NBER WORKING PAPER SERIES

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THE LONG-RUN ECONOMIC IMPACTS OF SALT IODIZATION IN THE UNITED STATES

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Working Paper 24847
http://www.nber.org/papers/w24847

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 2018

Thanks to Martha Bailey, Prashant Bharadwaj, Mark Duggan, Jeanne Lafortune, Claudia Olivetti, Dimitra Politi, Paul Rhode, John Shea, Atheen Venkataramani, and David Weil for helpful conversations and seminar audiences at the NBER (CS; CH), Stanford SITE, Maryland, Michigan, Michigan State, Appalachian State, Indian School of Business, NEUDC, and SOLE for useful comments. Adhvaryu gratefully acknowledges funding from the NIH/NICHD (5K01HD071949). Molina gratefully acknowledges funding from the USC Provost's Ph.D. Fellowship, the USC Dornsife INET graduate student fellowship, and the Oakley Endowed Fellowship. Thanks to David Carel for excellent research assistance. All errors are our own. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 24847
July 2018
JEL No. I15,I18,J24,N32

ABSTRACT

In 1924, The Morton Salt Company began nationwide distribution of iodine-fortified salt. Access to iodine, a key determinant of cognitive ability, rose sharply. We compare outcomes for cohorts exposed in utero with those of slightly older, unexposed cohorts, across states with high versus low baseline iodine deficiency. Income increased by 11%; labor force participation rose 0.68 percentage points; and full-time work went up 0.9 percentage points due to increased iodine availability. These impacts were largely driven by changes in the economic outcomes of young women. In later adulthood, both men and women had higher family incomes due to iodization.

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1 Introduction

Inadequate access to essential micronutrients such as iron, vitamin A, iodine, and zinc has staggering costs in terms of mortality, poor health, and lost productivity in low-income countries (Black et al., 2013). The benefits of improving micronutrient availability in the short term, especially for young children, are clear (Bhutta et al., 2013). But less is known about long-run impacts, particularly of large-scale supplementation policies. How long do the effects of improved access to vital micronutrients last? Do health effects spill over onto socioeconomic outcomes? Which individuals are most affected by blanket campaigns? With notable recent exceptions (Clay et al., 2015; Feyrer et al., 2017; Niemesh, 2015; Politi, 2010, 2014), these questions have received scarce attention, and are the focus of the present study.

We draw lessons from the historical experience of the United States, where until the mid-1920's, natural access to iodine was limited in some areas of the country compared to others. An essential micronutrient, iodine regulates thyroid hormone availability, which determines the density of fetal neural networks (Lamberg, 1991). Physiological studies suggest that iodine deficiency negatively affects cognitive function at all ages, but is particularly detrimental during gestation, when even mild deficiency can greatly hamper cognitive development (Cao et al., 1994). Moreover, the effects of fetal iodine deficiency disorder (IDD) are irreversible: an inadequate supply of iodine in the first trimester of gestation permanently reduces intelligence quotient (IQ), regardless of subsequent supplementation (Hetzel & Mano, 1989; Pharoah & Connolly, 1987; Zimmermann, 2009).[1]

We study the economic impacts of rapid, large-scale salt iodization in the twentieth century US. The Morton Salt Company, the largest salt producer in the US, initiated nationwide iodized salt distribution shortly after the invention of iodine-fortified salt in the mid-1920s. In less than half a decade, the US went from zero to nearly universal availability of iodized salt (Markel, 1987). Iodine deficiency rates plummeted in the following decade, most markedly in areas that were highly

[1] It bears mention that studies from the medical literature are either correlational or based on animal studies: causal evidence on the effects of iodine exposure in humans is limited. The study by Feyrer et al. (2017), which we discuss below, is important in this sense, because it provides the most rigorous evidence to date of the impact of fetal iodine access on adult cognitive performance.

iodine deficient prior to the introduction of iodized salt (Brush & Atland, 1952; Hamwi et al., 1952; Schiel & Wepfer, 1976).

Using a difference-in-differences strategy similar to the one used in this paper, Feyrer et al. (2017) show that, among men who enlisted in the Army during World War II, exposure to iodized salt increased the likelihood of being assigned to the Air Force (an indication of a high score on the Army General Classification Test). They estimate that the introduction of iodized salt increased IQ by approximately 15 points for those most deficient in iodine prior to this intervention. Building on this important work, which provides both a first stage and motivation for our study, we tackle several important questions about the economic consequences of this natural experiment. What happened to the labor market outcomes of those whose *in utero* access to iodine improved? Did increased IQ affect incomes, as was true in Switzerland (Politi, 2014), and labor supply? Importantly, because the sample in Feyrer et al. (2017) was exclusively male, we seek to estimate labor market effects for women. Did men and women benefit differentially? How did these impacts evolve over the life cycle? Did related outcomes like educational attainment and marriage respond differentially?

To answer these questions, we use a similar strategy to that of Feyrer et al. (2017), but look to the U.S. census for our comprehensive set of economic outcomes. We compare outcomes for cohorts born just before iodization (1920-1923) to those born during (1924-1927) and after (1928-1931), across areas with varying pre-iodization deficiency rates. For the latter source of variation, we use pre-iodization rates of goiter, the main physical manifestation of IDD (Love & Davenport, 1920; Olesen, 1929). We follow these cohorts through their productive lives, using data from the 1950-1980 censuses, during which these individuals were 19 to 60 years old. We present estimates of early career outcomes, pooling the 1950 and 1960 censuses, and later career outcomes, using the 1970 and 1980 censuses.

Individuals affected by salt iodization saw improved economic outcomes. Labor force participation rose by about 0.68 percentage points and total income increased by 11% in the pooled sample of individuals aged 19-60 in the 1950-1980 censuses. Women experienced the largest changes in employment (greater than 1 percentage point) and income (15 percent), though men also saw small increases in their income conditional on working (1 percent). The much larger labor supply effects for women likely reflect the fact that women exhibited much lower employment rates than men during this time period.[2]

These large increases in female labor supply were concentrated among women early in their careers (under age 40): women affected by salt iodization were not significantly more likely to be in the labor force in the 1970 and 1980 censuses. Impacts on female incomes do persist at later ages, but are smaller and less precisely estimated. This pattern is consistent with impacted women transitioning out of the labor force at later ages due to a negative income effect generated by their higher accumulated lifetime income.[3] Supporting this idea, we find that impacted women married at later ages (nearly a quarter of a year), married more educated and higher-income men, and had higher family income in their forties and fifties.

Like Politi (2010), which focuses on Switzerland's historical experience with salt iodization, we find a small but precisely estimated positive effect on educational attainment. Theoretical effects of increased cognition on schooling are ambiguous, as the direct wage returns to ability in entry-level labor opportunities may counteract any impacts of ability on schooling returns at early ages. Because the magnitude of our estimated effect is very small (equivalent to about two weeks of school), we interpret this result as evidence that both of these opposing effects are in play.[4]

Our study aims to contribute to three literatures. First, we add to the literature on the long-term effects of early life conditions.[5] Much of this "fetal origins" work has focused on demonstrating the impacts of traumatic experiences (disease, natural disasters, environmental factors, etc.) in early life. Fewer studies have estimated the gains to exposure to the purposeful large-scale distribution of resources. The distinction between the two types of studies is important because the latter "shock" can yield actionable information: policies with demonstrated positive impacts can be advocated

[2]This result is also consistent with medical evidence that female fetuses are more sensitive to maternal thyroid deficiency than male fetuses (Field et al., 2009; Friedhoff et al., 2000), though we argue in section 5.1.1 that this biological explanation is likely secondary.

[3]This pattern has been documented before, specifically in the "career then family" cohorts discussed in Goldin et al. (1997); Goldin & Katz (2002)

[4]This is consistent with Bleakley (2010), who finds mixed results on the effect of malaria eradication on schooling in four different countries.

[5]See Heckman (2006), Almond & Currie (2011), and Currie & Vogl (2013) for useful syntheses.

for and reproduced. A growing set of studies–including Hoynes et al. (2016), Bleakley (2007), Bleakley (2010), Field et al. (2009), Almond et al. (2010), Politi (2010), Bhalotra & Venkataramani (2015), and Feyrer et al. (2017)–have recently made strides in this direction. We build on this evidence base: the results of these studies and ours offer lessons from historical policy experiments from which present-day policymakers, particularly in developing countries, might profitably draw.

Second, we contribute to the understanding of women's decisions regarding the labor force in the historical United States. We find that labor market effects of iodine are particularly pronounced for women, consistent with evidence from recent studies on the effects of other early life interventions (Bleakley, 2007; Field et al., 2009; Hoynes et al., 2016; Maccini & Yang, 2009). Moreover, this pattern relates to important previous work on the drivers of the marked rise in labor force participation of women over the 20th century. Goldin (1991) and Goldin & Olivetti (2013) estimate that WWII led to a roughly 20 percent rise in female participation for higher-educated women in cohorts born between 1915 and 1924. Bailey (2006) and Goldin & Katz (2002) show that increased access to oral contraceptives led to later marriage, higher likelihood of professional and graduate training in high skill occupations, and increased rate and duration of labor force participation among cohorts born after 1940. We present complementary evidence documenting that salt iodization also contributed to the rise in female labor force participation, generating a 3 percent increase among females born in between the two sets of cohorts studied in these papers.

Finally, we add evidence on the long-run effects of micronutrient fortification campaigns and in particular mass salt iodization as a means of eradicating iodine deficiency. Nearly 2 billion people worldwide–a third of the world's population–do not have adequate access to iodine (De Benoist et al., 2004). Recent estimates from the economics literature suggest that the incidence of iodine deficiency, and thus the returns to reducing IDD, may be very large (Feyrer et al., 2017; Field et al., 2009; Politi, 2010). Policymakers in IDD-endemic countries, as well as the WHO, UNICEF, and other international organizations, have made increasing access to iodine a high priority. Mass salt iodization to prevent IDD is, far and away, the preferred policy: iodizing salt is much cheaper than continuous supplementation in populations with iodine-deficient diets, and, taken with other micronutrients such as iron, is highly cost-effective in terms of fetal and infant deaths averted (Horton et al., 2008).

The rest of the paper is organized as follows. Section 2 discusses iodine deficiency and its prevalence in the early twentieth century, as well as the history of salt iodization in the US. Section 3 discusses our data sources, section 4 our empirical strategy, and section 5 the results. Section 6 concludes with a discussion of the size of the economic benefits of iodization.

2 Background

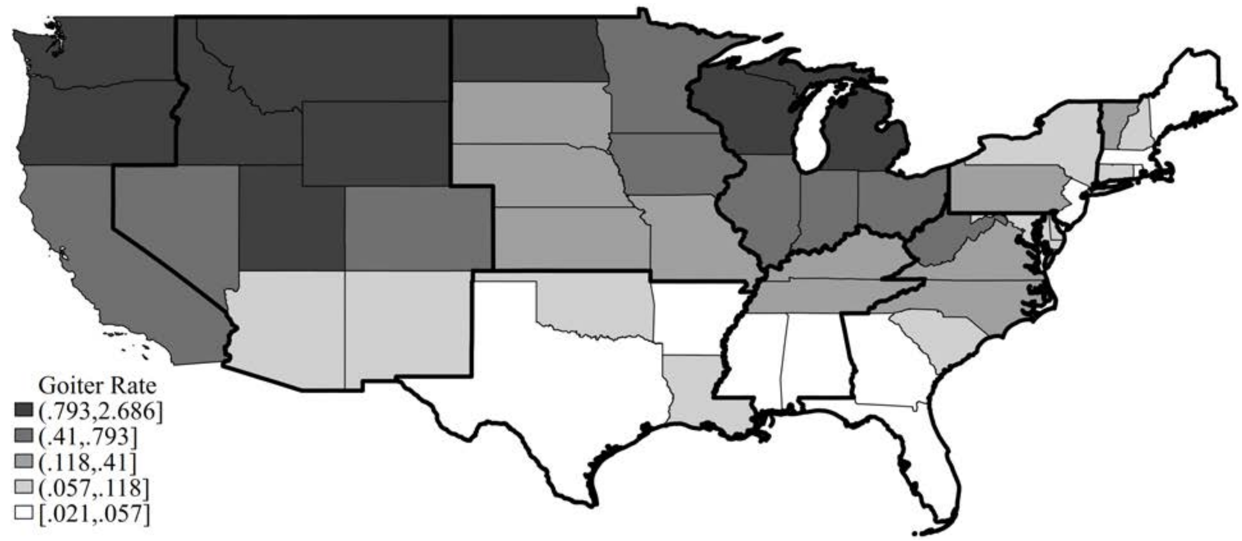
2.1 Iodine Deficiency and its Consequences

Iodine is crucial to the functioning of every body cell. The thyroid gland in the lower part of the neck uses iodine from foods to produce thyroid hormones, which are released into the blood stream to control metabolism (the conversion of oxygen and calories to energy). Optimal iodine intake as recommended by the WHO is very small: a daily dose of 90 μg for children of 0-59 months, 120 μg for ages 6 to 12, 150 μg for older ages (which is the amount found in half a teaspoon of iodized salt), and 200 μg for pregnant and lactating women (Clar et al., 2002). Foods with high iodine content include some milks, leafy vegetables, and seafood, but individuals in areas without natural access to iodine – far from the ocean or in mountain regions susceptible to erosion (Hetzel, 1989) – are at risk of not meeting these recommended levels of iodine intake.

At any point from the fetal stage to adulthood, insufficient iodine intake can cause a number of functional and developmental abnormalities, often referred to as iodine deficiency disorders (IDD). The main physical manifestation of IDD is goiter (the enlargement of the thyroid gland),[6] but other IDDs include hypothyroidism (which results in fatigue, lethargy, slow speech, and thought), impaired mental function, retarded physical development, and increased susceptibility of the thyroid gland to nuclear radiation (De Benoist et al., 2004). This paper focuses on the availability of io-

[6]Goiter may not be visible if iodine deficiency is minimal. On the other hand, iodine deficiency is the primary, but not exclusive, cause of goiter. Goiter, when sufficiently large, may cause complications such as respiratory difficulty.

Figure 1: State-Level Goiter Rates from World War I Draft Examinations



Notes:
State-level goiter rates, calculated from Love & Davenport (1920), are summarized in Table A1. Each shade represents a different quintile of the goiter distribution, with the darkest gray representing the highest quintile. Thick lines denote census division boundaries.

dine *in utero* because fetal iodine levels are particularly crucial for brain development: insufficient iodine intake during gestation can cause irreversible cognitive damage (De Escobar et al., 2004; Zimmermann, 2009).

2.2 The Geography of Iodine Deficiency in the US

The map in Figure 1 illustrates the geographic distribution of goiter incidence across the U.S., based on data from the 1917 WWI draft examinations. To our knowledge, this is the first nation-wide goiter survey in the US. Evidence from other sources suggest that the draft statistics offer a good representation of the geographic pattern of iodine availability for the general population. For example, Figure B1 in the online appendix highlights areas with low iodine content in drinking water and shows a similar "goiter belt" in the northern states.[7] Similarly, Olesen (1929) concludes

[7] We do not use the water iodine content data because the author presents numerical information for only 27 states, many of which use data from only one location.

that independent thyroid survey data from elementary school to college aged samples across the nation were consistent with the geographic variation in in goiter incidence from the draft statistics, in areas where he was able to collect data.

As can be seen in Figure 1 (as well as the corresponding Table A1), the draft statistics show considerable variation in goiter prevalence across states even within areas defined by the nine Census divisions. This variation is crucial as it allows us to control for division-level time effects to remove any systematic coincidence between the goiter distribution and geographic differences in economic development over time, such as the North-South divide.

2.3 Introduction of Iodized Salt in the US in 1924

The hypothesis that iodine can help prevent goiter has existed since the mid-1800's (Zimmermann, 2008). It was not until 1895, however, that iodine was first discovered in the thyroid gland (Baumann, 1896). After this, experiments were conducted to study the impact of changes in iodine content on the incidence of goiter in different kinds of animals (Marine & Feiss, 1915; Marine & Lenhart, 1909; Smith, 1917). In the United States, Hall (1914) and Olesen (1915) were the first to record goiter rates in humans in an organized manner. An experiment started in 1917 by scientist David Marine and colleagues, which involved providing iodated syrup to school girls in Ohio, offered the first direct evidence that iodine supplementation could control and prevent goiter in humans (Marine & Kimball, 1917, 1920). This evidence inspired Switzerland to set up prophylactic programs, one of which used salt as an iodization vehicle.

Around the same time as the Ohio experiment, a few other factors placed focus on goiter in humans as a health problem in America (Annegers & Mickelsen, 1973). These included (a) decline of other childhood diseases, which allowed more attention to shift to goiter, (b) McClendon's discovery of the relationship between goiter and the iodine content of drinking water, (c) the WWI draft examinations, which revealed the nationwide extent of goiter prevalence, and (d) a large incidence of goiter in Michigan (Levin, 1919).

According to Levin (1919), roughly 24 percent of army recruits from Houghton County, Michigan had simple goiter and 2.4 percent of the men were disqualified for the army based on the size or cystic type of goiter.[8] Dr. David Cowie, of the University of Michigan, became interested in eliminating widespread simple goiter in his home state. Cowie organized a symposium of the Michigan State Medical Society in June 1922, which created the Iodized Salt Committee to explore the feasibility of adding iodine to salt in Michigan. The committee initially entertained the idea of proposing a law prohibiting non-iodine fortified salt (Markel, 1987), but they were swayed to allow the profit motives of salt manufacturers to lead them to distribute a product endorsed by medical experts. Introducing iodine to salt was relatively costless as it could be added at the same time as magnesium, which is included to regulate salt flow from the container (Markel, 1987).

Cowie worked with several small salt manufacturers based in Michigan, who were eager to supply a product that they perceived would have a large demand with little extra cost to produce. The Executive Council of the Michigan State Medical Society officially endorsed salt on March 12, 1924 and iodized salt appeared in Michigan groceries on May 1, 1924. The product proved so popular that Morton Salt Company, who initially resisted because of concerns about the high cost of separating a different version of salt for Michigan retailers, began nationwide distribution a few months later. With educational efforts of the Michigan State Medical Society, which gave lectures on the medical benefits of iodized salt and zealous advertisements by salt producers,[9] iodized salt rapidly grew popular. By 1930, iodized salt sales were eight times plain salt sales (Markel, 1987).

Many later surveys found marked decreases in thyroid enlargement, especially among continuous users of iodized salts. Interestingly, Schiel & Wepfer (1976) found that, among Michigan school children in 1924-51, there was a decline in goiter rates among non-users. Cowie attributed this to ingestion of iodized salt without realizing it, such as in school canteens and restaurants, which seems plausible given that iodized salt made up 90% of salt sales in Michigan at the time

[8] "If these men were considered unacceptable to the US Army because of decreased mentation, inability to complete average mental or physical labor, dyspnea, cardiac, and metabolic abnormalities seen in patients with severe colloid goiter, how useful were they considered in daily functions and work productivity in civilian life?" (Markel, 1987, pg 221)

[9] Advertisements would often contain phrases such as "Remember, too, that Morton's Iodized Salt protects children against simple goiter - that often unnoticed nutritional disease which is frequently accompanied by underdevelopment, irritability and backwardness at school." (Women's Home Companion, June 1934)

(Markel, 1987). This observation alleviates concerns about self-selection into using iodized salt and supports the approximate universality of the intervention. The shaded areas in Figure B2 (in the online appendix) map the areas with endemic goiter as determined by goiter surveys compiled by the Chilean Iodine Educational Bureau in 1950 and the American Geographical Society in 1953. While it is unclear what definition of endemic goiter was used for these maps, prevalence decreased considerably between the WWI draft era (Figure B1) and 1950, and the diminishing trend continued to 1953.

2.4 Goiter and Confounding Factors

Marine's 1917-19 experiment was the first to inform the US public that iodine supplementation could prevent and treat goiter; hence there is little reason to suspect a *direct* role of iodine in residential selection or selection into iodine-rich diets. Supporting this claim, Figure B1 shows that goiter incidence was concentrated in the northern states, which were socioeconomically better off compared to the southern states.

However, one might worry that there may have been other important changes in the US diet, concurrent with the roll out of iodized salt. In fact, food fortification in the US began with salt iodization in 1924, with discoveries of the role of vitamin and mineral deficiencies in many diseases and sicknesses (Backstrand, 2002). However, the knowledge remained mostly in the laboratory until May 1941, when President Roosevelt called a National Nutrition Conference for Defense. Figure B3 in the online appendix shows the change in the per capita riboflavin, iron, niacin, and thiamin contents of American food between 1909 and 1994, which does not coincide with the timing of salt iodization.

Similarly, one might still suspect that high goiter areas prior to iodization were also more likely to have high incidence of other nutrient deficiencies or health issues such as malaria or hookworm. In order to address concerns about the contemporaneous eradication of these infectious diseases, we check the robustness of our main results to controlling for baseline geographic variation in the prevalence of malaria and hookworm, interacted with post-iodization dummies. The robustness of our results alleviates concerns about the geographic pattern of goiter incidence, and hence the pattern of expected benefits from iodized salt, coinciding with the geographic pattern of other health-related improvements.

3 Data

3.1 Goiter Data

Our information on the geographic distribution of goiter before 1924 comes from the data used to create Figure 1: medical examinations of over two and a half million drafted men aged 18 to 30 before World War I. Conducted on a large sample of men from all over the United States within a short period of time between 1917 and 1918, these examinations offer a snapshot of the geographic distribution of various mental and physical defects prior to the iodization of salt.[10] Love & Davenport (1920) documents prevalence rates in this sample for over 200 medical conditions, including goiter. In this paper, we use state-level prevalence rates, although rates for smaller regions (collections of counties known as sections) were recorded as well.[11] Table A1 reports for each state the goiter rate recorded in Love & Davenport (1920). The median state-level goiter rate is 0.214% and the maximum is 2.69%.

3.2 Census Data

We also use data from the United States Decennial Census (Ruggles et al., 2015), restricting to individuals born in the twelve-year period spanning 1920 to 1931, which includes the years before, during, and after the nationwide spread of iodized salt. We are interested in labor, education, and

[10] Because this paper focuses on *in utero* exposure to iodine, the ideal dataset would consist of goiter rates from a representative sample of women of childbearing age, instead of men. In the data collected by Olesen (1929), there is a high correlation (0.87) between goiter rates among school-aged girls and boys, which suggests that the distribution of female goiter rates across states should be similar to what is captured by the goiter rates in Love & Davenport (1920), calculated from men of the relevant age range. We do not use the Olesen (1929) goiter rates as our measure of iodine availability because the samples are not representative of each state and numerical rates are only available for 37 states.

[11] Unfortunately, we cannot use the section-level goiter data because we only have state of birth, not county of birth, for the individuals in our sample.

marriage outcomes for this cohort in the 1950 to 1980 censuses, during which they were working-aged adults aged 19 to 60. We use the 1% samples for 1950 to 1970 and the 5% sample for 1980.[12]

Individuals are assigned to the goiter rate in their state of birth, which proxies for their risk of being born to an iodine deficient mother. Individuals are also grouped according to their birth year. Those born in the years 1920 to 1923 are marked as "pre-iodization," those born in 1924 to 1927 are classified as born "during iodization," and those born in 1928 to 1931 are considered "post-iodization." Iodized salt first appeared in grocery stores in 1924 and was reported to have generated eight times more sales than regular salt by 1930 (Markel, 1987). In creating the "during" category, we allow four years of leeway following the initial introduction of iodized salt to ensure that the after cohort was exposed to an environment with sufficiently widespread iodized salt availability.

3.2.1 Outcome and Control Variables

We are primarily interested in labor market outcomes. To represent employment, we use two variables: a dummy for labor force participation (which includes job-seekers as participants) and a dummy for employment (which is set to zero for job-seekers). Individuals who report working in the last year also report the number of weeks they worked (in intervals). We create an indicator variable to represent individuals who worked at least 40 weeks (conditional on having worked in the past year) to study the intensive margin of labor supply. We also look at total income, which includes income from all sources, including wages and self-employment income. We transform total income using the inverse hyperbolic sine function.[13] For all of these labor market variables, we pool individuals from the 1950 to 1980 censuses, during which our sample was aged 19 to 60.

In addition to these labor market outcomes, we also study years of educational attainment, whether an individual has ever been married, and age at first marriage. Because these are all stock variables that are unlikely to be determined in the teenage years or twenties, we only look at individuals in the 1970 and 1980 censuses (when our sample is aged between 39 and 60). To further

[12] Summary statistics by census year are reported in Table B1 in the online appendix.

[13] $\sinh^{-1}(\widehat{\text{Income}}) = \ln(\text{Income} + (\text{Income}^2 + 1)^{1/2})$. The income variable is therefore not conditional on working, and includes zeros for those who do not work.

investigate marriage quality, we also study spousal income and education for individuals currently married (to a spouse currently living in the same the household), along with total family income.

Additional variables taken from the census include gender and race. In addition to including female and black indicator variables as controls, we also control for pre-iodization demographic conditions in the individual's state of birth. This is done by calculating the black and female proportions from the 1920 census in the individual's state of birth. For more details on the construction of variables, see the Data Appendix (in the online supplement).

3.2.2 Summary Statistics

Table 1 reports summary statistics for our sample population (individuals born between 1920 and 1931). The first column summarizes our outcome variables for the entire sample, the second restricts to females, and the third focuses on males. Women have much lower labor force participation, labor supply, and income than men. Marriage rates, age at first marriage, and years of schooling are more similar across both genders, although women are more likely to be married and get married slightly earlier.

3.3 Geographic Controls

Because of the clear regional patterns in the distribution of goiter, an important part of our strategy involves allowing for differential birth cohort trends by region. We use the nine Census Bureau divisions, listed in Table A1, to categorize states into regions. Another way we control for regional patterns is by using the average latitude of each individual's state of birth.[14]

3.4 Robustness Check Controls

In our robustness checks, we control for the pre-iodization rates of two other diseases: malaria and hookworm. For malaria, we use the malaria mortality rates from the 1890 Census, used in

[14]These numbers were obtained from the online database, MaxMind: http://dev.maxmind.com/geoip/legacy/codes/state_latlon/

Table 1: Summary Statistics

	(1)	(2)	(3)
	Whole Sample	Females	Males
1950-1980 Censuses			
1(Employed)	0.644	0.429	0.872
	(0.479)	(0.495)	(0.334)
1(Participated in Labor Force)	0.670	0.448	0.905
	(0.470)	(0.497)	(0.293)
1(Worked at least 40 weeks) conditional on working	0.790	0.659	0.867
	(0.408)	(0.474)	(0.339)
Total Income	19551.4	8690.0	31193.1
	(20266.0)	(12478.3)	(20544.1)
Number of Observations	2383143	1236420	1146723
1970-1980 Censuses			
Years of Schooling	11.38	11.31	11.45
	(3.137)	(2.841)	(3.426)
1(Ever Married)	0.945	0.951	0.937
	(0.229)	(0.216)	(0.242)
Age at First Marriage	22.74	21.43	24.16
	(5.345)	(5.013)	(5.331)
Spouse's Schooling	11.45	11.31	11.59
	(3.007)	(3.391)	(2.568)
Spouse's Total Income	25498.3	41443.6	9934.9
	(23175.8)	(20015.6)	(13414.9)
Total Family Income	48666.0	46772.0	50716.1
	(20703.5)	(21436.8)	(19674.9)
Number of Observations	1789907	930333	859574

Notes: Sample includes all individuals born 1920 to 1931. Statistics are calculated using person-level weights provided by the census. Total income in 1999 dollars.

Bleakley (2010). Hookworm rates are also taken from Bleakley (2010) and are the same data used by Bleakley (2007). These rates were drawn from around 20,000 recruits in 1917 and 1918, a smaller and separate sample from the recruits tested in Love & Davenport (1920) (Kofoid & Tucker, 1921). Each individual was assigned to the relevant prevalence rates from their state of birth.

In order to allow for differential trends across states that may have been affected differently by the Great Depression, we use state-level unemployment rates calculated from the 1930 census. Similarly, in order to allow for differential trends across states affected differently by the mid-century "Great Migration" of African Americans out of the rural South, we calculate the state-level change, between 1920 and 1940, in the black population share, as well as in the total share of the U.S. population made up by each state, to capture race composition shifts and overall population growth.

We also include years of compulsory schooling as an additional control. We obtained this variable from state-level data used in Lleras-Muney (2002), compiled from multiple sources. This data reports the number of years of required schooling (either by compulsory attendance laws or implied by child labor laws) in each state in each year from 1915 to 1939. Using the same strategy as Lleras-Muney (2002), we match each individual to the law in place in their state of birth in the year they turned 14 (the minimum leaving age across all states and years), as this is arguably the most relevant to their schooling continuation choices.

Finally, we also use WWII state mobilization rates, obtained from Acemoglu et al. (2004). If WWII mobilization had any impact on these individuals, it should have affected them during their young adult or adult life: we therefore use mobilization rates in the individual's state of residence rather than their state of birth.

4 Empirical Strategy

4.1 Overview of strategy

As described in section 2, once Morton Salt Co.'s decision to iodize its supply was made, the spread of iodized salt was wide scale and fairly rapid. Since iodization happened nationwide, incidentally there was no true exclusion from exposure. In the spirit of Bleakley (2010), Hornbeck (2012), and others, our basic strategy is to compare trends in economic outcomes among individuals born in states with different levels of pre-iodization iodine deficiency rates. Feyrer et al. (2017) uses similar strategy to identify the impacts of iodization on recruits' placement into the Army v. the Air Force.

We use the spatial distribution of goiter in 1924 in the continental US to identify differences in pre-iodization deficiency rates. As described in section 3, we use data from the Love & Davenport (1920) survey of military recruits. We link each individual in the census to a goiter rate using their state of birth. We use state of birth to draw focus to the effects of *in utero* exposure to iodine rather than exposure through one's life.

We interpret the goiter value as a proxy for the extent of iodine deficiency in one's state of birth during early life. This proxy will, of course, not fully reflect actual iodine exposure. Nevertheless, as shown in the previous sections, as well as in Feyrer et al. (2017), the spatial distribution of goiter generally mirrors the distribution of iodine content in water sources. While admittedly an imperfect proxy, the distribution allows a rough ordering of individuals according to their exposure to iodine *in utero*.

In our main results, we consider the outcomes of three cohorts: those born before (1920-1923), during (1924-1927), and after (1928-1931) salt iodization. We restrict to a fairly small window of birth cohorts to ensure that we are comparing cohorts of relatively similar ages in each census wave, and to avoid other important historical events around the same time (for example, the Spanish influenza outbreak in 1919). In our main specification, we do not go back further than 1920 but in alternative specifications, we explore longer "before" periods. We consider the middle ("during") group because, while the proliferation of iodized salt across the US was rapid, we do not have data on the geographic pattern of this nationwide spread. During the proliferation period, it would be possible to find muted effects simply because iodized salt had not yet reached some markets. To allow for this, we separate the "during" and "after" iodization periods. We also show that our results are robust to the use of a more flexible specification (an event-study analysis) that does not rely on this somewhat arbitrary assignment of cohort dummies (see Figure 2).

We interpret differences in trends in economic outcomes coincident with the proliferation of iodized salt across individuals born in states with varying pre-iodization levels of goiter as causally related to salt iodization. Because all three cohorts were eventually exposed to iodized salt by late childhood and for the remainder of their lives, we are identifying the impact of differential exposure to iodine specifically *in utero*, which is our primary interest because of the irreversible nature of the cognitive damage that can be caused by lack of iodine during the fetal period. Our estimates are therefore somewhat conservative because they do not consider the potential benefits of increased iodine availability later in life, which all of our cohorts (including our control cohort) may have experienced.

4.2 Specification

The basic difference in differences strategy, then, is to compare the outcomes of cohorts born before to those born during and after iodization, across individuals born in states of varying levels of iodine deficiency. We estimate the following specification, for individual i born in year t in state s (census division d), for outcome y recorded in census year c, where G_s is the continuous goiter rate, D_t is a dummy for belonging to the "during" cohort, and A_t is a dummy for belonging to the "after" cohort:

$$y_{istc} = \beta_1 G_s A_t + \beta_2 G_s D_t + \mu_s + \zeta_{dt} + \lambda_{ct} + \eta X_{istc} + \varepsilon_{istc}. \tag{1}$$

Here, β_1 and β_2 are the main coefficients of interest, measuring the difference in birth cohort trends in outcome y across individuals living in states with different levels of iodine deficiency. The specification includes state of birth fixed effects (μ_s) and year of birth fixed effects (which are interacted with census waves, in λ_{ct}, as well as census divisions, in ζ_{dt}) that absorb the main effects of G_s, D_t, and A_t. The census division of birth by birth year interactions (ζ_{dt}) are crucial because they control for any regional trends over time that may coincide with the national goiter distribution.[15] By including division-by-birth-year fixed effects, we ensure that we are comparing outcome variable trends (by birth cohort) across high and low goiter states of birth in their deviations from each Census division's average non-linear trend.[16] Census wave by birth year interactions (λ_{ct}) are included to account for differential cohort trends in the outcome variables as the cohorts age (from one census wave to the next). Included in X_{ist} are individual controls for race and gender, as well as controls for the proportion of the population that is female and that is black (measured in 1920) in the individual's state of birth, interacted with the during and after dummies. Finally, we also include average latitude (of the state of birth) interacted with during and after dummies in order to alleviate concerns about differential trends for Northern and Southern states confounding our estimates. Standard errors are clustered at the state of birth level to allow for arbitrary correlation of the errors for individuals born in the same state.

We conduct this analysis on all individuals born between 1920 and 1931,[17] using the 1950 to

[15] Evidence of differential regional trends potentially correlated with goiter rates give us reason to be believe the inclusion of these interactions is crucial. For example, we compare the division with the highest average goiter rate (Pacific) to the division with the lowest average goiter rate (East South Central). In the East South Central division, female labor force participation and income were growing faster than in the Pacific division in the years leading up to the iodization of salt (1914 to 1923). In addition, the female probability of working at least 40 hours a week was decreasing for the East South Central division but increasing for the Pacific division over this same time period. It is difficult to translate these trends into predictions about how the failure to account for division trends should change our coefficient estimates (because it depends on whether we expect these trends to diverge or converge in the absence of iodization). What is clear, however, is that divisions with different average levels of goiter were trending differently prior to salt iodization and it is important that we control for these division-by-cohort interactions in order to avoid picking up division-specific trends in our goiter coefficient of interest.

[16] There are many types of differential cohort trends that we could in theory control for, but given the geographic distribution of goiter that we observe, our major concern is in broad regional trends that may be non-linear (rather than linear trends at the state-level, for example). Once we have controlled for these division-by-birth-year interactions, we argue that controlling additionally for state-specific linear trends is less important, given that our analysis is now within division (and divisions are relatively small).

[17] As we explain in section 4.1, we use a relatively short window of birth years to ensure that the cohorts we are comparing are relatively similar in age and to avoid picking up the effects of other important historical events, but we show robustness to extending this period back to 1914.

1980 censuses. We then look at men and women separately. In order to trace out the effects of salt iodization on labor market outcomes as our cohorts age, we also run these by-gender regressions separately for the 1950-1960 censuses (when our sample was aged 19 to 40) and the 1970-1980 censuses (when they were aged 39 to 60). We test the robustness of our results to the inclusion of controls for contemporaneous disease eradication programs (related to hookworm and malaria), unemployment rates in 1930, demographic changes from 1920 to 1940, compulsory schooling laws, and WWII mobilization rates in an individual's state of residence.

In order to rule out the existence of differential pre-trends across high and low goiter states (which would indicate a potential violation of our difference-in-difference assumptions), we expand our sample to include individuals born in 1916-1919 and run the following regression:

$$y_{ist} = \beta_1 G_s A_t + \beta_2 G_s D_t + \beta_3 G_s P_t + \mu_s + \zeta_{dt} + \lambda_{ct} + \eta X_{ist} + \varepsilon_{ist}. \tag{2}$$

Here, P_t represents an indicator variable for those born in the pre-1920 "pre-trend" period. If there were no differential cohort trends across the goiter distribution prior to the introduction of iodized salt, we should be unable to reject the null that β_3 is equal to zero.

5 Results

5.1 Labor Supply and Income

In all of the regressions discussed in this section, our coefficients of interest are the after-by-goiter rate interaction and the during-by-goiter rate interaction: these represent the effect of salt iodization on our outcomes of interest. Although the following tables only report these two coefficients, all specifications also include state of birth fixed effects, year of birth by census wave interactions, census division of birth by birth year interactions, a female dummy, a black dummy, and after and during dummies interacted with average state latitude and 1920 state-level female and black proportions. We multiply each relevant coefficient by the inter-quartile range of the goiter distribution (0.709) to obtain a value that can be interpreted as the effect of moving from a relatively low goiter state (at the 25th percentile) to a high goiter state (at the 75th percentile) when discussing the results.

Table 2: Effects of Salt Iodization on Labor and Income Outcomes

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
After x Goiter Rate	0.00707***	0.00680**	0.00877**	0.105***
	(0.00248)	(0.00284)	(0.00371)	(0.0290)
During x Goiter Rate	0.00355	0.00323	0.00848***	0.0267
	(0.00231)	(0.00233)	(0.00268)	(0.0259)
Observations	2383143	2383143	1537003	2135396
Mean of Dep. Var.	0.644	0.670	0.790	7.902

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total incomeweeks, including zeros for those not working.

Table 2 reports the full-sample regression results for our labor outcomes of interest. The effects of salt iodization on the probability of being employed (column 1) and labor force participation (column 2) are both positive and significant, with effect sizes around 0.7 percentage points for the after-by-goiter interactions. The during-by-goiter interactions in these regressions are also positive, but smaller and statistically insignificant. These smaller during coefficients might be an indication that it took time for the take-up of iodized salt to spread nationwide, but we discuss evidence later (in Figure 2 and Table 5) that the effects of salt iodization do show up relatively quickly – just not immediately.

In Table 2, we also find that salt iodization increased the likelihood of working at least 40 weeks in the year, conditional on having worked in the last year, for both the during and after cohorts. In addition, we find an 11% increase in total income (for the after cohort).

Table 3: Pre-Trends in Labor and Income Outcomes

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$sinh^{-1}$(Income)
After x Goiter Rate	0.00707***	0.00680**	0.00880**	0.107***
	(0.00248)	(0.00284)	(0.00370)	(0.0288)
During x Goiter Rate	0.00356	0.00323	0.00854***	0.0274
	(0.00231)	(0.00233)	(0.00269)	(0.0259)
Pre-1920 x Goiter Rate	-0.00317	-0.00264	-0.00422	0.0107
	(0.00210)	(0.00183)	(0.00370)	(0.0253)
Observations	3114884	3114884	1940335	2784412
Mean of Dep. Var.	0.635	0.660	0.794	7.930

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). Pre-1920 is a dummy equal to 1 for those born before 1920. After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1916-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and Pre-1920, During, and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

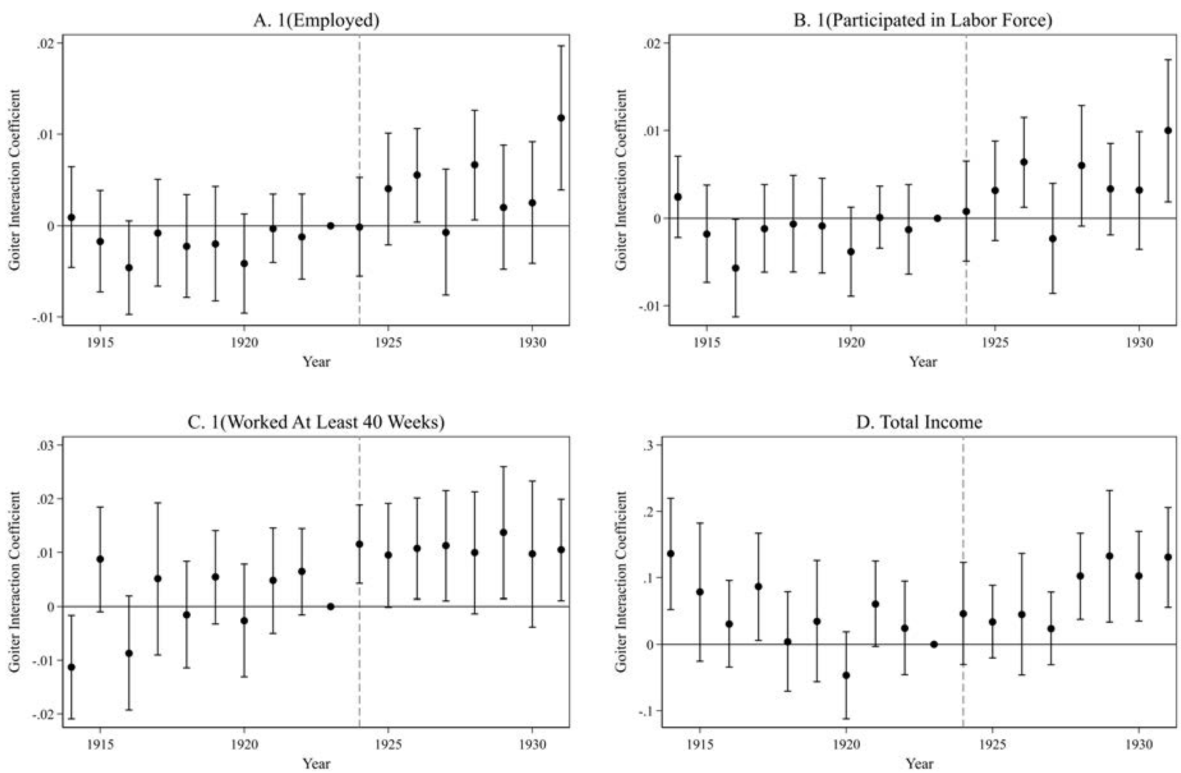
Our interpretation of these coefficients relies on attributing the change in trends after 1924 to the introduction of iodized salt. If, however, high and low goiter states were trending differently before 1924, this would suggest that the difference in trends after 1924 may not be due to salt iodization. In order to test for the existence of differential pre-trends, we run the regression specified in equation 2, including cohorts born in an even earlier period: 1916 to 1919. Results are reported in Table 3, where the pre-1920-by-goiter coefficient estimates the difference across the goiter distribution in cohort trends prior to the introduction of iodized salt. Across all specifications, these pre-1920 coefficients are not significantly different from zero. This alleviates concerns that states were experiencing different cohort trends – before 1924 – systematically correlated with the goiter distribution. Moreover, the during-by-goiter and after-by-goiter coefficient estimates are almost identical to those in the previous table.

In Figure 2, we present further graphical evidence using an event study analysis. Here, we employ a more flexible specification, modifying equation (2) by replacing the before, during, and after interactions with birth year dummies interacted with goiter rate. We extend our study period to include the 1914 birth cohort. We let 1923 serve as the omitted category because it is the last cohort with no exposure to iodized salt during the *in utero* period.[18] Figure 2 plots the coefficients and 90% confidence intervals for the birth-year by goiter interactions, for each of our labor market outcomes of interest.

These results are consistent with our previous findings. Across all outcomes, we see the coefficients shift upward starting in either 1924 or 1925, and coefficients remain higher than zero throughout the post-iodization period (with only two exceptions – 1927 in the first two panels). Though these coefficients are not precisely estimated, the patterns display an upward shift by 1925 (that continues to increase in Panels A, B, and D), which is consistent with the results of Feyrer et al. (2017).

Importantly, prior to 1924, the trend in coefficients is fairly flat across all outcomes, though there is a considerable amount of variation for the worked 40 weeks variable prior to 1924, and there is a slight downward trend in the income variable prior to 1924. We confirm (see Figure B4 in the online appendix) that the positive 1914 coefficient in the income regression appears to be a random fluctuation and that the pre-1924 trend flattens out when we extend the period back to 1912. These results are indicative of a rapid, though not instantaneous, take-up of iodized salt by the U.S. population, and validate our definitions of the During and After cohorts. Though we lack statistical precision in our estimates of this rigorous specification, these results are consistent with our baseline specification, which we use for the remainder of the paper.

Figure 2: Year-by-Year Effects of Salt Iodization on Labor and Income Outcomes



Notes: Each point represents the coefficient estimate (and 90% confidence interval) for Goiter Rate interacted with the birth year indicator listed on the x-axis. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1914-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During, After, and Pre-1920 dummies interacted with average state latitude and 1920 state-level female and black proportions.

Table 4: Effects of Salt Iodization on Labor and Income Outcomes, By Gender

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Panel A: Females				
After x Goiter Rate	0.0108***	0.0121***	0.0144***	0.149***
	(0.00360)	(0.00395)	(0.00525)	(0.0505)
During x Goiter Rate	0.00519	0.00579	0.0206***	0.0192
	(0.00372)	(0.00405)	(0.00466)	(0.0398)
Observations	1236420	1236420	606704	1108650
Mean of Dep. Var.	0.429	0.448	0.659	5.586
Panel B: Males				
After x Goiter Rate	0.00197	0.000148	0.00562	0.0288
	(0.00392)	(0.00364)	(0.00443)	(0.0173)
During x Goiter Rate	0.000934	-0.000487	0.000888	0.0116
	(0.00237)	(0.00247)	(0.00384)	(0.0240)
Observations	1146723	1146723	930299	1026746
Mean of Dep. Var.	0.872	0.905	0.867	10.38
Panel C: Female-Male Difference				
After x Goiter Rate	0.00884	0.0119**	0.00874	0.120**
	(0.00576)	(0.00521)	(0.00592)	(0.0504)
During x Goiter Rate	0.00425	0.00628	0.0197***	0.00759
	(0.00464)	(0.00516)	(0.00658)	(0.0424)

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

5.1.1 Gender Heterogeneity

We next ask whether this cognitive shock impacted labor market outcomes differently for men and women. Table 4 reports the results of two separate regressions: one for women (Panel A) and one for men (Panel B), along with the difference in our main coefficients across the two specifications (Panel C). Stark gender differences are apparent. All of the positive effects on labor supply and income, reported in the previous tables, are driven by women. In fact, there are no significant coefficients in the male regressions, and for labor force participation and income, the after interaction coefficients are significantly larger for women than for men. Comparing the dependent variable means for men and women, it is clear that women have much lower labor supply than men during this period. This implies a much larger scope for growth in female employment than male employment, which could explain this drastic heterogeneity. These results are also consistent with the hypothesis that female fetuses are more sensitive to maternal thyroid deficiency than male fetuses (Field et al., 2009; Friedhoff et al., 2000), but – as we discuss in the next paragraph – we suspect this biological explanation is a secondary one.

In Appendix Table A2, we repeat our analysis (separately for each gender) for three variants of our total income variable: income levels in dollars (including non-earners with zero income), income levels conditional on working, and log income (conditional on working). Interestingly, we do find positive effects on male income that are small in magnitude but significantly different from zero. In fact, both men and women show a 1% increase in income (significant for men, insignificant for women, but not significantly different from each other), conditional on working.

Taken together, our results suggest that the most meaningful labor market effect of salt iodization was a large increase in female labor supply. In addition, however, this shock generated small increases in income (conditional on working) that were similar in percentage terms for both men and women. Given that Feyrer et al. (2017) document that iodized salt had large effects on male cognitive ability, it appears that this cognitive improvement led to only small changes in male eco-

[18] 1924 is only a partially treated year, but our specification allows us to observe whether we begin to see any effects in this year.

nomic outcomes (a statistically significant increase in conditional income). Women, for whom the magnitude of the cognitive improvement generated by iodized salt is not known,[19] seemed to have been much more dramatically affected by iodization. However, it is important to note that the substantially larger effects on female labor force participation do not necessarily imply that the cognitive effects of iodine were larger for women. Indeed, the fact that men showed such large cognitive effects suggest that the reason for the gender difference we find is not biological but instead, market-related. As Molina (2016) shows, an early-life health shock can have vastly different effects on men and women because of the different labor market conditions that men and women face. In our context, almost all men in our sample were in the labor force, while most women were not. Put differently, the marginal man affected by salt iodization was already in the labor force, while the marginal woman was likely not, which could be an important explanation why a large cognitive shock only affected women along this dimension.

The next table breaks our sample down even further in order to study how the effects of salt iodization may have differed over the course of these individuals' careers. In particular, we are interested in comparing effects in young adulthood and prime ages to effects in later adulthood. Focusing on women, who were the only ones significantly impacted by salt iodization, we run our labor market outcome regressions using only the 1950 and 1960 censuses (during which our sample individuals were aged 19 to 40) and then using only the 1970 and 1980 censuses (during which they were 39 to 60 years old). Sample sizes are substantially larger in Panel B because we are using a 1% sample for all census waves except 1980 (which shows up in Panel B), for which we use the 5% sample. Table 5 reports these regressions in Panels A and B, respectively, and reveals a clear pattern. The effects of salt iodization on labor supply seem to be entirely driven by the large impact salt iodization had on women early in their careers. For all outcomes, the early census coefficients are larger in magnitude than the late census coefficients. With the exception of income – for which we see a 6% increase even in later census waves – none of the late census coefficients are significantly different from zero. It is worth noting that for three out of the four outcomes of

[19] The sample in Feyrer et al. (2017) was exclusively male.

Table 5: Effects of Salt Iodization on Female Labor and Income Outcomes in Early and Late Censuses

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Panel A: 1950-1960 Censuses (Ages 19 to 40)				
After x Goiter Rate	0.0185***	0.0221***	0.0288***	0.241**
	(0.00593)	(0.00657)	(0.0106)	(0.100)
During x Goiter Rate	0.0133**	0.0135*	0.0426***	0.0309
	(0.00631)	(0.00695)	(0.0111)	(0.0761)
Observations	306087	306087	80777	180375
Mean of Dep. Var.	0.357	0.374	0.568	4.534
Panel B: 1970-1980 Censuses (Ages 39 to 60)				
After x Goiter Rate	0.00266	0.00152	0.00286	0.0604*
	(0.00330)	(0.00329)	(0.00405)	(0.0327)
During x Goiter Rate	-0.00346	-0.00254	0.00218	0.00762
	(0.00265)	(0.00278)	(0.00457)	(0.0337)
Observations	930333	930333	525927	928275
Mean of Dep. Var.	0.505	0.526	0.736	6.701

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions restrict to women born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

interest in Panel A, there appear to be significant effects on the during cohort, emphasizing that the effects of iodization do appear to show up quite rapidly (as was the case in Feyrer et al. (2017)).

Salt iodization, as a positive shock to cognitive ability, made women more employable and increased their earning potential early in their careers. Later in life, the affected women appear to have dropped out of the labor force (as a result of higher accumulated lifetime income or higher-earning husbands, as we discuss in section 5.3), leaving them no more likely to be employed than their unaffected counterparts. In the appendix, Table A3 reveals no effects for men in either census wave pair, with the exception of a small income increase of 2% in later census waves (significant at the 10% level), much smaller than the female income effects.

5.2 Robustness

There are a number of reasons why trends in labor market outcomes across birth cohorts in the 1920's might differ across states. In order to interpret the coefficients discussed above as causal estimates of the effect of iodized salt specifically, we must assume that any other drivers of these differential birth cohort trends across states are uncorrelated with the distribution of goiter. A violation of this assumption means that we are omitting important variables that are potentially correlated with our outcomes of interest as well as our after-by-goiter and during-by-goiter interactions. To rule out alternative explanations for the effects that we find, we control for a number of important events or policies that could have potentially affected the state-specific trends in outcomes across our before, during, and after cohorts.

First, we consider contemporaneous health improvements, such as the eradication or treatment of diseases, which occurred roughly contemporaneously to the roll out of iodized salt. In particular, malaria and hookworm eradication programs, both concentrated in the South, took place in the decades immediately before and during the spread of iodized salt. Malaria eradication programs started in the 1920's, while the hookworm eradication campaign began around 1910. The correlation between early 1900's goiter prevalence and malaria and hookworm rates are weak and negative (-0.33 and -0.35, respectively) and thus unlikely to be driving our results. We validate

Table 6: Effects of Salt Iodization on Labor and Income Outcomes, By Gender, with Additional Controls

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Panel A: Females				
After x Goiter Rate	0.0165***	0.0187***	0.0176**	0.201***
	(0.00408)	(0.00432)	(0.00692)	(0.0607)
During x Goiter Rate	0.0109**	0.0126***	0.0281***	0.0914*
	(0.00450)	(0.00455)	(0.00631)	(0.0455)
Observations	1179112	1179112	574618	1052355
Mean of Dep. Var.	0.425	0.445	0.657	5.558
Panel B: Males				
After x Goiter Rate	-0.00428	-0.00603	0.00725	0.0228
	(0.00444)	(0.00414)	(0.00480)	(0.0264)
During x Goiter Rate	-0.00239	-0.00436	-0.00333	0.00763
	(0.00292)	(0.00267)	(0.00339)	(0.0266)
Observations	1092150	1092150	879680	973193
Mean of Dep. Var.	0.871	0.904	0.865	10.36
Panel C: Female-Male Difference				
After x Goiter Rate	0.0208***	0.0247***	0.0104	0.178***
	(0.00683)	(0.00613)	(0.00798)	(0.0622)
During x Goiter Rate	0.0133**	0.0170***	0.0314***	0.0838
	(0.00625)	(0.00626)	(0.00666)	(0.0520)
Additional Controls	state-of-birth hookworm and malaria prevalence rates (interacted with During and After), state-of-birth compulsory schooling requirements at age 14, state-of-residence WWII mobilization rates, state-of-birth unemployment rates in 1930 (interacted with During and After), state-of-birth change in black population share from 1920 to 1940 (interacted with Durng and After), state-of-birth change in the total share of US population living in state from 1920 to 1940 (interacted with During and After)			

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

this, however, by including controls for pre-iodization prevalence rates of malaria and hookworm, interacted with the during and after dummies.

We also address the possibility that changes in compulsory schooling laws, implemented at different times across states, resulted in differential trends in labor outcomes, which we are attributing to introduction of iodized salt. We use data collected by Lleras-Muney (2002), which records the minimum years of schooling required by law in each state from 1915 to 1939. Like Lleras-Muney (2002), we match each individual to the compulsory schooling laws in place in their state of birth at age 14 (the lowest minimum leaving age across all states). For the analysis discussed here, we use the number of years of school required according to compulsory attendance laws, although the results are similar when we use the number of years required according to child labor laws.

It is also well-documented that state mobilization rates for World War II affected labor force participation, particularly for females during this period (Acemoglu et al., 2004). To control for this, we use the state-level mobilization rate in an individual's state of residence from Acemoglu et al. (2004).

Finally, all of our sample individuals either lived through the Great Depression or its immediate aftermath, but the before, during, and after cohorts were exposed at different points in their life, which could have had important implications for the severity of the long-term impact on each cohort. If, in addition, the Great Depression hit some states harder than others, it becomes another potential reason for differential birth cohort trends across states. In order to proxy for a state's economic conditions during the Great Depression, we calculate state-level unemployment rates from the 1930 census.[20] We match this to individuals using their state of birth and control for the interaction with during and after dummies.

We use a similar strategy to address concerns that the Great Migration could have also resulted in the differential cohort trends that we are attributing to the iodization of salt. During the childhood years of our sample cohort, many of these individuals were exposed to large shares of African Americans either moving out of or moving into their communities. To rule out the possibility that

[20] Unemployment rates are not available in the 1920 census.

these demographic shifts are driving our results above, we allow for differential trends across states that experienced different racial composition changes and different levels of population growth between 1920 and 1940, two decades of substantial migration that coincided with the childhood years of our cohorts. Specifically, we include During and After interactions with the following two variables: the 1920 to 1940 change in the black population share in an individual's state of birth and the 1920 to 1940 change in the share of the total U.S. population living in an individual's state of birth.

Table 6 reports the results of regressions that control for all of the potential confounders just discussed. The first panel reports the results for women and the second panel reports the results for men. Across all outcomes and samples, we find very similar results: positive and significant effects on female labor supply and income, but no effects on male outcomes.

The online appendix contains additional robustness checks, where we (1) account for mean reversion (Table B3), (2) show that the Dust Bowl was not an important confounder (Table B4), (3) show that our results are robust to dropping states below the Mason-Dixon line (Table B5), (4) show that it is indeed goiter in the state of birth (rather than the state of residence) that is driving our results (Table B6), and (5) show that our results our robust to a specification that compares individuals at more similar ages (Table B7).

We also show that increased access to iodine did not affect the mortality rates of our cohorts, which alleviates concerns about our results being driven by a changing sample composition induced by differential mortality. Table A4 shows no differential trends across the goiter distribution in terms of cohort size or cohort gender composition.

5.3 Additional Outcomes

Having established that improved access to iodine substantially improved labor market outcomes, particularly for females, we next study the effects of this cognitive shock on other dimensions of life. Table 7 reports the results of our main regressions on educational attainment and marriage outcomes, restricting to the 1970-1980 census waves in order to focus on a sample of individuals

Table 7: Effects of Salt Iodization on Education and Marital Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Years of Schooling	1(Ever Married)	Age at First Marriage	Spouse's Years of Schooling	$sinh^{-1}$(Spouse's Income)	$sinh^{-1}$(Family Income)	1(Ever Married)
Panel A: Females							
After x Goiter Rate	0.0712*	0.000541	0.232***	0.0888**	0.00755	0.0177*	-0.00488**
	(0.0379)	(0.00182)	(0.0478)	(0.0402)	(0.0123)	(0.00936)	(0.00237)
During x Goiter Rate	0.0359	0.000702	0.0394	0.0727***	0.0277**	0.0113	0.000885
	(0.0274)	(0.00191)	(0.0543)	(0.0264)	(0.0112)	(0.00812)	(0.00236)
Age							0.0276***
							(0.000414)
Observations	930333	930333	761885	695464	692713	922124	25581376
Mean of Dep. Var.	11.31	0.951	21.43	11.31	11.05	11.18	0.731
Panel B: Males							
After x Goiter Rate	0.0313	0.00288	-0.0405	0.0189	0.0178	0.0168**	0.00388**
	(0.0464)	(0.00235)	(0.0454)	(0.0288)	(0.0448)	(0.00793)	(0.00168)
During x Goiter Rate	0.0990**	0.00220	-0.0355	0.0249	-0.00546	0.0202***	0.00321
	(0.0396)	(0.00187)	(0.0594)	(0.0259)	(0.0511)	(0.00641)	(0.00250)
Age							0.0334***
							(0.000207)
Observations	859574	859574	692623	716526	714625	846971	23566464
Mean of Dep. Var.	11.45	0.937	24.16	11.59	5.833	11.35	0.641
Panel C: Female-Male Difference							
After x Goiter Rate	0.0399	-0.00234	0.273***	0.0699**	-0.0102	0.000901	-0.00875***
	(0.0369)	(0.00355)	(0.0575)	(0.0262)	(0.0499)	(0.0103)	(0.00294)
During x Goiter Rate	-0.0631**	-0.00150	0.0749	0.0478*	0.0331	-0.00885	-0.00232
	(0.0302)	(0.00267)	(0.0716)	(0.0251)	(0.0571)	(0.00834)	(0.00282)

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1970 to 1980 censuses, restricting to individuals born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $sinh^{-1}$(income variable) takes the inverse hyperbolic sine of the relevant income variable (spouse's total income or total family income), including zeros for those not working. Column 7 uses a panel dataset, where each observation represents an individual-age for each age from 14 to 45 (the 1st and 99th percentiles of age at first marriage).

old enough to have completed their schooling and made their first marriage decisions.

First, we ask whether educational attainment was an important mechanism behind the positive labor market effects of improved cognitive ability. Column 1 of Table 7 suggests that it was not. Although the after-by-goiter coefficient is positive and statistically significant for women (and the during-by-goiter coefficient is positive and significant for men), the magnitudes of these coefficients are small, translating to about 2 weeks of school, much too small to be generating the large effects on income reported in Table 5. It should be noted that in a standard model of educational attainment (Card, 2001), a positive shock to the ability endowment can lead to either an increase or a decrease in educational attainment because it can raise the returns to education as well as the initial wage earned (without any education).[21] In this case, these two opposing effects appear to almost cancel each other out, leading to a small but significant increase in average educational attainment.

Next, we ask whether changes in labor market outcomes were accompanied by changes in marital decisions. Increased iodine availability does not appear to have affected overall ever-married rates, which is unsurprising given that over 90% of individuals have been married at least once. However, this cognitive shock does appear to have resulted in delays in marriage for women: we estimate a small but statistically significant increase in the age at first marriage (conditional on having ever married) of approximately a quarter of a year. Because age of marriage is a censored variable, we verify that our results hold when we conduct this analysis at the individual-age level, where each observation represents an individual at a particular age (from 14 to 45, the 1st and 99th percentiles of the age at first marriage variable). In column 7, we regress an indicator for whether the individual has ever been married by that age on our usual specification, controlling additionally for age. Consistent with column 3, column 7 reveals that salt iodization reduces the likelihood of a woman being ever-married at any given age. On the other hand, we see the opposite effect on men, who are more likely to be ever-married at any given age as a result of iodization.

Interestingly, the increased availability of iodine also appears to have affected spousal quality

[21] If the ability endowment shock increases the initial wage regardless of education and the return to education is relatively low, then lifetime income can increase with lower schooling. If there is disutility associated with schooling then there is further downward pressure on educational attainment.

for women, where spousal characteristics are measured for individuals living in the same household as their spouse. In columns 4 and 5, we see that women affected by salt iodization marry more educated and higher income spouses. We do not see the same effects on spousal quality for men. Consistent with the findings that exposure to iodine resulted in higher-income spouses as well as higher individual income for women (column 4 of Panel B of Table 5), increased access to iodine led to significantly higher family income for females. This result is also true for men (and the effect sizes are the same across genders).

These results – in particular, the spousal quality effects for women – help shed light on our findings in Table 5, which revealed that the positive labor force participation effects for women were largest in the early census waves and faded out later in their careers. Greater access to iodine increased female income early in their careers and also resulted in marriages to more educated and higher-income men. Both of these factors likely led to higher accumulated wealth for these women later in life (which is consistent with, though not fully captured by, the positive effects on total family income in Table 7). The fade-out of the female labor force participation effects can therefore be explained by a simple income effect (wealthier women demanding more leisure).[22]

We explore this hypothesis further in Appendix Table A5, where we look again at our main labor market outcomes for females in the late censuses, but allow for heterogeneity in the during and after interactions across women with above-median and below-median family income. We acknowledge that the endogeneity of the family income variable makes a definitive causal interpretation of these results impossible, but what we find does offer suggestive evidence for the hypothesis discussed above. In particular, for women with below-median family income, the positive labor force effects of iodization do persist into the late census waves. It is the women with above-median family income, for whom the negative income effect is likely to be more relevant, who are responsible for the overall null effects on labor force participation later in their careers.

In sum, increased availability of iodine *in utero* affected female marriage outcomes in addition

[22] An alternative explanation for the fade-out of female labor force participation effects is that women who were not affected by iodization eventually caught up to their affected counterparts, joining the labor force later in life. We are unable to provide any evidence that this was the case, though it is certainly possible that both of these explanations played a role.

to their labor market outcomes, which sheds some light on why the female labor force participation effects did not persist into the late census waves. Importantly, these results reveal several other outcomes (spousal quality for women and total family income for both genders) that, unlike female labor force participation, appear to have been persistently affected by the increased access to iodine.

6 Conclusion

In this study, we document the effects of the rapid nationwide iodization of salt in the United States. We estimate substantial impacts on employment and labor force participation for women early in their careers. There is evidence of smaller income effects for both genders that persist into their forties and fifties. Additional results show that impacted women marry more educated and higher-income spouses at later ages, consistent with treated new labor force entrants transitioning out of the work force at later ages due to a negative income effect.

Our results contribute to several strands of literature and current policy debates. First, this study contributes to the growing literature on the long-term effects of early-life conditions, particularly the smaller set of recent work, estimating gains to purposeful and beneficial large-scale policy interventions like fortification schemes. These results differ from earlier studies of early-life "shocks" in that they validate the impacts of actionable policies which can then be reproduced elsewhere. In this way, the study of historic successes, and failures for that matter, in the US and other developed settings, can potentially provide important predictions for academic researchers and policy-makers faced with similar issues in developing countries today.

Second, while previous studies have estimated the roles of historical events, such as World War II and the staged rise in access to contraception, in explaining increases in labor force participation among women (e.g. Goldin (1991), Goldin & Olivetti (2013), Goldin & Katz (2002), and Bailey (2006)), we contribute complementary evidence that salt iodization explains a rise of 2.21 percentage points in early censuses (roughly 6 percent of the total rise from 1950 to 1990). Our evidence pertains to cohorts born after those most affected by the war, but before those most affected by increased access to oral contraceptives.[23] Unlike for these previously studied events, impacts on participation of salt iodization are not focused on higher-educated women but prevail despite negligible impacts on schooling completion.

Additionally, our study provides evidence of the magnitude of benefits from eradication of deficiencies in essential micronutrients such as iodine. Many developing country populations face myriad nutritional constraints, which have long-lasting impacts on health, economic livelihoods, and general welfare. Our estimates show that salt iodization led to a roughly 1.21 percentage point rise in female labor force participation. From a base labor force of 13 million women in 1940 (Durand & Goldfield, 1944), this amounts to almost 2 billion USD in additional income using the mean income for the female sample inflated to 2016 dollars (13 million x 0.0121 x 12,514 USD = 1.97 billion USD).[24]

Lastly, it should be noted that the "intervention" cost the taxpayer nothing, in that the roll-out of iodized salt was completely undertaken by the private sector. That is, the cost of salt iodization was fully borne by the salt producer,[25] while the cognitive benefit was realized by the general population. We conjecture that the rapid rise in both supply and demand might be attributable to the efficiency and underlying profit motive of the private firm that undertook the intervention.

[23] Indeed, we estimate our rise in labor force participation due to salt iodization *relative* to the cohort affected by the war.

[24] This calculation does not take into account the value of home production, which could have decreased with more women entering the labor force.

[25] "The producers and the wholesale grocers each bore one half of the added expense so that the iodized salt would not cost the consumer one cent more." (Kimball, 1937, pg. 32)

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A Appendix

In Table A1, we list all states (excluding Hawaii) by Census division, along with their corresponding goiter rates from Love & Davenport (1920).

Table A1: State-Level Goiter Rates from Love & Davenport (1920)

Census Division	State	Love and Davenport (1920) Goiter Rate *(ppt)*
New England	Connecticut	0.089
New England	Maine	0.066
New England	Massachusetts	0.032
New England	New Hampshire	0.070
New England	Rhode Island	0.055
New England	Vermont	0.214
Middle Atlantic	New Jersey	0.043
Middle Atlantic	New York	0.119
Middle Atlantic	Pennsylvania	0.410
East North Central	Illinois	0.779
East North Central	Indiana	0.649
East North Central	Michigan	1.143
East North Central	Ohio	0.559
East North Central	Wisconsin	1.402
West North Central	Iowa	0.668
West North Central	Kansas	0.125
West North Central	Minnesota	0.804
West North Central	Missouri	0.399
West North Central	Nebraska	0.214
West North Central	North Dakota	0.873
West North Central	South Dakota	0.409
South Atlantic	Delaware	0.059
South Atlantic	District of Columbia	0.139
South Atlantic	Florida	0.025
South Atlantic	Georgia	0.052
South Atlantic	Maryland	0.094
South Atlantic	North Carolina	0.181
South Atlantic	South Carolina	0.094
South Atlantic	Virginia	0.338
South Atlantic	West Virginia	0.789
East South Central	Alabama	0.056
East South Central	Kentucky	0.141
East South Central	Mississippi	0.064
East South Central	Tennessee	0.196
West South Central	Arkansas	0.040
West South Central	Louisiana	0.062
West South Central	Oklahoma	0.072
West South Central	Texas	0.030
Mountain	Arizona	0.121
Mountain	Colorado	0.529
Mountain	Idaho	2.691
Mountain	Montana	2.100
Mountain	Nevada	0.638
Mountain	New Mexico	0.088
Mountain	Utah	1.572
Mountain	Wyoming	1.537
Pacific	Alaska	1.314
Pacific	California	0.445
Pacific	Oregon	2.631
Pacific	Washington	2.340

Table A2 reports regression results for three different variants of the total income variable.

Table A2: Effects of Salt Iodization on Income, By Gender

	(1)	(2)	(3)
	Income (in dollars)	Conditional Income (in dollars)	Log(Income)
Panel A: Females			
After x Goiter Rate	217.5***	113.6	0.0199
	(80.55)	(109.1)	(0.0139)
During x Goiter Rate	27.69	38.22	0.0116
	(81.29)	(116.5)	(0.0145)
Observations	1108650	716883	716883
Mean of Dep. Var.	8690.0	15294.7	9.139
Panel B: Males			
After x Goiter Rate	328.4**	293.8**	0.0142*
	(136.9)	(138.0)	(0.00811)
During x Goiter Rate	295.5***	297.0***	0.0108**
	(101.3)	(91.80)	(0.00456)
Observations	1026746	1003623	1003623
Mean of Dep. Var.	31193.1	32445.8	10.11
Panel C: Female-Male Difference			
After x Goiter Rate	-111.0	-180.2	0.00574
	(157.5)	(180.2)	(0.0169)
During x Goiter Rate	-267.8**	-258.8*	0.000813
	(125.4)	(145.5)	(0.0164)

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions.

Table A3 reports the results of our labor regressions on men, separately for early and late census waves.

Table A3: Effects of Salt Iodization on Male Labor and Income Outcomes in Early and Late Censuses

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Panel A: 1950-1960 Censuses (Ages 19 to 40)				
After x Goiter Rate	0.00385	0.00377	0.00862	0.0350
	(0.00660)	(0.00588)	(0.00816)	(0.0355)
During x Goiter Rate	0.000883	0.000452	-0.00239	-0.00530
	(0.00421)	(0.00427)	(0.00749)	(0.0450)
Observations	287149	287149	162305	170601
Mean of Dep. Var.	0.874	0.912	0.818	9.870
Panel B: 1970-1980 Censuses (Ages 39 to 60)				
After x Goiter Rate	0.000334	-0.00332	0.00137	0.0211
	(0.00263)	(0.00274)	(0.00184)	(0.0127)
During x Goiter Rate	0.00115	-0.00140	0.00303	0.0263*
	(0.00238)	(0.00231)	(0.00182)	(0.0140)
Observations	859574	859574	767994	856145
Mean of Dep. Var.	0.870	0.898	0.920	10.93

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions restrict to men born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

In order to assess whether the increased availability of iodine affected mortality, we take all individuals born between 1920 and 1931 in the 1940 census and collapse to the birth-year birth-state level, counting the total number of individuals as well as calculating the male fraction of each cohort. We use the 1940 census because it is the first census to record all of our birth cohorts of interest. If salt iodization affected mortality, we would expect to see effects on cohort size. We might also see effects on the male fraction because male fetuses are more vulnerable *in utero* (Cagnacci et al., 2004; Sanders & Stoecker, 2015; Trivers & Willard, 1973). We therefore regress cohort size and the male proportion on our after-by-goiter and during-by-goiter variables of interest, controlling for birth state and birth year fixed effects, along with after and during dummies interacted with state latitude and 1920 female and black proportions. We find no differential changes across the goiter distribution in cohort size or gender composition after the introduction of iodized salt. None of the coefficients in Table A4 are significantly different from zero (in terms of magnitude, they are at most a few hundredths of a standard deviation), suggesting that salt iodization did not affect our sample composition.

It is worth noting that Feyrer et al. (2017) document that salt iodization increased mortality among older adults, which could have resulted in reductions in our cohort size if any of the individuals that died were of child-bearing age. If these effects were large, it would be possible for the null effects estimated in Table A4 to be masking large decreases in mortality for children (because of the offsetting increases in mortality for would-be mothers). Based on the estimates in Feyrer et al. (2017), however, we argue that the number of adult deaths is much too small to be offsetting any important decreases in mortality on the other end of the age distribution.[26]

[26]Between 1921 and 1926, Feyrer et al. (2017) estimate an additional 2,340 deaths per year resulted from iodized salt. If we assume (conservatively) that half of these deaths were from people older than child-bearing age, this leaves us with an estimate of 1000 deaths per year (of which only a small proportion would have given birth in any given year), a very small number compared to an average cohort size of around 60,000.

Table A4: Salt Iodization and Cohort Composition

	(1)	(2)
	Cohort Size	Fraction Male
After x Goiter Rate	525.7	0.00602
	(416.1)	(0.00619)
During x Goiter Rate	-146.4	-0.0330
	(316.5)	(0.0217)
Observations	596	596
Mean of Dep. Var.	46912.7	0.495
Standard Deviation of Dep. Var.	43529.8	0.0660

Notes: Standard errors, clustered by state, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Each observation represents a birth-state birth-year combination. Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for birth years 1928-1931. During is a dummy equal to 1 for birth years 1924-1927. These regressions use the 1940 census, restricting to birth years 1920-1931. All regressions include During and After dummies interacted with average state latitude and 1920 state-level female and black proportions.

Table A5 reports the results of our regressions on female labor market outcomes in late census waves, allowing for heterogeneity in the effect of iodization across women with above-median family income and below-median family income. For those with below-median family income, we see that the effects of iodization on labor force participation do persist.

Table A5: Effects of Salt Iodization on Female Labor Market Outcomes, by Family Income Indicator

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
After x Goiter Rate x 1(Above Median Family Income)	-0.0168***	-0.0205***	-0.0110***	-0.188***
	(0.00441)	(0.00505)	(0.00364)	(0.0529)
During x Goiter Rate x 1(Above Median Family Income)	-0.0143***	-0.0168***	-0.00603*	-0.181***
	(0.00341)	(0.00350)	(0.00348)	(0.0419)
After x Goiter Rate	0.0132***	0.0147***	0.00978**	0.185***
	(0.00421)	(0.00457)	(0.00457)	(0.0510)
During x Goiter Rate	0.00517	0.00793*	0.00653	0.118**
	(0.00392)	(0.00400)	(0.00518)	(0.0444)
1(Above Median Family Income)	0.111***	0.101***	0.0649***	0.734***
	(0.00482)	(0.00502)	(0.00332)	(0.0561)
Observations	923887	923887	524163	921829
Mean of Dep. Var.	0.506	0.528	0.736	6.707

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1970 to 1980 censuses, restricting to women born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

Online Appendix

B2 Additional Tables and Figures

Table B1: Summary Statistics, by Census Year

	(1)	(2)	(3)	(4)
	1950 Census	1960 Census	1970 Census	1980 Census
1(Employed)	0.588	0.631	0.705	0.656
	(0.492)	(0.482)	(0.456)	(0.475)
1(Participated in Labor Force)	0.616	0.658	0.727	0.684
	(0.486)	(0.474)	(0.446)	(0.465)
1(Worked at least 40 weeks) conditional on working	0.671	0.794	0.843	0.850
	(0.470)	(0.405)	(0.364)	(0.357)
Total Income	9135.5	17812.2	25756.6	26450.3
	(10082.8)	(18050.1)	(22575.1)	(22990.8)
Years of Schooling			11.28	11.47
			(3.116)	(3.156)
1(Ever Married)			0.941	0.948
			(0.236)	(0.222)
Age at First Marriage			22.49	22.98
			(4.841)	(5.789)
Spouse's Schooling			11.35	11.56
			(2.982)	(3.028)
Spouse's Total Income			25352.4	25653.2
			(23211.6)	(23136.8)
Total Family Income			49056.7	48277.9
			(19756.3)	(21596.4)
Number of Observations	325602	267634	509165	1280742

Notes: Sample includes all individuals born 1920 to 1931. Statistics are calculated using person-level weights provided by the census. Total income in 1999 dollars.

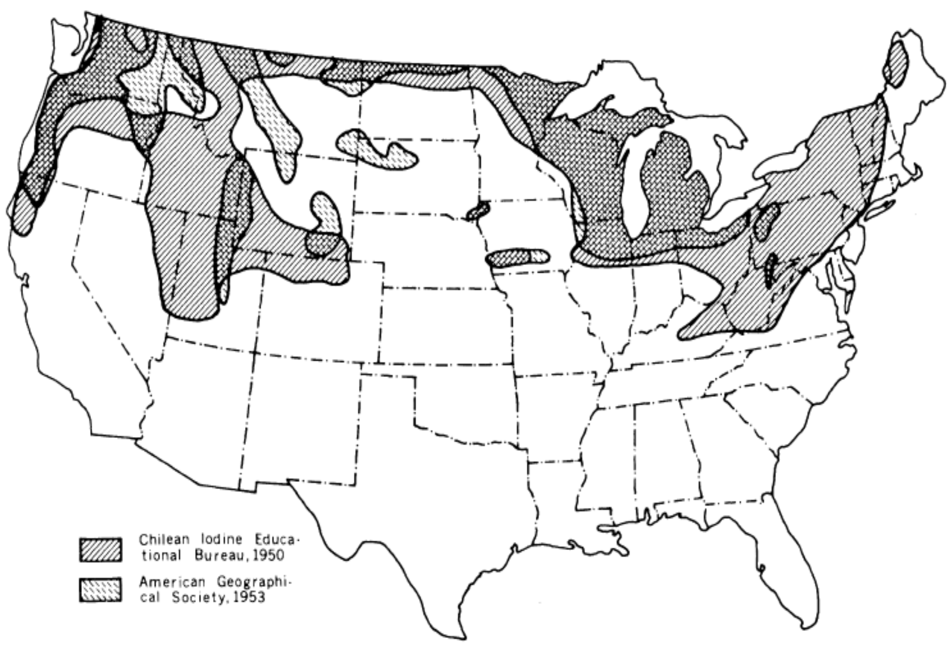
Figure B1: Iodine Content of Drinking Water in the US

Iodine content in drinking water in the US

Black areas: Iodine-poor, i.e. 22 and less parts of iodine per hundred billion parts of water
White areas: Iodine-rich, i.e. 23 and more parts of iodine per hundred billions parts of water

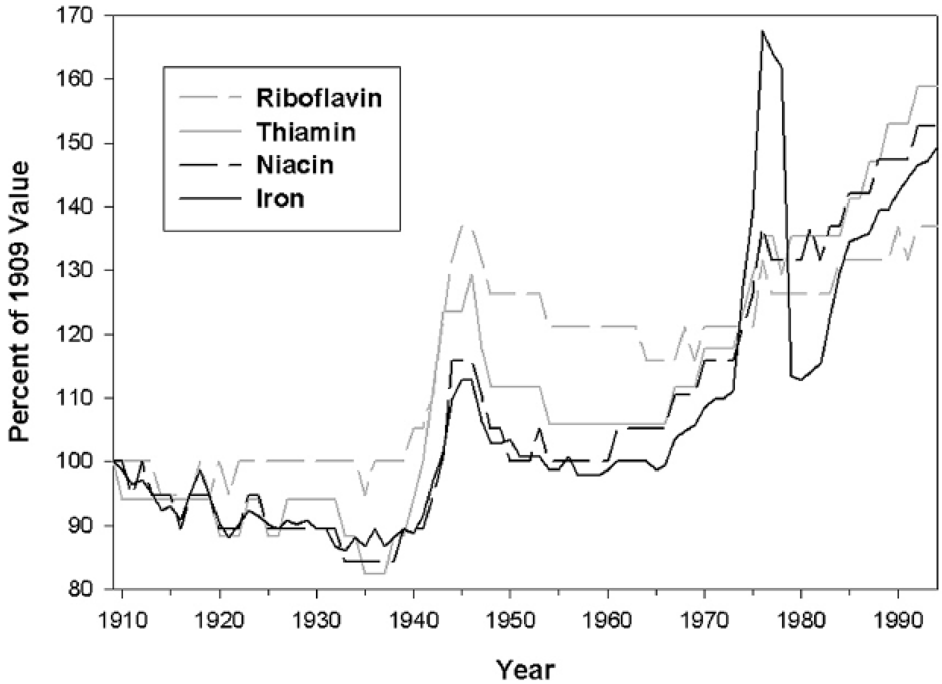
Source: McClendon and Hathaway (1924)

Figure B2: U.S. goiter distribution in the early 1950s



Source: Schiel and Wepfer (1976)

Figure B3: Change in the per capita riboflavin, iron, niacin, and thiamin content of the U.S. food supply between 1909 and 1994



Source: Backstrand (2002)

Table B2 reports the coefficient estimates for the event study specification that produced Figure 2.

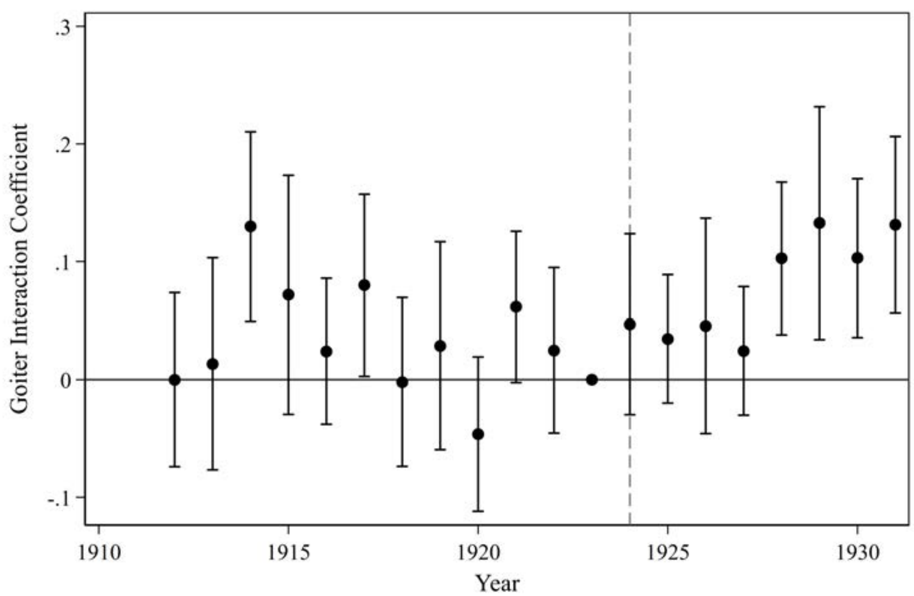
Table B2: Year-by-Year Effects of Salt Iodization on Labor and Income Outcomes

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Born 1914 x Goiter Rate	0.000920	0.00242	-0.0113*	0.136***
	(0.00328)	(0.00275)	(0.00575)	(0.0498)
Born 1915 x Goiter Rate	-0.00173	-0.00180	0.00873	0.0782
	(0.00330)	(0.00330)	(0.00579)	(0.0619)
Born 1916 x Goiter Rate	-0.00460	-0.00570*	-0.00871	0.0307
	(0.00306)	(0.00333)	(0.00631)	(0.0388)
Born 1917 x Goiter Rate	-0.000799	-0.00119	0.00509	0.0864*
	(0.00348)	(0.00297)	(0.00842)	(0.0480)
Born 1918 x Goiter Rate	-0.00225	-0.000649	-0.00154	0.00388
	(0.00334)	(0.00328)	(0.00590)	(0.0445)
Born 1919 x Goiter Rate	-0.00200	-0.000874	0.00541	0.0347
	(0.00373)	(0.00321)	(0.00516)	(0.0543)
Born 1920 x Goiter Rate	-0.00415	-0.00382	-0.00264	-0.0468
	(0.00325)	(0.00304)	(0.00624)	(0.0392)
Born 1921 x Goiter Rate	-0.000311	0.0000988	0.00477	0.0608
	(0.00222)	(0.00210)	(0.00583)	(0.0382)
Born 1922 x Goiter Rate	-0.00122	-0.00130	0.00643	0.0244
	(0.00277)	(0.00304)	(0.00477)	(0.0419)
Born 1924 x Goiter Rate	-0.000143	0.000792	0.0115**	0.0462
	(0.00321)	(0.00339)	(0.00435)	(0.0457)
Born 1925 x Goiter Rate	0.00401	0.00311	0.00949	0.0339
	(0.00364)	(0.00338)	(0.00575)	(0.0325)
Born 1926 x Goiter Rate	0.00551*	0.00637**	0.0107*	0.0451
	(0.00305)	(0.00305)	(0.00561)	(0.0545)
Born 1927 x Goiter Rate	-0.000723	-0.00233	0.0113*	0.0237
	(0.00410)	(0.00374)	(0.00610)	(0.0324)
Born 1928 x Goiter Rate	0.00663*	0.00598	0.00996	0.102**
	(0.00357)	(0.00410)	(0.00675)	(0.0385)
Born 1929 x Goiter Rate	0.00201	0.00330	0.0137*	0.132**
	(0.00405)	(0.00310)	(0.00733)	(0.0590)
Born 1930 x Goiter Rate	0.00252	0.00316	0.00971	0.102**
	(0.00396)	(0.00400)	(0.00810)	(0.0401)
Born 1931 x Goiter Rate	0.0118**	0.00999**	0.0105*	0.131***
	(0.00472)	(0.00483)	(0.00562)	(0.0447)
Observations	3463283	3463283	2103021	3090332
Mean of Dep. Var.	0.629	0.653	0.794	7.952

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1914-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and Pre-1920, During, and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

Figure B4 shows that the slight negative pre-trend that appeared in Panel D of Figure 2 appears to be a random fluctuation – when we extend birth years back to 1912, the trend flattens out.

Figure B4: Year-by-Year Effects of Salt Iodization on Total Income, Including Birth Years Back to 1912



Notes: Each point represents the coefficient estimate (and 90% confidence interval) for Goiter Rate interacted with the birth year indicator listed on the x-axis. This regression uses the 1950 to 1980 censuses, restricting to individuals born in 1912-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During, After, and Pre-1920 dummies interacted with average state latitude and 1920 state-level female and black proportions.

Table B3 addresses the concern that mean reversion could be driving our results, by allowing for differential cohort trends across areas with varying levels of the dependent variable at baseline. To allow for these trends, the ideal strategy would involve including interactions between our During and After dummies and state-level averages of each of our dependent variables from a baseline year. In our case, 1920 is the obvious choice, as this is the year of the census that immediately preceded salt iodization. Unfortunately, the 1920 census did not collect data on almost all of our dependent variables, with the exception of labor force participation. Therefore, for the majority of our regressions, we use 1920 state-level averages of the closest proxy available. To proxy for employment and weeks worked, we use labor force participation. For income, we use the occupation score, a score given to each individual based on their occupation, where higher scores represent occupations with higher median income (based on 1950's income and occupation data). Because we run our regressions separately for men and women, we calculate these state-level averages by gender and use the relevant gender-specific values in each gender-specific regression. In Table B3, it is clear that including these mean reversion controls (1920 state-level averages interacted with During and After dummies) has no effect on our main results.

Table B3: Effects of Salt Iodization on Labor and Income Outcomes, By Gender, Accounting for Mean Reversion

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Panel A: Females				
After x Goiter Rate	0.0113***	0.0128***	0.0128**	0.150***
	(0.00374)	(0.00413)	(0.00558)	(0.0510)
During x Goiter Rate	0.00585	0.00662	0.0212***	0.0240
	(0.00389)	(0.00421)	(0.00467)	(0.0392)
Observations	1236420	1236420	606704	1108650
Mean of Dep. Var.	0.429	0.448	0.659	5.586
Panel B: Males				
After x Goiter Rate	0.00247	0.000325	0.00582	0.0296
	(0.00411)	(0.00382)	(0.00459)	(0.0185)
During x Goiter Rate	0.00118	-0.0000895	0.000862	0.0127
	(0.00269)	(0.00279)	(0.00395)	(0.0229)
Observations	1146723	1146723	930299	1026746
Mean of Dep. Var.	0.872	0.905	0.867	10.38
Panel C: Female-Male Difference				
After x Goiter Rate	0.00884	0.0124**	0.00702	0.120**
	(0.00578)	(0.00518)	(0.00650)	(0.0514)
During x Goiter Rate	0.00467	0.00671	0.0204***	0.0113
	(0.00489)	(0.00532)	(0.00660)	(0.0400)

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1920-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working. All regressions control for mean reversion by interacting 1920 state-level averages of the dependent variable (or its closest available proxy) with During and After dummies.

The Dust Bowl was another event that roughly coincided with the introduction of iodized salt. In the 1930's, large dust storms in the Great Plains states caused massive soil erosion and reduced agricultural land values in highly eroded areas (Hornbeck, 2012), which could have resulted in differential cohort trends that we might be incorrectly attributing to salt iodization. Because the negative effects of the Dust Bowl were felt almost exclusively by a limited number of geographically concentrated states, we can check to see whether this event was a potential confounder by excluding these states from our sample and repeating our analysis. Table B4 reports the results of this exercise, excluding individuals born in the Great Plains and neighboring states (Arkansas, Colorado, Iowa, Kansas, Louisiana, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahmoa, South Dakota). These results lead us to the same conclusions as before, implying that the Dust Bowl was not the reason for the results we find.

Table B4: Effects of Salt Iodization on Labor and Income Outcomes, By Gender, Excluding Dust Bowl States

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$sinh^{-1}$(Income)
Panel A: Females				
After x Goiter Rate	0.0116***	0.0137***	0.0163*	0.217***
	(0.00402)	(0.00434)	(0.00807)	(0.0512)
During x Goiter Rate	0.0102**	0.0105**	0.0202***	0.0532
	(0.00428)	(0.00456)	(0.00644)	(0.0522)
Observations	938025	938025	460665	840341
Mean of Dep. Var.	0.435	0.455	0.667	5.660
Panel B: Males				
After x Goiter Rate	0.00234	0.000359	0.00688	0.0207
	(0.00487)	(0.00474)	(0.00484)	(0.0147)
During x Goiter Rate	0.000571	-0.000963	0.00102	0.0104
	(0.00367)	(0.00383)	(0.00498)	(0.0312)
Observations	869965	869965	704195	778417
Mean of Dep. Var.	0.870	0.904	0.867	10.38
Panel C: Female-Male Difference				
After x Goiter Rate	0.00928	0.0134**	0.00939	0.197***
	(0.00612)	(0.00544)	(0.00891)	(0.0527)
During x Goiter Rate	0.00961	0.0115*	0.0192*	0.0428
	(0.00618)	(0.00675)	(0.00943)	(0.0606)

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1920-1931 and excluding individuals born in Arkansas, Colorado, Iowa, Kansas, Louisiana, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahmoa, South Dakota, Texas, and Wyoming. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

To address concerns that our results are being driven by differential trends across the North-South divide, we drop states below the Mason-Dixon line (all Southern census divisions) and repeat our analysis. As the results below show, our pattern of results remains the same.

Table B5: Effects of Salt Iodization on Labor and Income Outcomes, By Gender, Excluding States Below Mason-Dixon Line

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Panel A: Females				
After x Goiter Rate	0.0103***	0.0106**	0.0149**	0.106
	(0.00368)	(0.00401)	(0.00653)	(0.0626)
During x Goiter Rate	0.00528	0.00574	0.0184***	-0.0235
	(0.00443)	(0.00461)	(0.00583)	(0.0528)
Observations	782490	782490	390240	705656
Mean of Dep. Var.	0.433	0.452	0.667	5.619
Panel B: Males				
After x Goiter Rate	0.00508	0.00180	0.00835	0.0424*
	(0.00461)	(0.00394)	(0.00601)	(0.0218)
During x Goiter Rate	0.000867	-0.00279	0.00631	0.00630
	(0.00195)	(0.00212)	(0.00464)	(0.0291)
Observations	739070	739070	613373	665189
Mean of Dep. Var.	0.882	0.915	0.876	10.52
Panel C: Female-Male Difference				
After x Goiter Rate	0.00518	0.00878	0.00659	0.0634
	(0.00618)	(0.00540)	(0.00932)	(0.0566)
During x Goiter Rate	0.00441	0.00853*	0.0121	-0.0298
	(0.00468)	(0.00490)	(0.00807)	(0.0579)

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1920-1931, dropping all individuals born in the South Atlantic, East South Central, and West South Central divisions. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

For our interpretation of results to be correct, it needs to be the goiter rate in an individual's state of *birth* that affects cohort trends, not the goiter rate in the state of residence. To verify that this is the case, we run our exact same specification with two additional variables of interest: goiter in the individual's state of residence interacted with during and after dummies (along with state of residence fixed effects). For those who still live in their state of birth, these variables provide no more additional information, but for those who have migrated, these variables help us identify whether the main results discussed above are being driven by the characteristics of an individual's state of residence (rather than the state of birth). As Table B6 shows, the effects are clearly being driven by goiter in the state of birth, and not the state of residence (for which coefficients are small, imprecisely estimated, and often of the opposite sign).

Table B6: Effects of Salt Iodization on Labor and Income Outcomes, By Gender, Controlling for State-of-Residence Goiter Rate

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Panel A: Females				
After x Goiter Rate	0.0122**	0.0123**	0.0157**	0.175***
in State of Birth	(0.00472)	(0.00494)	(0.00625)	(0.0508)
During x Goiter Rate	0.00771	0.00859*	0.0232***	0.0641
in State of Birth	(0.00483)	(0.00494)	(0.00510)	(0.0443)
After x Goiter Rate	0.000170	0.00219	0.00119	-0.00968
in State of Residence	(0.00353)	(0.00350)	(0.00465)	(0.0355)
During x Goiter Rate	-0.00236	-0.00281	-0.000631	-0.0446
in State of Residence	(0.00291)	(0.00305)	(0.00371)	(0.0378)
Observations	1188488	1188488	579715	1060779
Mean of Dep. Var.	0.426	0.446	0.658	5.569
Panel B: Males				
After x Goiter Rate	0.00350	0.0000201	0.00583	0.00825
in State of Birth	(0.00446)	(0.00411)	(0.00503)	(0.0222)
During x Goiter Rate	0.00181	-0.00142	0.00251	-0.0109
in State of Birth	(0.00277)	(0.00282)	(0.00423)	(0.0261)
After x Goiter Rate	-0.00281	-0.000300	-0.00105	0.0227
in State of Residence	(0.00243)	(0.00194)	(0.00339)	(0.0180)
During x Goiter Rate	-0.00229	0.000534	-0.00384	0.0193
in State of Residence	(0.00155)	(0.00159)	(0.00310)	(0.0136)
Observations	1101223	1101223	886967	981453
Mean of Dep. Var.	0.870	0.904	0.865	10.36

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth or state of residence (as specified) from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions use the 1950 to 1980 censuses, restricting to individuals born in 1920-1931. All regressions include state of birth fixed effects, state of residence fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

In our main specification, due to the use of three different birth cohorts (before, during, and after), we end up comparing individuals of very different ages. For example, in the 1950 census, the after cohort is aged 19-22 while the before and during cohorts are in their mid- to late-twenties. This is one reason why we include birth year by census wave fixed effects in all of our regressions, but we also conduct a robustness check to ensure that our results are not an artifact of the vastly different ages of our cohorts. To do this, we use only the 1950 census for the before group (when they are aged 27 to 30) and the 1960 census for the during and after groups (when they are aged 29 to 36), and repeat our analysis. As Table B7 shows, our conclusions remain the same: strong labor force participation effects for women, but no effects for men.

Table B7: Effects of Salt Iodization on Labor and Income Outcomes, By Gender, Restricting to Individuals Aged 27-36

	(1)	(2)	(3)	(4)
	1(Employed)	1(Participated in the Labor Force)	1(Worked at least 40 weeks)	$\sinh^{-1}$(Income)
Panel A: Females				
After x Goiter Rate	0.0276***	0.0319***	0.0269	0.361***
	(0.00733)	(0.00729)	(0.0186)	(0.0793)
During x Goiter Rate	0.0222***	0.0225**	0.0185	0.234**
	(0.00819)	(0.00885)	(0.0163)	(0.115)
Observations	158098	158098	47815	113298
Mean of Dep. Var.	0.324	0.340	0.564	4.185
Panel B: Males				
After x Goiter Rate	-0.00203	0.00559	0.0101	-0.0833
	(0.00588)	(0.00520)	(0.00920)	(0.0500)
During x Goiter Rate	0.00115	0.00310	0.0153*	-0.0936*
	(0.00548)	(0.00452)	(0.00887)	(0.0533)
Observations	147207	147207	104152	107678
Mean of Dep. Var.	0.915	0.949	0.872	10.37
Panel C: Female-Male Difference				
After x Goiter Rate	0.0296***	0.0263***	0.0168	0.444***
	(0.00972)	(0.00898)	(0.0241)	(0.0905)
During x Goiter Rate	0.0211*	0.0194*	0.00314	0.327**
	(0.0112)	(0.0101)	(0.0197)	(0.137)

Notes: Standard errors, clustered by state of birth, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Goiter Rate is the goiter rate in the individual's state of birth from Love and Davenport (1920), scaled by the difference between the 75th and 25th percentile of the goiter distribution (0.71). After is a dummy equal to 1 for those born 1928-1931. During is a dummy equal to 1 for those born 1924-1927. These regressions restrict to individuals born in 1920-1931, using the 1950 census for those born 1920-1923 and the 1960 census for those born 1924-1931. All regressions include state of birth fixed effects, year of birth x census year dummies, census division of birth x birth year dummies, gender, race, and During and After dummies interacted with average state latitude and 1920 state-level female and black proportions. 1(Worked at least 40 weeks) is conditional on having worked in the past year. $\sinh^{-1}$(Income) takes the inverse hyperbolic sine of total income, including zeros for those not working.

B3 Data Appendix

B3.1 Independent Indicator Variables

- *Before*=1 if individual was born in 1920-1924; *Before*=0 otherwise
- *During*=1 if individual was born in 1924-1927; *During*=0 otherwise
- *After*=1 if individual was born in 1928-1931; *After*=0 otherwise
- *Pre-1920*=1 if individual was born before 1920; *Pre-1920*=0 otherwise
- *Goiter Rate*: goiter rate, from Love & Davenport (1920), in the individual's state of birth

B3.2 Outcome Variables

B3.2.1 Basic Outcomes

- *1(Participated in Labor Force)*=1 if the individual participated in the labor force (by either working or looking for work) in the last week;
  1(Participated in Labor Force)=0 if the individual did not participate in the labor force.
- *1(Employed)*=1 if the individual was employed in the last week;
  1(Employed)=0 if the individual did not work, irrespective of whether the individual looked for a job.
- *1(Worked at least 40 weeks)*=1 if the individual reported working at least 40 weeks in the last year. *1(Worked at least 40 weeks)*=0 if the individual worked fewer than 40 weeks in the last year. This variable is missing for individuals who did not work in the past year.
- *Total Income*: This is the inverse hyperbolic sine of the total annual income earned by the individual. All values are adjusted to 1999 prices according to Census-provided multipliers. Although this variable is top-coded differently across Census years, we applied the top-

coding from the 1950 Census to all years (setting the maximum income to \$70,000). The inverse hyperbolic sine transformation was made after all of the adjustments were made.

- *Years of Schooling*: Years of schooling completed by the individual.

- *1(Ever Married)*=1 if the individual is currently married, divorced, separated, or widowed. *1(Ever Married)*=0 if the individual has never been married.

- *Age at First Marriage*: Individual's age at first marriage, conditional on being ever-married.

- *Spouse's Years of Schooling*: Years of schooling completed by the individual's spouse, for individuals who can be matched to their spouse living in the same household.

- *Spouse's Income*: This is the inverse hyperbolic sine of the total annual income earned by the individual's spouse, for individuals who can be matched to their spouse living in the same household. All values are adjusted to 1999 prices according to Census-provided multipliers. Although this variable is top-coded differently across Census years, we applied the top-coding from the 1950 Census to all years (setting the maximum income to \$70,000). The inverse hyperbolic sine transformation was made after all of the adjustments were made.

- *Family Income*: This is the inverse hyperbolic sine of the sum of total annual income earned by the individual's family (living in the same household). All values are adjusted to 1999 prices according to Census-provided multipliers. Although this variable is top-coded differently across Census years, we applied the top-coding from the 1950 Census to all years (setting the maximum income to \$70,000). The inverse hyperbolic sine transformation was made after all of the adjustments were made.

B3.3 Other Variables

- *female*=1 for females; *female*=0 for males

- *black*=1 for black individuals; *black*=0 for all other races

- *1920 female share*: The state-level proportion of the population that was female in the individual's state of birth, calculated from the 1920 Census.
- *1920 black share*: The state-level proportion of the population that was black in the individual's state of birth, calculated from the 1920 Census.
- *Latitude*: Average latitude for the individual's state of birth
- *Malaria*: Pre-iodization malaria rate in state of birth according to Bleakley (2010)
- *Hookworm*: Pre-iodization hookworm rate in state of birth according to Bleakley (2010)
- *Compulsory Schooling*: Number of years of schooling required by compulsory attendance laws in the individual's state of birth in the year they turned 14 (which is the minimum leaving age across all states and years), from Lleras-Muney (2002).
- *Mobilization Rate*: WWII mobilization rate for individual's state of residence, from Acemoglu et al. (2004).
- *1930 unemployment rate*: The state-level unemployment rate in the individual's state of birth, calculated from the 1930 census.
- *1920-1940 population growth*: The state-level change, between the 1920 and 1940 census, in the share of the U.S. population living in an individual's state of birth.
- *1920-1940 change in black share*: The state-level change, between the 1920 and 1940 census, in the black population share in an individual's state of birth.