Edinburgh School of Economics

Discussion Paper Series

Number 202

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Date
October 2010

Published by
School of Economics
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http://edin.ac/16ja6A6

THE UNIVERSITY *of* EDINBURGH

The effects of the generalized use of iodized salt on occupational patterns in Switzerland.

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October 15, 2010

Abstract

This paper examines the impact of salt iodization in Switzerland in the 1920s and 1930s on occupational patterns of cohorts born after the intervention. The generalized use of iodized salt successfully combatted iodine deficiency disorders, which were previously endemic in some areas of Switzerland. The most important effect of universal prophylaxis by means of iodized salt was the eradication of mental retardation inflicted in utero by lack of iodine. This paper looks for evidence of increased cognitive ability of those treated with iodine in utero by examining the occupational choice and characteristics of occupations chosen by cohorts born after the intervention. By exploiting variation in pre-existing conditions and in the timing of the intervention, I find that cohorts born in previously highly-deficient areas after the introduction of iodized salt self-selected into higher-paying occupations. I also find that the characteristics of occupations in those areas changed, and that cohorts born after the intervention engaged to a higher degree in occupations with higher cognitive demands, whereas they opted out of physical-labor-intensive occupations.

JEL classification: I12, I18, J24, N34
Keywords: Iodine deficiency, cognitive ability, occupational choice, human capital, productivity

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1 Introduction

Nutrition is inextricably linked to a population's health capital. Malnutrition, especially when it occurs early in life, can have serious detrimental effects on a person's lifetime productivity and economic prospects. Micronutrient deficiencies are a common source of malnutrition, caused by insufficient intake of necessary vitamins and minerals. Iodine is one such micronutrient.

Lack of iodine causes many disorders, the most common of which is an enlargement of the thyroid gland, when there is not enough iodine for the production of hormones which regulate metabolism. This enlargement is called a goiter. Other symptoms include short stature and deaf-mutism. However, the most catastrophic consequence of iodine deficiency is brain damage, which is irreversible and can go unnoticed in a population. Iodine deficiency results in various degrees of mental underdevelopment when it occurs in utero and the first three months of life. Cretinism, which is an acute form of mental retardation, often coupled with goiter and deaf-mutism, occurs when iodine deficiency is utero is most severe.

Iodine deficiency is the leading cause of preventable mental retardation in the world today. The WHO estimates that nearly 50 million people suffer some degree of mental impairment due to a lack of iodine in their diets[1]. According to WHO's Global Database on Iodine Deficiency, more than 285 million children receive inadequate amounts of iodine in their diet [2]. Despite efforts to decrease the prevalence of iodine deficiency in the 1990s, there are still 38 million children born annually at the risk of developing iodine deficiency disorders. The most vulnerable areas in the world are South Asia and Central and Eastern Europe (UNICEF 2008).

Although iodine deficiency is eradicated in developed countries today, the picture looked quite different in early 20th century. Many countries, for reasons related to their geography, had "pockets" of endemic iodine deficiency within their boundaries. For example, the area

[1]Source: WHO, http://www.who.int/features/qa/17/en/index.html.

[2]Source: de Benoist, Andersson, Egli, Takkouche and Allen, eds (2004).

around the Great Lakes in the USA, as well as some Northwestern states had rates of iodine deficiency that were only paralleled by the prevalence in the Swiss Alps. Indeed, Switzerland was the worst-afflicted country in the world, because its soil has been stripped of its iodine content in many localities during the last Ice Age.

This paper estimates the effects of iodine deficiency eradication on occupational patterns using data from Switzerland. Switzerland was the first country in the world to introduce iodized salt in 1922. It was the first major nutritional intervention ever recorded. Iodized salt proved a cost-effective measure to eradicate endemic goiter, which is an enlargement of the thyroid gland, occurring when there is not enough iodine in the body. The invisible effects of iodine deficiency on mental development and cognitive ability were not fully understood at the time, and public health authorities did not know that they were fighting against mental retardation as well as endemic goiter. As a result of the countrywide iodization campaign, there were no more endemic cretins born after 1930, deaf-mutism rates dropped significantly, and goiter disappeared in children and young recruits (Bürgi, Supersaxo and Selz 1990). Salt iodization also had a significant impact on graduation rates of those born in highly-deficient areas (Politi 2009). In this paper I find that occupational patterns in previously-deficient areas changed too, reflecting a shift towards higher-paying occupations, and also towards occupations with a lower physical- and a higher cognitive-skills component.

I use microdata from the comprehensive 1970 Swiss Census, combined with data on occupational characteristics. I identify the effect of iodization on occupational patterns by exploiting variation in pre-existing prevalence of iodine deficiency, and also differences in the timing of adoption of iodized salt across localities. I also use a fuzzy regression discontinuity design, where I identify the effect of iodization by looking at sudden jumps in iodized salt sales, and then compare occupational outcomes for cohorts born right before and right after the jump. Overall, I find that iodine deficiency eradication pushed cohorts affected by it towards higher-paying occupations, and occupations with higher cognitive demands. My estimates imply that between 37% and 45% of the shift towards higher-paying occupations that took place in high-goiter areas over that period is accounted for by the eradication of iodine deficiency.

The rest of the paper is organized as follows: Section 2 provides some background on iodine deficiency disorders, and section 3 describes the campaign for salt iodization in Switzerland. Section 4 describes the data used to define the sources of variation for my identification. Section 5 describes the Swiss Census microdata, as well as the occupational variables used to identify the effect of iodization on occupations. Sections 6 outlines my identification strategy, and empirical results are presented on sections 7 and 8. Section 9 concludes.

2 Iodine Deficiency Disorders

Iodine, together with Iron and Vitamin A, is a necessary micronutrient, found in very small quantities in the human body. Most of the body's iodine is located in the thyroid gland. Iodine is essential in the synthesis of the two thyroid hormones which regulate metabolism and "play a determining part in early growth and development of most organs, especially of the brain" (Delange 2001).

When the thyroid does not receive sufficient amounts of iodine it adapts by enlarging in order to maximize the use of available iodine. This enlargement is called a goiter, and it is one of the many symptoms of iodine deficiency. Goiters can occur at any point in one's lifetime, whenever the iodine intake is not sufficient. Some goiters are reversible, especially in young individuals. Reversing goiter in adults is harder, especially when they have been subject to iodine deficiency for many years.

Goiter is a visible effect of iodine deficiency. Apart from goiter, however, iodine deficiency can have irreversible and harder to observe consequences if it occurs in utero and in the first three months of life. Iodine deficiency in utero results in various degrees of mental retardation and abnormal brain development, which might even go undetected in a population. In the worst case scenario, severe iodine deficiency causes cretinism. Cretinism is an acute condition characterized by a combination of mental retardation, stunting and physical deformation. Bleichrodt and Born (1994) estimate that the average IQ of iodine-deficient groups is 13.5 points lower than the non-deficient groups[3]. If this is true, then iodine deficiency should have sizable economic effects for any afflicted population. It is this "intelligence-enhancing" aspect of correcting iodine deficiency in a population that is at the heart of this paper.

Endemic goiter and endemic cretinism are primarily due to the geographic location of a population. The main store of iodine is the ocean. As ocean water evaporates, iodine falls on the upper layers of soil through rainfall. Therefore, geographic areas close to the ocean are naturally rich in iodine. On the contrary, regions subject to heavy rain or intense glaciation in the past may be iodine-poor due to soil erosion. It takes thousands of years for rain water to replenish the superficial layers of soil with iodine, so the iodine content of the soil and water of those regions is extremely low. Regions naturally poor in iodine include mountainous areas such as the Andes, the Alps, the Pyrenees, and the Himalayas (Koutras, Matovinovic and Vought 1980).

A more detailed description of iodine deficiency disorders is provided in Politi (2009).

Iodine has been explicitly used in the treatment of goiter ever since Bernard Courtois isolated it as an element in 1811[4]. The idea that endemic goiter is due to iodine deficiency was first put forward in 1846, by Jean-Louis Prévost and A.C. Maffoni (Prévost and Maffoni 1846). Even though cretinism was associated with endemic goiter, the crucial role of iodine in mental development was not understood until more than a century later. When large-scale interventions of iodine supplementation took place around the 1920s and after, the objective was goiter eradication. People did not know that they were also fighting against mental retardation.

After doctors started prescribing iodide to their patients in order to fight goiter, toxic side-effects resulting from over-dosing triggered opposition to the universal use of iodine. The

[3]This estimate is based on a meta-analysis of 21 studies of the effect of iodine deficiency on cognitive ability.

[4]However, iodine-rich foods and plants, such as seaweed, were used by ancient civilizations, such as the Chinese and the Greeks, to treat the swelling of the neck before the isolation of iodine as an element.

first larger-scale iodine supplementation program took place from 1917 to 1922 in Akron, Ohio, and it involved administering sodium iodide regularly to schoolgirls from 5th grade and above. When it began, the intervention was very controversial, but its undeniable success in decreasing the young girls' goiters paved the way for larger-scale programs in the USA and in Europe.

Iodized salt started circulating in Switzerland in 1922. Almost simultaneously, fortification of salt with iodine began in the USA, where iodized salt first appeared in 1924. Both interventions eliminated endemic cretinism and goiter in children, and they decreased goiter prevalence in adults, even though they were followed by an initial spike in goiter-related surgeries and deaths, which then subsided[5]. Information on the program in Switzerland is provided in the following section.

3 Swiss Iodization Campaign

Switzerland was known for its high prevalence of goiter and cretinism since ancient times (Roman writers mentioned it in their works). During Napoleonic Wars, the low performance of Swiss recruits for the French Army troubled Napoleon and the local authorities in today's canton of Valais. Under Napoleon's orders, a survey was conducted, which showed an extremely high prevalence of cretinism in the population (Bürgi et al. 1990). Further studies revealed that Switzerland had a much higher rate of goiter and cretinism than any of its neighboring countries (Italy, France, Germany).

Swiss data on goiter prevalence confirmed the link between iodine deficiency and goiter prevalence: the canton of Ticino ranked the lowest among cantons in goiter prevalence. This is to be expected, since Ticino is in the southernmost part of Switzerland, bordering Italy and enjoying a milder climate, proximity to the Mediterranean Sea and possibly more iodine-

[5]This adverse consequence of iodine supplementation was due to the existence of nodular goiters in the population. Nodular goiters were caused by chronic iodine deficiency. Nodular goiters may become toxic following a sudden increase in iodine intake after a long period of deprivation. This side-effect of iodization is known as iodine-induced hyperthyroidism).

rich foods coming from Italy than the rest of the country. Another canton with unusually low goiter prevalence was Vaud. Historically, Vaud had an exclusive salt mine, which was rich in iodine (Bürgi et al. 1990, p.581).

As a result of the studies showing the extent of the goiter problem, a Swiss Committee for the study of goiter was established in 1907. At that time, goiter was still attributed to some agent in the drinking water, even though experiments with iodine supplementation for the treatment of goiter were already taking place in France and, later, in the USA. Right before his death in 1917, Kocher suggested goiter treatment with small doses of iodine (Bürgi et al. 1990).

The first canton to iodize salt was Appenzell-Ausserrhoden, where iodization started in February 1922, with the initiative of a local doctor, H. Eggenberger. In June 1922, the Swiss Goitre Commission recommended the addition of small amounts of iodine in salt and the additional weekly consumption of iodine tablets by schoolchildren. In November 1922, the Swiss salt monopoly [United Swiss Rhine Salt Works (USRSW)[6]] started adding iodine to salt and selling the new product at the same price as non-iodized salt. Even before that date, though, iodine prophylaxis had become popular by means of tablets or other supplements. After the recommendations of the Swiss Goiter Committee and the success of salt iodization in Appenzell-Ausserrhoden, the other cantons started allowing the sale of iodized salt in their markets.

Not all cantons introduced iodized salt simultaneously, though. For instance, Valais iodized in 1925, Zürich in 1932 and Bern in 1936[7]. On the other hand, Aargau and Basel-Land didn't iodize until 1952 and 1950 respectively. In 1925 fewer than one fourth of cantons had iodized salt sales that exceeded 60% of total salt sales. By 1945 fewer than one fourth of cantons had salt sales that were below 20% of total salt sales. By 1955, iodized salt sales exceeded 60% of total salt sales in all cantons, and in many of them only iodized salt was

[6]USRSW was "the exclusive supplier of salt to 24 of the 25 cantons" of Switzerland, the exception being the canton of Vaud (Bürgi et al. 1990, p.582).

[7]This is the first year that the cantons' iodized sales exceeded 40% of total salt sales.

sold and consumed (Wespi 1962).

The success of the iodization program was indisputable. According to Bürgi et al. (1990), "no new endemic cretins born after 1930 have been identified" (p.577). Deaf-mutism rates fell sharply for cohorts born after 1922. In Appenzell-Ausserrhoden, which was the first canton to provide iodized salt to its inhabitants, the prevalence of goiter in newborns fell from 20% to 6.4% within the first year after iodization. The prevalence dropped further when, in later years, the iodine content of salt was raised. The beneficial effects on iodization were also seen in the increased height of 6-year-olds entering school, as well as young recruits. In the city of Lausanne, 23.7% of young recruits had large goiters in 1924/1925, but the figure had dropped to 0.2% by 1983-1987 (Bürgi et al. 1990).

More information on the Swiss Iodization Campaign is provided in Politi (2009).

4 Bircher's monograph and Iodized Salt Sales

To identify the effect of iodization on occupational outcomes, I employ two sources of variation: the first in the naturally-occurring geographical variation in underlying iodine deficiency prior to the generalized use of iodized salt. The second source of variation arises because of differences in the timing of adoption of iodized salt across Swiss localities.

In 1883, Swiss physician Heinrich Bircher published a monograph with details on the geographic variation in goiter rates across Switzerland (Bircher 1883). Over the period 1875-1880, he toured every town and village in Switzerland and recorded goiter cases in recruits, which served as a proxy for goiter prevalence in the local population. Bircher's monograph was eye-opening to public health authorities at the time, because it showed the extent of the problem across the country, and also the big differences in goiter prevalence, even in villages within a short distance from each other. The data correlates well with measurements of iodine content of the water and soil across Swiss localities.

I use the data collected by Bircher to group Swiss districts according to their goiter prevalence. Goiter prevalence serves as a proxy for underlying iodine deficiency in the population. I classify a district as being "high-goiter" if it belongs to the top 25% of the population-weighted goiter distribution. This corresponds to districts where goiter prevalence was 11.7% or higher. Correspondingly, a district is "low-goiter" if its goiter prevalence is within the lowest 25% of the goiter distribution in the population, corresponding to goiter rates lower than 3.5%. High-goiter districts are where I expect to observe the treatment effect of iodization. On the contrary, I expect the treatment effect to be much lower in low-goiter districts.

After iodized salt became available in 1922, it was not adopted at the same time or speed by all cantons. Some cantons, such as Nidwalden and Schaffhausen, were early adopters, whereas other cantons, such as Aargau, Basel-Stadt, and Basel-Land were much slower. The sale of iodized salt had to be approved and allowed by each canton's constitution. In 1962 H. J. Wespi, M.D. and Chief Doctor of Women's Clinic in Aarau, published a paper containing data on yearly iodized salt sales as a percentage of total salt sales per canton, from 1922 to 1961 (Wespi 1962). These data show how widespread the use of the "new salt" was at any point in time.

Some cantons, such as Schwyz and Luzern made a very fast transition to iodized salt, whereas for other cantons, such as Thurgau and Graubünden, the transition was much more gradual. It appears that low-goiter cantons were the ones that adopted iodized salt earlier than highly-affected cantons. This reluctance from the part of those most likely to benefit from the intervention is puzzling at first. However, one needs to take into account that this was the first major nutritional intervention to ever take place, and it was not without controversy, especially in light of many thyroid-related deaths resulting from iodine overdoses to people who had been severely deficient throughout their lives. It is reasonable to expect those cantons where the stakes were higher to be the ones where the transition took the longer to finally occur, since public debate on the issue would have been more heated.

I use the data contained in Wespi's paper as a measure of treatment. Also, based on Wespi's data I construct a variable corresponding to one's age relative to iodization in their canton of birth. In particular, I identify jumps in the sales of iodized salt, and I look at individuals' occupational choice outcomes, comparing those born right before and right after the jump in sales. This is feasible because once one takes a glance at the data, it becomes obvious that most cantons had a steep transition to iodized salt, as opposed to a more gradual adoption.

For more information on Bircher's monograph and on the geographic variation of goiter prevalence, as well as on the iodized salt sales data, and how iodized salt adoption coincides with a drop in deaf-mutism rates, see Politi (2009).

5 The 1970 Swiss Census and Dictionary of Occupational Titles

I identify the effect of iodization on occupational choice using microdata from the 1970 Swiss Census (Federal Statistical Office 1970), which includes detailed information on a person's year and location of birth. Switzerland is a federation made up of 26 cantons (comparable to US States, but much smaller), 184 districts and 2896 municipalities. The 1970 Swiss Census records an individual's municipality of birth. This low level of aggregation is particularly important, because endemic iodine deficiency was a very localized phenomenon, and it depended on the iodine content of a population's local sources of food and water. Municipalities within a short distance of each other might have had very different exposure to iodine before iodized salt was introduced, so it is important to know in as much detail as possible the location of one's birth.

I use all individuals born in Switzerland from 1900 to 1944 (inclusive) whose occupation is recorded in the Swiss Census. Unfortunately, this only includes people actively employed (both part- and full-time) at the time of the Census. This excludes most women in my sample. Table 1 shows that out of 2,575,933 individuals born in the period 1900-1944, only 1,625,400 held a job in 1970, and only 36% of females were active in the labor force.

Table 1: Actively employed individuals in 1970 Swiss Census

	Active	**Non-active**	**Total**
Males	1,149,692	109,524	1,259,216
Females	475,708	841,009	1,316,717
Total	1,625,400	950,533	2,575,933

(Source: 1970 Swiss Census)

The 1970 Swiss Census contains detailed information on each individual's occupation, using 4-digit codes according to the International Standard Classification of Occupations (ISCO). Using these data, and grouping individuals into 9 broad occupation categories (according to the first digit of their ISCO code), I construct an indicator variable for whether an individual was employed in the top three occupational categories. These categories include individuals employed in executive/managerial positions, senior officials and legislators, professionals such as physicians, engineers and lawyers, as well as technicians and associate professionals such as police inspectors, trade brokers, and health associates. These occupational categories have earned higher wages historically, compared to the other categories of occupations in the data. For example, in the second trimester of 2007, the annualized median income of full-time workers in these top categories was over 84,000 Swiss Franks or more, whereas the corresponding number for all other occupation categories was less than 65,000 Swiss Franks (Communication from the Swiss Federal Statistical Office). Occupational groups not included in the three top categories include clerks, service and shop sales workers, skilled agricultural workers, craft and related trades workers, machine operators, and people employed in elementary occupations such as street vendors, cleaners, and unskilled laborers. Table 2 shows how many individuals were employed in each of the nine broadly-defined occupational categories in the 1970 Swiss Census. A little over 25% of individuals (almost 29% of males) are employed in the three higher-paying occupational categories.

I combine the occupational data of the 1970 Swiss Census with data on occupational char-

Table 2: Broad occupational categories in 1970 Swiss Census

	Occupational Category	Males	Females	Total
High-paying occupations	1: Legislators, senior officials, managers	85,317	20,317	105,634
	2: Professionals	78,644	18,934	97,578
	3: Technicians and Associate Professionals	168,871	55,286	224,157
	4: Clerks	157,625	117,620	275,245
	5: Service, shop and market sales workers	47,697	104,859	152,556
	6: Skilled agricultural and fishery workers	124,209	41,832	166,041
	7: Craft and related trades workers	311,402	53,799	365,201
	8: Plant and machine operators and assemblers	122,068	19,133	141,201
	9: Elementary Occupations	53,859	43,928	97,787
	Total	1,149,692	475,708	1,625,400

(Source: 1970 Swiss Census)

acteristics compiled by Paula England and Barbara Kilbourne from the Dictionary of Occupational Titles for 1980 US Census Detailed Occupations (England and Kilbourne 1988). The dataset is available in electronic format and freely distributed by the Inter-university Consortium for Political and Social Research (ICPSR). These data contain scores on a variety of characteristics for all occupational codes used in the 1980 US Census. For example, occupations get scores according to verbal, numerical, spatial, and other aptitudes needed to perform the job, as well as the physical demands of the job.

I match occupational codes from the 1980 US Census with ISCO codes, which are used in the coding of occupations in the Swiss Census. In this way, I am able to get scores of many occupational characteristics and merge them with the 1970 Swiss Census. As for many four-digit ISCO categories there were no entries or a direct correspondence with US Occupational codes, I aggregate ISCO codes to three-digit categories, and compute the average value of each characteristic in each category.

I look into eight occupational characteristics, grouped into two categories: physical requirements and cognitive demands of occupations [This is the same methodology as the one used in Case and Paxson (2006).]. The variables corresponding to physical requirements are manual dexterity, motor coordination, physical demands (such as climbing, kneeling, and reaching), and strength. The variables related to the cognitive requirements of a given occupation are spatial, verbal, and numerical aptitude, as well as intelligence. As in Case and Paxson (2006), in some cases I reverse-coded some of these variables, in a way that a higher value corresponds to higher requirements for a given characteristic in an occupation. Values for each characteristics typically range from 1 to 5, except in the case of physical demands, which ranges from 0 to 4, and motor coordination and intelligence, which range from 1 to 4.

As expected, cognitive requirements such as verbal and numerical aptitude tend to have higher values for occupations in upper ISCO categories (1, 2, 3), whereas the opposite is true for physical requirements such as manual dexterity and strength. This is shown in table 3, which lists average scores and standard deviations for each job characteristic for each broad ISCO category. For example, legal professionals (a sub-category of ISCO category 2, which includes lawyers and judges) have really high scores for numerical and verbal aptitude (4.2 and 4.4 respectively). On the contrary, this occupational category only has a score of 0.4 for physical demands, and 1.2 for strength. On the other hand, agricultural laborers (part of ISCO category 9) have scores of 2 and 2.2 for numerical and verbal aptitude, whereas they have scores of 2.9 and 3.5 for physical demands and strength.

6 Identification using geographical and temporal variation

The main idea behind the identification strategy is to use two sources of variation in order to identify the effect of iodization on occupational outcomes. The first source of variation is geographical; not all areas in Switzerland were affected by iodine deficiency to the same extent. What defined the prevalence of iodine deficiency across localities was the iodine content of soil and drinking water, which in turn was determined by geological developments

Table 3: Job characteristics for occupational categories in 1970 Swiss Census

ISCO category	Manual Dexterity	Motor Coordination	Physical Demands	Strength
1	2.2052	2.1933	0.7502	1.7039
	(0.0680)	(0.0557)	(0.2306)	(0.1341)
2	2.5256	2.4086	1.0425	1.7536
	(0.5371)	(0.3076)	(0.6282)	(0.3077)
3	2.5544	2.5896	1.3572	1.8623
	(0.4548)	(0.3985)	(0.7021)	(0.3315)
4	2.6782	3.0950	1.7675	1.5043
	(0.0961)	(0.4348)	(0.2062)	(0.4200)
5	2.5622	2.5112	1.4389	2.2582
	(0.1734)	(0.2752)	(0.3600)	(0.2722)
6	2.5081	2.2774	3.0692	3.4742
	(0.0653)	(0.0633)	(0.1572)	(0.0812)
7	3.2093	2.8661	2.6782	2.8385
	(0.2143)	(0.0818)	(0.5528)	(0.3927)
8	2.8371	2.7467	2.0387	2.6882
	(0.0898)	(0.1407)	(0.1684)	(0.2429)
9	2.9034	2.4706	2.3261	3.1635
	(0.0554)	(0.1305)	(0.2928)	(0.2992)
Total	2.7578	2.6830	2.0061	2.3790
	(0.3795)	(0.8017)	(0.7382)	(0.7382)

ISCO category	Spatial Aptitude	Numerical Aptitude	Verbal Aptitude	Intelligence
1	2.3255	3.1489	3.7353	2.8395
	(0.1013)	(0.0665)	(0.0779)	(0.0881)
2	3.1514	3.7347	4.3509	3.4330
	(0.6944)	(0.4738)	(0.2069)	(0.2345)
3	2.6859	3.1512	3.5000	2.6139
	(0.5859)	(0.3687)	(0.3124)	(0.2569)
4	2.2449	2.6962	3.1454	2.1783
	(0.129)	(0.1324)	(0.0909)	(0.0719)
5	2.3215	2.6254	2.8821	1.9442
	(0.2453)	(0.3455)	(0.2330)	(0.2058)
6	3.0425	2.6244	2.7457	2.2911
	(0.1222)	(0.1009)	(0.0624)	(0.1289)
7	3.1094	2.6329	2.7408	1.9864
	(0.3124)	(0.1953)	(0.1531)	(0.0980)
8	2.6209	2.3042	2.5312	1.7804
	(0.1900)	(0.2146)	(0.2015)	(0.2091)
9	2.4313	2.1324	2.3319	1.5312
	(0.0934)	(0.1665)	(0.1096)	(0.1009)
Total	2.7014	2.7381	3.0214	2.2071
	(0.4879)	(0.4460)	(0.5258)	(0.4714)

(Source: 1970 Swiss Census and England and Kilbourne (1988)) in that areas, which took place thousands of years before the period of study. Using Bircher's rich dataset, I am able to identify districts where the prevalence of goiter was very high, signifying a high prevalence of underlying iodine deficiency in the population. I treat all districts where goiter rates are at the top 25% of the population-weighted goiter distribution as being high-goiter. These are the districts where goiter prevalence is 11% or higher.

I expect iodization to have a greater impact on the cognitive ability of those populations born in high-goiter districts compared to any effects measured for people born in low-goiter districts. Thus, this source of variation identifies a treatment group (people born in high-goiter districts) and a control group (people born in low-goiter districts).

The second source of variation is temporal; once the salt monopoly started producing iodized salt, each canton had to authorize its sale by amending its constitution. As a result, the "new product" did not become available across all cantons at the same time. Therefore, people born after iodized salt was introduced constitute the treated population, whereas people born before iodization are a control group.

As discussed in section 4, a glance at the data shows that high-goiter cantons allowed the sale of iodized salt later, compared to low-goiter cantons. This might reflect reluctance from the part of the authorities in those cantons to introduce such a far-reaching public health measure, in light of the debate ignited by the spike in thyroid-related deaths following iodine overdose in some chronically deficient populations. If this is the only reason of the different timing between high- and low-goiter cantons, then that should not pose a problem for my identification.

The non-random nature of the difference in the timing of adoption is problematic for my identification strategy to the extent that it reflects time-variant unobserved differences between high- and low-goiter cantons, which affected the timing of adoption of iodized salt in the 1920s and 1930s, and also affected occupational patterns many years later, when the treated population entered the labor market. Although it seems unlikely that a common unobserved factor would affect both these outcomes, I do introduce a linear, canton-specific time trend in all specifications.

Combining the geographical and temporal sources of variation, the treatment group includes **people born in high-goiter districts after iodized salt was introduced**. On the contrary, people born in low-goiter districts, and people born before iodization form the control group.

6.1 Iodized salt sales and birth location

I introduce iodized salt sales at the canton level directly as a regressor. The outcome variables include an indicator for being employed in a high-paying occupation (as defined by belonging to the top 3 ISCO one-digit occupational categories), as well as each of the 8 occupational characteristics described in section 5.

In particular, I control for the percentage of iodized salt sales in total salt sales one year prior to birth in one's canton of birth. I also control for canton and cohort fixed effects, to remove the effect of any omitted variables that are canton- or cohort-specific. In addition, I introduce a canton-specific time trend, to control for any other gradual changes that might have affected one's occupational outcomes.

I run the following regression for an individual i born in canton c in year y:

$outcome_{idy} = \alpha + \beta \cdot$ *Iodized salt 1 year prior to birth*

$+$ *Canton of birth Fixed Effects*

$+$ *Canton of birth time trend*

$+$ *Cohort of Birth Fixed Effects* $+\epsilon_{idy}$,

where standard errors are clustered at the canton-cohort level.

I estimate the above regression for the sample as a whole and then separately by gender. I cluster standard errors on the canton of birth - cohort level. My sample includes all individuals born in Switzerland between 1900 and 1944 (inclusive), for whom occupational data were recorded during the 1970 Census.

6.2 Jumps in iodized salt sales; a Fuzzy Regression Discontinuity Approach

I use Wespi's data on the percentage of iodized salt sales to get information on the timing and speed of iodization in each canton. Most cantons experienced a big jump in iodized salt sales within a period of 1 to 2 years, so that the timing of the intervention is easy to identify in the majority of cases. The probability of someone being treated with adequate iodine in utero changes discontinuously depending on whether they were born before or after the jump in sales. I use these jumps in a "fuzzy regression discontinuity" (FRD) framework (for a description of FRD see, for example, Imbens and Lemieux (2008)).

Based on the year of the jump in iodized salt sales, which is particular to each canton, I construct a new variable, age relative to iodization, which will be common across all people born in the same canton in the same year, but will generally be different across cohorts born in different cantons. Because of the difference in the timing of adoption, I can control for unobserved, time-invariant canton characteristics, as well as unobserved, space-invariant cohort characteristics, and a cantons-specific trend. Since these jumps all occurred in a small window of time, this method is "cleaner" than a simple regression of outcomes on iodized salt sales, as there are fewer possible confounding effects taking place within same small time frame in a particular canton.

I check for some preliminary evidence of how being born in a high-goiter district right after a jump in iodized salt sales affects one's occupational outcomes, after controlling for district and cohort of birth fixed effects, as well as a district-specific time trend.

I run the following regression for an individual i born in district d in year y:

$outcome_{idy} = \alpha + \beta \cdot$ *1 (Born in high-goiter district) X 1 (Born after jump in sales of iodized salt)*

+ District of birth Fixed Effects

+ District of birth time trend

+ Cohort of Birth Fixed Effects $+\epsilon_{idy}$,

where outcomes are an indicator variable for being employed in a high-paying occupation, as well as the occupational characteristics described in section 5. Standard errors are clustered at the district-cohort level. First, I run the regression on the whole sample, and then for males and females separately. I first use the whole sample and then only the sub-sample of those people born within ten years of the jump in iodized salt sales. In some specifications I use cohort fixed effects that are common for high-goiter districts and the rest of the country, whereas in others I allow cohort fixed effects to be different for high-goiter districts.

Next, I follow the FRD approach, and regress outcomes on the percentage of iodized salt sales (at the canton-level) one year prior to birth (and additional controls), but I instrument iodized salt sales with an indicator variable equal to 1 if someone is born after the big jump in sales which marked each canton's decisive transition to iodized salt.

I run the following regression for an individual i born in canton c in year y:

$outcome_{idy} = \alpha + \beta \cdot$ *Iodized salt 1 year prior to birth*

$+$ *Trend before jump in iodized salt sales*

$+$ *Trend after jump in iodized salt sales*

$+$ *Canton of birth Fixed Effects*

$+$ *Canton of birth time trend*

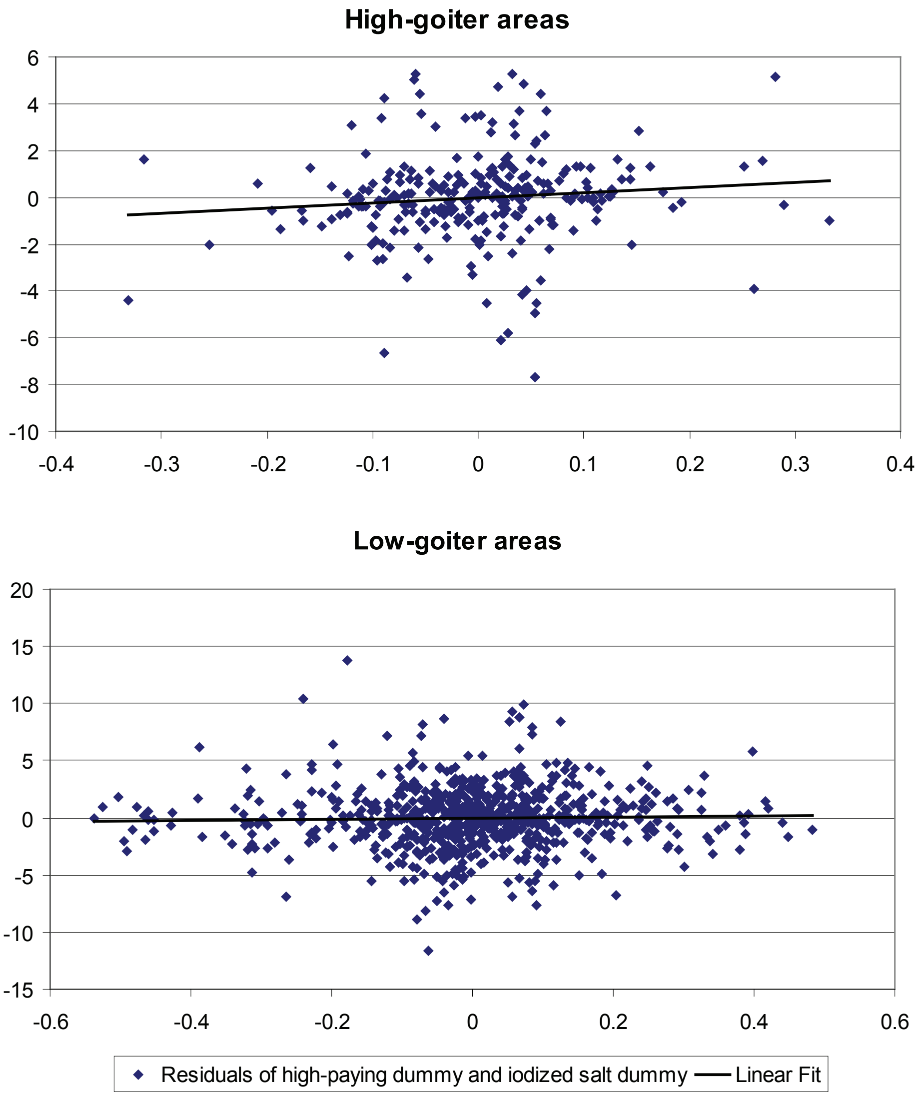
$+$ *Cohort of Birth Fixed Effects* $+\epsilon_{idy}$,

where $outcome_{idy}$ is either an indicator variable for being employed in a high-paying occupation, or one of the occupational characteristics described in section 5. Standard errors are clustered at the canton-cohort level. I include both a linear canton-specific time trend, but also linear nationwide trends which are allowed to differ before and after the jump in iodized salt sales.

I estimate the treatment effect for the whole sample and all areas, and then I use only those observations corresponding to high- and low-goiter districts, and estimate the effects of iodization separately for each of these two populations. I then estimate effects for males and females separately, using the same cuts of the data.

7 The effect of Iodization on Occupational Choice

Figure 1: Residuals graph of high-paying dummy and iodized salt



Note: Scatterplot of average residuals (at the canton-cohort level) from regressing high-paying occupation dummy and iodized salt sales one year prior to birth on year and canton of birth fixed effects, as well as a canton-specific time trend.
(Source: 1970 Swiss Census and England and Kilbourne (1988))

Figure 1 is a graphical representation of the regression results outlined later in this section. Figure 1 includes two scatterplots of average residuals (at the canton - year of birth level) from regressing a high-paying occupation dummy and iodized salt sales one year prior to birth on canton and cohort fixed effects, as well as a canton-specific linear trend. The first scatterplot comes from including only those individuals born in high-goiter districts, whereas the second one only includes people born in low-goiter districts. There are fewer observations in the first scatterplot because iodine deficiency was localized in certain parts of the country, so high-goiter districts are found in fewer cantons than low-goiter districts. As a result, when residuals are averaged at the canton - year of birth level, there are fewer observations.

What Figure 1 shows is that whereas (regression-adjusted) higher sales of iodized salt around one's time of birth are associated with a (regression-adjusted) higher probability of being employed in a high-paying occupation in the future, such a relationship does not exist for people born in low-goiter areas, where I expect the treatment effect to have been lower.

Table 4 shows results from regressing a high-paying occupation dummy on iodized salt sales (1 year prior to birth), as well as canton and cohort fixed effects. I also include a canton-specific linear trend. As shown in table 4, this makes the coefficients of interest somewhat bigger. The treatment effect is estimated for the whole sample and then separately by gender, and also for all areas, and then separately for high- and low-goiter districts only. The coefficients in table 4 correspond to percentage point changes, and standard errors are clustered at the year and canton of birth level.

Looking at the sample as a whole, the treatment effect is significant (when I include the canton-specific trend) but very small for the country as a whole. However, when I limit the sample to those observations to individuals born in high-goiter areas, the effect of iodization increases both in magnitude and significance. Specifically, born in a high-goiter district after iodized salt sales have gone from 0% to 100% increases one's probability of employment in the top occupational categories later in life by 3.2 percentage points. Given that less than a third of the population as a whole is employed in these categories over the period of examination, this is a significant increase in one's chances of receiving higher wages. Low-goiter districts, as expected, were not affected.

Table 4: Salt sales and occupational choice

Salt sales and occupational choice: Coefficient on Iodized Salt 1 year prior to birth			
		WHOLE SAMPLE	
	ALL AREAS	HIGH-GOITER	LOW-GOITER
High-paying occupation dummy	0.69367**	3.20205***	-0.14225
	(0.30658)	(0.67162)	(0.40538)
Canton-specific trend	YES	YES	YES
Number of Observations	1620246	402781	397334
R-squared	0.0176	0.013	0.019
High-paying occupation dummy	-0.02581	2.74317***	0.39774
	(0.22437)	(0.54258)	(0.35071)
Canton-specific trend	NO	NO	NO
Number of Observations	1620246	402781	397334
R-squared	0.0174	0.013	0.0187
		MALES ONLY	
	ALL AREAS	HIGH-GOITER	LOW-GOITER
High-paying occupation dummy	1.00143***	3.24884***	0.0302
	(0.37611)	(0.93727)	(0.50349)
Canton-specific trend	YES	YES	YES
Number of Observations	1145756	288765	280378
R-squared	0.0271	0.0191	0.0288
High-paying occupation dummy	0.26264	3.31585***	0.71948*
	(0.27115)	(0.7564)	(0.43602)
Canton-specific trend	NO	NO	NO
Number of Observations	1145756	288765	280378
R-squared	0.0269	0.019	0.0285
		FEMALES ONLY	
	ALL AREAS	HIGH-GOITER	LOW-GOITER
High-paying occupation dummy	0.07639	2.68974**	-0.43441
	(0.38722)	(1.19814)	(0.57743)
Canton-specific trend	YES	YES	YES
Number of Observations	474490	114016	116956
R-squared	0.0063	0.0045	0.0089
High-paying occupation dummy	-0.52803*	1.32781	-0.16256
	(0.31723)	(0.94442)	(0.51836)
Canton-specific trend	NO	NO	NO
Number of Observations	474490	114016	116956
R-squared	0.0059	0.0044	0.0083

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

Coefficients correspond to changes in percentage points.

High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.

Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.

All regressions include people born in Switzerland in 1900-1944 and interviewed for the 1970 Census.

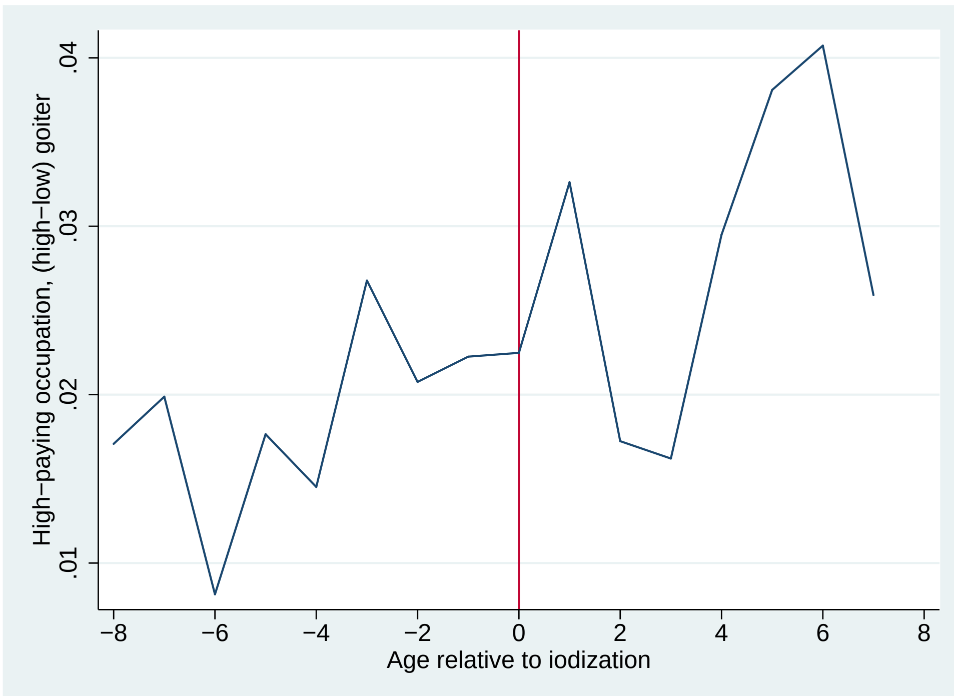
Standard errors in parentheses, clustered at the canton-year of birth level.

When I break the sample down by gender, it is clear that most of the effect of iodization is driven by males. This is a departure from the conclusion reached in Politi (2009), where the effect of iodization on increased schooling was mainly driven by the effect on females. However, in this case females did not participate in the labor force as regularly as males, so there are much fewer female observations. Indeed, only a third of females in my sample were recorded as being employed. In addition, female selection into employment was probably not random, therefore it is hard to make any meaningful conclusions about the effect of iodization on occupational characteristics for females.

Results which are similar in direction but smaller in magnitude are shown on table 5, which estimates a departure from trend in outcomes for those born in high-goiter districts following a jump in iodized salt sales. Table 5, in particular, shows results from a regression of a high-paying occupation indicator variable on an indicator variable for being in the treatment group (which is the interaction of two indicator variables: being born in a high-goiter district, and being born after a jump in iodized salt sales). The regression also includes district fixed effects, a district-specific time trend (I also show results without including the district-specific trend, and they are very similar), and year of birth fixed effects, which in columns (1) and (3) are the same for high-goiter districts and the rest of the country, but which are allowed to be different for high-goiter districts in columns (2) and (4). Standard errors are clustered at the district-year of birth level. Columns (1) and (2) include the whole sample, whereas columns (3) and (4) only include people born within 10 years of the jump in iodized salt sales.

As shown on table 5, the treatment effect is concentrated on males, regardless of whether we look at the whole sample or the limited age range. The gain in percentage points for males here is of the order of 1.2 to 1.5 percentage points, which is somewhat smaller than the effect estimated in table 4. This might because even before the jump in sales, iodized salt was available and consumed in smaller quantities, so it is likely that part of the control group in this exercise was actually treated with iodine. According to table 5 females did not benefit from iodine supplementation. However, as discussed above, this is not necessarily accurate since female labor participation was limited over that period.

Figure 2: Regression-adjusted probability of being employed in a highly-paid occupation by age relative to iodization; difference between high- and low-goiter districts



(Source: 1970 Swiss Census and England and Kilbourne (1988))

Figure 2 is a plot of the regression-adjusted difference in probabilities of being employed in a high-paying occupation people born in high- and low-goiter districts against age relative to iodization. The line represents the difference in coefficients on relative age indicator variables between those born in high- and low-goiter areas, after factoring out canton and cohort fixed effects, as well as a canton-specific trend. It is the regression equivalent of the "Fuzzy Regression Discontinuity" approach, the results of which are shown on table 6 (A short description of the FRD method can be found in section 6.2). Figure 2 shows that right around the time of a jump in iodized salt sales there was a corresponding jump in a cohort's probability of being employed in a high-paying occupation when they entered the labor market.

Table 5: Salt sales and occupational choice if born after jump

Coefficient on high-goiter dummy X Born after jump in iodized salt sales

	WHOLE SAMPLE			
	All cohorts		Born +/- 10 years from jump	
	(1)	(2)	(3)	(4)
High-paying occupation dummy	1.10215***	1.09991***	1.04325**	0.80215
	(0.33805)	(0.40945)	(0.45021)	(0.53454)
District-specific trend	YES	YES	YES	YES
Number of Observations	1625400	1625400	689302	689302
R-squared	0.029	0.029	0.0272	0.0272
High-paying occupation dummy	1.20967***	0.88392**	1.1873***	0.62239
	(0.3003)	(0.36071)	(0.3248)	(0.46633)
District-specific trend	NO	NO	NO	NO
Number of Observations	1625400	1625400	689302	689302
R-squared	0.0286	0.0287	0.0268	0.0269
	MALES ONLY			
	All cohorts		Born +/- 10 years from jump	
	(1)	(2)	(3)	(4)
High-paying occupation dummy	1.4672***	1.21396**	1.31045**	1.1849*
	(0.42132)	(0.50823)	(0.54966)	(0.68766)
District-specific trend	YES	YES	YES	YES
Number of Observations	1149692	1149692	489047	489047
R-squared	0.0443	0.0443	0.0418	0.0418
High-paying occupation dummy	1.55246***	1.11773**	1.68413***	0.95469*
	(0.39325)	(0.458)	(0.41176)	(0.57837)
District-specific trend	NO	NO	NO	NO
Number of Observations	1149692	1149692	489047	489047
R-squared	0.0439	0.044	0.0413	0.0413
	FEMALES ONLY			
	All cohorts		Born +/- 10 years from jump	
	(1)	(2)	(3)	(4)
High-paying occupation dummy	0.36269	0.84244	0.17463	0.27335
	(0.56023)	(0.67139)	(0.82643)	(0.83241)
District-specific trend	YES	YES	YES	YES
Number of Observations	475708	475708	200255	200255
R-squared	0.0104	0.0105	0.0115	0.0116
High-paying occupation dummy	0.48832	0.47301	0.18643	0.20132
	(0.42429)	(0.52234)	(0.5024)	(0.72193)
District-specific trend	NO	NO	NO	NO
Number of Observations	475708	475708	200255	200255
R-squared	0.0095	0.0096	0.0106	0.0107

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

Coefficients correspond to changes in percentage points.

Columns (1) and (3) assume common cohort fixed effects for high- and non-high-goiter districts.

Columns (2) and (4) assume different cohort fixed effects for high- and non-high-goiter districts.

Standard errors in parentheses, clustered at the district-year of birth level.

Table 6 tells the same story. The results of the "Fuzzy Regression Discontinuity" approach are much more similar to table 4 than table 5 was, although they are still somewhat smaller in magnitude. According to table 6, when looking at the country as a whole, iodization seems to not have had much of an effect on people's occupational choice. But the intra-region difference becomes clear when one looks separately at people born in high- and low-goiter districts. People born in high-goiter districts after a jump in iodized salt sales had a higher and significant probability of being employed in a high-paying occupation. The increase in the probability is of the order of 2.3 percentage points, which is economically significant, given the low baseline probability of being employed in the top occupational categories (less than 30%). As in table 5, the effect is driven by males, where the probability of being employed in a high-paying occupation rose by 3.1 percentage points.

In high-goiter areas, 23.4% of all people born prior to a jump in iodized salt sales selected into a high-paying occupation, whereas almost 30% of people born after a jump in sales were employed in one of the top three occupational categories. Using my estimates, this means that at least 37% of the change can be directly attributed to iodization. For males, the percentage of people employed in a high-paying occupation rises from 25.4% to 32.2%. If iodization increases one's chances of belonging to that category by 3.1%, then my estimates imply that iodization accounts for almost 45% of the rise in the percentage of males employed in high-paying occupations over that period. Therefore, iodization accounts for a big part of the shift towards higher-paying occupations observed in high-goiter areas over the period of examination.

8 The effect of Iodization on Characteristics of Occupations

In this section I analyze the effects of the introduction of iodized salt on occupational characteristics. As outlined in section 5, I match eight characteristics of occupations from the

Table 6: High-paying occupation: Fuzzy Regression Discontinuity

Salt sales and occupational choice: Coefficient on Iodized Salt 1 year prior to birth

	WHOLE SAMPLE		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
High-paying occupation dummy	0.15069	2.29497**	-0.42023
	(0.36849)	(0.90451)	(0.40623)
Canton-specific trend	YES	YES	YES
Number of Observations	1620246	402781	397334
R-squared	0.0176	0.0131	0.019
High-paying occupation dummy	0.21984	1.71321*	-0.93815**
	(0.41011)	(0.9106)	(0.4299)
Canton-specific trend	NO	NO	NO
Number of Observations	1620246	402781	397334
R-squared	0.0174	0.013	0.0188
	MALES ONLY		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
High-paying occupation dummy	0.28545	3.14385**	-0.28615
	(0.45591)	(1.30235)	(0.5056)
Canton-specific trend	YES	YES	YES
Number of Observations	1145756	288765	280378
R-squared	0.0271	0.0191	0.0288
High-paying occupation dummy	0.47256	2.88057**	-0.97047*
	(0.49684)	(1.2956)	(0.52103)
Canton-specific trend	NO	NO	NO
Number of Observations	1145756	288765	280378
R-squared	0.0269	0.019	0.0286
	FEMALES ONLY		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
High-paying occupation dummy	-0.3093	0.44348	-0.69028
	(0.45086)	(1.5619)	(0.62258)
Canton-specific trend	YES	YES	YES
Number of Observations	474490	114016	116956
R-squared	0.0063	0.0045	0.0089
High-paying occupation dummy	-0.54469	-0.52011	-0.76598
	(0.46783)	(1.41248)	(0.68906)
Canton-specific trend	NO	NO	NO
Number of Observations	474490	114016	116956
R-squared	0.0059	0.0044	0.0083

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

Coefficients correspond to changes in percentage points.

High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.

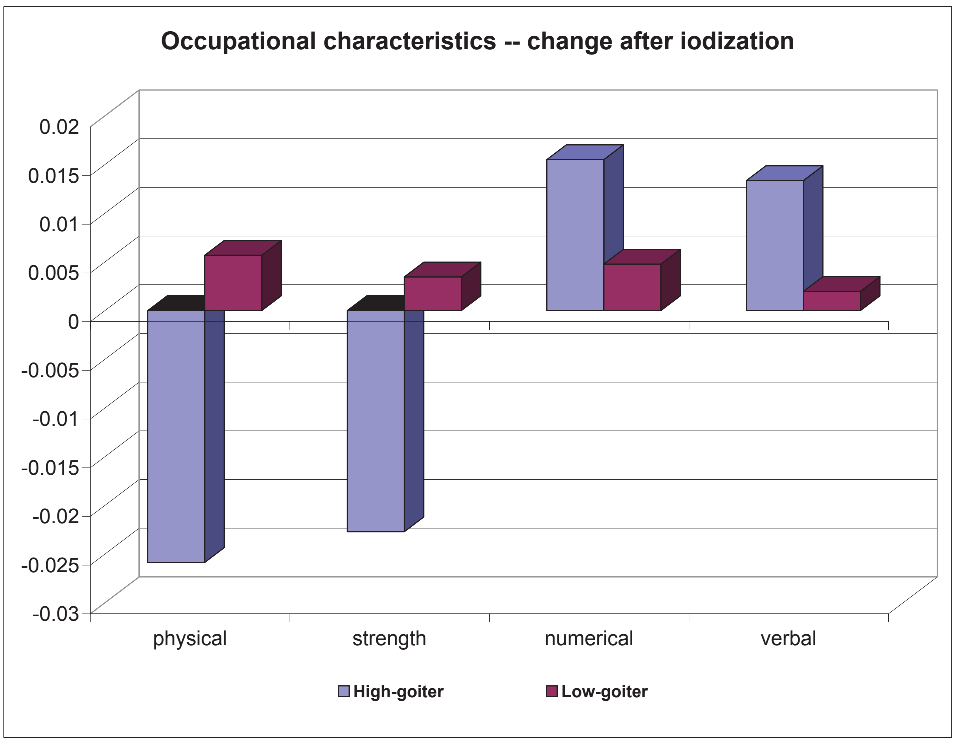
Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.

All regressions include people born in Switzerland in 1900-1944 and interviewed for the 1970 Census.

Standard errors in parentheses, clustered at the canton-year of birth level.

book *"Occupational Measures from the Dictionary of Occupational Titles for 1980 Census Detailed Occupations"* with ISCO occupational codes used in the Swiss Census (England and Kilbourne 1988). These characteristics sum up the physical and cognitive skills required by a given occupation. The variables used are: *Manual Dexterity, Motor Coordination, Physical Demands, Strength, Spatial Aptitude, Numerical Aptitude, Verbal Aptitude, and Intelligence.* The first four of these characteristics refer to physical skills, whereas the final four reflect cognitive skills required by a given occupation.

Figure 3: Change in occupational characteristics after iodization



(Source: 1970 Swiss Census and England and Kilbourne (1988))

Figure 3 shows how the mix of four of these characteristics changed differentially for high- and low-goiter areas after iodization. More specifically, figure 3 shows the coefficients on an indicator variable equal to 1 if an individual was born after a jump in sales of iodized salt, in a regression which also controls for canton and cohort fixed effects, as well as a canton-specific trend. What is easy to see from figure 3 is that whereas people in low-goiter areas had the

Table 7: Occupational characteristics: Coefficient on Iodized Salt 1 year prior to birth, whole sample

	WHOLE SAMPLE		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
Manual Dexterity	-0.0065267**	-0.0054148	-0.0055883
	(0.0025958)	(0.007351)	(0.0037123)
Motor Control	-0.0019655	-0.0094397	-0.0007528
	(0.0023743)	(0.0070648)	(0.0038487)
Physical Demands	-0.0093404*	-0.0362085**	0.006235
	(0.0050766)	(0.0147821)	(0.007376)
Strength	-0.0069763	-0.0283815**	0.0039593
	(0.0046804)	(0.0133594)	(0.0061834)
Spatial Ability	0.0015487	-0.0007003	0.0058368
	(0.0031976)	(0.0097206)	(0.004653)
Numerical Ability	0.0110898***	0.033474***	0.0091073*
	(0.0035736)	(0.0076685)	(0.004735)
Verbal Ability	0.0107766***	0.0270125***	0.0060569
	(0.0037826)	(0.0080725)	(0.004766)
Intelligence	0.0107693***	0.0221547***	0.0086688*
	(0.0035202)	(0.0074428)	(0.0045106)
Number of observations	1542006	385322	377347

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.
Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.
All regressions include people born in Switzerland in 1900-1944 and interviewed for the 1970 Census.
Standard errors in parentheses, clustered at the canton-year of birth level.

same mix of characteristics pre- and post-iodization, high-goiter areas saw a decrease in the physical and a corresponding increase in the cognitive component of occupations, signifying a shift towards occupations with higher cognitive demands than before.

Table 11 shows results for the sample as a whole of regressing each occupational characteristic on the percentage of iodized salt sales one year prior to birth, controlling for canton and cohort fixed effects, as well as a canton-specific trend. Looking at all areas, there seems to be a slight decrease in physical skills, and a slight increase in cognitive skills. When we only look at high-goiter regions, the coefficients increase both in magnitude and significance, with the exception of manual dexterity and spatial ability. The change is of the order of 0.03 (in absolute value), which, depending on the coefficient, is between 4 and 8% of a standard deviation in the sample. This is a tiny change, but it is significant. Moreover, as in the case of high-paying occupations, results are driven by the effect of iodization on males. This is apparent once we look at Table 8, which breaks the sample down by gender. There's a big drop in physical demands (kneeling, climbing, reaching, etc) for females, and a big increase in verbal abilities, but no other characteristic seems affected.

Tables 9 and 10 show the results of regressing occupational characteristics on an indicator variable for belonging to the treatment group (born in a high-goiter district after a jump in iodized salt sales) and other covariates. There are cohort fixed effects which are allowed to be both common across all districts and different for high-goiter districts and the rest of the country. As in the case of table 5, which was the equivalent of table 9 when I used a high-paying occupation dummy as the outcome of interest, the results here are weaker than in tables 7 and 8, and for most characteristics the average value of a significant coefficient is between 0.011 and 0.022. However, the general results are the same: positive coefficients are related to cognitive skills, whereas negative coefficients correspond to physical skills. These results are strong for males (table 10), especially when I limit the sample to those born within ten years of the intervention. As in the previous table, females don't seem affected, although there is some evidence of a decrease in the physical demands and strength requirement of the occupation that they select into.

Results from the fuzzy regression discontinuity exercise appear on tables 11 and 12. The values of coefficients for the high-goiter group are somewhat larger in absolute value compared to those in tables 7 and 8, especially for physical skills, and for the results on males born in high-goiter districts (Table 12). Coefficients on occupational characteristics change by 0.025-0.053 points, or 7.2% of a standard deviation in the case of physical demands. There is a big decrease in the physical demands component for females (table 12), which goes down by 0.06 points, more than 8% of a standard deviation.

To summarize, the mix of occupational characteristics shifted slightly towards a bigger cognitive component for those cohorts born after iodization in previously highly-deficient

Table 8: Occupational characteristics: Coefficient on Iodized Salt 1 year prior to birth, by gender

	MALES ONLY		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
Manual Dexterity	-0.0085004***	-0.0083534	-0.0050923
	(0.0032936)	(0.0085289)	(0.0048492)
Motor Control	-0.005372**	-0.0125601*	-0.0007246
	(0.0026382)	(0.0066056)	(0.0043759)
Physical Demands	-0.0108344*	-0.0306461*	0.0074013
	(0.0061104)	(0.0159415)	(0.0088791)
Strength	-0.0054226	-0.026537*	0.0051245
	(0.0056623)	(0.013511)	(0.0076101)
Spatial Ability	0.0028744	0.0018137	0.0066139
	(0.0039967)	(0.0116746)	(0.0058114)
Numerical Ability	0.0125323***	0.0397279***	0.0075499
	(0.0045392)	(0.0093934)	(0.0061012)
Verbal Ability	0.0121351***	0.0268816***	0.0069954
	(0.0045387)	(0.0095628)	(0.0062836)
Intelligence	0.0124379***	0.0230924***	0.0094617
	(0.004258)	(0.0087863)	(0.0058803)
Number of observations	1080860	274227	263677
	FEMALES ONLY		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
Manual Dexterity	-0.0032167	0.0013695	-0.006952
	(0.0031127)	(0.0095191)	(0.0043611)
Motor Control	0.0044321	-0.000404	-0.0020479
	(0.0048784)	(0.0135774)	(0.0073923)
Physical Demands	-0.0083425	-0.0488137**	0.0044071
	(0.0077268)	(0.0198685)	(0.0092193)
Strength	-.0111087	-0.0324223	0.0038235
	(0.007762)	(0.0201268)	(0.0104108)
Spatial Ability	-0.0014131	-0.0081934	0.0070284
	(0.0049119)	(0.0126684)	(0.0067052)
Numerical Ability	0.0087602**	0.0167783	0.0145821**
	(0.0044105)	(0.0126285)	(0.0059269)
Verbal Ability	0.0083115	0.0256555*	0.0038328
	(0.0054498)	(0.0145434)	(0.007123)
Intelligence	0.0079433	0.01827	0.0081388
	(0.0049782)	(0.0149586)	(0.0063557)
Number of observations	461146	111095	113670

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.

Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.

All regressions include people born in Switzerland in 1900-1944 and interviewed for the 1970 Census.

Standard errors in parentheses, clustered at the canton-year of birth level.

Table 9: Occupational characteristics: Born after iodization, whole sample

	WHOLE SAMPLE			
	All cohorts		Born +/- 10 years from jump	
	(1)	(2)	(3)	(4)
Manual Dexterity	0.0040157	0.0036855	0.0077488*	0.0071808
	(0.0031435)	(0.0038862)	(0.0045885)	(0.0057727)
Motor Control	0.0006691	-0.0001699	0.0020538	0.0019644
	(0.003453)	(0.0040769)	(0.004833)	(0.0056653)
Physical Demands	-0.013304*	-0.0220961***	-0.006845	-0.0130432
	(0.0069865)	(0.0083442)	(0.0097762)	(0.0125692)
Strength	-0.0082357	-0.0172355**	-0.0102562	-0.0140808
	(0.0067016)	(0.00785)	(0.0093749)	(0.0108008)
Spatial Ability	-0.0026036	-0.0014481	0.0122934**	0.0084329
	(0.0043484)	(0.0050618)	(0.0060556)	(0.0075997)
Numerical Ability	0.0086838**	0.0125876***	0.017797***	0.0174269***
	(0.0033974)	(0.0042332)	(0.0047274)	(0.0057999)
Verbal Ability	0.0065171	0.0093804*	0.0149158***	0.0143708**
	(0.0040434)	(0.0049353)	(0.005796)	(0.0068862)
Intelligence	0.0037387	0.0042264	0.0116246**	0.0085775
	(0.0036296)	(0.0043923)	(0.0049898)	(0.0058129)
Number of observations	1546952	1546952	655388	655388

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

Columns (1) and (3) assume common cohort fixed effects for high- and non-high-goiter districts.

Columns (2) and (4) assume different cohort fixed effects for high- and non-high-goiter districts.

Standard errors in parentheses, clustered at the district-year of birth level.

Table 10: Occupational characteristics: Born after iodization, by gender

	MALES ONLY			
	All cohorts		Born +/- 10 years from jump	
	(1)	(2)	(3)	(4)
Manual Dexterity	0.0023531	0.0030134	0.0071247	0.0084666
	(0.0038217)	(0.0046336)	(0.0054618)	(0.0065581)
Motor Control	-0.0025219	-0.0025243	-0.0003748	-0.0017929
	(0.0035052)	(0.0041845)	(0.0049609)	(0.005474)
Physical Demands	-0.0125781	-0.0190955*	-0.0114189	-0.0108484
	(0.0083503)	(0.0097889)	(0.0112654)	(0.0142136)
Strength	-0.0046247	-0.0142717*	-0.0138346	-0.0130591
	(0.0075081)	(0.0086543)	(0.0098678)	(0.0113806)
Spatial Ability	-0.0006729	0.0004197	0.0149853**	0.0167077*
	(0.0051193)	(0.0058652)	(0.0072967)	(0.0085963)
Numerical Ability	0.0127004***	0.0163939***	0.0241815***	0.0263489***
	(0.0041941)	(0.0051006)	(0.0054625)	(0.0067043)
Verbal Ability	0.0091454*	0.0095034	0.0196572***	0.019442**
	(0.0048549)	(0.0058286)	(0.0064798)	(0.0077836)
Intelligence	0.0074831*	0.0050152	0.0157109***	0.014659**
	(0.0042551)	(0.0050422)	(0.0055496)	(0.0066602)
	FEMALES ONLY			
	All cohorts		Born +/- 10 years from jump	
	(1)	(2)	(3)	(4)
Manual Dexterity	0.0064285	0.0073436	0.0085276	0.007532
	(0.0044443)	(0.0056172)	(0.0066839)	(0.0074156)
Motor Control	0.0060262	0.0048897	0.010965	0.0111891
	(0.0059711)	(0.0072029)	(0.0084836)	(0.0099415)
Physical Demands	-0.0197688*	-0.0209538	0.0025781	-0.0097583
	(0.0115914)	(0.0141631)	(0.0156304)	(0.0185495)
Strength	-0.0188164*	-0.0159859	-0.005453	-0.0066519
	(0.0110188)	(0.013405)	(0.0156243)	(0.0179133)
Spatial Ability	-0.0096534	0.0012857	0.0026633	-0.001783
	(0.0065412)	(0.008028)	(0.00846)	(0.009888)
Numerical Ability	-0.0017882	0.0058379	-0.0001548	-0.0005088
	(0.0059043)	(0.0071167)	(0.0087851)	(0.0095157)
Verbal Ability	0.0010073	0.0080343	0.001617	0.0025178
	(0.0069625)	(0.0084891)	(0.0108522)	(0.0117831)
Intelligence	-0.0053049	0.0040373	-0.0005824	-0.0023293
	(0.0066161)	(0.0080397)	(0.0100097)	(0.0104068)
Number of observations	462336	462336	194259	194259

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

Columns (1) and (3) assume common cohort fixed effects for high- and non-high-goiter districts.

Columns (2) and (4) assume different cohort fixed effects for high- and non-high-goiter districts.

Standard errors in parentheses, clustered at the district-year of birth level.

Table 11: Occupational characteristics: Fuzzy Regression Discontinuity, whole sample

	WHOLE SAMPLE		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
Manual Dexterity	-0.0009472	0.0041189	-0.0024479
	(0.0028367)	(0.0118249)	(0.0039328)
Motor Control	0.0000163	-0.0024329	-0.0007358
	(0.0025496)	(0.008796)	(0.0038433)
Physical Demands	-0.0076898	-0.0532868**	0.0066527
	(0.0058905)	(0.0211891)	(0.0079619)
Strength	-0.0040244	-0.0363888**	0.0057858
	(0.0055137)	(0.0174469)	(0.0067376)
Spatial Ability	-0.0011264	-0.0008482	0.004219
	(0.0036201)	(0.013549)	(0.0049332)
Numerical Ability	0.0035306	0.0294672***	0.0045859
	(0.0042218)	(0.0101903)	(0.0045452)
Verbal Ability	0.0003645	0.0258381**	0.001003
	(0.004452)	(0.0107883)	(0.0048576)
Intelligence	-0.0009932	0.0129775	0.0033626
	(0.0040607)	(0.0091739)	(0.0043635)
Number of observations	1542006	385322	377347

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.

Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.

All regressions include people born in Switzerland in 1900-1944 and interviewed for the 1970 Census.

Standard errors in parentheses, clustered at the canton-year of birth level.

Table 12: Occupational characteristics: Fuzzy Regression Discontinuity, by gender

	MALES ONLY		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
Manual Dexterity	-0.0030607	0.0053442	-0.0026801
	(0.0035813)	(0.0140892)	(0.0050988)
Motor Control	-0.003096	-0.0086938	-0.0013496
	(0.0029474)	(0.0098406)	(0.0045082)
Physical Demands	-0.0092432	-0.0439352*	0.0055413
	(0.0070682)	(0.0246903)	(0.0097755)
Strength	-0.000927	-0.0306259*	0.006546
	(0.0064875)	(0.0174439)	(0.00822)
Spatial Ability	-0.0006293	0.0129399	0.0042163
	(0.0048196)	(0.0183486)	(0.0062829)
Numerical Ability	0.0049506	0.041329***	0.0030917
	(0.0053631)	(0.0128449)	(0.0058297)
Verbal Ability	0.0002278	0.0331184***	0.0018294
	(0.0052992)	(0.0118991)	(0.0064191)
Intelligence	-0.0008748	0.0221407**	0.0035545
	(0.004987)	(0.0106555)	(0.0058077)
Number of observations	1080860	274227	263677
	FEMALES ONLY		
	ALL AREAS	HIGH-GOITER	LOW-GOITER
Manual Dexterity	0.0040697	0.0060009	-0.002506
	(0.0035782)	(0.0144809)	(0.0046641)
Motor Control	0.0088829	0.0132889	0.0007584
	(0.0055917)	(0.0190334)	(0.0077163)
Physical Demands	-0.0030604	-0.0587841**	0.0073969
	(0.0090979)	(0.0236899)	(0.0100802)
Strength	-0.011987	-0.0324252	0.0024774
	(0.0095886)	(0.0290438)	(0.011036)
Spatial Ability	-0.0031325	-0.0160187	0.0055695
	(0.00581)	(0.0155782)	(0.0071093)
Numerical Ability	-0.0008476	0.0087092	0.0096535
	(0.004911)	(0.0168866)	(0.0060933)
Verbal Ability	-0.0005356	0.0088448	-0.0008637
	(0.0061051)	(0.0193026)	(0.0074627)
Intelligence	-0.0021015	-0.0023815	0.0034093
	(0.0057062)	(0.0206379)	(0.0067172)
Number of observations	461146	111095	113670

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

High-goiter districts are those belonging to the top 25% of the population-weighted goiter distribution.

Low-goiter districts are those belonging to the bottom 25% of the population-weighted goiter distribution.

All regressions include people born in Switzerland in 1900-1944 and interviewed for the 1970 Census.

Standard errors in parentheses, clustered at the canton-year of birth level.

areas. The shift was very small -accounting at most for about 8% of a standard deviation- but it was significant. The effect is stronger for males than for females, but as discussed above, female labor market participation was very limited and possibly non-random over that period, so the results on females are harder to interpret.

9 Concluding remarks

The Swiss Iodization Campaign was the first major nutritional intervention, and many others, such as milk fortification with vitamin D, followed. Yet its effects on economic outcomes have never been studied before. The effects of correcting iodine deficiency on cognition had real and significant effects for the populations treated. The cost-effectiveness of providing universal prophylaxis with iodized salt is indisputable, even if one only takes into account the lower hospitalization costs of people with thyroid disorders, without factoring in the big impact on the economy that increased cognition might have in a population.

Apart from an policy impact evaluation, though, the Swiss Iodization Campaign can also be viewed as an experiment of what happens to a given country and a given population within that country when there is an arguably exogenous change in its cognitive ability. Indeed, one can view iodine deficiency eradication as an "injection of IQ" in the population[8].

Once one thinks about iodization in that light, new and interesting empirical questions pop up. For example, it is usually very hard to de-couple innate ability from schooling when measuring the returns to education in a population, because there is usually not enough variation in the data, as presumably people of low ability do not achieve high education levels, whereas most high-ability people do (for a discussion of this issue, see Heckman and Vytlacil (2001)). In the case of iodization interventions, however, we are faced with a change in overall ability in the population for all levels of schooling, so we are already one step further in solving that problem. It is still a complex issue, however, since one would have to make assumptions about the initial distribution of ability in the population prior to

[8]I thank Prof. Yona Rubinstein who came up with this graphic expression.

the intervention, and how it changed after the correction. Average observed ability could increase either by a shift of the ability distribution to the right, or by a decrease of its left tail, however the implications for the interpretation of the findings would be different in each case, so would be our capacity to de-couple ability from schooling.

Another question arises from treating iodization in a given population as resulting in a shift of its comparative advantage, as workers select into more cognitive-demanding occupations. This can have implications for the local economy (which we can treat as open), as well as the economy of the country as a whole. For example, do we observe worker migration into other areas, and if yes, what is the profile of the workers who migrate and of the receiving regions? How are local and countrywide relative wages affected? These are intriguing questions which could be answered by looking at the various iodization interventions that have taken place around the world, starting with the Swiss and North American experience of the 1920s.

Tremendous steps have been taken for the global eradication of iodine deficiency in the past 20 years, but there is still a long way to go before nobody is affected by iodine deficiency disorders. Given the obvious cost-effectiveness of universal salt iodization, and the beneficial impacts for the treated populations as they were estimated in this paper, it should be clear that eradicating iodine deficiency should be at the top list of priorities for governments and health-promoting organizations.

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