THE IMPACT OF "SANITARY ENVIRONMENT" ON HEALTH IN UMBRIA AND SARDINIA AT THE END OF THE 19th CENTURY

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1. Introduction

Our understanding of people's health status has increasingly benefited from many studies carried out in different fields - demography, economic history, anthropology and more recently epidemiology - which use anthropometric measures, particularly height, to assess the well-being of population in the past.

Traditionally, most of the demographic debate concerning the relationship between health and height has relied on evidence of their significant correlation. It has been shown that height can be used as a valid proxy of the living conditions of the population since stature is not only a product of genetic factors but is also affected by environmental conditions experienced during childhood and youth (Tanner, 1992). That is, the extent to which a person can reach his genetically determined adult height is influenced by several environmental factors which can affect growth velocity, especially during infancy and adolescence, and therefore reduce final physical stature. The human body thrives well in a healthy environment, while prolonged and severe deprivation, poverty and unsanitary conditions stunt body growth. In consequence, taller people are healthier and live longer (Deaton, 2006). This relation is then stronger in historical context characterised by poorer environment with basic needs close to subsistence and primitive public health measures. There is a long literature that examines the relationship between height and the biological standard of living which includes net nutritional status, housing conditions, income, sanitary infrastructure and improved hygiene, contaminated food or water, access to health care, physical burden of child labour, access to education (Tanner, 1981; Komlos, 1985; Steckel, 1995). The most recognized non-genetic factors are nutrition and disease since height reflect the net nutritional status given by the difference between food intake and losses due to activities and diseases, in particular diarrheal diseases, fevers and

respiratory infections. In consequence adult height can be seen as an indicator of both nutritional and disease environment (Tanner, 1989).

Many anthropometric studies have focused on the substantial changes in adult body size of successive generations which is a common feature of European populations, expressed by the term "secular trend" beginning in the late 19th century. This phenomenon reinforces the hypothesis of the deterministic role of environmental factors.

In Italy the average increase in height of men born in the period 1854-1980 has been well documented and has been related with modern economic growth resulting in improving sanitary conditions and increases in food intake (Federico, 2003; Arcaleni, 2006).

In this study we aim to empirically revise the relationship between height and health conditions by using individual data recorded in the military registers for two Italian regions, Umbria and Sardinia. Records collected by the army enable us to explore the health status and height of the cohorts of military conscripts born at the end of the 19th century that faced the beginning of the demographic transition and, in particular, the "health transition" . Specifically we focus on military conscripts born in 1880 and 1881 in Sardinia and Umbria, two Italian regions located in the Southern and Central Italy respectively, and visited 20 years later. The historical period is of crucial importance because the demographic transition determined a substantial reduction of mortality, followed by the decline of fertility rates and a subsequent increase of living standards and life expectancy (Caselli 1987, 1991, 1994, 1995; Caselli and Egidi, 1991; Caselli *et al.* 2002). The health transition theory was developed to include the determinants that intervened on the changes of mortality patterns and disease profiles, namely the shift from a phase characterized by high mortality levels, with infectious diseases as primary cause, to one in which mortality levels had fallen steadily, with the prevalence of degenerative and chronic disease (Lerner 1973; Caselli 1996).

Our contribution is to test whether the individual stature of conscripts is positively linked with the propensity to be fit for military service, the latter interpreted as an observable indicator of "good health conditions". Empirical studies have largely demonstrated that health conditions are not only influenced by factors strictly linked to personal characteristics, but are also the consequence of the social, economic and sanitary development of a specific context, especially in the past (Baten and Murray, 2000). From

a methodological point of view, it means that the analysis of individuals' health living in different areas requires two different types of information, one at individual level and one at a macro-level to be combined together in a more complex research strategy. Based on this argument we propose to use multilevel models for the two regions to investigate the extent to which a significant cross-territorial variability within regions exists, respectively. We assume that the existence of this variability depends on socio-economic differences and public health infrastructures. On the contrary, the rejection of this hypothesis will lead to conclude that health conditions are mainly linked with individual characteristics.

We motivate the use of the conscription lists because they are rich sources of information on the anthropometric and socio-economic characteristics of the conscripts. The records used are representative of male population because do not suffer from truncation due to a minimum height requirement which pertain to many datasets of conscripts. Our data virtually include all young men subjected to be enrolled for military service. Nevertheless, while historical height data are relatively plentiful for different periods and places, thanks to archival collection of military records, individual data on morbidity are rare. This is not our case: in addition to anthropometric indicators we can analyze the diseases recorded in a very detailed way during the medical examination performed on every 18-year-old boy in order to check his fitness for military service. We believe that this information is extremely important to assess the relationship between height and health status investigating in more detail the characteristics of those people who have been discharged from military service on medical grounds.

In the last decades, many studies have attempted to investigate the relationship between economic and social development and health by using anthropometric measure but little attention has been devoted to the "sanitary environment", e.g. availability of public health services. Specifically, public health infrastructure can be interpreted as sewage and drainage systems, waste disposal, clean water supply and basic health care.

Several studies showed that the creation of new infrastructures and the implementation of new technologies in Italy at the end of 19th century were deemed necessary in order to improve the sanitary and social conditions of the urban population. Environmental interventions clearly played an important role in improving health, as the most dramatic

drops in infectious disease occurred before the widespread availability of vaccines and antibiotics (Giovannini, 1996). The installation of comprehensive sewer systems, improvements in building designs to ensure that residents had light and fresh air, all brought significant improvements in health. In particular, pure water and efficient sewage systems were considered the most important field of intervention (Faccini, 1984). Although improvements in public health infrastructure were affecting the newborn Italian country in that period, it was already emerging a large regional variety, confirming the presence of strong social, economic and territorial disparities (Arcaleni, 2006).

2. Data

Military recruitment records are used as the main data source for the empirical analysis. We consider a cohort of military conscripts born in 1881 for Umbria and conscripts born in 1880 for Sardinia.

Because of universal conscription, almost all male individuals aged 18 years were subject to medical examination in order to check their fitness for military service. The conscripts were collected on the basis of their personal data (name, date and place of birth, place of residence), occupation and degree of literacy, anthropometric measures (height and thoracic perimeter), personal characteristics (distinguishing marks, teeth). Furthermore, their health status was assessed by a doctor enabling us to know about the most frequent health impairments. Individuals reporting a disease or a physical imperfection, for which improvements could not be expected in the following year, were declared temporarily unfit for military service.

On the other hand, people affected by more serious health problems were declared permanently unfit for military service. The patterns of conditions leading to medical discharge from the Army are of great interest since they tend to mirror the physical conditions which are prevalent at that time in the civilian population.

Despite of military service in Italy was compulsory for all male citizens not all young people belonging to a specific birth cohort were visited and measured. We have no data for the following categories: draft dodgers who, according to some studies, do not reflect the unpopularity of military service but the presence of migration flow (Ilari, 1990); people with severe disabilities visited elsewhere by physicians in civil hospitals; enrolled

without the medical examination (including volunteers). This is an irrecoverable loss of information even if, in our case, it represents small percentages.

In addition, our dataset includes data about the sanitary infrastructures and the supply of basic health care taken from the Survey on the Italian municipalities carried out in 1885 - when the conscripts were children – and published in 1886 by the General Directorate of Statistics in Italy (DIRSTAT, 1886). We assume that different epidemiological, economic and social contexts may affect the impact of early life conditions on later health. If people live in a poor physical environment their health when they are adult will suffer. In consequence not only the individual socioeconomic factors affect the health of the conscripts, but also the environment in which they grew up. This source, which aimed to register the sanitary conditions of the municipalities in the newborn country of Italy, investigated the conditions of housing, streets, air, water, sewage, primary health care service (doctors, pharmacies, midwifes…). Specifically, the following qualitative indicators were taken into account for the statistical analysis: water quality (bad, medium, good), quantity of water available (poor, sufficient), the presence of sewers (no, in part, yes), size of dwellings (insufficient or adequate), presence of stagnant water (no, yes), malaria and cholera frequency (no cases, rare, common). Furthermore, the count data about the presence of basic health care service, like pharmacies, midwifes and doctors were considered. The main weaknesses stem mainly from the mechanism of data collection. The answers provided by the mayors to the questionnaire – by using adjectives such as sufficient, insufficient, rare, frequent – were in some cases approximate and not always supported by the technical opinion of specialists such as doctors and hygienists. However, the survey provides for the first time qualitative and quantitative information at a national level, pretty reliable, on the living conditions of the Italian population.

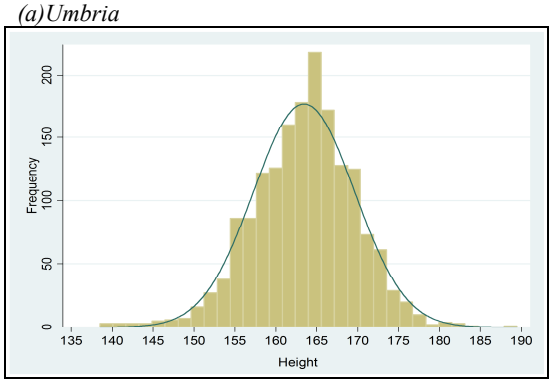
In collecting the above macro-variables for all the communities investigated we referred to the birth place of individuals: in most cases birth place and residence community coincide because of the low incidence of migration, in particular migration flows in Sardinia were limited by the fact to live in an island. Nevertheless, when the place of birth and residence differed, we decided to take into account the place of birth hypothesizing that an individual has a higher probability to live, especially in the first life years, in the community where he was born.

3. Descriptive statistics

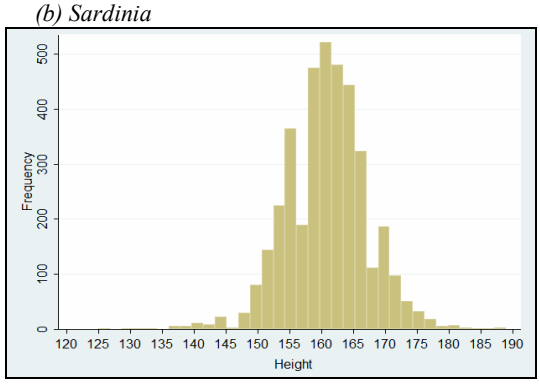
In this section we report descriptive statistics for both individual and aggregate variables used in the statistical analysis. The average height for individuals aged 20 years old and living in Umbria is about 163.4 cm, in line with the national average stature measured by using ISTAT data (Arcaleni, 2006). When we compare this value with that one recorded for the Sardinian population for 1880 birth cohort, it emerges that Sardinian recruits are on average much shorter respect to Umbrian recruits registering a value of 160.8. Furthermore, we can note from Figure 1 that only for Umbria height data are normally distributed. Although data referred to Sardinia apparently show a normal distribution, it is worth noting that a bimodal distribution arises from the empirical data supported by the cutting around 157 cm in the left part of the height distribution.

Figure 1 - Height distribution of conscripts

(a)Umbria



(b) Sardinia



Sardinia and Umbria show a fairly similar percentage of recruits found fit for military service (just under 50%), while a marked difference concerns the percentage of rejected, which is almost twice in Sardinia (Table 1). The analysis of pathologies which could lead a conscripts to be rejected or judged temporarily unfit for military service shows that among those declared unfit for military service, the majority suffered from an incomplete physical development, specifically a weak constitution, short stature and thoracic insufficiency (Table 2). This health condition probably reflects the non favorable environmental and socio-economic situation of the two populations visited in 1901, denoting the backwardness of the Kingdom of Italy, particularly severe in the South.

Looking at the physical impairments recorded in the registers, we find that the conscripts living in Sardinia had a probability to be declared unfit for being too short almost three times higher than in Umbria. Short stature is a characteristic of Sardinian people due inevitably to genetic factors even if it may reflect the worst environmental conditions of the island. The extraordinary high incidence of severe ophthalmic diseases –like trachoma, conjunctivitis, glaucoma- which could reduce visual capacity and, in the worst case provoke blindness, is also noteworthy for Sardinia. Moreover, some recruits were affected by infectious diseases like malaria, tuberculosis or "scrofula" still not completely eradicated. Malaria, trachoma and tuberculosis have represented over time in Sardinia the most important infectious diseases on a social base and were generally referred to as factors responsible for its delay in the development (Cau *et al*., 2007). Other shared pathologies of the two regions concerned problems to limbs which could limit walking or using upper limbs, or evident scars. Inguinal and visceral hernias, oligaemia were also common.

The conscripts' occupation and literacy are reported in Table 3. It emerges a very low educational level, in terms of writing and reading skills, which reflected in more than 50% of illiterate individuals. While Sardinian conscripts were more often farmers, sheep-farmers, fishermen and mineworkers, Umbrian economy was typically based on agriculture, activity that employed more than 70% of the male population at the beginning of XX century. Finally, Table 4 compares the selected indicators of sanitary settlements at the municipality level extracted from the source DIRSTAT for the two regions. It appears that the provision of clean water supply was active in the majority of the municipalities, even if it seems that the quality water in Umbria was less good than Sardinia. This result should, however, be interpreted with caution because it is worth noting that the answers given by the Mayors were not always completely reliable, especially with regard to the evaluation of organoleptic quality, which was based mostly on olfactory and visual parameters rather than chemical analysis. Another relevant indicator of sanitary conditions of local context, in which people lived in the late nineteenth century, were the sewers which were lacking in almost all the municipalities in Sardinia. On the contrary, Umbria had a highly developed drainage system with a lack of sewers that was limited to less than 30% of the municipalities. Dwelling size is a good

proxy of the living conditions since overcrowded housing could facilitate a more rapid transmission of infectious diseases and, subsequently, a higher probability of being in poor health. Moreover, in the literature there is evidence of a relationship between housing and health and also some evidence of poor housing experience in childhood affecting adult health (Dunn, 2002; MacIntyre et al., 2003). The majority of the communities were characterized by a "sufficient" dwelling size.

Finally, we have included data to consider the vulnerability of these communities to the impacts of malaria and cholera epidemics, which occurred during the early life of conscripts born in 1880-1881. Data show that malaria and cholera outbreaks have occurred most frequently in Sardinia, this seems to be linked to the fact that most of the Sardinians municipalities (37.2%) were characterized by stagnant water, while in Umbria only a small percentage of the municipalities had offensive dirty pools. In addition, as previously noticed, Sardinian people lived in an environment exposed to such hazards like the deterioration of water and sanitation sector which were the primary causes of diseases such as malaria, cholera, dysentery and trachoma.

Tab. 1. *Distribution of conscripts according to the final report of military medical examination*

Categories	Umbria	%	Sardinia	%
Fit	921	47.6	1983	50.8
Permanently unfit	352	18.2	1424	36.5
Temporarily unfit	581	30.0	491	12.6
Others	81	4.2	8	0.2
Total	1935	100.0	3906	100.0

Tab. 2. *Reasons of temporary or permanent unfitness*

Motive	Umbria	%	Sardinia	%
Weak constitution	281	30.2	188	18.6
Thoracic insufficiency	321	34.4	130	12.9
Short stature	114	12.2	315	31.2
Obesity	2	0.2	3	0.3
Teeth decay, teeth loss	-	-	18	1,8
Hernia, hydrocele, varicocele	49	5.3	63	6.2
Malaria, scrofula	-	-	14	1.4
Hearth problems	29	3.1	4	0.4
Oligaemia	49	5.3	78	7.7
Eyes diseases	17	1.8	148	14.7
Limb, skin diseases	53	5.7	37	3.7
Mental problems	3	0.3	5	0.5
Goitre	8	0.9	-	-
Others	6	0.6	7	0.7
Total	932	100.0	1010	100.0

Tab. 3. *Conscripts' education and occupation*

	Umbria	%	Sardinia	%
Education				
Literate	840	48.3	1658	43.4
Illiterate	899	51.7	2158	56.6
Total	1739	100.0	3816	100.0
Occupation				
Farmer, fisherman, sheeperd	1250	71.8	2414	63.8
Craftsmen, merchants, shopkeeper, miners	391	22.5	1102	29.1
Students	66	3.8	128	3.4
White collars, landowners	34	2.0	141	3.7
Total	1741	100.0	3785	100.0

Tab. 4. *Percentage of communities with public health infrastructures, basic health care and diseases*

Water quality	Umbria	Sardinia	*Stagnant water*	Umbria	Sardinia
bad	29.4	11.5	not present	88.2	62.8
good, medium	70.6	88.5	present	11.8	37.2
Water quantity			*Cholera*		
insufficient	23.5	19.2	no cases	47.1	40.6
sufficient	76.5	80.8	common	52.9	59.4
Sewage system			*Pharmacies*		
not present	29.4	92.7	any pharmacies	-	74.4
present	70.6	7.3	at least one	100	25.6
Dwelling size			*Doctors*		
insufficient	47.1	34.6	any doctors	-	35.0
sufficient	52.9	65.4	at least one	100	65.0
Malaria fever			*Midwifes*		
no cases	23.5	9.0	any midwifes	-	79.1
common	76.5	91.0	at least one	100	20.9

4.Results

4.1. Model specification

In order to investigate whether height and sanitary environment conditions may explain health status, cross-sectional logit estimations are separately run for Umbria and the island of Sardinia. To make it empirically tractable, we use a probabilistic model for health outcomes in which the dependent variable is the binary variable to be declared fit for military service or not (i.e. we assume 1 if individuals are declared fit for military service and 0 otherwise). Since stature data are available for all the municipalities of the island of Sardinia and Umbria, height is used as a continuous variable in the estimations. Although we estimate the effects of several individual covariates, in the final specification we only include the significant categorical variable being “literate”.

Following the discussion reported in the previous section, we believe that other dimension than the individual one plays an important role in determining differences on

health status, such as the characteristics of environment in which conscripts lived until age 20. We assume that contextual variables, here considered at the municipality level, may affect individual health outcomes. Namely, conscripts with selected characteristics and belonging to one specific municipality have different health patterns from those with the same characteristics but belonging to another area. We formally test it in a way that we are able to choose if a multilevel model is needed.

Before to carry out the specification tests, we write in log-odds form the multilevel logit model as:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \alpha_0 + \alpha_1 x_{ij} + u_j \qquad (1)$$

$$u_j \approx N(0, \sigma_u^2)$$

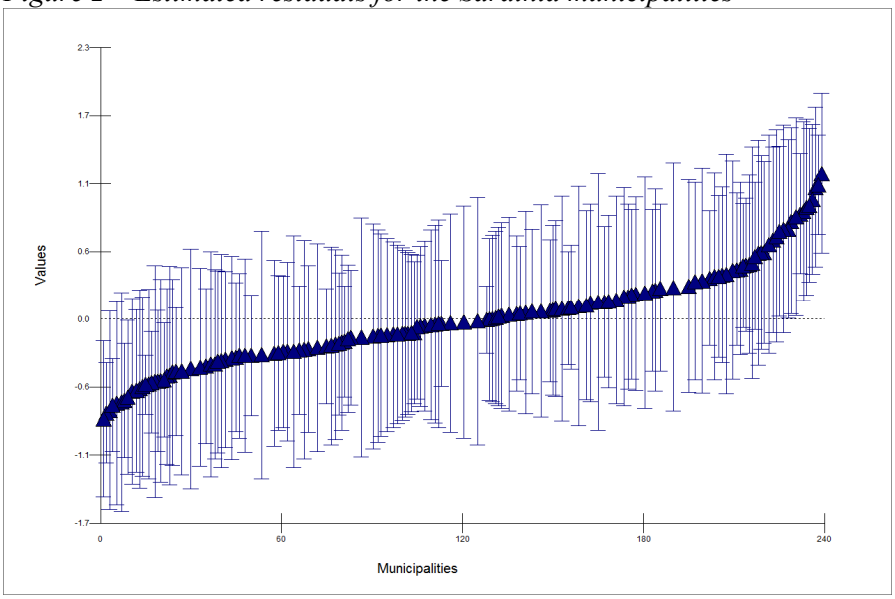
where α_0 is the log-odds that the health response variable $y = 1$, when x and u are zero, while α_1 is the unit-specific effect of the individual variables. u_j is the effect of being in group j on the log-odds that $y = 1$. σ_u^2 is the between-group variance or level two residual variance.

A typical strategy to implement these tests in our data is to verify the hypothesis that the variance between municipalities for being declared fit for military service is non-significant, i.e. $\sigma_u^2 = 0$. For Umbria region, we perform a Wald test that produces a test statistic of 1.8 which is compared with a χ^2 H_0 distribution on one degree of freedom with critical value of 3.84 at the five percent level. As already argued in Lanari and Bussini (2007), we do not reject the hypothesis that individuals born in different municipalities of Umbria experiment similar health conditions.

On the other hand, we reject the hypothesis that the effects of the second level in the multilevel probabilistic model are not significant for the island of Sardinia. The Wald test statistic is 29.48 that rejects at five percent level the hypothesis of $\sigma_u^2 = 0$. This can be explained by the large number of municipalities included in the analysis and by the heterogeneity of sanitary and economic factors, linked with health conditions, across the municipalities of Sardinia. After unification of the Kingdom of Italy living standards

were very low everywhere, especially in southern Italy, but the situation was even worst in some Sardinian communities which had to face more precarious conditions due principally to the diffusion of various diseases such as malaria, tuberculosis and cholera as a natural consequence of the lack of sewage system and wide areas of stagnant pools. We can hypothesize that the more developed area, characterized by healthier environment, could have an important role in improving health status. Figure 2 shows the estimated residuals for the 234 municipalities in the sample. For a substantial number of these, the 95% confidence interval does not overlap the horizontal line at zero, indicating that health conditions in these municipalities are significantly above average (above the zero line) or below average (below the zero line). In the estimation section we attempt to identify the factors responsible of this heterogeneity on health responses at the municipal level.

Figure 2 – Estimated residuals for the Sardinia municipalities



4.2. **Estimation and discussion**

In this section we present the estimation results carried out for Umbria and the island of Sardinia. Table 5 shows the regressions obtained by the logit model for Umbria where the impact of the stature on health conditions is controlled by the extension of literacy and some contextual variables. The estimated parameters of stature look very similar for all

the three specifications shown with a significant positive effect on good health status evaluated throughout the fitness for military service. As expected, a positive relationship between literacy and being declared fit for military service is found. This implies that schooling represents a way to leave unhealthy conditions behind. In addition, we find that the clean water supply for the municipality of Umbria positively influences the probability to experiment better health conditions. In a similar way, the availability of doctors in the municipality is able to characterize positively the health conditions of individuals living in that area.

Table 5 - Estimated parameters for the logit model of Umbria

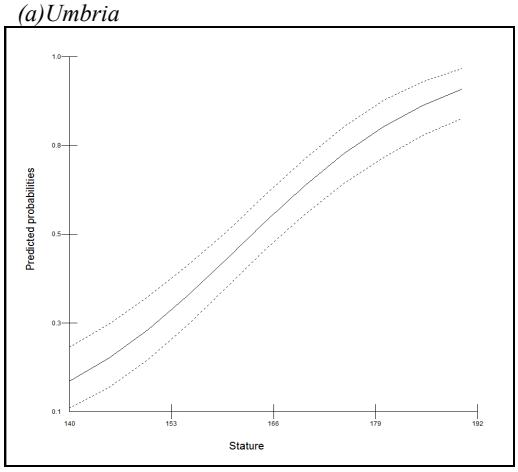
	Model 1			Model 2			Model 3		
Variables	Coeff.	St. Error	[95% C.I.]	Coeff.	St. Error	[95% C.I.]	Coeff.	St. Error	[95% C.I.]
Constant	-13.553	1.453	[-16.40 ; -10.70]	-13.773	1.461	[-16.63 ; -10.90]	-13.540	1.783	[-17.03 ; -10.04]
Stature	.081	.008	[.063 ; .098]	.081	.008	[.063 ; .098]	.076	.010	[.055 ; .097]
Literacy	.398	.101	[.199 ; .597]	.416	.102	[.216 ; .616]	.283	.125	[.037 ; .529]
Water quality				.097	.051	[-.002 ; .198]	.253	.094	[.068 ; .439]
Doctors							.025	.010	[.004; .047]

The tests provided in the previous section have shown that the probability to be declared fit for military service in the island of Sardinia depends on the municipality where the individual was born. This was achieved by allowing the model intercept to vary randomly across municipalities (Table 6). The estimation of the second-level variance component is 0.586, corresponding to an intra-class correlation coefficient ρ of 0.095. This means that 9.5 percent of the variability in health conditions, not explained by the variables included in the model, is due to the second-level variance component (variability between municipalities). With regard to the various steps of analysis leading to the selected model presented here it should be stressed that stature provides significant estimates of the associated parameter, confirming that a high stature represents a good predictor of good health conditions. Figure 3 reports for sake of comparison the predicted probabilities to be fit for military service with respect to the regional height. Although we have different ranges of height between the samples, with Umbrian conscripts higher of about 3 centimeters, it is confirmed the empirical regularity that a high stature determines, on average, better health conditions in young people. For the highest levels of height in

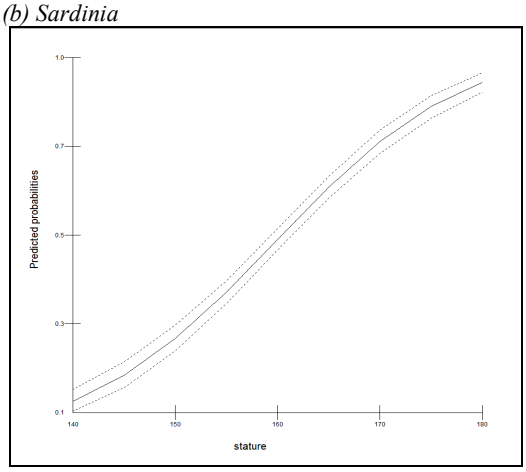
Umbria region, it is confirmed the relationship between stature and health outcomes even if the predicted probabilities rise at decreasing rates.

Figure 3 - Predicted probabilities to be fit for military service

(a)Umbria



(b) Sardinia



In the extended multilevel model presented in Table 6, we estimate the parameters adding a set of contextual variables collected at the municipal level described in section 2. We find similar results for Sardinia, as already discussed for Umbria, concerning the positive impact of literacy on individual health conditions. Literate individuals are more likely to be declared fit for military service. This well-known relationship originates from the fact that literate conscripts had higher probability to live in families not so poor to guarantee a basic education. The second-level variables we included in the estimations are statistically significant and with the expected sign. Health conditions of young conscripts benefit from living in areas characterized by healthier environments provided of sufficient quantity of water, sewers, basic health care. On the contrary, the negative sign of the coefficient "stagnant water" indicates that unsanitary condition can lead to a deterioration of health conditions. Furthermore, we notice that in adding contextual variables it is largely reduced the dimension of variance partition coefficient. In particular the estimate of second-level variance is reduced in this model, falling from 0.586 to 0.288 with a corresponding ρ value of 0.02. This indicates that once the second-level variables

have been introduced, the amount of variance unexplained by the model and deriving from context variability falls to 2 per cent.

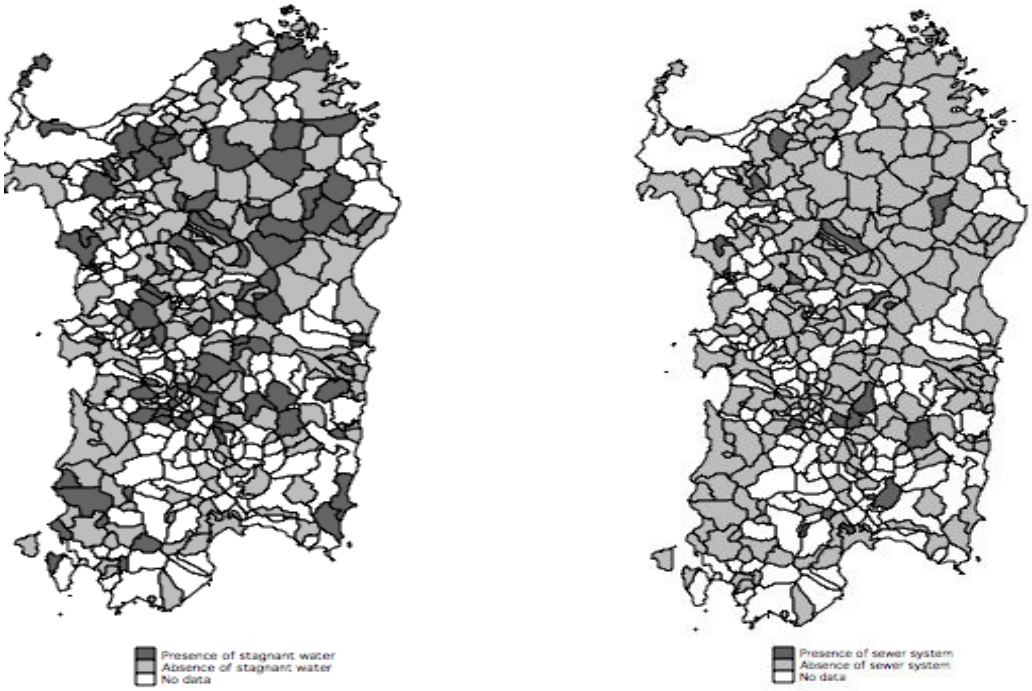
Table 6 - Estimated parameters for the random intercept logit models of Sardinia

	Random intercept Model			Ext. random intercept Model		
Variables	Coefficients	Std. Error	[95% C.I.]	Coefficients	Std. Error	[95% C.I.]
Individual variables						
Constant	-20.060	1.100	[-22.21 ; -17.90]	-15.854	1.648	[19.08 ; -12.62]
Stature	.122	.006	[.109 ; .136]	.095	.010	[.075 ; .115]
Literacy	.328	.075	[.180 ; .476]	.301	.121	[.062 ; .540]
Contextual variables						
Stagnant Water				-.524	.211	[-.939 ; -.110]
Water quantity				.624	.210	[.212; 1.03]
Sewer system				.496	.237	[.030 ; .962]
Midwifes				.046	.026	[-.006; .098]
Pharmacies				.164	.060	[.045 ; .283]
Random Part						
$\sigma^2 u$	.586	.064	[.473 ; .727]	.288	.103	[.143 ; .581]
ρ	.095	.018	[.063 ; .138]	.024	.017	[.006 ; .093]

Figure 4 illustrates the distribution of the two relevant contextual variables, stagnant water and sewer systems, for Sardinia at the municipality level. The stagnant water map shows the existence of clusters of municipalities not linked with specific geographical locations or districts. While it is clear the negative impact of stagnant water on health outcome, is not sure that it could be associated with productive activities of that time, such as agricultural and livestock farming.

A lack of sanitary infrastructure arises from the second map concerning sewage system. Since only few municipalities were provided, it suggests that this condition may have been a constraint for the improvement of health and well-being of local population. In particular, the constraints in infrastructure investment would have kept Sardinia in an under-development trap for a long time in the XX century.

Figure 4 – *Maps of the presence of stagnant water and sewer systems in Sardinia by municipalities (1885)*



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