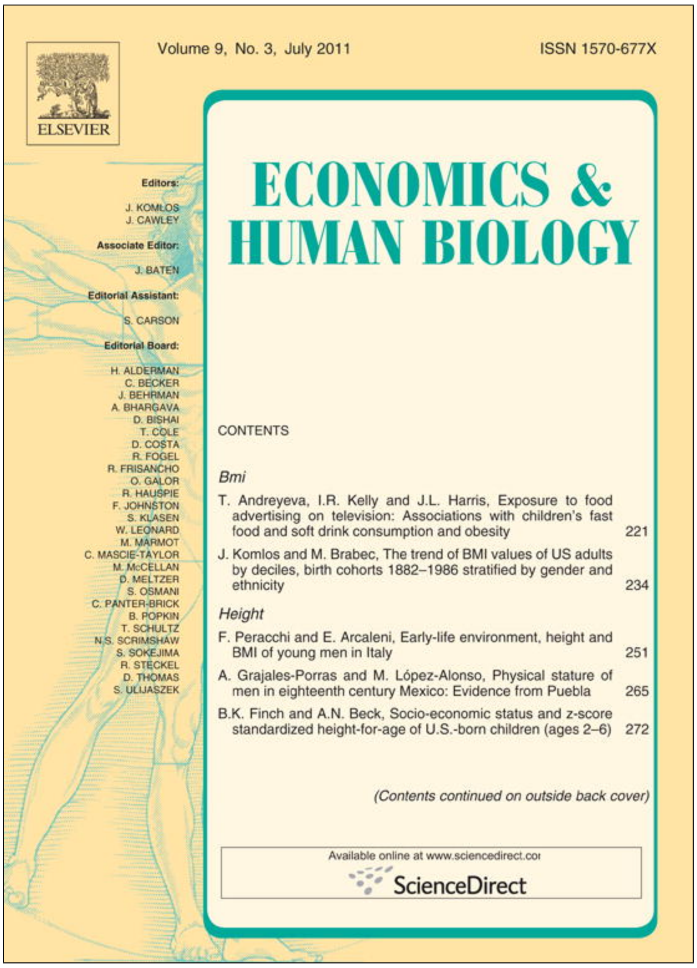
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Early-life environment, height and BMI of young men in Italy

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Abstract: This paper explores the relationship between the two main dimensions of early-life environment, namely disease burden (measured by infant mortality) and economic conditions (measured by income or consumption per capita), and height and body-mass index (BMI) for six annual cohorts of young Italian men born between 1973 and 1978. By combining micro-level data on height and weight with regional- and province-level information, we are able to link individual height and BMI at age 18 to regional and provincial averages of environmental variables in the year of birth. Our results are consistent with the hypothesis that, in rich low-mortality settings, the negative effects of childhood disease dominate the positive selection effects of mortality. We find that both income and disease matter, although income matters more than disease for height, while the opposite is true for BMI.

1. Introduction

This paper uses Italian micro-level data to examine the relationship between body height and the two main dimensions of early-life environment, namely disease burden (measured by infant mortality) and economic conditions (measured by income or consumption per capita). Body height is an indicator of health and wellbeing that complements more conventional indicators, such as self-reported health, income or consumption. For this reason, it has long been of interest to demographers, nutritionists and public health researchers, and has now become popular also among economists (Komlos and Meerman, 2007; Bozzoli et al., 2009; Deaton and Arora, 2009). In addition to height, we also consider the body-mass index (BMI), i.e. the ratio of weight to squared height, and related measures such as the fraction of people who are overweight or obese.

Italy is an interesting country to consider because of its very large and persistent regional differences in economic conditions, disease environment, access to health care, and other dimensions. These differences offer the possibility of separating the respective role of income and disease in a relatively homogeneous country, thus avoiding issues of comparability and measurement that typically arise in cross-country analysis.

The paper is organized as follows. Section 2 reviews the literature on link between childhood environment and height and BMI. Section 3 describes the data. Section 4 presents preliminary descriptive statistics. Section 5 presents the results of our regression analysis. Finally, Section 6 concludes.

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2. Literature review

Living conditions during the growing years, especially in early childhood, influence body height through their impact on net nutrition, i.e. the balance between the supply of nutrients and the demands of metabolism, physical exertion, and disease (Silventoinen, 2003; Steckel, 2009). Thus, adult height is a useful marker of the economic and disease environment in childhood. The relative abundance of data on adult height and the link between income and height have been exploited by economic historians to analyze the well-being of populations and historical periods for which other data sources are lacking (Fogel, 1994; Komlos, 1998). As argued by Deaton (2007), however, this link "is importantly contingent on the disease environment".

Several studies document the importance of childhood circumstances for adult height and health. For example, Banerjee et al. (2010) analyze the direct link between early-life environment and the height of young adult man in 19th century France. Tucker-Seeleya and Subramanian (2011) investigate the association between height of people aged 50+ in the USA and three indicators of childhood circumstances: mother's education, childhood financial hardship, and childhood health. They find a positive association between mother's education and adult height. Other studies document the role of height as a bridge between the present and the future, by showing that adult height is a strong predictor of earnings, cognitive function, and health outcomes at older ages, including longevity (Baten and Komlos, 2004; Strauss and Thomas, 2008; Case and Paxson, 2008a,b).

Body weight is a measure of mass. Unlike height, which remains stable during adult life until old age, body weight changes with the amount of fat and muscle in the body. BMI is just one way of combining weight and height into a single measure. Although not a direct measure of body fat, BMI is considered a useful but imperfect proxy for total body fat in adults (Burkhauser et al., 2009). Because it is easy to measure and calculate, BMI is the most widely used diagnostic tool to identify obesity problems within a population. As such, it has received a great deal of attention in the recent literature on the obesity epidemic and its economic and public health consequences (Cutler et al., 2003; Philipson and Posner, 2008; Brunello et al., 2009; Cawley et al., 2009; García Villar and Quintana-Domeque, 2009). The relationship between early life-environment and BMI has instead received less attention. Barker (1997) put forward the hypothesis that prenatal nutritional and disease experience is related to both small size and pathologies such as obesity and cardiovascular disease in later life. Power et al. (2003) find that gestation/early infancy for men and the period of "adiposity rebound" (5–7 years) for women are important periods during which socio-economic conditions may influence adult obesity. Kestilä et al. (2009) find that childhood circumstances, such as parental-education, parental unemployment and single-parent family, increase the risk of being overweight or obese in early adulthood (18–29 years of age). They also find that their effect is stronger on obesity than on overweight, and in women than in men.

Early-life environment not only affects height, and possibly BMI, but also plays a prominent role in the development of cognitive and non-cognitive skills (Cunha and Heckman, 2007; Strauss and Thomas, 2008; Cawley and Spiess, 2008; Doyle et al., 2009; Currie, 2009). Our paper does not consider problems of skill formation and focuses exclusively on physical development. It complements recent work by Akachi and Canning (2007, 2010); Bozzoli et al. (2009); Bosch et al. (2009) and Hatton (2011) who use cohort data, aggregated at the country, region or town level, to explore the relationship between adult height and the two main dimensions of early-life environment, namely income and disease, trying to establish their respective roles.

Akachi and Canning (2007) focus on mean cohort height of women born between 1945 and 1985 in 25 countries of Sub-Saharan Africa. They combine country-level averages of micro-data on height from the Demographic and Health Surveys (DHS) with country-level data on infant mortality, GDP per capita, and average protein and calorie consumption. Although country effects capture most of the observed variation in cohort height over time, they find some role for the variables that describe the early-life environment. Akachi and Canning (2010) analyze trends in infant mortality rates and adult height in 39 developing countries since 1961. They show that while improved nutrition and reduced childhood exposure to disease have lead to improvements in both infant mortality and adult stature in most regions of the world, in Sub-Saharan Africa adult height has not increased despite declining infant mortality rates. They attribute this finding to interventions that prevent infant deaths, rather than improved nutrition and childhood morbidity.

Bozzoli et al. (2009) combine data on mean height of cohorts born between 1950 and 1980 in the USA (from the National Health Interview Survey) and 11 European countries (from the European Community Household Panel) with country-level data on infant mortality and GDP per capita. They find that postneonatal mortality (defined as death between one month and one year of age) is strongly negatively associated with height even after controlling for GDP per capita and country and year effects. They argue that "given that postneonatal mortality is a sensitive indicator of the disease environment in the first year of life, these results support accounts in which some form of 'scarring' in infancy negatively affects lifetime health, as marked by adult height. In [. . .] low mortality countries, the stunting effect of childhood disease dominates any possible height-based selective mortality in childhood that would induce a positive relationship between disease in early life and adult health". Based on these findings, they develop a formal model in which the early life burden of nutrition and disease is not only responsible for mortality, but also may lead to lower adult height and a higher risk of late-life disease. Their model predicts that, at sufficiently high mortality levels, selection (the positive effect of mortality on height) dominates scarring (the stunting effect on the height of survivors) leaving a taller population of survivors. Using data for developing countries from the DHS, they find evidence of this on women height in the poorest and highest mortality countries of the world.

Bosch et al. (2009) combine data on mean height of cohorts born between 1969 and 1999 in 17 Spanish regions (from the Spanish Health Survey) with region-level data on infant mortality and GDP per capita. They find that infant mortality dominates the relationship between adult height and early-life environment. Hatton (2011) uses data on the average height of children aged 6–13 in 20 towns and rural districts of England and Scotland during the period of rapid decline in infant mortality between 1910 and 1950. He finds some evidence of scarring, but no evidence of selection. Both papers suggest that improvements in the disease environment account for an important fraction of the observed increase in average height. Their paper are the most similar to ours in that they look at differences within a single developed and relatively homogeneous country. Focusing on a single country, as they do, has the important advantage of avoiding the problems associated with cross-country differences in the definition and measurement of the variables describing early-life environment, and the issue of what country effects stand for. Both these issues can hardly be ignored in cross-country studies.

3. Data

Our paper examines the relationship between early-life environment and anthropometric outcomes in early adulthood for six annual cohorts of Italian men born between 1973 and 1978. We combine two different types of data: individual-level data on height, weight and a few demographic variables, and aggregate data on early-life environment. The individual-level data are drawn from the Italian military archives, which contain detailed information on the conscripts for the Army and the Air Force. Most of the information describing the early-life environment consists instead of aggregate data at the region and province level on economic conditions and disease burden in the year of birth of the conscripts.

3.1. Height and weight

These data are drawn from the Italian military archives, which contain individual-level information on all the men who, between 1991 and 1996, underwent the compulsory medical inspection to ascertain fitness for service in the Army and the Air Force. Our data have been obtained by merging several electronic tapes produced by the Italian Ministry of Defense and stored at the Italian National Statistical Institute (Istat).[1] To our knowledge, this is the first time that they are used for scholarly research.

During the period considered, the military draft was organized as follows. Each year, municipal authorities compiled a conscription list with the names of all resident Italian male citizens who turned 17 that year. The following year, when draft operations started, the conscription list was updated taking changes of citizenship into account, dropping those who died or were selected for the Navy draft, and adding draft dodgers and people deferred from the previous draft or erroneously omitted. Every conscript on the list was expected to show up at the local conscription center (about one per province) for the medical inspection, or send a justification to avoid being declared a dodger. Although we do not know the exact date of the medical inspection, regulations required that it took place within three months from the 18th birthday. After the inspection, conscripts were assigned to three categories: fit for service, unfit for service, or deferred to the next draft. In a few special cases (e.g., residents abroad, people already enrolled in military bodies as volunteers, or people with a documented serious disability), the assignment was made without medical inspection.

The individual-level information generally available in our data includes: the year of the medical inspection, the place of birth (province and municipality, or foreign born), the place of residence (province and municipality, or resident abroad), the date of birth (day, month and year), the reasons for cancelation from the conscription list, the reasons for exemption from medical inspection, the result of the physical and psychological examination (fit, unfit, or deferred to the next draft), the reason for being declared unfit, height (in cm), and weight (in kg). From this information, we compute the individual BMI as the ratio of weight to squared height (kg/m^2). We do not use other information contained in the data, such as marital status, educational attainments, type of job, thoracic perimeter, a synthetic health profile, and a measure of general intelligence, because it is more fragmentary and less reliable.

Compared to the survey data usually employed in the literature, our data offer several important advantages. First, due to the compulsory nature of military service in Italy during the period considered, they provide nearly complete coverage of the population subject to the Army and Air Force draft. On average during our period, conscripts represent 96% of all men born 18 years before, the remainder 4% consisting of non Italians and people who changed citizenship or died. Our data cover 96.5% of the Army and Air Force conscripts, which represent 87.1% of all the conscripts, the remainder 12.9% consisting of the Navy conscripts (Ilari and Battistelli, 2005). Second, because of the large size of our data, issues of statistical precision are of second order. Third, we control for age at the time of the medical inspection, thus avoiding spurious effects due to changes in the age composition of the sample (A'Hearn et al., 2009). Fourth, the available measures are the outcomes of a detailed physical inspection by a medical team and do not suffer the distortions typically associated with self-reported measures. This is important because people tend to underreport their weight and overreport their height, resulting in underestimation of BMI and related measures (see e.g. Bolton-Smith et al., 2000; Danubio et al., 2008).

Our data are not without problems, however. First, only men were subject to military conscription, so we have no information on women.

[1] The tapes were produced in the late 1990s by a working group composed of Istat researchers, Army officials and university professors. The group dissolved after the sudden death of its leader, Floriano Pagnanelli. For further information on these data please contact Emilia Arcaleni (arcaleni@istat.it).

Second, the lack of data on conscripts for the Navy raises issues of selection bias. These conscripts were selected from coastal areas and among people with particular skills (shipyard work experience, fishing activities, or maritime studies), and were examined by different selection teams in two centralized sites. Taking the Navy draft into account, the size of our provincial samples roughly matches Istat demographic data on cohort size by province. The available evidence suggests that excluding the Navy draft should not cause important biases, at least not for mean height. For example, using data for the 1928–1929 birth cohorts, Arcaleni (1998) shows that Navy conscripts from Southern regions were slightly taller on average than the other conscripts (less than 2 mm) although, at the national level, there was no noticeable difference. These small regional differences may be attributed to a healthier diet (more fish) and better life conditions in coastal areas.

Third, we focus on conscripts aged 18. This may still be a relatively early age and adult height may not have been reached by a non-negligible fraction of conscripts, especially in areas of the country lagging behind economically.

Fourth, our data were originally collected for administrative purposes, so they lack the rich personal and household-level information that is typically available in household surveys. In particular, they offer little information on early-life environment, except that on date and place of birth and that on migration patterns obtained by comparing the place of birth with the place of residence at the time of the medical inspection. Thus, our strategy consists of relating individual height and BMI to the few variables available at the individual level and to region- and province-level information on economic conditions and disease burden in the year of birth of each cohort.

Finally, other problems in our data include missing records and accuracy of measurements. In particular, we have a large fraction of missing data for conscripts from Sardinia born in 1974, a relatively large fraction of missing data on weight, and some evidence of rounding and heaping in measured height and weight. Other minor issues include editing errors and a few duplicated records in the available data. After discarding the very few cases with missing values on age, place of birth and place of residence, we are left with an average sample of about 333 thousands annual observations on the cohorts born between 1973 and 1978 (Table 1). The cases with missing or implausible values for height (namely height below 60 cm or above 250 cm) represent only 1% of the available cases. Missing data on weight, and therefore BMI, is more of a problem. In particular, the fraction of cases with BMI missing is especially high for the 1973 and 1978 cohorts (17.3%), but falls steadily for the later cohorts reaching 6.6% for the 1978 cohort.

3.2. Early-life environment

To describe the early-life environment we use region- and province-level data on economic conditions and disease burden in the year of birth of the conscripts. These data refer to the Italian regions and provinces existing in the early 1970s. For consistency, we work with data broken down into 94 provinces, 18 regions and 5 macro-regions (or areas), namely North-West, North-East, Center, South, and Islands (Sicily and Sardinia). The average size of an Italian province is about 600 thousands inhabitants, that of an Italian region is about 5 times larger.

Our main indicator of economic conditions is income per capita in real terms. For regional incomes we use the series of real value added per capita at 1990 prices produced in the late 1990s by the Istituto per lo Sviluppo del Mezzogiorno (Svimez). For provincial incomes we use the series at 1999 prices produced in 2001 by the Istituto Guglielmo Tagliacarne (IGT). As a proxy of economic conditions we also consider private consumption per capita at 1990 prices, only available at the regional level from Svimez. All series use region-level prices to deflate nominal values. The main drawback of provincial data is that, being largely based on the decennial census, they are only available every ten years. The available years closest to the span of our height and weight data are 1971 and 1981. We use them to impute the provincial values for the years from 1973 to 1978 by interpolation, which may be justified by the low-frequency nature of the relationship linking height, weight and early-life environment.

Our main indicator of disease burden is infant mortality, namely the fraction of newborn males who die before their first birthday (per thousand) by region or province. Unfortunately, unlike Bozzoli et al. (2009), our data do not allow us to distinguish between neonatal and postneonatal mortality. Region-level data at the annual frequency have been obtained from Istat. Because these data are only available from 1974, we impute the values for 1973 using the predictions from simple time-trend models fitted separately by region. Province-level data, taken from the database constructed by Professor Graziella Caselli of the University of Rome "La Sapienza", are only available at decennial intervals and are computed as averages over a 3-year period. Similarly to what was done for provincial

Table 1
Anthropometric characteristics of our sample.

Cohort	Total obs.	Height (cm)			Weight (kg)			BMI (kg/m^2)			Overw.	Obese
		N	Mean	Std.	*N*	Mean	Std.	*N*	Mean	Std.	%	%
1973	372,467	369,116	173.6	6.8	304,608	68.3	10.5	304,595	22.6	3.1	15.4	2.9
1974	348,701	345,594	173.9	6.7	292,004	68.5	10.6	291,973	22.6	3.1	15.4	2.9
1975	343,945	341,063	173.9	6.8	303,000	68.5	11.1	302,967	22.6	3.3	15.3	3.3
1976	326,335	320,182	173.9	6.8	289,178	68.6	11.1	287,249	22.6	3.3	15.5	3.4
1977	306,710	303,875	173.9	6.7	282,694	68.7	11.3	282,664	22.7	3.3	15.7	3.6
1978	296,881	294,446	173.8	6.7	277,349	68.6	11.5	277,236	22.7	3.4	15.7	3.8

incomes, we use the data for 1971–1973 and 1981–1983 to impute provincial values for the years 1973–1978 by interpolation.

In addition to income per capita and infant mortality, we consider province-level indicators of the quality of the housing stock (the average number of people per room and the percentage of homes without a toilet), the ease of access to the health-care system (the number of hospital beds per 1000 people), and extra indicators of the disease environment such as the mortality of mothers (proxied by the female mortality rate for the 25–29 age group) and the number of cases of measles, mumps and rubella (MMR) and chickenpox, pertussis and scarlet fever (CPSF) per 1000 inhabitants. Following Thomas et al. (1991), we also consider province-level indicators of the educational attainments of mothers, such as the fraction of women aged 6+ who are illiterate or hold at least a high-school degree. The indicators of the housing stock and the indicators of the educational attainments of mothers are drawn from the 1971 and 1981 censuses, while the indicators of the health care system and the incidence of MMR and CPSF are drawn from administrative health statistics for 1971 and 1980. Mortality rates of mothers are taken from the Caselli database. Similarly to what was done for real incomes, for all province-level indicators we impute the values for the years 1973–1978 by interpolation.

4. Descriptive statistics

The total number of available observations in our data falls steadily from about 372 thousands for the 1973 cohort to about 297 thousands for the 1978 cohort, a decline of about 20% (Table 1). This trend is largely due to the shrinking size of the cohorts born after 1964, the year when the baby boom reached its peak in Italy. According to Istat demographic statistics, after decreasing slowly from 1964 to 1973, cohort size in Italy began falling swiftly from about 888 thousands life births in 1973 (of whom 450 thousand were males) to about 721 thousands in 1978 (of whom 365 thousand were males), a decrease of about 19%. This reflects the rapidly declining fertility of Italian women, a trend that during the period considered affects mainly the regions in the North and the Center, and is the result of the increasing share of women with at most two children. The delay in childbearing starts only in the late 1970s, and is not an issue for the period that we consider (Pinnelli et al., 2001).

Mean height at age 18 changes little between the 1973 cohort (173.6 cm) and the 1978 cohort (173.8 cm). This pattern, which contrasts sharply with the rapid height growth experienced by the cohorts born in the 1950s and 1960s (Arcaleni, 2006), mainly reflects three factors: a small increase of mean height in the Northern regions (equal to .25 cm in the North-West and .20 cm in the North-East) where conscripts are on average taller, a more sizeable increase of mean height in the Southern regions (equal to .38 cm in the South and .35 cm in the Islands) where conscripts are on average shorter, and a rising importance of the Southern regions, whose weight in the sample increased from 38.6% for the 1973 cohort to 42% for the 1978 cohort.

Mean weight at age 18 increases slightly from 68.3 kg for the 1973 cohort to 68.6 kg for the 1978 cohort, whereas mean BMI at age 18 goes from 22.6 for the 1973 cohort to 22.7 for the 1978 cohort. Again, this is mainly a compositional effect, due to the rising importance of the Southern regions, where conscripts have on average a higher BMI than in the North and the Center.

Although mean weight and mean BMI change only little across cohorts, their variability increases substantially at the national level, with the standard deviation of weight rising from 10.5 to 11.5 kg and the standard deviation of BMI rising from 3.1 to 3.4. As a result of the rising dispersion, the fraction of overweight conscripts ($25\leq$ BMI <30) increases from 15.4% for the 1973 cohort to 15.7% for the 1978 cohort, while the fraction of obese conscripts (BMI ≥ 30) increases more substantially from 2.9% for the 1973 cohort to 3.8% for the 1978 cohort. Table 2 presents means and standard deviations of our region-level indicators of early-life environment. Two opposite trends were at work for the cohorts considered. In the case of infant mortality, both the mean level and the variability between regions fell. The mean fell by one third between 1973 and 1978 (from 28.7 to 19.4 deaths per thousand), whereas the between-region variation, measured by the standard deviation, fell by more than 40% (from 6.3 to 3.6 deaths per thousand), as infant mortality dropped more in the South and the Islands where it was initially higher. In the case of income and consumption per capita, instead, both the mean and the variability between regions increased, with the variability increasing faster than the mean. For example, the mean of real income per capita increased by 16% (from 15.1 to 17.5 million Liras at 1990 prices), whereas its standard deviation increased by 21% (from 3.4 to 4.1 million Liras). The pattern for consumption per capita, which represents about 60% of income per capita, is very similar. Thus, while Italian regions became more equal in terms of infant mortality, they became less equal in terms of income and consumption per capita.

Table 2
Mean and standard deviation of region-level variables describing early-life environment.

	Infant mortality		Income per capita		Consumption per capita	
Cohort	Mean	Std.	Mean	Std.	Mean	Std.
1973	28.7	6.3	15.1	3.4	8.7	1.6
1974	25.3	5.4	14.7	3.1	8.7	1.6
1975	24.4	5.1	15.6	3.6	9.1	1.8
1976	22.5	3.9	16.0	3.6	9.4	1.8
1977	21.2	3.9	16.5	3.8	9.7	1.9
1978	19.4	3.6	17.5	4.1	10.4	2.0

Data sources: Infant mortality (per thousands) from Istat; income and consumption per capita (in million Liras at 1990 prices) from Svimez.

Table 3
Correlation patterns at the region level.

	Height	Weight	BMI	Infant mort.	Income pc
Weight	.526				
BMI	−.345	.615			
Infant mort.	−.487	−.152	.286		
Income pc	.731	.150	−.507	−.668	
Consumption pc	.792	.238	−.464	−.692	.960

Data sources: Infant mortality from Istat; income and consumption per capita from Svimez.

Table 3 describes the correlation pattern of our variables at the region level. Height at age 18 is strongly positively correlated with weight, income per capita and consumption per capita, and negatively correlated with BMI at age 18 and infant mortality. Weight at age 18 is strongly positively correlated with BMI, negatively correlated with infant mortality, and positively but weakly correlated with income and consumption per capita. BMI at age 18, on the other hand, is weakly positively correlated with infant mortality and negatively correlated with income and consumption per capita. Although not shown in the table, there is also a substantial amount of correlation between the variables describing early-life environment. In particular, income and consumption per capita are very strongly positively correlated (their correlation coefficient is above 90%), while infant mortality is negatively correlated with income and consumption per capita.

Turning to the province level, Figs. 1 and 2 show the scatterplots of average provincial height at age 18 for the 1973 and 1978 cohorts against, respectively, infant mortality and real income per capita in 1973 and 1978 (both on a log scale). The 1973 and 1978 cohorts are distinguished using different shades of grey. We also use a triangle for the provinces in the North-Center (North-West, North-East and Center) and a circle for those in the South (South and Islands). The solid lines are the fits from bivariate OLS regressions using province-level data. Figs. 3 and 4 show the scatterplots of average provincial BMI at age 18 against our two main environmental indicators. The

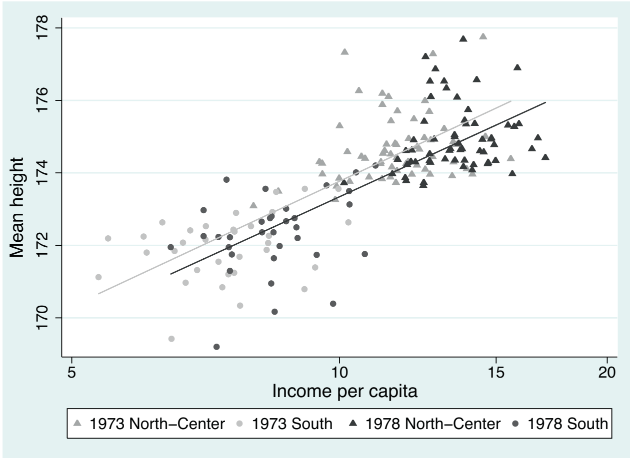

Fig. 2. Income per capita at birth and mean height at age 18 by province.

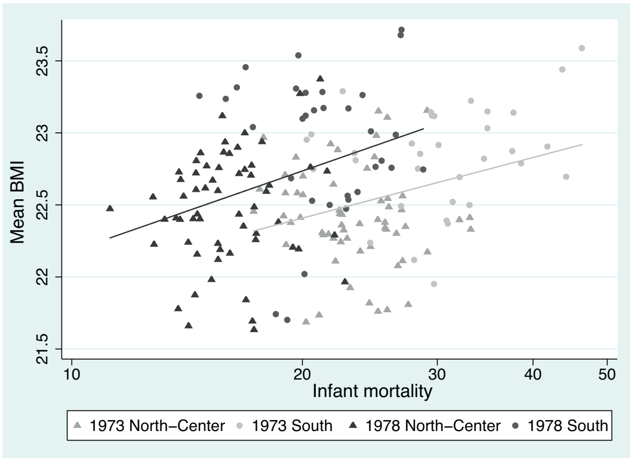

Fig. 3. Infant mortality at birth and mean BMI at age 18 by province.

figures reveal the presence of strong differences between the North-Center and the South: the former has taller conscripts, lower BMI, lower infant mortality, and higher incomes, while the latter has shorter conscripts, higher BMI, higher infant mortality, and lower incomes. In general, the R^2 is highest (about 60%) for the regressions

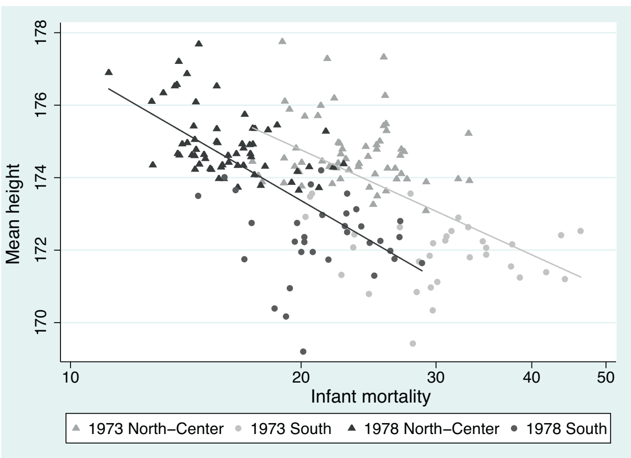

Fig. 1. Infant mortality at birth and mean height at age 18 by province.

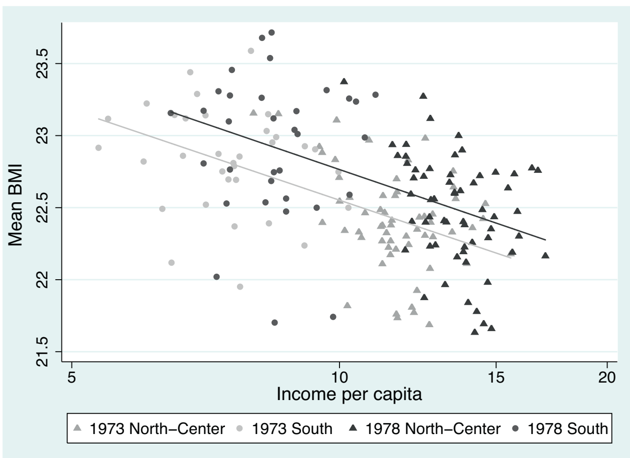

Fig. 4. Income per capita at birth and mean BMI at age 18 by province.

Table 4
Mean and standard deviation of environmental variables at the province level and correlation with income per capita.

	1971			1981		
	Mean	Std.	Corr.	Mean	Std.	Corr.
Income pc (million Liras)	9.7	2.3		12.9	3.1	
Infant mortality (‰)	28.3	6.9	−.529	13.5	3.0	−.412
People per room	.94	.16	−.581	.95	.14	−.669
No toilet (% homes)	5.9	5.5	−.601	1.9	1.5	−.484
Hospital beds (‰)	10.7	4.4	.506	9.9	2.9	.466
Female mort. 25–29 (‰)	3.9	.8	−.339	2.6	.6	−.044
Incidence of MMR (‰)	2.4	1.8	.494	1.2	.9	.377
Incidence of CPSF (‰)	1.0	.9	.591	1.6	1.3	.562
Female HS grad. (%)	5.8	1.1	.293	10.3	1.5	.351
Female illiteracy (%)	7.1	5.7	−.765	4.3	3.6	−.754

Data sources: Mortality from Caselli; income per capita (at 1999 prices) from IGT; people per room, no toilet, female education from censuses; hospital beds, female mortality, MMR and CPSF from Istat.

of height on log real income, and lowest (about 11%) for the regressions of BMI on log infant mortality.

Table 4 presents the mean and standard deviation in 1971 and 1981 of the environmental variables at the province level and their contemporaneous correlation with income per capita. The main changes observed between 1971 and 1981 are a significant increase in incomes per capita (an increase of about 34%) and in the fraction of women with a high-school or a university degree, and a sharp decline in infant mortality, female mortality for the 25–29 age group, the fraction of illiterate women, the fraction of homes without toilet, and the incidence of infectious disease such as measles, mumps and rubella, but not chickenpox, pertussis and scarlet fever. The average number of hospital beds and the number of people per room change instead only slightly.

At the same time, we observe a substantial reduction of the between-province variation for most indicators except income per capita, the fraction of women with a high school degree, and the incidence of chickenpox, pertussis and scarlet fever. As for the correlation between income per capita and the other environmental variables, in 1971 this is highest in absolute term for the fraction of illiterate women (−.77), followed by the fraction of homes without toilet (−.60), the incidence of chickenpox, pertussis and scarlet fever (.59), and the number of people per room (−.58). In 1981, it is again highest for illiterate women (−.75), followed by by the number of people per room (−.67), the incidence of chickenpox, pertussis and scarlet fever (.56), and the fraction of homes without toilet (−.48).

5. Regression analysis

In this section we present the results obtained by regressing four outcomes, namely individual height and BMI plus indicators for being overweight or obese, on variables describing economic conditions and disease burden in the year of birth of each cohort. We present results separately depending on whether environmental variables are measured at the region (Section 5.2) or province level (Section 5.3).

Table 5
Height and BMI regressions with region-level environmental variables.

	Height				BMI			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log infant mortality	−.994 ***	−.288	−.422 *	−.384 *	.160	.188	1.338 ***	1.401 ***
	(.245)	(.267)	(.235)	(.226)	(.133)	(.161)	(.184)	(.185)
Log income pc	3.704 ***		−.647		−1.311 ***		−1.217 ***	
	(.185)		(.583)		(.118)		(.231)	
Log consumption pc		5.997 ***		1.737 **		−1.621 ***		−.502
		(.330)		(.693)		(.159)		(.373)
Dummies:								
Area			Yes	Yes			Yes	Yes
Cohort			Yes	Yes			Yes	Yes
Month-of-birth			Yes	Yes			Yes	Yes
Migration			Yes	Yes			Yes	Yes
No. regressors	2	2	45	45	2	2	45	45
Adj. R^2	.0259	.0289	.0382	.0382	.0123	.0104	.0199	.0195
RMSE	6.67	6.66	6.63	6.63	3.22	3.22	3.21	3.21
F-Stat.	266	291	134	133	62.5	53	41.6	41.4

Note: Sample size *N* = 1,974,286.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

5.1. Methods

Our model for height and BMI is the linear regression

$$Y_{icr} = \alpha + \beta' X_{cr} + \gamma' W_{cr} + \delta' Z_{icr} + \tau_c + \mu_r + U_{icr}$$

where Y_{icr} is the outcome of interest for individual i of cohort c in region or province r, X_{cr} is the vector of focus regressors, namely the logarithms of infant mortality and income or consumption per capita in the year of birth of the individual, W_{cr} is a vector of additional province-specific regressors, such as indicators of quality of the housing stock and ease of access to the health care system, Z_{icr} is a vector of individual-specific regressors, such as indicators for the month of birth and the migration pattern, τ_c is a cohort effect, μ_r is an area or region fixed effect, U_{icr} is a random error assumed to be mean-independent of all variables on the right-hand side of the regression, and α, β, γ and δ are unknown parameters to be estimated by ordinary least squares (OLS). When the outcome is the indicator for being overweight or obese, we use a logit specification instead of linear regression, and we estimate the model parameters by maximum likelihood instead of OLS.

Tables 5 and 6 show the results for the case when the environmental variables are measured at the region level. To better understand the role of our two focus regressors, namely infant mortality and income per capita, we also consider regressions with environmental variables measured at the finer province level (Tables 7–10). Standard errors, reported in parentheses under the point estimates, are robust to heteroskedasticity of unknown form and are clustered geographically by municipality. At the bottom of the tables, F and χ^2 respectively denote the F and chi-square statistics for the significance of the linear and logit regressions.

5.2. Region-level environmental variables

We use four different specifications for the region-level regressions. The baseline specifications (1) and (5) include as regressors only the constant term and the logarithms of infant mortality and real income per capita in the year of birth. Specifications (2) and (6) instead use the logarithm of private consumption per capita as a measure of economic conditions. Specifications (3)–(4) and (7)–(8) are analogs of (1)–(2) and (5)–(6) with added dummies for year and month of birth, area of birth, birth in a maritime province (to partly control for the Navy draft), and migration pattern. Our set of dummies for migration pattern distinguishes between changes of province within the same region, changes of region within the same area, and changes from one area to another. Ignoring the dummies for month of birth and migration pattern, the models for height and BMI may be interpreted as regressing the deviations of individual outcomes from their area-level averages on the deviations of region-level regressors from their area-level averages. Dividing by 10 the coefficients in the tables, gives an estimate of the difference in the mean value (or in the log-odds) of an outcome associated with a 10% change in one of the focus regressors, holding all the other regressors constant.

Deaton (2007) and Bozzoli et al. (2009) argue that in richer low-mortality settings, such as contemporary Italy, the effect of infant mortality on height is likely to be negative as the stunting effect dominates the selection effect. The results in column (1) of Table 5 support their conclusion by indicating that a 10% reduction in infant mortality, other things being equal, is associated with an increase of about .10 cm in mean height. However, this effect is small compared to the increase of about .40 cm associated with a 10% increase in income per capita. Measuring economic conditions by consumption rather than income per capita (column (2)), further weakens the effect of infant mortality and increases the effect of economic conditions. When we include our full set of dummies (columns (3) and (4)), the coefficient on consumption remains positive and sizeable but the coefficient on income becomes negative and loses statistical significance. On the other hand, the coefficient on

Table 6
Logit models for the probability of being overweight and obese with region-level environmental variables.

	Overweight				Obese			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log infant mortality	.154 **	.172 **	.792 ***	.823 ***	.146 *	.188 *	1.097 ***	1.149 ***
	(.073)	(.087)	(.093)	(.093)	(.081)	(.101)	(.100)	(.103)
Log income pc	−.732 ***		−.791 ***		−.867 ***		−1.185 ***	
	(.071)		(.148)		(.069)		(.251)	
Log consumption pc		−.910 ***		−.279		−1.041 ***		−.324
		(.091)		(.227)		(.108)		(.331)
Dummies:								
Area			Yes	Yes			Yes	Yes
Cohort			Yes	Yes			Yes	Yes
Month-of-birth			Yes	Yes			Yes	Yes
Migration			Yes	Yes			Yes	Yes
No. regressors	2	2	45	45	2	2	45	45
Pseudo R^2	.0069	.0060	.0109	.0106	.0068	.0057	.0128	.0123
Max. log lik. (10^3)	748.4	−749.1	−745.5	−745.7	−253.1	−253.4	−251.5	−251.7
χ^2-Stat.	113	115	1603	1600	161	116	1703	1738

Note: Sample size N = 1,746,694.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Table 7
Height regressions with province-level environmental variables.

	(1)	(2)	(3)	(4)	(5)
Log infant mortality	−1.319 ***	−.356	−.357	−.339	−.215
	(.244)	(.223)	(.237)	(.237)	(.230)
Log income pc	3.082 ***	.741 **	.301	.392	−.119
	(.245)	(.299)	(.371)	(.357)	(.345)
No toilet			−.038 **	−.043 **	−.032 *
			(.017)	(.017)	(.019)
People per room			.013	.132	.112
			(.421)	(.463)	(.494)
Hospital beds				.013	.007
				(.012)	(.012)
Incidence of MMR				−.003	.010
				(.041)	(.040)
Incidence of CPSF				−.130 **	−.144 **
				(.063)	(.064)
Female mort. 25–29				−.103 **	−.091 *
				(.051)	(.049)
Female HS grad.					.049 **
					(.023)
Female illiteracy					−.009
					(.016)
Region dummies		Yes	Yes	Yes	Yes
Cohort dummies		Yes	Yes	Yes	Yes
Month-of-birth dummies		Yes	Yes	Yes	Yes
Migration dummies		Yes	Yes	Yes	Yes
No. regressors	2	60	62	66	68
Adj. R^2	.0262	.0425	.0426	.0427	.0428
RMSE	6.67	6.62	6.62	6.62	6.62
F-Stat.	173	161	163	152	151

Note: Sample size N = 1,974,286.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

infant mortality remains negative and statistically significant no matter what measure of economic conditions is used, but now a 10% reduction in infant mortality translates into only a .04 cm increase in mean height. To save space, we do not present the coefficients on the other variables in the specifications (3)–(4) and only briefly report on their pattern.[2] People born in a maritime province are only slightly taller on average. The coefficients on the area dummies are small and not statistically significant for the North-West, positive and statistically significant for the North-East (1 cm taller than the Center), and large and negative for the South (between 1.3 and 2.1 cm shorter than the Center depending on the specification) and the Islands (between 2.5 and 3.2 cm shorter than the Center depending on the specification). The coefficients on the cohort dummies are positive and statistically significant, and indicate an average gain of about .10 cm for each of the first two cohorts and no further gain afterwards. Month-of-birth effects agree with the evidence reviewed by Bogin (1999, pp. 295–296), that is, they are highest for the months of May and June, lower for the fall months, and even negative for the winter months. These effects are not well understood yet, but may be related to sunlight influencing the patterns of human growth during the late fetal and early postnatal period. They may also reflect variation in mother and child diet, especially with respect to mineral and vitamin-rich fruits and vegetables that yield micronutrients essential to successful early childhood development. Relative to stayers, those who moved from low- to high-stature areas (e.g. from the South to the North) are on average taller, while those who moved from high- to low-stature areas are on average shorter. This may reflect both area-specific effects and features of within-country migration during the period considered, especially the fact that the 1970s and 1980s are characterized by the end of the migration flows from the South to the North and by return migration from the North to the South.

As for the BMI regressions (the last four columns in Table 5), the relative importance of economic conditions and disease burden changes substantially depending on whether or not we include area, cohort, month-of-birth and migration dummies. When we exclude these dummies (specifications (5) and (6)), the coefficients on infant mortality are positive but small and not statistically significant, whereas the coefficients on economic conditions are large, negative and strongly statistically significant. When we instead include the dummies (specifications (7) and (8)), infant mortality gains importance relative to economic conditions. In particular, specification (7) implies that a 10% decrease in infant mortality has about the same effect as a 10% increase in income per capita, namely a reduction of BMI by about .12–.13 points. In specification (8), the positive coefficient on

[2] Tables with all the estimated coefficients and their standard errors are available from the authors upon request.

Table 8
BMI regressions with province-level environmental variables.

	(1)	(2)	(3)	(4)	(5)
Log infant mortality	.347 **	.113	.163	.198 **	.207 **
	(.158)	(.089)	(.099)	(.092)	(.088)
Log income pc	−.968 ***	.373 ***	.344 **	.249	.206
	(.095)	(.131)	(.164)	(.153)	(.152)
No toilet			−.005	−.007	−.011 *
			(.006)	(.007)	(.006)
People per room			−.174	−.191	−.224
			(.194)	(.208)	(.218)
Hospital beds				−.003	−.001
				(.004)	(.004)
Incidence of MMR				−.035 **	−.029 **
				(.016)	(.015)
Incidence of CPSF				.060 **	.058 **
				(.025)	(.025)
Female mort. 25–29				−.012	−.014
				(.023)	(.023)
Female HS grad.					.006
					(.010)
Female illiteracy					.007
					(.007)
Region dummies		Yes	Yes	Yes	Yes
Cohort dummies		Yes	Yes	Yes	Yes
Month-of-birth dummies		Yes	Yes	Yes	Yes
Migration dummies		Yes	Yes	Yes	Yes
No. regressors	2	60	62	66	68
Adj. R^2	.0106	.0253	.0253	.0254	.0254
RMSE	3.22	3.2	3.2	3.2	3.2
F-Stat.	54.1	116	114	114	106

Note: Sample size N = 1,974,286.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

infant mortality is about the same as in specification (7), but the negative coefficient on consumption per capita is much smaller than in specification (6) and no longer statistically significant.

To save space, we again report only briefly on the other coefficients in the last two specifications for BMI. People born in maritime provinces have on average a slightly higher BMI. The coefficients on the area dummies show that, after controlling for all other things, BMI is on average lower in the North and the Islands. Cohort effects are positive and strongly statistically significant (+.7 in BMI units between the 1973 and 1978 cohort), whereas month-of-birth effects show no clear pattern. Relative to stayers, those who moved from low- to high-BMI areas (e.g. from the North to either the Center or the South) have on average a higher BMI, while those who moved from high- to low-BMI areas have on average a lower BMI. As already mentioned, this may reflect both environmental effects and feature of within-country migration during the period considered. The results from the logit models for being overweight or obese (Table 6) are consistent with the findings from the BMI regressions. Even after controlling for our full set of dummies, the coefficients on infant mortality are positive and statistically significant, while the coefficients on income and consumption are negative but are statistically significant only in the case of income. Finally, we again observe strongly positive and statistically significant cohort trends, especially for the probability of being obese.

5.3. Province-level environmental variables

To better understand the role of our two focus regressors, namely infant mortality and income per capita, we now consider regressions with environmental variables measured at the finer province level (Tables 7–10).

We use five different specifications for these province-level regressions. The baseline specification in column (1), which is directly comparable to specifications (1) and (5) in the region-level analysis, includes as predictors only the constant term and our focus regressors. Specification (2) adds to (1) a set of dummies for the region of birth, the year and month of birth, and the migration pattern, and is directly comparable to specifications (3) and (7) in the previous section. Specifications (3)–(5) add to (2) an increasing set of variables that are intended to describe in more detail the characteristics of the early-life environment at the province level. Thus, specification (3) adds to (2) indicators for the quality of the housing stock, namely the average number of people per room and the percentage of homes without toilet. Specification (4) adds to (3) the number of hospital beds and, as additional indicators of disease environment, female mortality in the 25–29 age group, and the number of cases of measles, mumps and

Table 9
Logit models for the probability of being overweight with province-level environmental variables.

	(1)	(2)	(3)	(4)	(5)
Log infant mortality	.271 ***	.089 *	.117 *	.124 **	.145 ***
	(.084)	(.050)	(.060)	(.057)	(.055)
Log income pc	−.529 ***	.214 ***	.226 **	.184 **	.105
	(.059)	(.071)	(.089)	(.085)	(.087)
No toilet			−.000	.000	−.000
			(.003)	(.003)	(.003)
People per room			−.086	−.079	−.097
			(.109)	(.118)	(.121)
Hospital beds				−.000	−.000
				(.002)	(.003)
Incidence of MMR				−.017 *	−.013
				(.009)	(.009)
Incidence of CPSF				.036 **	.034 **
				(.014)	(.014)
Female mort. 25–29				−.000	.001
				(.013)	(.013)
Female HS grad.					.009
					(.005)
Female illiteracy					.002
					(.003)
Region dummies		Yes	Yes	Yes	Yes
Cohort dummies		Yes	Yes	Yes	Yes
Month-of-birth dummies		Yes	Yes	Yes	Yes
Migration dummies		Yes	Yes	Yes	Yes
No. regressors	2	60	62	66	68
Pseudo R^2	.0061	.0137	.0137	.0137	.0138
Max. log lik. (10^3)	−746.2	−740.5	−740.5	−740.5	−740.5
χ^2-Stat.	98.8	4974	5057	5211	5217

Note: Sample size N = 1,746,694.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

rubella (MMR) and chickenpox, pertussis and scarlet fever (CPSF) for 1000 inhabitants. Finally, specification (5) adds to (4) indicators for the educational attainments of mothers, proxied by the fraction of women aged 6+ who are illiterate and the fraction of women aged 6+ who hold a high-school or a university degree. In the case of height and BMI, the specifications in columns (2)–(5) may be interpreted as regressing the deviations individual outcomes from their region-level averages on the deviations of province-level regressors from their region-level averages.

For all outcomes considered, the results from specifications (1) tend to agree in sign, magnitude and statistical significance with those from specifications (1) in the previous section, so we focus on the results from the other four specifications. In the case of height, specification (2) in Table 7 produces very similar results to specification (3) in Table 5. Adding indicators for the quality of the housing stock, the number of hospital beds and extra indicators of the disease environment does not change much the size and statistical significance of the coefficients on infant mortality but essentially eliminates the role of income per capita. This result is important because it shows that income per capita is really a proxy for a variety of environmental indicators that are highly correlated with economic conditions. In particular, we find a strong and significant negative association between height and the percentage of homes without toilet, the incidence of chickenpox, pertussis and scarlet fever, and female mortality for the 25–29 age group. Consistently with the results in Thomas et al. (1991), we also find that height is positively associated with the fraction of women with a high-school degree and negatively associated with the fraction of women who are illiterate. In the case of BMI, while the results for specification (1) in Table 8 agree with those for specification (5) in Table 5, those for specification (2) (which replaces area dummies with region dummies) differ from those from specification (7) in the previous table. The main difference is the fact that the coefficient on income per capita remains statistically significant but becomes much smaller and switches from negative to positive. Introducing additional indicators of early-life environment (the last three specifications) does not change the sign (positive) and the size of the coefficient on infant mortality, which actually becomes statistically significant in specifications (4) and (5), but again eliminates the role of income per capita. Results that appear to be robust to alternative specifications are the positive association between average BMI and the incidence of chickenpox, pertussis and scarlet fever, and the negative association between BMI and the average number of people per room and the incidence of MMR.

We find similar patterns in the case of the logit models for being overweight (Table 9) or obese (Table 10). In both

Table 10
Logit models for the probability of being obese with province-level environmental variables.

	(1)	(2)	(3)	(4)	(5)
Log infant mortality	.231 **	.105	.201 **	.251 ***	.203 **
	(.102)	(.081)	(.087)	(.087)	(.086)
Log income pc	−.662 ***	.133	.101	−.026	.132
	(.061)	(.123)	(.150)	(.148)	(.163)
No toilet			−.005	−.007	−.008
			(.005)	(.005)	(.005)
People per room			−.279 *	−.293 *	−.265
			(.158)	(.159)	(.167)
Hospital beds				−.007	−.006
				(.005)	(.005)
Incidence of MMR				−.042 **	−.050 ***
				(.018)	(.019)
Incidence of CPSF				.091 ***	.095 ***
				(.026)	(.027)
Female mort. 25–29				−.017	−.020
				(.020)	(.020)
Female HS grad.					−.016
					(.012)
Female illiteracy					−.001
					(.005)
Region dummies		Yes	Yes	Yes	Yes
Cohort dummies		Yes	Yes	Yes	Yes
Month-of-birth dummies		Yes	Yes	Yes	Yes
Migration dummies		Yes	Yes	Yes	Yes
No. regressors	2	60	62	66	68
Pseudo R^2	.00581	.0164	.0165	.0166	.0166
Max. log lik. (10^3)	−253.3	−250.6	−250.6	−250.6	−250.6
χ^2-Stat.	136	4749	4665	4713	4689

Note: Sample size N = 1,746,694.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

cases, replacing area dummies with region dummies leads to substantial changes in the sign and magnitude of the estimated coefficients on the focus regressors relative to the corresponding specifications in the previous section. In particular, comparing the various specifications in Tables 9 and 10 shows that income is never statistically significant in the specifications that include our full set of regressors.

6. Conclusions

In this paper we studied the relative importance of two dimensions of early-life environment, namely disease burden (measured by infant mortality) and economic conditions (measured by income or consumption per capita), for various health outcomes, namely height, BMI and related measures, using data on young men in Italy.

Our results are consistent with the evidence in Bozzoli et al. (2009), Bosch et al. (2009), and Hatton (2011) that, in rich low-mortality settings, the negative long-term effects of disease on survivors ("scarring") dominate the positive selection effects. We also show that both disease burden and economic conditions matter, and their relative importance differs depending on the outcome considered and the available background information. In particular, economic conditions appear to matter more than disease burden for height, while the opposite is true for BMI and the probability of being overweight or obese.

Finally, using detailed province-level information, we show that income per capita is a proxy for a variety of environmental indicators that are highly correlated with economic conditions. Among these, particularly important appear to be the incidence of infectious diseases, such as chickenpox, pertussis and scarlet fever, and the quality of the housing stock (especially the availability of toilet). This suggest a potentially important role for sanitation and policies aimed at preventing infectious diseases and improving the quality of the housing stock.

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Appendix A

See Table A.1

Table A.1
Cohorts born between 1973 and 1978: demographic data, draft data and available information in our database.

	Birth year	1973	1974	1975	1976	1977	1978	Average 1973–1978
	Year of the visit	1991	1992	1993	1994	1995	1996	
1	Male births	449,999	447,131	426,160	402,728	381,158	364,841	412,003
2	Dead, not Italian, changed to foreign citizenship	20,837	24,581	12,038	19,842	17,341	4,806	16,574
3	Conscripts [1 – 2] [4 + 5]	429,162	422,550	414,122	382,886	363,817	360,035	395,429
	% out of male births (1)	95.37	94.50	97.18	95.07	95.45	98.68	95.98
4	Army and Airforce (AAF) conscripts	383,489	364,570	358,933	330,006	317,251	313,355	344,601
	% out of coscripts (3)	89.36	86.28	86.67	86.19	87.20	87.03	87.15
5	Navy conscripts	45,673	57,980	55,189	52,880	46,566	46,680	50,828
	% out of coscripts (3)	10.64	13.72	13.33	13.81	12.80	12.97	12.85
6	Total observations in the database	372,467	348,701	343,945	326,335	306,710	296,881	332,507
	% out of AAF coscripts (4)	97.13	95.65	95.82	98.89	96.68	94.74	96.49
	% out of births (1)	82.77	77.99	80.71	81.03	80.47	81.37	80.70
7	Valid observations on height	369,116	345,594	341,063	320,182	303,875	294,446	329,046
	% out of obs (6)	99.10	99.11	99.16	98.11	99.08	99.18	98.96
	% out of conscripts (3)	86.01	81.79	82.36	83.62	83.52	81.78	83.21
8	Valid observations on BMI	304,595	291,973	302,967	287,249	282,664	277,236	291,114
	% out of obs (6)	81.78	83.73	88.09	88.02	92.16	93.38	87.55
	% out of conscripts (3)	70.97	69.10	73.16	75.02	77.69	77.00	73.62

Data sources: Lines 1–5 from Ilari and Battistelli (2005); lines 6–8 from our database.

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