Nutrition, Health, and Human Capital Development: Evidence from South Korea, 1946-1977

Chulhee Lee
Department of Economics
Seoul National University

Background

Motivation (1)

- South Korea experienced rapid economic growth since the liberation from the Japanese occupation in 1945.
- There is general consensus that the rise in economic prosperity should be beneficial for the wellbeing of the population.
- Various pieces of evidence for improvement in standards of living in South Korea since 1945.
  - Per capita income: $67 in 1953 → $27,633 in 2016.
  - Life expectancy: 52 years in 1960 → 82 years in 2016.
  - Male adult height: 165.4 cm for the 1950 birth cohorts → 174.2 cm for the 1991-1995 birth cohorts.

Motivation (2)

- How and why measures of wellbeing have improved in South Korea is not fully understood.
- In particular, little is known regarding what happened from 1945 to the early 1960s. In-depth studies of the periods are seriously restricted by shortage of good data (“Statistical Dark Age”).
- It is crucial to examine the early-life experiences of the aging birth cohorts today (those born in the 1940s and 1950s) to understand their current problems (severe poverty, poor physical and mental health, high suicide rate, etc.)

Motivation (3)

- In general, the experiences of newly-developed countries have been less researched.
- How rapid economic and social changes affected the wellbeing of the population in those countries could differ from the historical experiences of developed countries.
- Some experimental features of Korean history provide opportunities for studying the determinants of health and standards of living.
  - Liberation from Japanese colonial occupation (1945)
  - The Korean War (1950-1953)
  - Recovery from the war (1953-1959)
  - The 1960s and 1970s: Rapid industrialization and social changes
- Dramatically different early-life experiences across birth cohorts and across place of residence.

Aims of the Research Project

- Collect micro-level data on health, human capital development, and local environmental conditions for the birth cohorts born prior to 1960.
- Determine major individual, family, and environmental factors that influenced the measures of health and human capital development.
- Explain the long-term changes in health and human capital development in South Korea from 1945.

Major Questions

- How local nutritional availability and ecological environment in early childhood and adolescence as well as family background affected measures of health (anthropometric measures and results of medical examination) and human capital development (education, occupation, and military experiences)?
- Effects of negative health shocks in early childhood and adolescence (exposure to war, local crop failure, natural disasters, etc.).
- Can better family characteristics or/and improved nutritional supply mitigate the effects of early exposure to negative health shocks?
- Any differences in medium-term effects (around age 20) and long-term effects (older age) of early-life experiences?

This Presentation

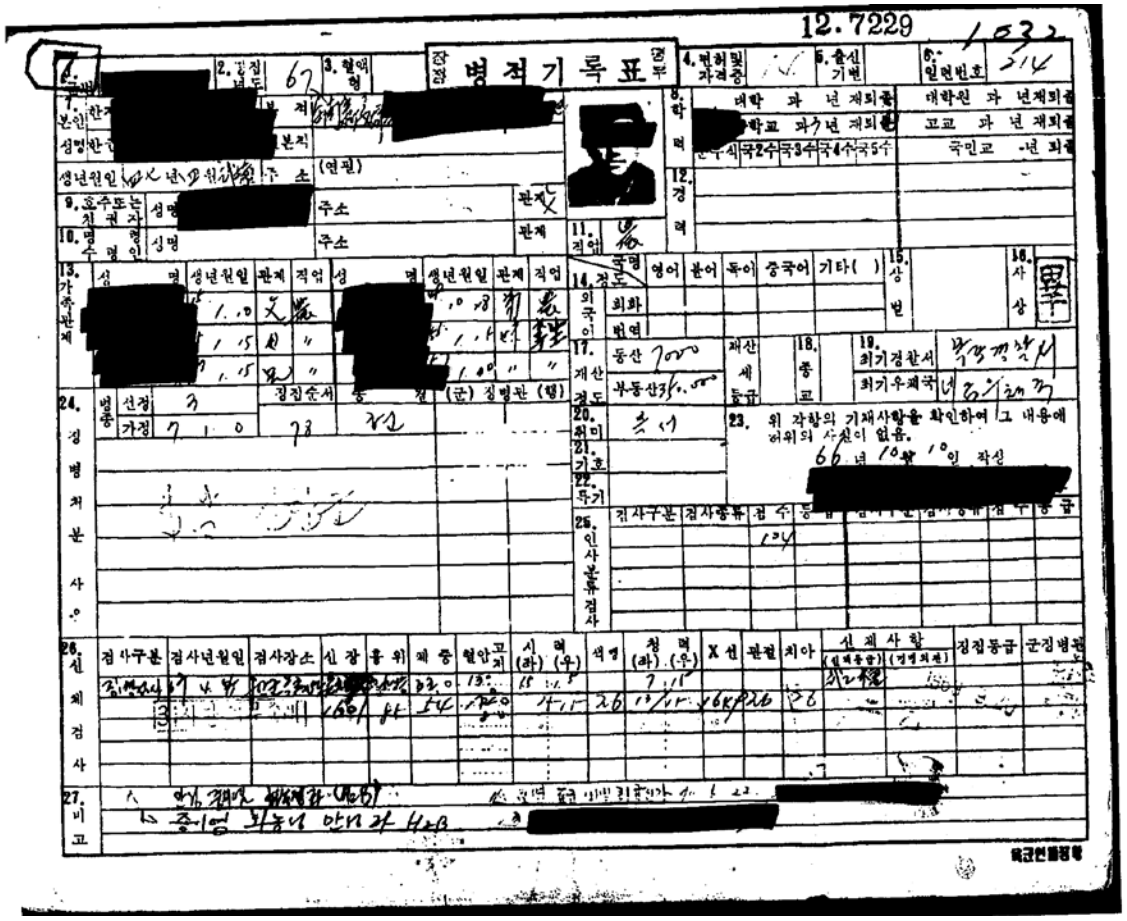
- Introduction of major data: sample of Korean military records and county-level food production data.
- Investigate how local nutritional availability, local ecological environment, and personal/family characteristics affected height and education at age 20.
- Examine if higher nutritional availability in adolescence mitigate the negative effects of early-life exposure to the Korean War.
- Account for the increase in heights for the 1951 to 1957 birth cohorts.

Data and Methods

Data on Military Records in Korea

- All males are subject to conscription, and are required to have a military medical examination at age 20.
- Military record cards are produced for all males including those exempt from service.
- The records are kept in the Military Manpower Administration (MMA).
- For the years from 2002 (birth cohorts born after 1982), the records are in machine-readable forms.
- For earlier birth cohorts, image files (discharged in 1971 or later) micro films (discharged before 1971) of military record cards are available.
- Judging from the number of records, the data available at MMA are complete at least from the mid 1960s.

Military Record: Form #1



병적기록표

12.7229

Data on Military Records in Korea

- The original plan was to collect a 2% sample for the cohorts born from 1946 to 1982.
- Because of various constraints, a random 0.5% sample for the cohorts born from 1946 to 1957 was collected.
- Deleted information for protecting privacy
  - Names
  - Military ID number
  - Last 6-digit numbers of National Identification Number
  - Address below the level of country/district
- Obtaining image files of military record cards with sensitive personal information deleted.
- Information drawn from image files were inputted into machine-readable forms.

Data on Military Records in Korea

- Personal characteristics: year and month of birth, place of residence, family place (*Bongjeok*), education, occupation.
- Family characteristics: relationship to the conscript, year and month of birth, and occupation for family members.
- Medical examination results: conscripts' anthropometric measures (height and weight), general rating, outcome (e.g. fit for service and rejection), other test results (blood pressure, X-ray examination result, eyesight, hearing, and particular medical problems)
- Military experiences

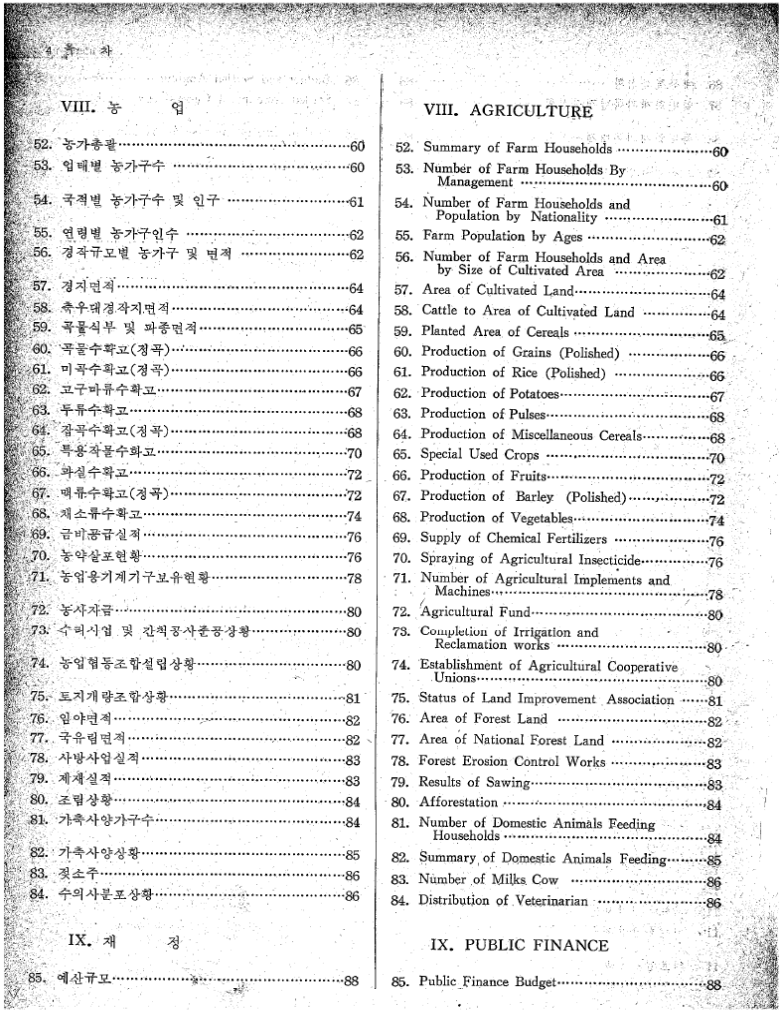
Data on Local Agricultural Production

- We collected and constructed province- and county-level data on all types of agricultural productions from 1950 to 1980.
- Annual Statistical Year Books of each province/city and county, are the major sources.
- Supplemented by several other sources.
- These sources are located in a number of places in various forms (e.g. pdf files available online; deposited in local libraries; and on sale in used book stores).
- Copied and inputted into machine-readable form.

Primary Official Surveys or Statistical reports about the Farm Production

Name	Publication Cycle	Start Year
Farm Household Economy Survey	Annual	1953
Food, Agriculture, Forestry and Fisheries Statistical Yearbook	Annual	1952
Agricultural Production Survey	Annual	1965
Survey of Production Index of Agriculture and Forestry	Annual	1965
Statistical yearbooks of each province or county	Annual	Generally in the middle of 1950s
Agriculture, Forestry and Fisheries Cencus	5 years	In case of agriculture survey, 1960

Sample of Statistical Year Book: The 1970 Seoul Statistics Yearbook



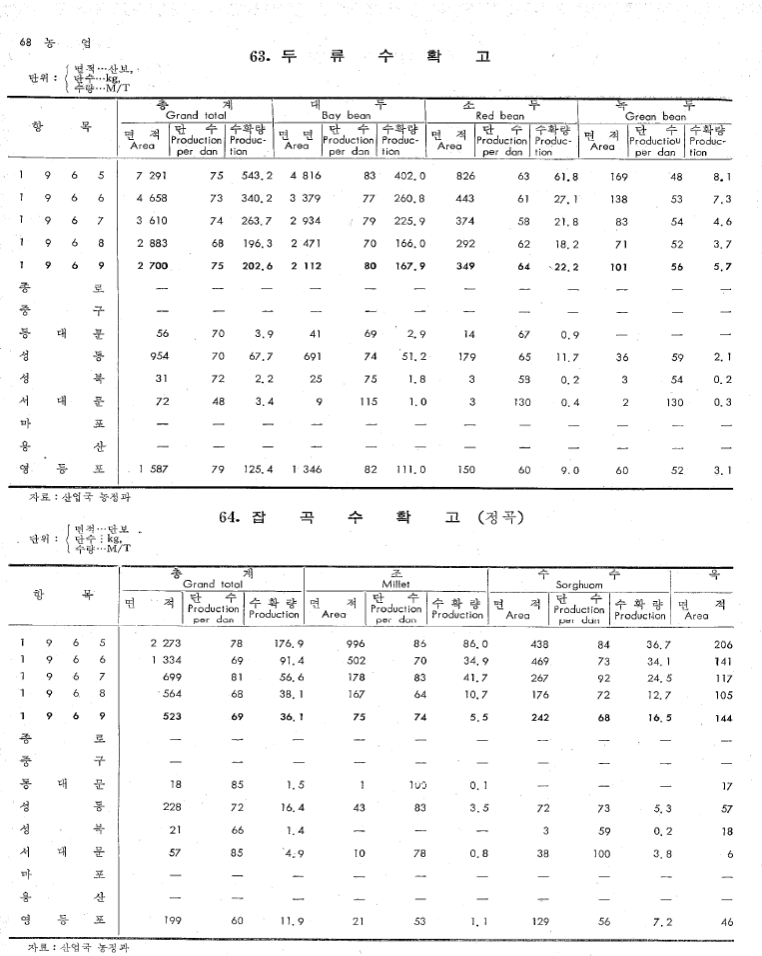
목 차

VIII. 농 업

IX. 재 정

VIII. AGRICULTURE

IX. PUBLIC FINANCE



68 농 업

63. 두 류 수 확 고

단위 : 면적…산보, 단수…kg, 수량…M/T

항 목	총계 Grand total 면적 Area	단수 Production per dan	수확량 Production	대두 Bay bean 면적 Area	단수 Production per dan	수확량 Production	소두 Red bean 면적 Area	단수 Production per dan	수확량 Production	녹두 Grean bean 면적 Area	단수 Production per dan	수확량 Production
1 9 6 5	7 291	75	543.2	4 816	83	402.0	826	63	61.8	169	48	8.1
1 9 6 6	4 658	73	340.2	3 379	77	260.8	443	61	27.1	138	53	7.3
1 9 6 7	3 610	74	263.7	2 934	79	225.9	374	58	21.8	83	54	4.6
1 9 6 8	2 883	68	196.3	2 471	70	166.0	292	62	18.2	71	52	3.7
1 9 6 9	**2 700**	**75**	**202.6**	**2 112**	**80**	**167.9**	**349**	**64**	**22.2**	**101**	**56**	**5.7**
종로	—	—	—	—	—	—	—	—	—	—	—	—
중구	—	—	—	—	—	—	—	—	—	—	—	—
동대문	56	70	3.9	41	69	2.9	14	67	0.9	—	—	—
성동	954	70	67.7	691	74	51.2	179	65	11.7	36	59	2.1
성북	31	72	2.2	25	75	1.8	3	59	0.2	3	54	0.2
서대문	72	48	3.4	9	115	1.0	3	130	0.4	2	130	0.3
마포	—	—	—	—	—	—	—	—	—	—	—	—
용산	—	—	—	—	—	—	—	—	—	—	—	—
영등포	1 587	79	125.4	1 346	82	111.0	150	60	9.0	60	52	3.1

자료 : 산업국 농정과

64. 잡 곡 수 확 고 (정곡)

단위 : 면적…단보, 단수…kg, 수량…M/T

항 목	총계 Grand total 면적	단수 Production per dan	수확량 Production	조 Millet 면적 Area	단수 Production per dan	수확량 Production	수수 Sorghuom 면적 Area	단수 Production per dan	수확량 Production	옥 면적 Area
1 9 6 5	2 273	78	176.9	996	86	86.0	438	84	36.7	206
1 9 6 6	1 334	69	91.4	502	70	34.9	469	73	34.1	141
1 9 6 7	699	81	56.6	178	83	41.7	267	92	24.5	117
1 9 6 8	564	68	38.1	167	64	10.7	176	72	12.7	105
1 9 6 9	**523**	**69**	**36.1**	**75**	**74**	**5.5**	**242**	**68**	**16.5**	**144**
종로	—	—	—	—	—	—	—	—	—	—
중구	—	—	—	—	—	—	—	—	—	—
동대문	18	85	1.5	1	100	0.1	—	—	—	17
성동	228	72	16.4	43	83	3.5	72	73	5.3	57
성북	21	66	1.4	—	—	—	3	59	0.2	18
서대문	57	85	4.9	10	78	0.8	38	100	3.8	6
마포	—	—	—	—	—	—	—	—	—	—
용산	—	—	—	—	—	—	—	—	—	—
영등포	199	60	11.9	21	53	1.1	129	56	7.2	46

자료 : 산업국 농정과

Data on Local Nutritional Availability

- Units of agricultural productions were standardized.
- The physical quantity of each product was transformed into available calories and nutrients (protein, fat, carbohydrate, iron, vitamins, etc.).
- Estimated agricultural outputs and nutritional productions per adult male equivalent and per farm household adult male equivalent population in each province and county, using age- and gender-specific population in the place.
- Province-level data on nutritional availability are available from 1950.
- County-level data on nutritional availability are available from 1960.

Calorie and Nutrition Ingredient per 100g of Each Food in Agricultural Output and Nutrition Supply Dataset (partial)

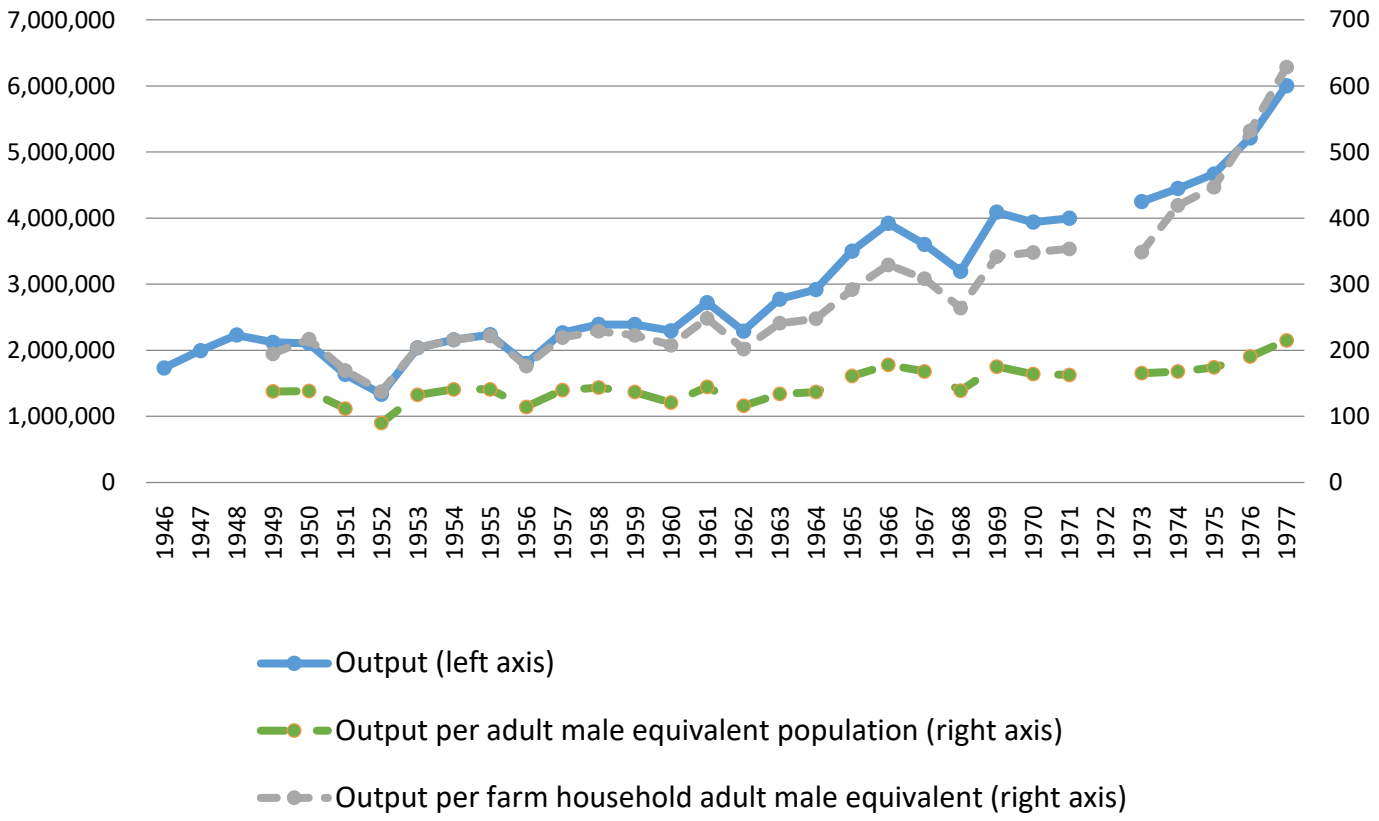
Food	Detailed	Calorie (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Kalium (mg)	Natrium (mg)	Vitamin A (RE)	Vitamin B1 (mg)	Vitamin B2 (mg)	Vitamin B3 (Niacin) (mg)	Vitamin C (mg)
Rice	White rice	363	79.5	6.4	0.4	7	87	1.3	170	8	1	0.23	0.02	1.2	0
Barley		352	78	10	1	24	129	1.7	270	18	0	0.27	0.07	1.4	0
Naked barley		347	77.7	9.9	0.6	19	72	1.4	270	5	0	0.41	0.04	0.9	0
Wheat		333	75.8	10.6	1	52	254	4.7	538	17	0	0.43	0.12	2.4	0
Rye	Whole rye	334	70.7	15.9	1.5	10	378	6.4	501	2	0	0.26	0.16	1.8	0
Foxtain millet	Nonglutinous millet	386	76	9.7	4.2	11	184	2.3	368	3	0	0.21	0.09	1.5	0
Barnyard millet		367	72.4	9.7	3.7	7	280	1.6	240	3	0	0.05	0.03	2	0
Common millet		357	74.6	11.2	1.4	14	226	2.8	233	6	0	0.42	0.09	2	0
Sorghum		364	74.1	9.5	2.6	14	290	2.4	410	2	0	0.1	0.03	3	0
Corn	Glutinous corn	142	29.4	4.9	1.2	21	131	2.2	370	1	9	0.25	0.11	2.6	0
Buck wheat		374	74.7	11.5	2.3	18	308	2.6	477	14	17	0.46	0.26	1.2	0
Soy bean		420	30.7	36.2	17.8	245	620	6.5	1340	2	0	0.53	0.28	2.2	0
Red bean		356	68.4	19.3	0.1	82	424	5.6	1180	1	0	0.54	0.14	3.3	0
Green bean		354	62	22.3	1.5	100	335	5.5	1323	2	12	0.4	0.14	2	0
Kidney bean		169	29.2	10	1.2	62	97	3.7	732	5	0	0.48	0.11	1.6	4
Pea		79	13.2	5.8	0.3	25	134	1.6	356	13	1	0.01	0.09	0.8	12

Average Caloric Consumption as a Proportion of That of Males Aged 20 to 39 by Sex

Age interval	Average Caloric Consumption of **Males** as a Proportion of That of Males 20 to 39	Average Caloric Consumption of **Females** as a Proportion of That of Males 20 to 39
0 to 4	0.4413	0.4367
5 to 9	0.7100	0.6667
10 to 14	0.9000	0.8000
15 to 19	1.0167	0.7833
20 to 39	1.0000	0.7333
40 to 49	0.9500	0.6967
50 to 59	0.9000	0.6600
60 to 69	0.8000	0.5867
70 or older	0.7000	0.5133

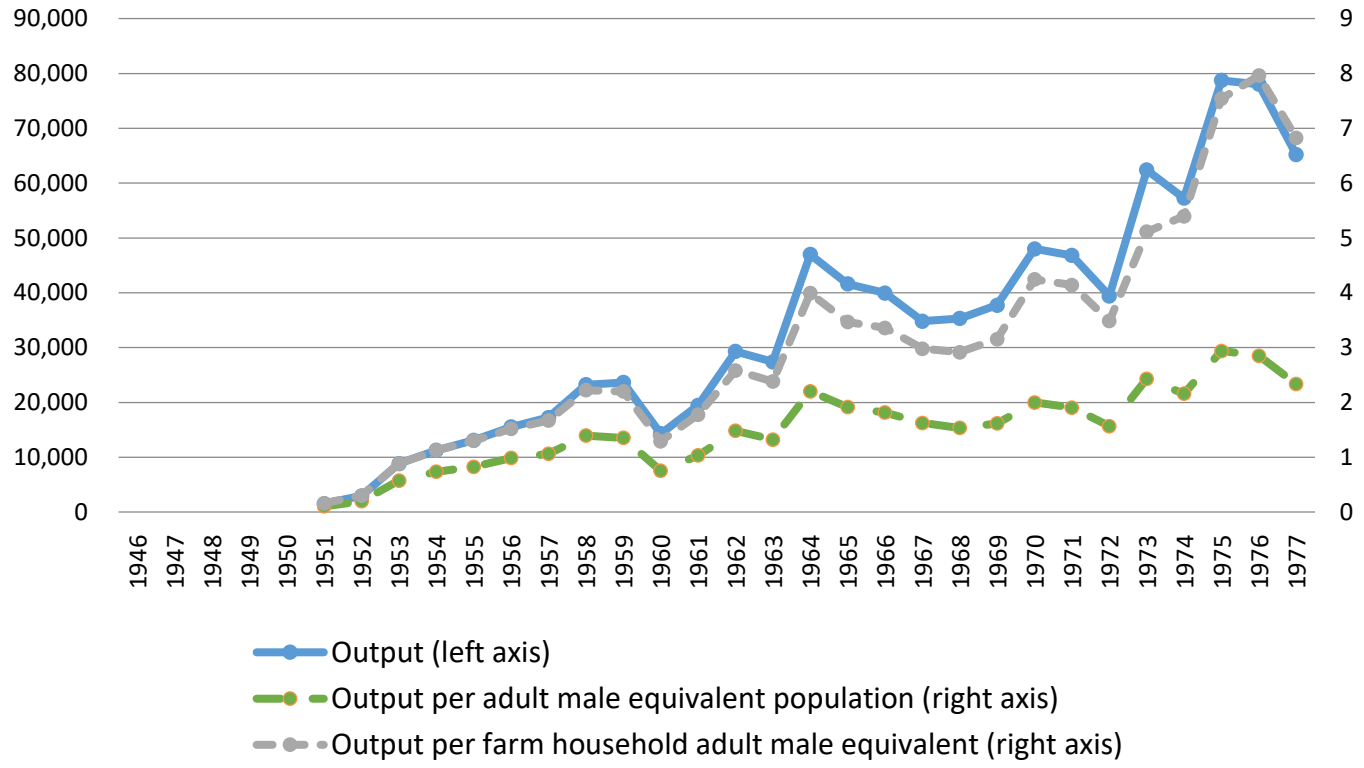
Rice Production

(tons, kilograms per adult male equivalent population and per farm household adult male equivalent)



Beef Production

(tons, kilograms per adult male equivalent population and per farm household adult male equivalent)



Measuring Nutritional Availability

- Previous historical studies used per capita food production (or nutritional production) in a country or a region as an index of food consumption or nutritional intake of the population (Fogel 1986, Floud et al. 2011, Haines et al. 2003).
- Problem: Trades across regions could not be considered. Nutritional availability in urban areas (traditionally net importers of food) could be underestimated.
- We use calories and major nutrients (protein, fat, and carbohydrate) per farm household adult male equivalent population in the locality.
  - Mitigate the problem that food availability becomes extremely low in urban areas.
  - A crude measure of farm productivity that could affect both local food availability and income.
- Use alternative samples (full sample with minimum nutritional production, rural counties, farmers' sons in rural counties) for whom the effects of agricultural production per farm population may differ.

Nutrition Variable during Growth Periods

- Linking the sample of military records with data on local nutritional availability using the conscript's current address, family place (*Bonjeok*), and year of birth.
- Measuring nutritional availability in growth periods.

➢ Selected two crucial ages for human growth: 1) conception to age 3 (4 years), and 2) early adolescence (age 12 to 16)

➢ Assumption: the county of conscription = county of residence in adolescence, and the province of conscription = province of birth. (Use a subsample for whom current address = *Bonjeok*)

➢ Nutritional availability in infancy: average calories and major nutrients for 4 years covering ages -1 to 3 in the province of residence.

➢ Nutritional availability in adolescence: average calories and major nutrients for 5 years covering ages 12 to 16 in the county of residence.

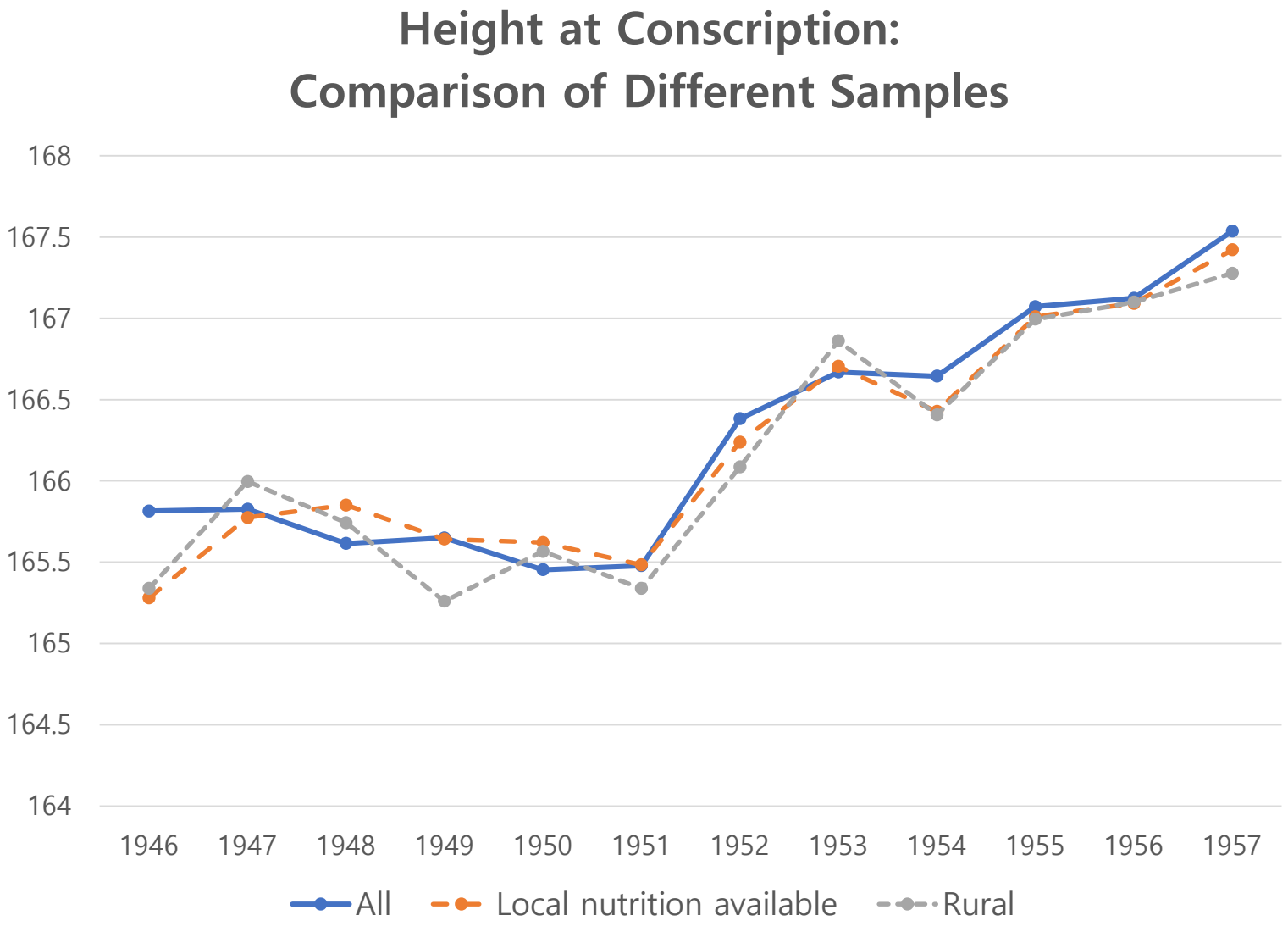
Variable	Definition
Height	Height at age 20 (in centimeter)
Food availability in fetus & infancy	
Calories, Infancy	Average calorie production for 4 years (from prenatal period to age 2) in the province of residence (1000s of kcals per farm household adult male equivalent per day).
Protein, Infancy	Average protein production for 4 years (from prenatal period to age 2) in the province of residence (100s of grams per farm household adult male equivalent per day).
Fat, Infancy	Average fat production for 4 years (from prenatal period to age 2) in the state of residence (100s of grams per farm household adult male equivalent per day).
Carb, Infancy	Average carbohydrate production for 4 years (from prenatal period to age 2) in the state of residence (100s of grams per farm household adult male equivalent per day).
Food availability in adolescence	
Calories, Adolescence	Average calorie production for 5 years (from age 12 to age 16) in the county of residence (1000s of kcals per farm household adult male equivalent per day).
Protein, Adolescence	Average protein production for 5 years (from age 12 to age 16) in the county of residence (100s of grams per farm household adult male equivalent per day).
Fat, Adolescence	Average fat production for 5 years (from age 12 to age 16) in the county of residence (100s of grams per farm household adult male equivalent per day).
Carb, Adolescence	Average carbohydrate production for 5 years (from age 12 to age 16) in the county of residence (100s of grams per farm household adult male equivalent per day).

Variable	Definition
Environmental characteristics	
Population density	Population (100s of persons) per 1 square kilometers in the county of residence at age 14.
Nonfarm population share	The share of nonfarm population (percent) in the county of residence at age 14.
Seasonality of birth	
First quarter	Equals 1 if born from January to March.
Second quarter	Equals 1 if born from April to June.
Third quarter	Equals 1 if born from July to September.
Fourth quarter	Equals 1 if born from October to December.
Family size	
Number of family 1-3	Equals 1 if two or less family members are reported.
Number of family 4-6	Equals 1 if three to five family members are reported.
Number of family 7 or more	Equals 1 if six family members are reported.
Father's occupation	
Professional	Equals 1 if father had a professional or managerial job.
Clerical	Equals 1 if father had a semi-professional or clerical job.
Service	Equals 1 if father had a service job.
Farming	Equals 1 if father's occupation was farmer.
Manual	Equals 1 if father had a manual job.
No job reported	Equals 1 if father's job is not reported.
Father absent	Equals 1 if father was absent.

Comparison of Selected Samples

	(1) Full Sample	(2) Information on height	(3) Height + County (nutrition in adolescence)
Measure of net nutritional status			
Height (centimeter)		166.446	166.408
Food availability in fetus & infancy			
Calories (1000s of Kcal)			
Protein (100s of grams)			
Fat (100s of grams)			
Carbohydrate (100s of grams)			
Food availability in adolescence			
Calories (1000s of Kcal)			4.380
Protein (100s of grams)			1.211
Fat (100s of grams)			0.270
Carbohydrate (100s of grams)			8.987
Environmental characteristics			
Population density (100s/km^2)			20.298
Nonfarm population share (%)			45.661
Seasonality of birth (proportion)			
First quarter	0.286	0.284	0.284
Second quarter	0.230	0.231	0.232
Third quarter	0.242	0.242	0.238
Fourth quarter	0.242	0.242	0.246
Family size (proportion)			
Number of family 1-3	0.096	0.092	0.087
Number of family 4-6	0.609	0.611	0.610
Number of family 7 or more	0.295	0.297	0.303
Father's occupation (proportion)			
Professional	0.007	0.007	0.006
Clerical	0.024	0.024	0.022
Service	0.005	0.005	0.005
Farming	0.391	0.389	0.415
Manual	0.023	0.023	0.022
No job reported	0.341	0.343	0.328
Father absent	0.204	0.204	0.328
Own education (proportion)			
Primary school or less	0.239	0.242	0.254
Middle school	0.282	0.283	0.287
High school	0.363	0.363	0.355
College	0.112	0.108	0.101
Education missing	0.004	0.004	0.003
Number	17833	16838	11508

	(4) Rural counties	(5) Rural counties, 1951-1957 cohorts	(6) Farmer's sons in rural counties, 1951-1957 cohorts
Measure of net nutritional status			
Height (centimeter)	166.338	166.656	166.731
Food availability in fetus & infancy			
Calories (1000s of Kcal)		2.811	2.880
Protein (100s of grams)		0.698	0.714
Fat (100s of grams)		0.113	0.115
Carbohydrate (100s of grams)		5.958	6.107
Food availability in adolescence			
Calories (1000s of Kcal)	4.662	5.090	5.132
Protein (100s of grams)	1.146	1.257	1.248
Fat (100s of grams)	0.187	0.207	0.195
Carbohydrate (100s of grams)	9.921	10.832	10.960
Environmental characteristics			
Population density (100s/km^2)	4.663	5.155	3.181
Nonfarm population share (%)	25.922	26.240	22.490
Seasonality of birth (proportion)			
First quarter	0.287	0.284	0.290
Second quarter	0.234	0.235	0.229
Third quarter	0.235	0.234	0.238
Fourth quarter	0.244	0.247	0.243
Family size (proportion)			
Number of family 1-3	0.077	0.064	0.023
Number of family 4-6	0.601	0.614	0.600
Number of family 7 or more	0.321	0.322	0.377
Father's occupation (proportion)			
Professional	0.004	0.004	0
Cleric	0.016	0.018	0
Service	0.003	0.003	0
Farming	0.512	0.501	1.000
Manual	0.013	0.015	0
No job reported	0.260	0.279	0
Father absent	0.189	0.177	0
Own education (proportion)			
Primary school or less	0.295	0.281	0.299
Middle school	0.306	0.307	0.323
High school	0.329	0.343	0.329
College	0.067	0.067	0.048
Education unreported	0.003	0.001	0.001
Number	7850	5560	2784


Height at Conscription:
Comparison of Different Samples
168
167.5
167
166.5
166
165.5
165
164.5
164
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
All
Local nutrition available
Rural

Height Regressions

Regression Analysis: Baseline Model

$$(1) \qquad H_{i,j,c} = \beta_0 + \beta_1 N^I_{j,c} + \beta_2 N^A_{j,c} + \beta_3 Z_{j.c} + \beta_4 X_{i,j.c} + \varepsilon_{i,j,c}$$

- $H_{i,j,c}$: Height of *i*th person from *j*th county who belongs to *c*th birth cohort.
- $N^I_{j,c}$ and $N^A_{j,c}$: Nutritional availability in infancy and in adolescence
- $Z_{j,c}$: Environmental conditions in county of residence at age 14,
- $X_{i,j,c}$: Family and personal characteristics
- Standard errors were clustered at county level.

Regression Analysis: Baseline Sample

- Information on height and county of residence
- Matched with county-level agricultural production statistics
- Conscripts from rural counties (excluding Seoul, Busan, Incheon, Daejeon, Gwangju, and Daegu)
- Calories per farm household adult male equivalent in the county of residence in adolescence are at least 1000Kcals.
- Born between 1951 and 1957.
- N=5,560

Local Nutritional Availability and Height: 1951-1957 Birth Cohort in Rural Counties

Variable	(1)	(2)	(3)	(4)
Intercept	165.4625***	165.2796***	166.4755***	165.4818***
	(0.3999)	(0.4309)	(0.3309)	(0.3945)
Local Nutritional availability				
Calories, Infancy	0.2546**			
	(0.0995)			
Calories, Adolescence	0.1303**			
	(0.0497)			
Protein, Infancy		1.3243***		
		(0.4415)		
Protein, Adolescence		0.5698***		
		(0.1941)		
Fat, Infancy			1.7949	
			(2.5847)	
Fat, Adolescence			1.5865*	
			(0.9061)	
Carbohydrate, Infancy				0.1186**
				(0.0458)
Carbohydrate, Adolescence				0.0585**
				(0.0226)

Variable	(1)	(2)	(3)	(4)
Local environment				
Population density	0.01689	0.0165	0.0120	0.0169
	(0.0121)	(0.0115)	(0.0113)	(0.0122)
Nonfarm population share	-0.0051	-0.0082	-0.0100	-0.0043
	(0.0084)	(0.0081)	(0.0070)	(0.0085)
Season of Birth				
First quarter	NI	NI	NI	NI
Second quarter	0.2235	0.2253	0.2134	0.2234
	(0.1791)	(0.1795)	(0.1773)	(0.1790)
Third quarter	-0.2126	-0.2019	-0.1925	-0.2141
	(0.1688)	(0.1682)	(0.1688)	(0.1689)
Fourth quarter	-0.3076	-0.3069	-0.3124	-0.3081
	(0.2109)	(0.2103)	(0.2113)	(0.2110)
Family size				
1 to 3	0.3611	0.3733	0.3368	0.3593
	(0.3377)	(0.3389)	(0.3400)	(0.3376)
4 to 6	NI	NI	NI	NI
7 or more	0.0169	0.0082	0.0115	0.0192
	(0.1494)	(0.1501)	(0.1516)	(0.1494)
Father's occupation				
Professional	-0.1198	-0.0932	-0.0897	-0.1262
	(0.9222)	(0.9256)	(0.9325)	(0.9211)
Clerical	1.0196**	1.0070**	1.0074**	1.0212**
	(0.4777)	(0.4787)	(0.4765)	(0.4774)
Service	-0.9528	-0.9629	-0.8128	-0.9545
	(1.6111)	(1.6141)	(1.6371)	(1.6100)
Farming	NI	NI	NI	NI
Manual	-1.2294**	-1.2309**	-1.2340**	-1.2296**
	(0.5973)	(0.5966)	(0.5923)	(0.5973)
No job	-0.2662	-0.2574	-0.2961*	-0.2667
	(0.1735)	(0.1730)	(0.1735)	(0.1736)
Father absent	-0.1025	-0.0935	-0.1079	-0.1044
	(0.2029)	(0.2026)	(0.2035)	(0.2030)
R-square	0.0075	0.0080	0.0051	0.0075
F-value	3.54***	3.75***	2.76***	3.53***
N	5560	5560	5560	5560

Summary of Baseline Results

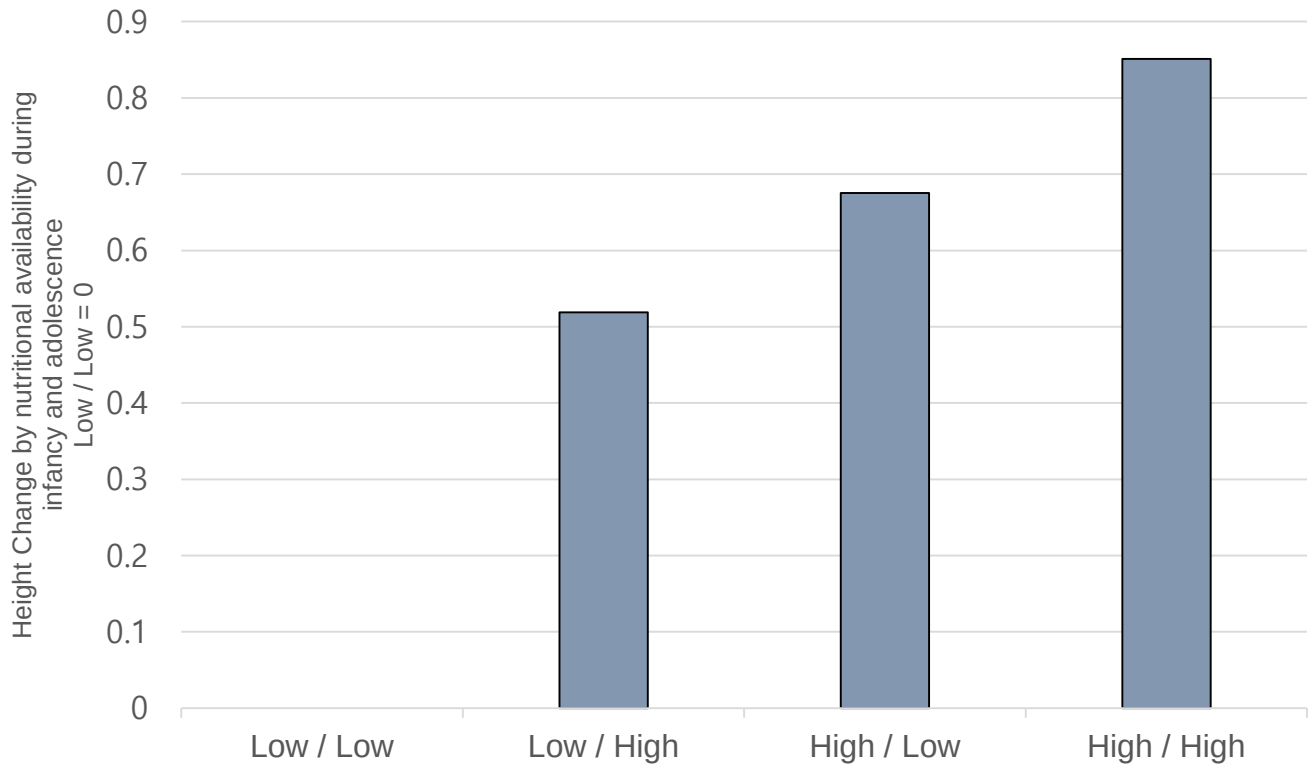
- The variables on nutritional availability are positive and statistically significant.
- A person who spent infancy in a province that produced calories per farm household population one standard deviation (0.711 Kcal) above the mean would have been 0.18 centimeters taller at age 20, if other things being equal.
- One standard deviation grater productions in protein in infancy (0.156) and carbohydrate in infancy (1.545) would increase adult height by 0.21 centimeters and 0.18 centimeters, respectively.
- The estimated coefficients for food availability in adolescence are smaller than those in infancy. But, the effects of one standard deviation change in nutritional variables in adolescence and in infancy are similar in magnitude.

Local Nutritional Availability and Height: 1951-1957 Birth Cohort in Rural Counties (Alternative Specifications)

Variable	(1) Calories	(2) Protein	(3) Fat	(4) Carbohydrate
(A) Infancy only				
Nutrition, Infancy	0.3280***	1.5530***	3.6797	0.1511***
	(0.0973)	(0.4321)	(2.5611)	(0.0448)
Other controls	Yes	Yes	Yes	Yes
R-square	0.0061	0.0063	0.0068	0.0090
F-value	3.74***	3.82***	6.21***	6.31***
N	5560	5560	5560	5560
(B) Adolescence only				
Nutrition, Adolescence	0.1610***	0.6570***	1.8159**	0.0725***
	(0.0508)	(0.2024)	(0.8880)	(0.0231)
Other controls	Yes	Yes	Yes	Yes
R-square	0.0064	0.0065	0.0050	0.0063
F-value	3.20***	3.34***	2.95***	3.19***
N	5560	5560	5560	5560

Variable	(1) Calories	(2) Protein	(3) Fat	(4) Carbohydrate
(C) Categorical variable				
Second quartile, infancy	-0.1361	-0.0085	-0.0793	-0.1420
	(0.1939)	(0.2074)	(0.2553)	(0.1974)
Third quartile, infancy	0.3890*	0.4281**	0.1877	0.4730**
	(0.2182)	(0.1927)	(0.2309)	(0.2233)
Highest quartile, infancy	0.4047*	0.3408	0.5211**	0.3687*
	(0.2112)	(0.2104)	(0.2405)	(0.2127)
Second quartile, Adolescence	0.5211***	0.8108***	0.0375	0.3290*
	(0.1856)	(0.1780)	(0.2207)	(0.1825)
Third quartile, Adolescence	0.5359***	0.7013***	-0.1329	0.4851**
	(0.2010)	(0.1940)	(0.2077)	(0.2032)
Highest quartile, Adolescence	0.6296***	0.6380***	-0.0102	0.5823***
	(0.2015)	(0.1879)	(0.9636)	(0.2073)
Other controls	Yes	Yes	Yes	Yes
R-square	0.0095	0.0102	0.0059	0.0091
F-value	5.17***	3.95***	2.64***	3.07***
N	5560	5560	5560	5560
(D) Infancy / Adolescence				
Low / High	0.5187**	0.5848***	-0.2599	0.5519***
	(0.1986)	(0.2006)	(0.2218)	(0.2009)
High / Low	0.6755***	0.8314***	0.1971	0.7400***
	(0.2125)	(0.2178)	(0.2198)	(0.2088)
High / High	0.8511***	0.7044***	0.3129*	0.8847***
	(0.1990)	(0.1979)	(0.1782)	(0.1992)
Other controls	Yes	Yes	Yes	Yes
R-square	0.0084	0.0083	0.0055	0.0088
F-value	3.22***	3.10***	2.63***	3.27***
N	5560	5560	5560	5560

Local Nutritional Availability during Infancy and Adolescence and Height Change (centimeter)



Alternative Specifications: Summary

- If included separately, the coefficients for nutritional availability variables in infancy and adolescence slightly increase in magnitude.
- Including dummy variable for each quartile of nutritional availability reveals non-linear relationship
  - Discrete increase between 2nd and 3rd quartiles for nutritional availability in infancy, and between 1st and 2nd quartiles for adolescence.
  - Critical threshold? (3,000~4,000 Kcals per adult living in farm households)
- Joint effects of nutritional availability in infancy and adolescence
  - Critical importance of nutrition during early childhood.
  - Sign of substitution between nutrition in infancy and adolescence: marginal effect of better nutrition in one period is larger if nutritional provision is low in the other period.
  - Improved nutrition in late childhood can compensate nutritional deficiencies in early childhoold.

Local Nutritional Availability and Height: Additional Controls

Variable	(1) Calories	(2) Protein	(3) Fat	(4) Carbohydrate
(A) Variety of sources (HI)				
Nutrition, Infancy	0.2983**	1.1501**	2.1780	0.1333**
	(0.1234)	(0.4993)	(2.7865)	(0.0562)
Nutrition, Adolescence	0.1474**	0.8656***	1.6374	0.0621**
	(0.0599)	(0.2983)	(1.0771)	(0.0264)
HI, Infancy	-1.8037	1.2664	-0.5522	-1.2606
	(1.7034)	(1.1713)	(1.3210)	(1.5826)
HI, Adolescence	-0.0551	1.0507	-0.4322	-0.1367
	(0.5452)	(0.6530)	(0.8840)	(0.5622)
Other controls	Yes	Yes	Yes	Yes
R-square	0.0078	0.0089	0.0052	0.0076
F-value	3.29***	3.35***	2.82***	3.32***
N	5560	5560	5560	5560

Variable	(1) Calories	(2) Protein	(3) Fat	(4) Carbohydrate
(B) Sample with information on local disease mortality				
Nutrition, Infancy	0.1055	0.6238	-1.3216	0.0520
	(0.1326)	(0.6238)	(3.5939)	(0.0610)
Nutrition, Adolescence	0.1575**	0.5689**	1.8257	0.0725**
	(0.0736)	(0.2772)	(1.4284)	(0.0338)
Other controls	Yes	Yes	Yes	Yes
R-square	0.0106	0.0105	0.0084	0.0107
F-value	2.11**	2.16**	1.95**	2.10**
N	3025	3025	3025	3025
(C) Local disease mortality				
Nutrition, Infancy	0.1036	0.6290	-1.0079	0.0509
	(0.4357)	(0.5872)	(3.6830)	(0.0609)
Nutrition, Adolescence	0.1612**	0.6135**	1.9076	0.0739**
	(0.0743)	(0.2787)	(1.4357)	(0.0341)
Local disease mortality	0.0025	0.0027	0.0022	0.0023
	(0.0071)	(0.0071)	(0.0075)	(0.0071)
Other controls	Yes	Yes	Yes	Yes
R-square	0.0107	0.0106	0.0085	0.0107
F-value	1.97**	2.02**	1.84**	1.97**
N	3025	3025	3025	3025

Controlling Own Education and Province Fixed Effect

Variable	(1)	(2)	(3)	(4)
(A) Education				
Calories, Infancy	0.2305**			
	(0.0977)			
Calories, Adolescence	0.0994**			
	(0.0497)			
Protein, Infancy		1.1955***		
		(0.4375)		
Protein, Adolescence		0.4731**		
		(0.1955)		
Fat, Infancy			1.7589	
			(2.6168)	
Fat, Adolescence			1.5002*	
			(0.9050)	
Carbohydrate, Infancy				0.1070**
				(0.0449)
Carbohydrate, Adolescence				0.0440*
				(0.0226)
Primary school or less	NI	NI	NI	NI
Middle school	0.8319***	0.8309***	0.8698***	0.8314***
	(0.1706)	(0.1707)	(0.1702)	(0.1705)
High school	1.4880***	1.4896***	1.5366***	1.4871***
	(0.1724)	(0.1721)	(0.1714)	(0.1724)
College	1.9143***	1.9163***	1.9549***	1.9147***
	(0.2998)	(0.2994)	(0.2996)	(0.2998)
Education Missing	3.1830*	3.1976*	3.1837	3.1774*
	(1.9007)	(1.8995)	(1.9253)	(1.9007)
Other controls	Yes	Yes	Yes	Yes
N	5560	5560	5560	5560

Variable	(1)	(2)	(3)	(4)
(B) Education & Province				
Calories, Infancy	0.7592*** (0.1595)			
Calories, Adolescence	0.1187 (0.0822)			
Protein, Infancy		3.0234*** (0.7187)		
Protein, Adolescence		0.4278 (0.3591)		
Fat, Infancy			7.8572*	
Fat, Adolescence			1.7740 (1.4385)	
Carbohydrate, Infancy				0.3570*** (0.0729)
Carbohydrate, Adolescence				0.0535 (0.0370)
Education	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes
Province dummy	Yes	Yes	Yes	Yes
R-square	0.0227	0.0282	0.0240	0.0292
F-value	10.49***	10.04***	8.61***	10.48***
N	5560	5560	5560	5560

Adding Additional Controls: Summary

- Including indices of variety of nutritional sources (Herfindahl-Hirschman Index)
  - Effects of nutrition variables remain unchanged
  - HHI has no significant effect.
- Including local disease mortality (number of deaths per 100,000 caused by type-1 infectious diseases)
  - Restricting the sample weakens the effect of nutrition in infancy
  - Adding disease mortality does not change the effects of nutrition variables.
- Adding own education does not change the results much.
- Including province fixed effect increases the magnitude of the effect of nutritional availability in early childhood.

Measurement Errors in Place of Birth

- To reduce potential measurement errors arising from geographic mobility, we used a subsample of men from rural counties whose province of residence at the time of conscription is the same as the province of “original family place (*Bonjeok*).”
- If a conscript’s current address and *Bonjeok* are identical, it is likely that he was born in the current province of residence.
- Of the 13,999 men in our sample for whom both current address and *Bonjeok* are available, about 79 percent report no province change. It is 90% for rural county sample.
- For the birth cohorts under study (especially those in the rural county sample), geographic mobility was probably low.

Local Nutritional Availability and Height: 1951-1957 Birth Cohort in Rural Counties Living in Family Place

Variable	(1)	(2)	(3)	(4)
Intercept	165.3111***	165.1875***	166.5838***	165.3213***
	(0.4315)	(0.4544)	(0.3316)	(0.4264)
Local Nutritional availability				
Calories, Infancy	0.3010***			
	(0.1011)			
Calories, Adolescence	0.1370***			
	(0.0515)			
Protein, Infancy		1.4468***		
		(0.4478)		
Protein, Adolescence		0.5923***		
		(0.1973)		
Fat, Infancy			0.8730	
			(2.5709)	
Fat, Adolescence			1.7227*	
			(0.9057)	
Carbohydrate, Infancy				0.1414***
				(0.0465)
Carbohydrate, Adolescence				0.0617***
				(0.0234)
Other Controls	Yes	Yes	Yes	Yes
N	5044	5044	5044	5044

Local Nutritional Availability and Height: Farmer's Sons in Rural Counties

Variable	(1)	(2)	(3)	(4)
Intercept	164.9700***	164.6855***	166.0229***	165.0222***
	(0.5722)	(0.5871)	(0.4066)	(0.5718)
Local Nutritional availability				
Calories, Infancy	0.4594***			
	(0.1435)			
Calories, Adolescence	0.0913			
	(0.0677)			
Protein, Infancy		2.2225***		
		(0.6180)		
Protein, Adolescence		0.4459*		
		(0.2523)		
Fat, Infancy			5.8666	
			(3.6528)	
Fat, Adolescence			0.9934	
			(1.1792)	
Carbohydrate, Infancy				0.2106***
				(0.0663)
Carbohydrate, Adolescence				0.0398
				(0.0311)
R-square	0.0077	0.0083	0.0040	0.0075
F-value	5.29***	5.87***	2.49**	5.19***
N	2784	2784	2784	2784

Local Nutritional Availability and Height: All Persons with Information on Local Nutritional Productions

Variable	(1)	(2)	(3)	(4)
Intercept	165.2001***	165.7656***	166.4914***	165.2691***
	(0.3690)	(0.2868)	(0.1767)	(0.3640)
Local Nutritional availability				
Calories, Infancy	0.3570***			
	(0.0923)			
Calories, Adolescence	0.0760*			
	(0.0438)			
Protein, Infancy		1.0424***		
		(0.3138)		
Protein, Adolescence		0.1181		
		(0.1057)		
Fat, Infancy			1.3876*	
			(0.7584)	
Fat, Adolescence			-0.0902	
			(0.1810)	
Carbohydrate, Infancy				0.1405***
				(0.0423)
Carbohydrate, Adolescence				0.0427**
				(0.0202)
R-square	0.0074	0.0067	0.0050	0.0069
F-value	4.53***	3.80***	2.93***	4.42***

Comparison of the Results from the 1946-1957 Cohorts and the 1951-1957 Cohorts

Variable	(1)	(2)	(3)	(4)
(A) 1946-1951 Cohorts				
Calories, Adolescence	0.2390***			
	(0.0455)			
Protein, Adolescence		1.0066***		
		(0.1892)		
Fat, Adolescence			3.2564***	
			(0.8288)	
Carbohydrate, Adolescence				0.1078***
				(0.0206)
R-square	0.0092	0.0095	0.0068	0.0090
F-value	6.31***	6.75***	6.21***	6.31***
N	7850	7850	7850	7850
(B) 1951-1957 Cohorts				
Calories, Adolescence	0.1610***			
	(0.0508)			
Protein, Adolescence		0.6570***		
		(0.2024)		
Fat, Adolescence			1.8159**	
			(0.8880)	
Carbohydrate, Adolescence				0.0725***
				(0.0231)
R-square	0.0064	0.0065	0.0050	0.0063
F-value	3.20***	3.34***	2.95***	3.19***
N	5560	5560	5560	5560

Results of Robustness Checks: Summary

- Regressions using the subsample (for whom the current and Bongjeok provinces are the same) reveal larger effects of nutritional availability on height.
  - Measurement errors likely attenuate the effects of local nutritional availability in growth periods on adult height.
- If sample is limited to farmers' sons from rural counties, the estimated coefficients for nutrition variables become larger.
- If sample is extended to include men from urban counties with minimum agricultural productions, the results are similar to those of baseline results.
- The effects of nutrition variables in adolescence are stronger for early birth cohorts (1946-1950) than for late birth cohorts (1951-1957).

Results for Other Outcomes

Local Nutritional Availability and Years of Schooling: 1951-1957 Birth Cohort in Rural Counties

Variable	(1)	(2)	(3)	(4)
Intercept	9.9545***	9.8648***	8.9954***	9.9364***
	(1.0990)	(1.4344)	(1.2912)	(1.0233)
Local Nutritional availability				
Calories, Infancy	0.1732*			
	(0.0957)			
Calories, Adolescence	0.1793***			
	(0.0451)			
Protein, Infancy		0.8449*		
		(0.4337)		
Protein, Adolescence		0.5418***		
		(0.2075)		
Fat, Infancy			6.3710**	
			(2.5340)	
Fat, Adolescence			0.3781	
			(1.0112)	
Carbohydrate, Infancy				0.0793*
				(0.0437)
Carbohydrate, Adolescence				0.0840***
				(0.0203)

Local Nutritional Availability and Years of Schooling: 1951-1957 Birth Cohort in Rural Counties (Continued)

Variable	(1)	(2)	(3)	(4)
Local environment				
Population density	-0.0307 (0.0209)	-0.0310 (0.0278)	-0.0052 (0.0288)	-0.0284 (0.0193)
Nonfarm population share	0.0066 (0.0049)	0.0060 (0.0049)	0.0047 (0.0049)	0.0065 (0.0049)
Season of Birth				
First quarter	NI	NI	NI	NI
Second quarter	0.0631 (0.0899)	0.0632 (0.0893)	0.0552 (0.0898)	0.0625 (0.0899)
Third quarter	0.1317 (0.1008)	0.1387 (0.1008)	0.1404 (0.1008)	0.1309 (0.1008)
Fourth quarter	0.0301 (0.0917)	-0.0339 (0.0919)	-0.0404 (0.6620)	-0.0302 (0.0916)
Family size				
1 to 3	0.3152** (0.1541)	0.3149** (0.1542)	0.3011* (0.1545)	0.3148** (0.1541)
4 to 6	NI	NI	NI	NI
7 or more	0.1624* (0.0827)	-0.1704** (0.0819)	-0.1812** (0.0835)	-0.1614* (0.0827)
Father's occupation				
Professional	1.7458*** (0.6031)	1.7758*** (0.6067)	1.7816*** (0.6109)	1.7418*** (0.6027)
Clerical	2.3718*** (0.2058)	2.3674*** (0.2069)	2.3935*** (0.2066)	2.3738*** (0.2055)
Service	0.4717 (0.8630)	0.4653 (0.8665)	0.5444 (0.8708)	0.4747 (0.8619)
Farming	NI	NI	NI	NI
Manual	0.0998 (0.3118)	0.0846 (0.3115)	0.0654 (0.3150)	0.1009 (0.3121)
No job	0.5139*** (0.1019)	0.5201*** (0.1032)	0.5204*** (0.1024)	0.5128*** (0.1017)
Father absent	-0.2827** (0.1105)	-0.2828** (0.1108)	-0.2949*** (0.1101)	-0.2832*** (0.1105)
Province fixed effect	Yes	Yes	Yes	Yes
R-square	0.0407	0.0425	0.0391	0.0449
F-value	38.27***	37.12***	34.76***	38.52***
N	5553	5553	5553	5553

Local Nutritional Availability and Education with Controlling for Height: 1951-1957 Birth Cohort in Rural Counties

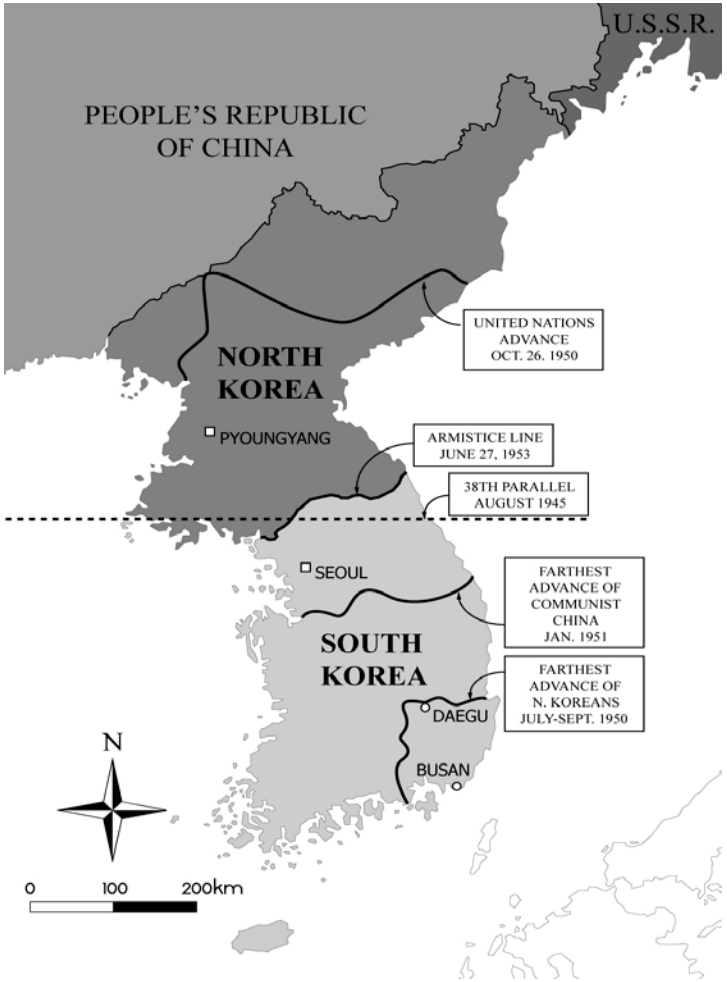
Variable	(1)	(2)	(3)	(4)
Intercept	-0.6207	-0.7651	-1.8740	-0.6377
	(1.3558)	(1.6017)	(1.5151)	(1.3059)
Local Nutritional availability				
Calories, Infancy	0.1213			
	(0.0932)			
Calories, Adolescence	0.1692***			
	(0.0445)			
Protein, Infancy		0.6330		
		(0.4226)		
Protein, Adolescence		0.5067**		
		(0.2068)		
Fat, Infancy			5.7228**	
			(2.4857)	
Fat, Adolescence			0.2528	
			(1.010)	
Carbohydrate, Infancy				0.0550
				(0.0426)
Carbohydrate, Adolescence				0.0793***
				(0.0201)
Height	0.0636***	0.0641***	0.0658***	0.0636***
	(0.0061)	(0.0062)	(0.0062)	(0.0061)
Other Characteristics	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
R-square	0.0597	0.0573	0.0549	0.0595
F-value	41.51***	40.49***	38.20***	41.85***
N	5553	5553	5553	5553

Education Regressions: Summary

- The variables on nutritional availability are positively related to the years of schooling.
- Except for fat, nutritional availability in adolescence had stronger effects on education compared to nutrition in infancy.
- One standard deviation increase in calories in adolescence (1.588 Kcal) would increase the years of schooling by 0.28 years at age 20, if other things being equal.
- One standard deviation grater productions in protein in adolescence (0.391) and carbohydrate in infancy (3.464) would increase the years of schooling by 0.33 years and 0.29 years, respectively.
- Controlling height does not change the results.
- Large stature, smaller family size and higher father's occupation were associated with more schooling.

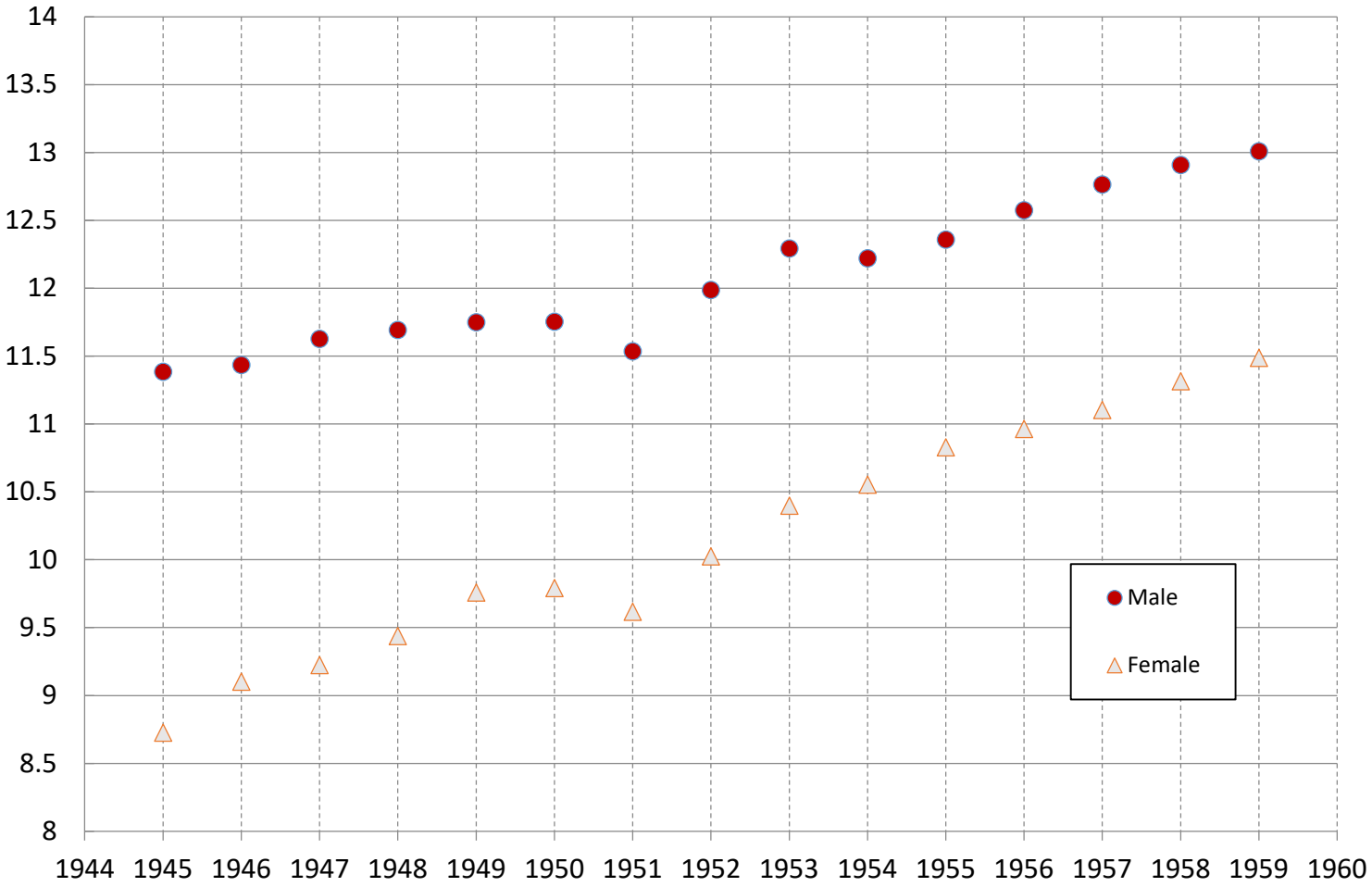
Nutrition and Effects of Early-Life Exposure to the Korean War

Long-Term Consequences of Early-Life Exposure to the Korean War (1950-1953)



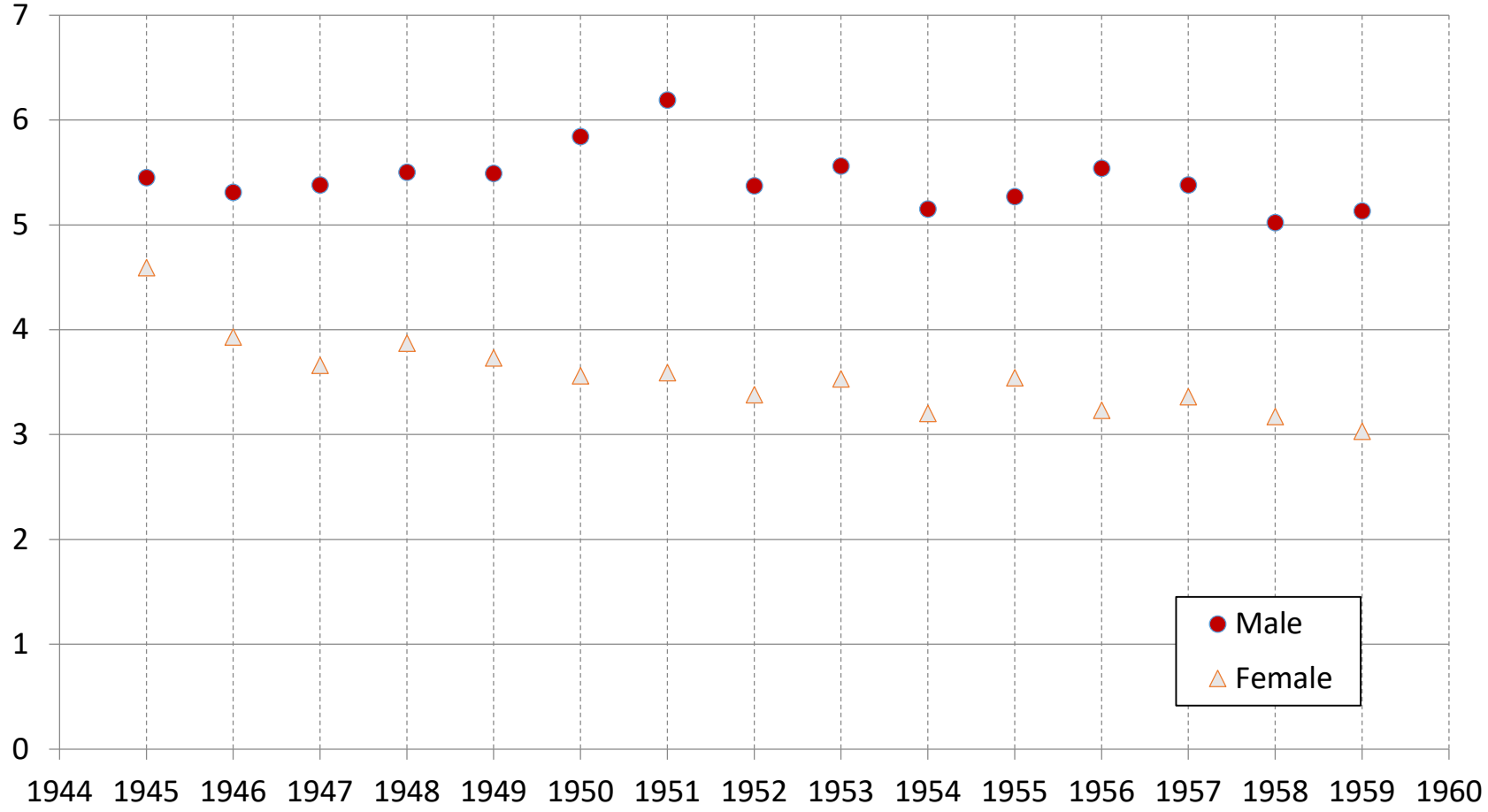
- In-utero exposure to the first 10 months of the war had long-term negative effects on socioeconomic and health outcomes.
- Lee (2014): education, occupation, marriage, mortality.
- Lee (2017): functional limitations in older age.

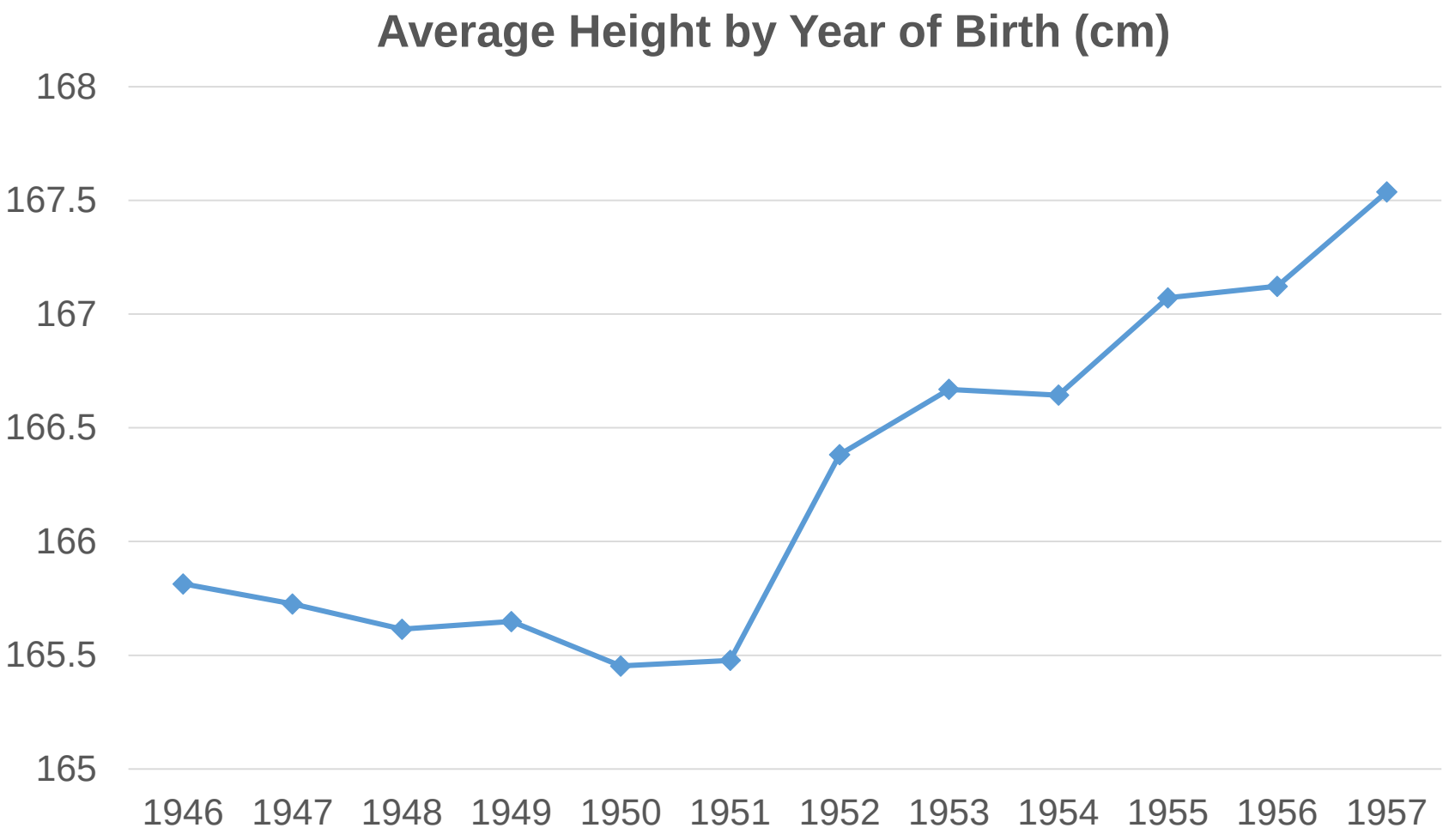
Years of Schooling by Birth Cohort: Born in the Central Region

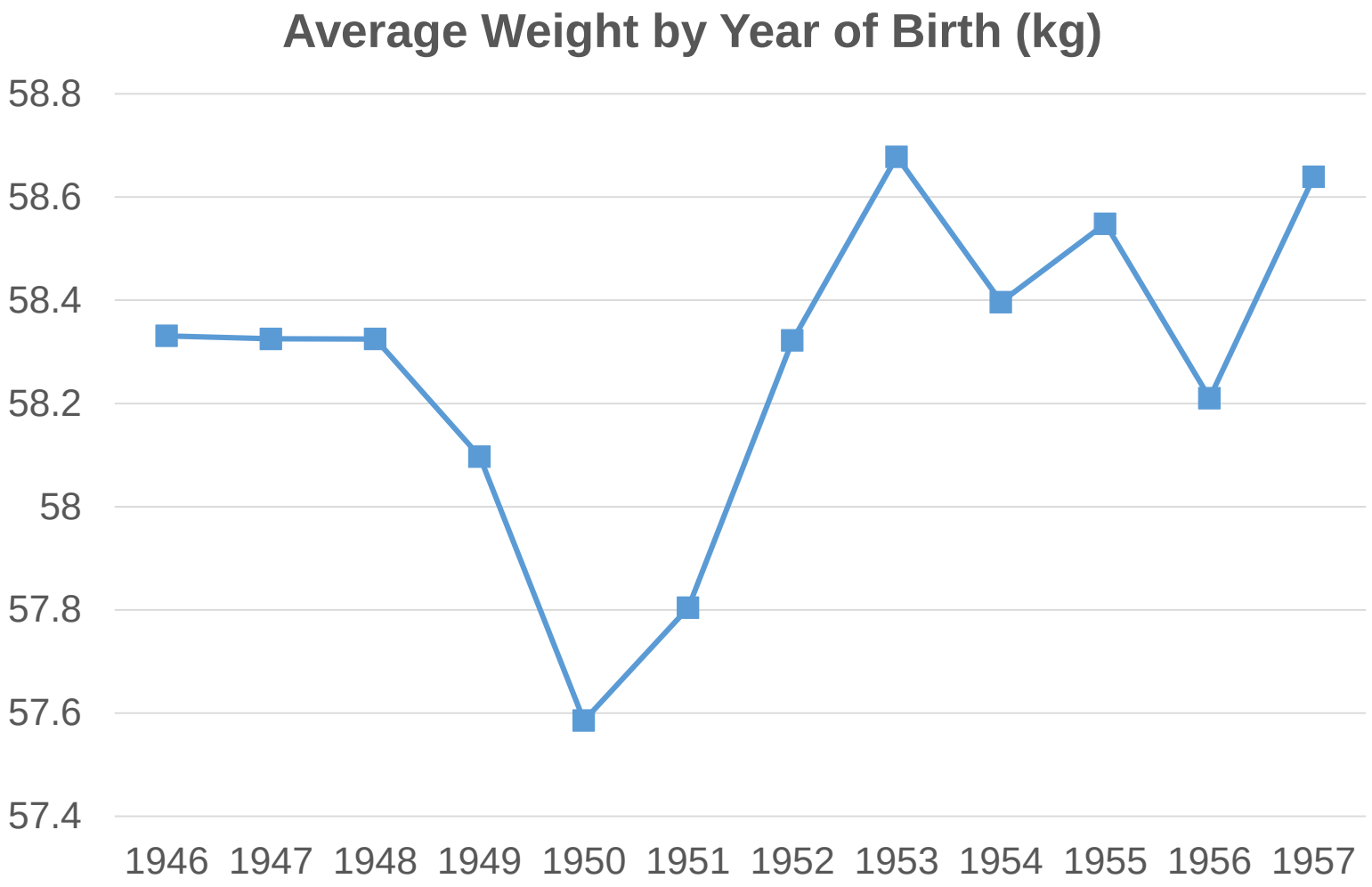


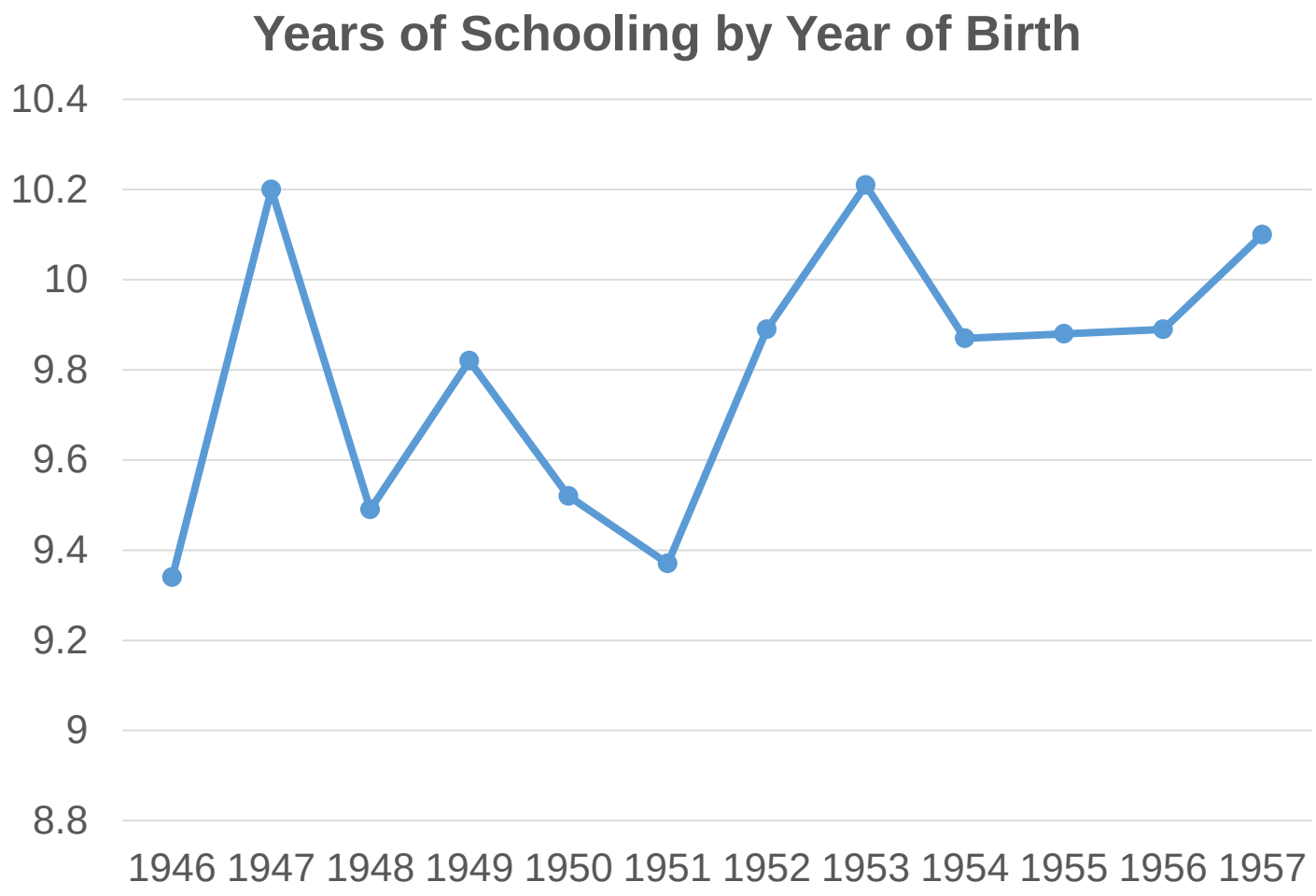
Source: Pooled data of the 2% samples of the 1990 and 2000 censuses

% Persons with Mental Impairments in 2010 Birth Cohort: Born in the Central Region




Average Height by Year of Birth (cm)
168
167.5
167
166.5
166
165.5
165
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957


Average Weight by Year of Birth (kg)
58.8
58.6
58.4
58.2
58
57.8
57.6
57.4
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957


Years of Schooling by Year of Birth
10.4
10.2
10
9.8
9.6
9.4
9.2
9
8.8
1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957

Regressions Estimating Cohort Effect

- Do outcomes of the cohorts born in 1950 or 1951 deviate from smooth cohort trend?
- Regression controlling for smooth cohort trend

$$h_i = \alpha + \sum_{t=1950}^{1951} \beta_t I_{it} + \gamma_1 YOB_i + \gamma_2 YOB_i^2 + \gamma_3 YOB_i^3 + \varepsilon_i$$

- Adding interaction term between cohort dummy (1950/1951) and local nutritional availability in adolescence for the cohort.

$$h_i = \alpha + \sum_{t=1950}^{1951} [\beta_t I_{it} + \theta_t (I_{it} \times N_{it})] + \gamma_1 YOB_i + \gamma_2 YOB_i^2 + \gamma_3 YOB_i^3 + \varepsilon_i$$

- $\beta+(\theta\times N)$ shows the magnitude of deviation from smooth cohort trend of the subject of the 1950/1951 birth cohorts who spent adolescence in counties with particular quantity (N) of local nutritional production.

Early-Life Exposure to the Korean War, Local Nutritional Availability in Adolescence, and Human Capital Outcomes at Conscriptions: Farmers' Sons from Rural Counties

Variable	(1) Height	(2) Weight	(3) Years of schooling	(4) High school entrance
(A)				
1950	-0.2993	-0.7003*	-0.4826**	-0.0580*
	(0.3439)	(0.3919)	(0.1950)	(0.0338)
1951	-0.6252*	-0.5710	-0.6401***	-0.1097***
	(0.3301)	(0.3894)	(0.1877)	(0.0311)
Cubic cohort trend Birth month	Yes	Yes	Yes	Yes
R-square	0.0244	0.0064	0.0123	0.0080
F-value	5.97***	2.05**	3.30***	2.34***
N	4016	3879	4008	4008

Early-Life Exposure to the Korean War, Local Nutritional Availability in Adolescence, and Human Capital Outcomes at Conscriptions: Farmers' Sons from Rural Counties

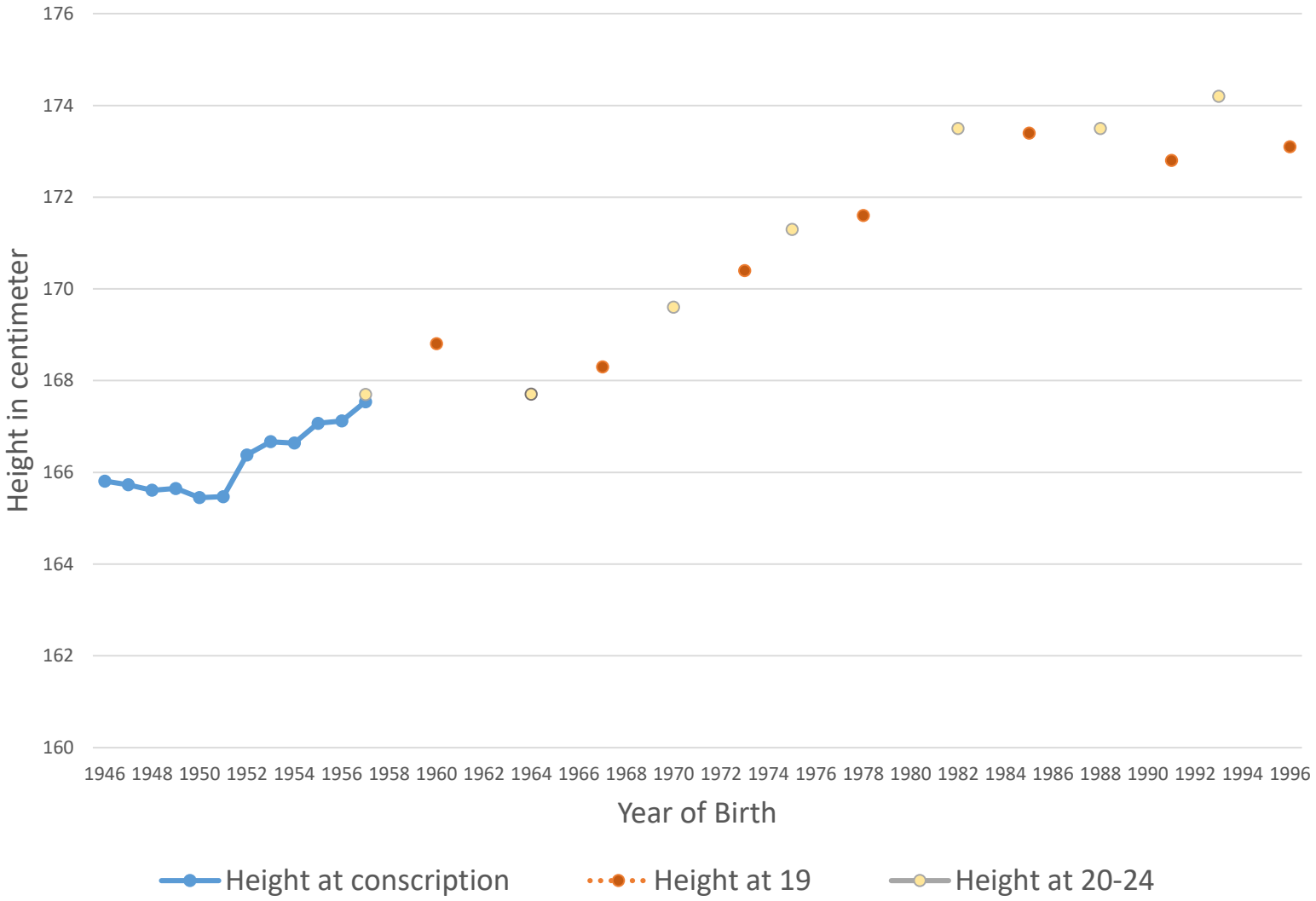
Variable	(1) Height	(2) Weight	(3) Years of schooling	(4) High school entrance
(B)				
1950	-0.2913	-2.7762**	-1.1346**	-0.1014*
	(1.0372)	(1.1667)	(0.5258)	(0.0966)
1950 × Calories, Adolescence	0.0028	0.5083*	0.1597	0.0106
	(0.2339)	(0.2841)	(0.1137)	(0.0211)
1951	-2.5892**	-0.5199	-2.1029***	-0.2811***
	(1.1637)	(1.1425)	(0.6344)	(0.0871)
1951 × Calories, Adolescence	0.4864*	-0.0130	0.3621**	0.0424**
	(0.2642)	(0.2893)	(0.1441)	(0.0189)
Cubic cohort trend, Birth month	Yes	Yes	Yes	Yes
R-square	0.0252	0.0073	0.0144	0.0102
F-value	5.55***	2.16***	3.27***	2.03**
N	4016	3879	4008	4008

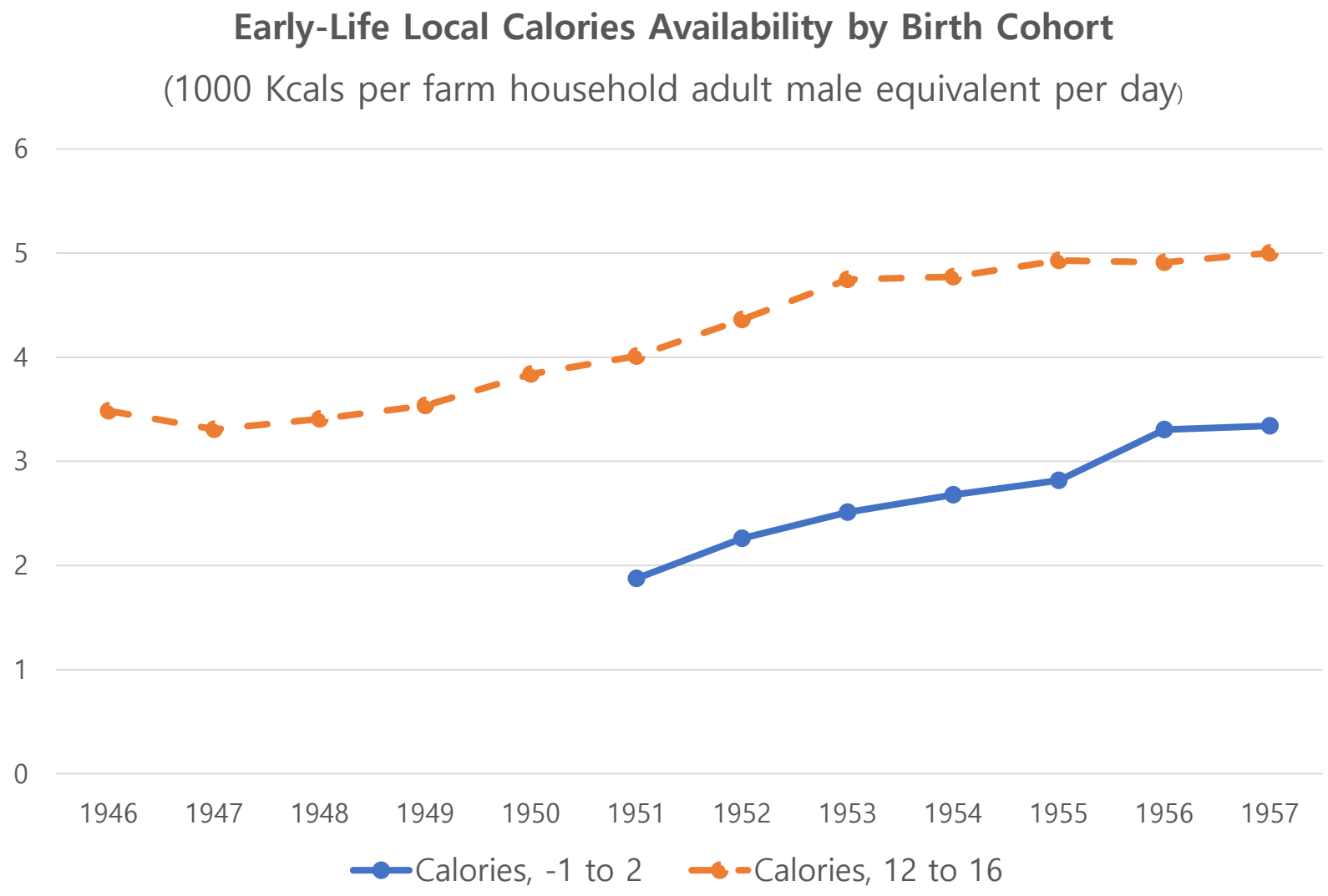
Nutrition and Effects of Early-Life Exposure to the Korean War: Summary

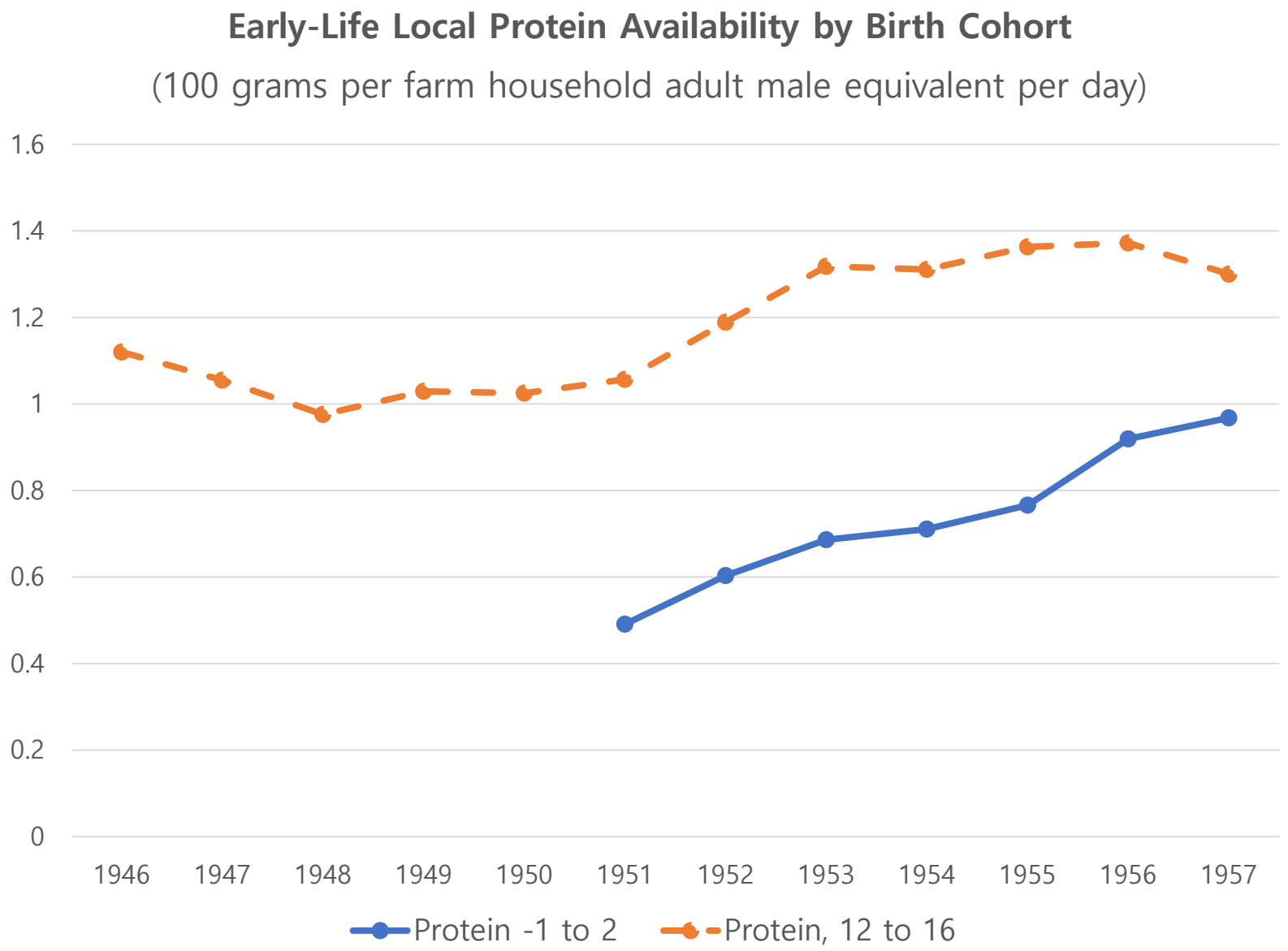
- Average height and educational attainment around age 20 of the 1951 birth cohort were lower than adjacent birth cohorts.
- Average weight of the 1950 birth cohort was significantly lower than that of neighboring cohorts.
- Interaction terms between 1950/1951 cohort dummy and the cohort's local nutritional availability in adolescence are positive and statistically significant.
- The negative cohort effects of early exposure to the war were smaller for those who lived in counties with higher nutritional availability.
- Suggestive evidence that improved nutrition in adolescence could compensate the negative consequences of early exposure to wartime shocks.

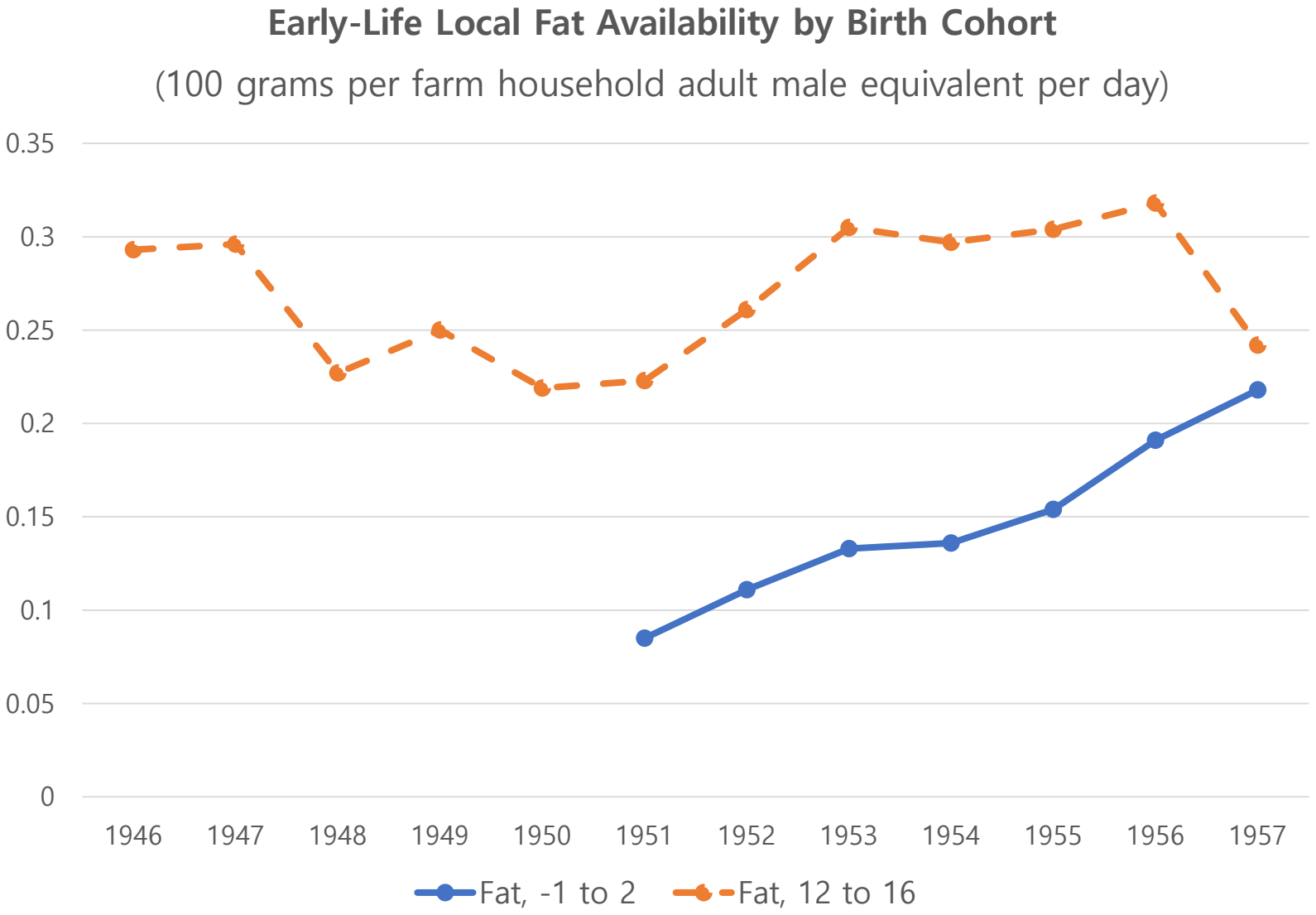
Accounting for the Increase in Height for the 1951-1957 Birth Cohorts

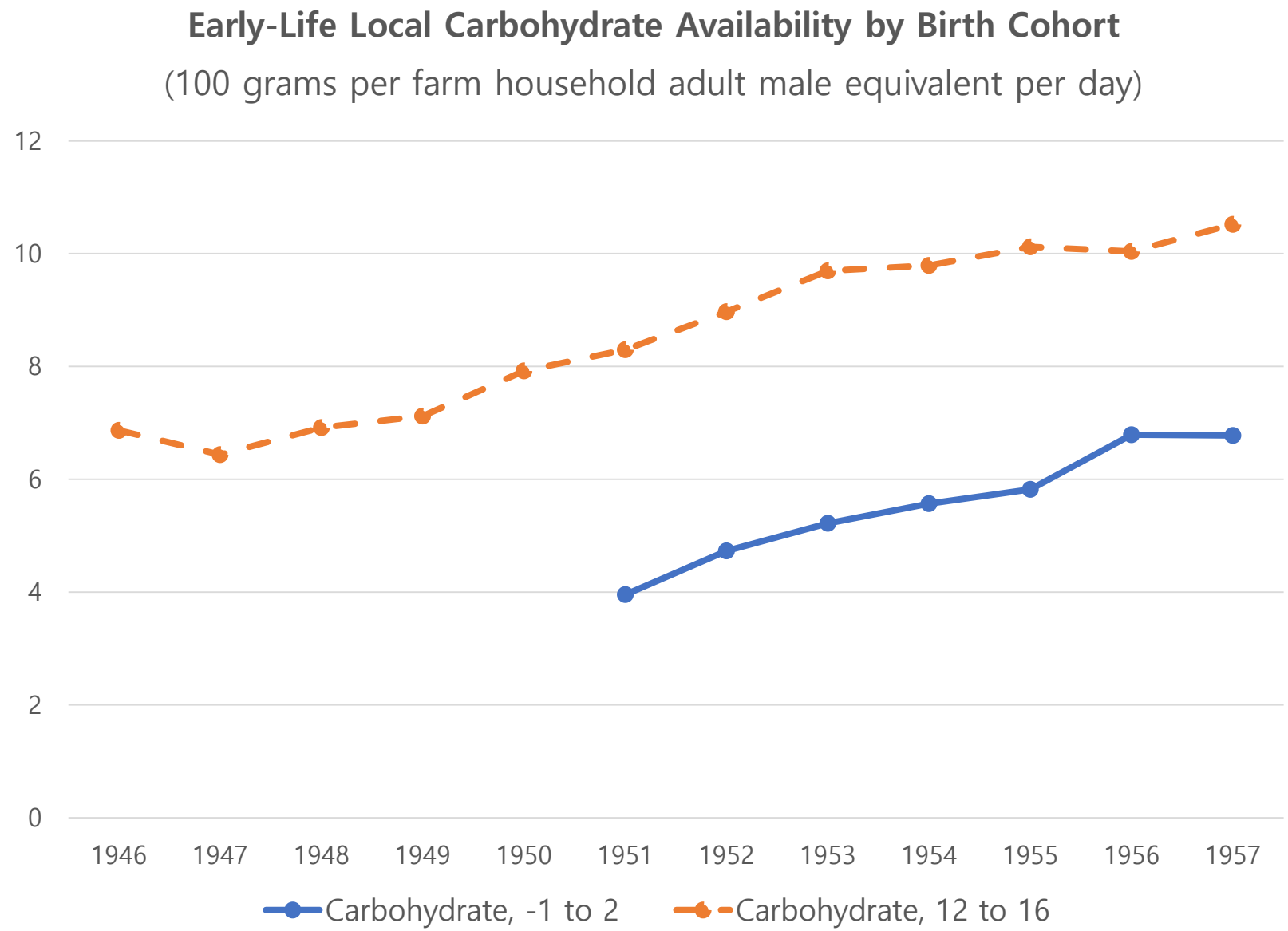
Long-Term Trends of Adult Heights in Korea
(Korean Agency for Technology and Standards data for the cohorts born after 1957)




Early-Life Local Calories Availability by Birth Cohort
(1000 Kcals per farm household adult male equivalent per day)
6
5
4
3
2
1
0
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
Calories, -1 to 2
Calories, 12 to 16


Early-Life Local Protein Availability by Birth Cohort
(100 grams per farm household adult male equivalent per day)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
Protein -1 to 2
Protein, 12 to 16


Early-Life Local Fat Availability by Birth Cohort
(100 grams per farm household adult male equivalent per day)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
Fat, -1 to 2
Fat, 12 to 16


Early-Life Local Carbohydrate Availability by Birth Cohort
(100 grams per farm household adult male equivalent per day)
12
10
8
6
4
2
0
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
Carbohydrate, -1 to 2
Carbohydrate, 12 to 16

Height Change Predicted by Increase in Nutritional Production

	(1) Calories (1000Kcals)		(2) Protein (100g)		(3) Fat (100g)		(4) Carbohydrate (100g)	
	Age -1 to 3	Age 12-16	Age -1 to 3	Age 12-16	Age -1 to 3	Age 12-16	Age -1 to 3	Age 12-16
A. 1951 cohort	1.876	4.011	0.491	1.057	0.085	0.223	3.958	8.296
B. 1952 cohort	2.260	4.361	0.603	1.189	0.111	0.261	4.731	8.973
C. 1953 cohort	2.511	4.747	0.686	1.318	0.133	0.305	5.222	9.698
D. 1954 cohort	2.678	4.773	0.711	1.311	0.136	0.297	5.576	9.792
E. 1955 cohort	2.818	4.929	0.766	1.363	0.154	0.304	5.823	10.121
F. 1956 cohort	3.304	4.910	0.919	1.372	0.191	0.318	6.793	10.042
G. 1957 cohort	3.341	5.002	0.968	1.299	0.218	0.242	6.777	10.521
H. Change (G-A)	1.465	0.991	0.477	0.242	0.133	0.019	2.819	2.225
I. Regression Coefficient	0.357	0.076	1.042	0.118+	1.388	-0.090+	0.141	0.043
J. Predicted height change (H×I)	0.523	0.074	0.497	0	0.185	0	0.397	0.096

Improved Nutrition and Increase in Height

- The increase in height between the 1951 and 1957 cohorts was considerably rapid in long-run perspectives.
  - 2 cm for 6 years (0.33cm per year); 6 cm for the next 30 years (0.2 cm per year)
- The cohort trends of nutritional availability and heights seem to match well (Figures).
- We estimated how much improved nutrition contributed to the increase in height between the 1951 and 1957 cohorts.
  - The regression coefficients (estimated from using the largest sample with necessary information) were applied to the magnitude of the change in nutritional availability between 1951 and 1957.
- Improved nutrition accounts for 30% to 50% of the increase in adult height between the 1951 cohort and the 1957 cohort.
- Increased nutritional availability during early childhood accounts for a lion's share of this contribution.

Conclusion

- Local nutritional availability in two crucial periods for human growth (early childhood and adolescence) significantly affected height and educational attainment measured at age 20.
  - Nutrition in infancy had much stronger effects on heights, whereas education was more strongly influenced by nutrition in adolescence.
- Improved nutrition in adolescence reduced the magnitude of the negative consequences of early-life exposure to the Korean War.
- Improved nutritional availability (nutrition in infancy in particular) accounts for a considerable fraction (perhaps 30% to 50%) of the increase in height from the 1951 to 1957 birth cohorts.

Implications for ODA

- Aids aiming at enhancing agricultural productivity as well as provision of foods are good investments in health and human capital in developing countries.
- Improved nutrition in late childhood can compensate nutritional deficiencies experienced during pre-natal period or early childhood.
- There might be substitutability in nutritional status in different stages of human development.
  - High return to making investment in children with poor nutritional status.
  - Especially strong substitutability between provisions of protein during early- and late-childhood.

Work in Progress / Work to be Done

- Additional indices of nutritional availability: micro nutrients (iron, vitamins, etc.)
- Effects of short-term decrease in nutritional availability caused by crop failure.
- Identifying exogenous variations in nutritional supply
  - Currently collecting inputs in agricultural productions.
  - Estimating agricultural production function
  - Identify supply shocks in agricultural production
- Investigating long-run consequences: health and socio-economic outcomes at old age.