0.008)
Middle	0.187**	0.686	-0.072	-0.049	-0.004
	(0.066)	(0.474)	(0.064)	(0.156)	(0.012)
Richer	0.197**	1.279*	-0.093	-0.085	-0.022
	(0.087)	(0.721)	(0.068)	(0.181)	(0.013)
Richest	0.255**	2.598***	-0.055	-0.421	-0.018
	(0.100)	(0.828)	(0.072)	(0.262)	(0.022)
Girl	-0.015	0.226	0.049	0.058	-0.005
	(0.047)	(0.354)	(0.032)	(0.162)	(0.015)
Constant	0.372	4.349	0.693**	19.554***	0.594***
	(0.409)	(2.859)	(0.257)	(1.210)	(0.097)
Observations	756	749	752	756	4882
R^2	0.375	0.349	0.278	0.892	0.113

Notes: This table shows the reduced form placebo regressions for pregnancy related outcomes. The covariates included in all specifications are described in subsection 4 but are not shown due to space restrictions. Robust standard errors are clustered on state and are shown in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.