Can health conditions predict body weight? An analysis of Italian conscript patterns in the cohorts of 1951 and 1980

Pieroni L.**, Lanari D.*

**University of Perugia (Italy) and University of the West of England (UK)

*University of Perugia (Italy)

Corresponding author: Pieroni L., Department of Economics, Finance and Statistics,

Via Pascoli 20, 06123 Perugia, Italy. E-mail: lpieroni@unipg.it

1 Introduction

Understanding some of the correlates of high body mass (BMI)[1] is useful from a health perspective, although the rapid increase in obesity around the world has become the focus of attention not only of health researchers. Increasing numbers of social scientists have also started to explore the economic correlates of the increase in body weight. As a result, the emerging literature found that in developing countries high body mass is associated with more affluent individuals (Araar et al. 2009, Molini et al. 2010), whereas in developed countries a negative relationship between income and obesity has been observed (Sobal & Stunkard 1989, McLaren 2007). With respect to other well-being indicators as ''height", which reflects living conditions during growth years, BMI is a reliable indicator of short-term effects of nutritional status and health conditions (Steckel 1995, Linares & Su 2005).

The purpose of this study is approaching the well-being of Italian population from the perspective of the biological standard of living. Because we analyse trends in BMI of nationally representative samples of male conscripts born in 1951 and 1980, we provide a picture of changes between these cohorts. This period is an interesting setting to investigate since Italy was experiencing an intense process of economic, social and cultural development and its population had undergone profound transformations in reducing

[1]The body mass index (BMI) is a measure of body fat based on height and weight, which applies to both adult men and women. BMI is defined as an individual's body weight divided by height squared. Four categories are generally used to classify adults: i) Underweight BMI < 18.5; ii) Normal weight =18.5-24.9; iii) Overweight = 25-29.9; iv) Obesity = 30 or over.

health risks. The second half of the twentieth century also witnessed an increase in human body weight in Italy, as in other rich Countries, because of access to more calories, reduced exposure to disease or reduced work loads, the main determinants of BMI (Sahn & Younger 2009). To study these changes, we also refer to the inequality literature following Sen (1985) pioneering works, now widely accepted to define inequalities in developing countries not only in terms of income or expenditure differences (**?**Pradhan et al. 2003).

However, in our investigation, we cannot use BMI as a marker of well-being success (see, Molini et al. (2010)) to compare the two generations since the empirical distribution of the conscripts is very different, skewed in the cohort of 1980 towards the overweight. The risk of overweight correlated to the onset of diseases in new generations, such as diabetes mellitus, asthma, and respiratory, cardiovascular and psychological diseases, appears a growing issue in juvenile phase of the youngest cohort. We motivate the analysis of these determinants because the overweight problem has also become significant in Italy (Costa-Font et al. 2009), where the percentage of adults classified as overweight (including the various forms of obesity) has risen by 4 percent in the last decade (ISTAT, 2007). Gallus et al. (2006) analysed BMI in Italy by sex and age in 2004, showing that overweight and obesity was reported by 20.6% of men aged 18-24 years, with higher obesity prevalence in the southern (and more deprived) areas of the country (Gallus et al. 2006).

In this paper to show the evolution of the BMI and to characterise the relationship with individual health, we use data of conscripts from the archives of various military districts situated in all areas (North, Centre and South) of Italy, and collected in a single dataset. In particular, we have information on young men born in 1951 and 1980 who underwent the compulsory medical examination to ascertain their fitness for military service in the Army in 1969 and 1998, respectively. Unlike surveys derived from interview, the body mass is measured directly by a competent medical team without being unduly intrusive (see, Burkhauser & Cawley (2008)). In addition, the dataset includes some socio-economic indicators so as education level of conscripts, that will be used as a proxy for socio-economic status (SES).

While the changes in BMI across geographical areas of Italy and conditionally to education is achieved by restricting the sample to the representative provinces in terms of number of conscripts in the two cohorts, the statistical relationships between some diseases responsible for individuals classified as unfit for military service and BMI are investigated under plausible assumption that BMI is the result of the effects of diseases in conscripts at the medical examination (e.g. 18 years); thus, we obtain differential estimates of conscripts that does not experiment these illness on response variable, after controlling for biological endowment and socio-economic conditions (e.g., education level), that probably play an important role in the adult BMI (Heineck 2006).

The increase of the BMI between Italian cohorts in the passage from pre- to industrialised countries leads to postulate a different response to the factors which drives to weight gains. In this paper, we use quantile regressions to determine how the health determinants of overweight come into play. We proceed with this econometric technique, keeping our work close in spirit to that of other papers in the literature on determinants of problematic measure of BMI, including works by Kan & Tsai (2004), Garca et al. (2009), Classen (2005), Atella et al. (2008), Auld & Powell (2009), Garcia & Labeaga (1996).

Our results seem to reflect the commonly held hypothesis that, in a poor and not uniformly developed economic and social context, a higher weight is correlated to higher SES group and underweight to lower, respectively, whereas it is after the transition to a modern wealthier society that the burden of overweight is posited to shift to low socio-economic status (SES). By exploring how disease groups affect BMI, we clearly find that some diseases affect significantly overweight and obese in the more recent cohort; in particular, the disease group including diabetes show a wide magnitude in the estimated parameter of BMI. This also suggests that some of the control policies, as the onset of mellitus diabetes in young people, should be considered with respect to the ''distance" between overweight and normal adult individuals, since it complements in these health concerns and may exacerbate the issue linked with the health costs.

2 Data: the Italian male conscripts for the cohorts of the 1951 and 1980

We used data of conscripts from the archives of various military districts situated in the North, Centre and South of Italy, and collected in a single database ''Banca dati PRIN 2004"[2]. We have got information on young men born in 1951 and 1980 who underwent

[2]The database used in this study is not the original one collected by each Research Unit participating in the Reasearch Project of National Interest (PRIN) financed by the Italian Ministry of University and Research in 2004. We used the database which had been corrected by Prof. De Iasio, who was asked to edit the database for errors, incongruence, etc..

the compulsory medical examination to ascertain their fitness for military service in the Army in 1970 and 1998, respectively. The Army's rigorous selection procedures, aimed at recruiting individuals who were free from disease and physically and mental robust, involved a compulsory medical examination for all Italian men at the age of 18 (although the 1951 cohort was examined at age 19)[3]. However, this difference should not bias our results since we consider the relatively long time-span (30 years) between the two cohorts and, more importantly, the recent phenomenon of acceleration of maturity which implies that, over time, final adult stature is achieved at earlier ages (Sanna 2002).

The collected data include the following variables: *(i) socio-demographic*: surname, date of birth, municipality of birth and of residence, profession, education (highest degree attained, last class attended); *(ii) anthropometric*: height while standing (height while sitting, only for 1980), chest and abdominal perimeter, weight; *(iii) health*: pathologies, disabilities, physical and mental impairments recorded for conscripts judged temporarily or permanently unfit.

The quality and quantity of information do not vary greatly between the two cohorts, except for 1951, for which the richness of data on health status and education is greater. This is due to the fact that, while data for the 1951 cohort were recorded on computerized supports by each Research Unit, computerized data for the 1980 conscripts were provided by the Italian Ministry of Defence. We have a large sample of very detailed data for the two cohorts. After a correction procedure, we have 111,834 individual records for the 1951 cohort and 162,295 for the 1980 cohort.

In line with the Army selection procedures, those who were found unfit for military service and who were unlikely to be restored to fitness within one year, were medically discharged. However, since we were interested in knowing whether a young man suffered from a specific disease and not whether he was declared unfit, we examined all the pathologies recorded by physicians (not only the reasons for temporary and permanent unfitness, but also pathologies which did not give rise to disabling diseases) for an exhaustive picture of the health status of conscripts.

The use of this unique dataset at micro-level for Italy has a few of limitations and several important advantages. Even if we partly cover the territorial areas of the country,

We thank him for his valuable work.

[3]For the a detailed description of Italian laws which, over time, have modified the age at which military conscripts were required to undergo a medical examination, see Corsini (2008), p. 15.

this issue is alleviated by the large size of the sample, such that ''the findings reflect the different environmental characteristics of the North, Centre and South of the country" (Corsini 2008). In addition, the findings inferred from the study are relative to the male population while some other issues are connected with selection biases deriving from the conscription process, since we do not have data for the following categories: conscripts enrolled in the Navy, residents abroad, people already enrolled in the military apparatus as volunteers, or very sick people with documented serious disability, for whom assignment to various categories (fit, permanently unfit, temporarily unfit, exempted for family reasons) was made without the medical examination being carried out. These omissions should not cause a significant bias in our data because they represent small percentages.

Our dataset has, however, significant positive aspects. First, we stress that the compulsory nature of military service in Italy guarantees nearly complete coverage of the population, at least for the areas investigated. Second, the database provides information on conscripts' height but also on weight, so that the related measure of BMI can be calculated when studying the prevalence of overweight and obesity. In addition, information on height and weight are not self-reported, and consequently do not suffer from the potential biases found in the literature, according to which people tend to overestimate (or over-report) their height and underestimate (or under-report) their weight (see, e.g., Bolton-Smith et al. (2000)). Empirically, this literature has also shown that the measurement error in self-reported height is not random but systematic (Boström & Diderichsen 1997, Burkhauser & Cawley 2008) and height is overestimated in self-report data, particularly among men Finally, (Niedhammer et al. 2000, Dauphinot et al. 2009). The same findings were found by **?**Ezzati et al. (2006), who showed that men in the U.S. over-report their height. Gil & Mora (2011) reported that, when distortions refer to BMI, errors in estimates may be systematically affected by other factors in the regression. Lastly, as for heights and weights, physical and mental diseases or imperfections were further the result of detailed medical examinations made by the teams of doctors.

3 Evolution of body mass index (BMI) during the second half of the 20^{th} century

In this section, we feature the evolution of the BMI in the cohorts of conscripts of the 1951 and 1980 for Italy. Since the dataset has a different representativeness between the two cohorts at the territorial level, we used the Italian provinces that had a consistent number of observations in the two cohorts to describe changes in well-being indicator. Using this dataset, we can verify whether these changes were bigger in the southern of Italy, a known disadvantaged socio-economic areas. This should imply a decline of the territorial disparities of well-being measured between the cohorts. However, micro-data hold another added value: it allows focusing on the distribution of the well-being indicator. Whether the effects are heterogeneous across individuals or groups, detrimental effects of the BMI growth may arise on the measure of the dimension of health well-being when affects risky classes of BMI, in particular overweight and obese; this implies to make questionable the use of the ‘’mean” as a well-being indicator. Third, we show that disparities in SES, such as education level, are correlated with economic well-being and the evolution of the BMI across the cohorts of conscripts (1951-1980) is able to disentangle when this indicator is a marker for development economic and to characterise negative externalities of individuals with lower SES to determine the highest BMI that are become an issue for a public health perspective.

3.1 The sample and the descriptive analysis

Many efforts were made to create a common platform for the two cohorts of conscripts, in order to facilitate temporal and geographical comparisons. We selected those provinces included in both databases, which had a statistically significant amount of observations. In particular, we did not consider provinces which were recorded in one dataset (e.g., the 1951 dataset) but not in the other (1980 dataset), or vice versa.

We grouped provinces into 5 macro-areas, representing the North-East, North-West, Centre, South, and Islands. Lastly, to avoid the influence of the massive migration flows experienced by the 1951 cohort, especially from South to North, we considered only those individuals who were born and had lived in the same geographical area, thus excluding all those who had moved to areas other than those of their birth. This necessary restriction

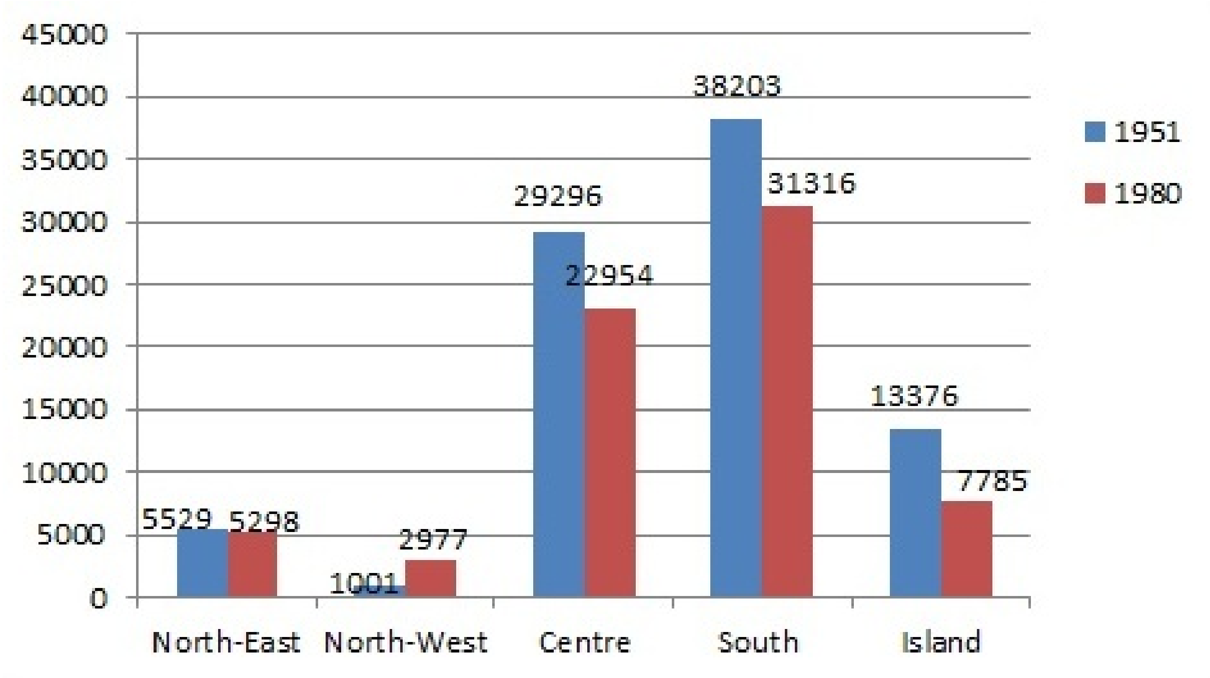

Figure 1: Trends of mean height and BMI, by macro-area of Italy: restricted sample

tends to eliminate the effects of differing environmental conditions on BMI for those who migrated, since we did not have information on their age at the time of their move, nor on what environmental circumstances they encountered during their lives. Some adjustments were also necessary to guarantee comparability between the municipalities of two datasets referring to 1969 and 1998 because, in the meantime several provinces, which had not previously existed, were created. The restricted sample does not cover the whole territory of Italy uniformly: conscripts from districts in Northern Italy are under-represented in the national sample, with respect to the others macro-areas. In the case of the islands' macro-areas, we only hold data for Sardinia. However, the number of conscripts to analyse trends of BMI holds very large for our aim, with 87,405 observations for the 1951 cohort and 70,330 for the 1980 one. The distribution of the sample by the geographical investigated areas (province, region and military district) and birth cohorts are listed in Appendix A.

From Table 1, we find that in 1951 about 43 percent of young men, as regards schooling, had ''none or elementary degree". By exploiting the modality ''low education", that results comparable between cohorts, data report a cut of this share of about 30 percent in the youngest cohort. As known, the increase in school participation rate determined that

Table 1: Characteristics of the sample of conscripts born in 1951 and 1980

	1951	**1980**		**1951**	**1980**
	1951	1980		1951	1980
Region	%	%	**Height**	%	%
North-East	6.3	7.5	less than 160 cm	7	1.5
North-West	1.1	4.2	160-169.9 cm	46.2	24.9
Centre	33.5	32.6	170-179.9 cm	40.7	54.8
South	46.3	44.5	180-189.9 cm	5.9	17.8
Island	12.7	11.1	190 cm and more	0.2	1.1
Education			**Weight**		
Low (none, elementary school)	43.4	9.3	less than 50 Kg	3.3	0.9
Mid-level (middle school)	42.9	88.5	50-59 kg	36.2	17.4
High (high school)	13.7	2.2	60-69 kg	41.8	37.8
Occupation			70-79kg	13.8	25.7
Student	32.5	70	80-89 kg	3.5	11.6
Umployed	65.6	20.6	90-109 kg	1.3	6.1
Unemployed	1.9	9.4	110 kg and more	0.1	0.6
Health			**BMI**		
Fit	77.6	81.9	Underweight	22	18.5
Permanently unfit	10.3	17.4	Normalweight	67.3	61.8
Temporarily unfit	5.3	0.7	Overweight	9.5	15.7
Others	6.8	-	Obese	1.3	4

Notes: Number of observations for 1951 cohort: is 87,405 and 70,330 for 1980 cohort. ''Others": candidates exempt for family and other reasons (priest, died, ect..). Source: database on military conscripts Prin 2004 (Corsini); our processing.

most of the men born in 1980 were still attending high school. This was supported by the distribution of frequencies of occupation: 70 percent of conscripts were ''students" in 1998, versus 32 percent of their peers born 30 years before. Looking at the BMI emerges that men weighing less than 60 kg are less frequent in the recent cohort, whereas the number of those weighing over 70 kg increases. However, weight gains are partly explained in this period by a sustained increase in height (see, **?**). Most interestingly, we list the conscript distribution (in percentage) of BMI within the traditional fat classes in the last part of the Table 1. We can note a re-allocation of the shares of conscripts from underweight and normal-weight young people to overweight and obese conscripts examined in 1998, a pattern correlated with the economic growth rate registered in Italy in those years [4] (Peracchi & Arcaleni 2011) that, on the other hand, may make questionable the use of BMI as a direct marker of well-being, given the onset of health concerns in overweight people.

[4]For a discussion of the economic growth rate, see, Paci & Pigliaru (1997)

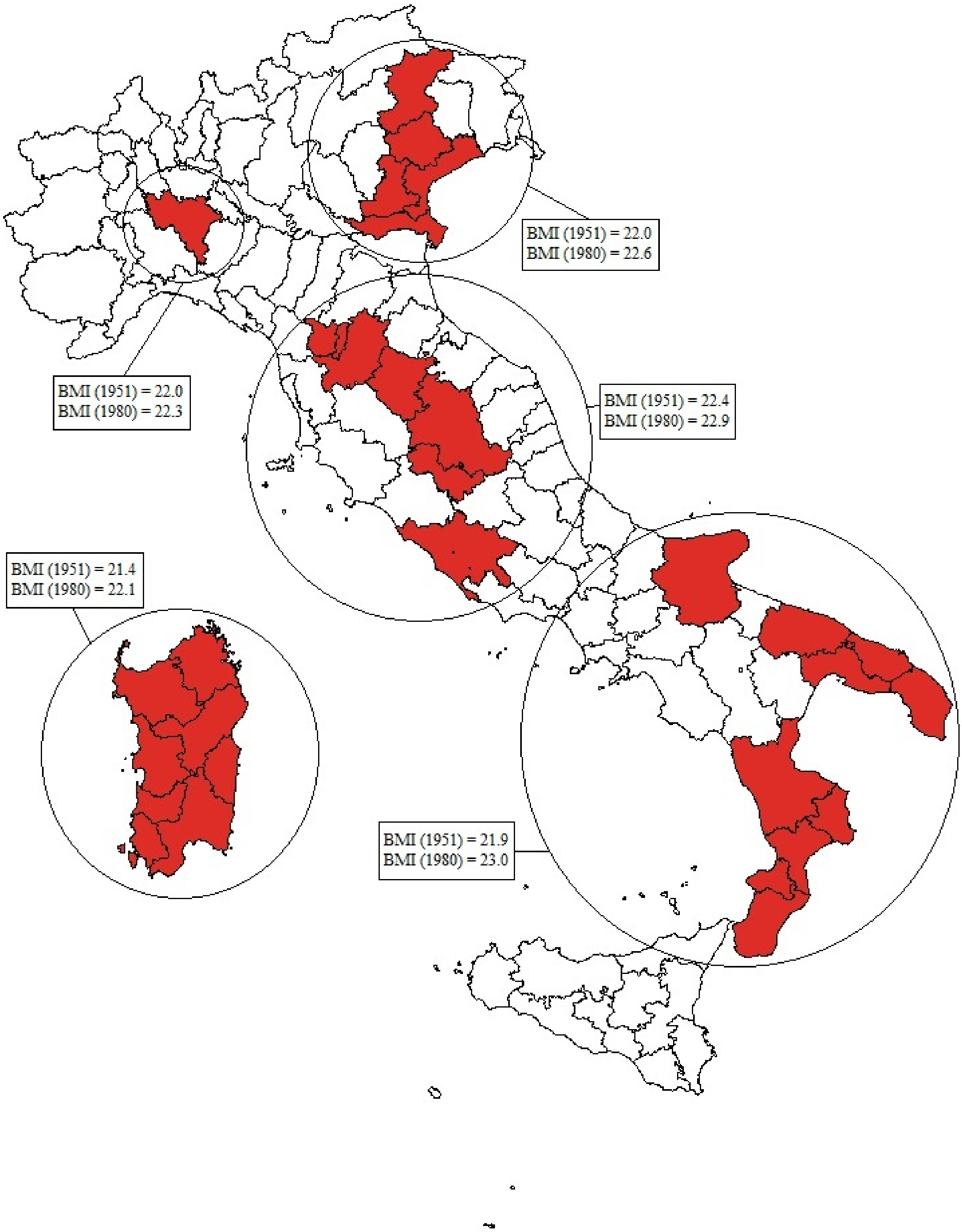

Figure 2: Territorial distribution of BMI

However, it is a stylised fact that the mean of BMI values increased over time in all areas (Figure 2): men born in 1980 were on average 0.7 BMI points higher than their peers born 30 years before. Whereas the youngest cohort had a mean BMI of 22.6, the oldest one records a value of 21.9. The areas which experienced the highest increases in male BMI were southern Italy and Sardinia (from 21.9 to 23.1), whereas northern and central Italy had the lowest increases in BMI. The Appendix B lists the statistics of changes in BMI and a very detailed description of the evolution of BMI between the two cohorts by province[5].

3.2 Opulence meets well-being? A focus on obesity and overweight trends (1951-1980)

As argued, the considerable interest in the composition of the changes in BMI arises from the current trends in overweight, a result of rapid changes in the socio-economic conditions that have taken place in Italy since the 1970s and of the nutrition patterns of the Italian population. Ulizzi & Terrenato (1985) stressed the importance of some important dietary components for growth, such as milk, meat, eggs, sugar, proteins and fats, in order to explain the secular trends in Italian conscripts born at the end of the nineteenth century and in 1960. It is a fact that food consumption increased considerably in Italy during the ''economic boom". Some of the changes in the consumption of some products certainly had a positive effect on secular height changes in the Italian population, but an increase in total energy from 2850 Kcal/day in 1969 to 3600 in 1997 also occurred. In addition to energy intake, the amount of energy expended through lack of physical activity may also explain the increased prevalence of weight gains in Europe (see, **?**). Figures 3 and 4, respectively, show the prevalence of overweight and obesity in the two cohorts by macro-area. Note that, as a large fraction of weights for the North-East is missing, we cannot infer changes in BMI in a representative way, and this information should therefore be viewed with caution. During the 30-year period, the percentage of overweight of 18-year-old Italian men increased from 9.5% to 15.7%, and the prevalence of obesity increased significantly from 1.3% to 4%.

However, a clear macro-regional disparity emerges. While the percentages of overweight

[5] The data for each cohort reveal a homogeneous variation in provincial BMI, except in the southern macro-area. In this case, the highest contribution came from the provinces of Calabria in 1980, explaining the highest BMI value in absolute terms of this macro-area.

Figure 3: Overweight changes in percentages by macro-area of Italy. (BMI: 25.00-29.99 kg/m2)

Figure 4: Overweight changes in percentages by macro-area of Italy. (BMI> 30.00 kg/m2)

conscripts measured in 1969 were higher in the Centre and North-West than in the South and Islands, during the whole period the proportion of overweight increased to a higher extent in the latter regions of Italy.

Figure 3 shows that, among young men resident in the South, the percentage of overweight conscripts born in 1980, almost doubled with respect to the 1951 cohort, while young men residing on the island of Sardinia represented 9.8% of the male population, with an increase in terms of their share of more than twice that of their peers born 30 years previously.

A similar North-South gradient is found for obesity. Figure 4 shows that in southern Italy 18-year-old men were more often obese than those living in the north. The prevalence of obesity in conscripts born in 1980 and living in Sardinia was 3%, but this is substantially higher than the average sample in 1951 (0.5%). This result for Sardinia is partly explained by the fact that Sardinian conscripts are characterised, even in 1998, by very short stature with respect to the national mean height. Following the BMI patterns described above, Figure 3 indicates a significant increase of obese persons in the South, contributing towards explaining the rise in BMI and its highest value in the 1980 cohort.

As a first conclusion, the increase of BMI between the two cohorts should justify better standard of living of new generations and a reduction of disparity across areas of Italy. However, this process seems to be conditioned by the composition in weight gains of conscripts across the macro-areas and, in particular from a public health perspective, of the increase of risky BMI classes that may determine negative externalities in terms of well-being.

3.3 Is it education a socio-economic predictor of trends on economic well-being?

The previous results suggest using with caution the BMI indicator to analyse changes in individual well-being and territorial inequality, which may provide evidence of the improvement in living conditions. As a stylised fact underpins a literature in developed countries, studies investigating the association between BMI and education have found that highly educated people tend to be taller and healthier than their less educated peers (**??**). The issue is that, when societies are in transformation these relationships may be confounded by a spontaneous dynamics that affect the well-being indicator. A society composed by individuals at birth that on average have low-income, as the cohort of conscripts born in 1951, have generally in juvenile age low education and are employed in jobs which required more physical work. Table 2 shows predicted BMI by education for each macro-area. Conscripts were assigned to two educational broad groups: ''Low education" comprises those who attained low secondary school; ''High education" comprises conscripts with secondary school diplomas or unfinished secondary school (since diplomas are usually obtained at age 18-19). In this way, we made comparable the different schooling of recruits in 1951 and 1980. The results show differences in marginal effects of education-related BMI outcomes, although BMI increased in all macro-areas (Table x). In according with the idea that BMI is a multidimensional indicator of well-being with a high content in health, we find that the conscripts subjected to greater increases in BMI are those with low education. Although these effects are quite evenly distributed in the central and northern areas of Italy, the impact of people with lower education is very large in the South (variation of BMI estimated at +1.4 points). The mechanism at work appears to be clear. Individuals born in 1951 and with a lower education have relatively unsatisfying well-being with respect conscripts with higher SES. This means that there is a section of the population (largely living in the south of Italy) with standards of living comparable to those found in developing societies that experiment during these 30 years the highest increase of BMI sustained by general improved health conditions and disposable income to use for food, that have determined the onset of the excesses in body weight. However, an unexpected growth rate of BMI is predicted by the typologies of education in Sardinia. Indeed, the growth rate is almost two times for people with higher education than those with low education. The statistic is explained by the lowest level of BMI for educated people in 1951 and mainly depends on ''genetics", because this regional population were homogeneously distant from the mean height and on ''economic nature", either because the general low income does not generate great differences across economic well-being of education groups, or because young people were employed in the primary sector (e.g., mainly agricultural sector), which requires physically demanding work. Note that, these conscripts occupied in these sectors had generally a greater muscle mass, which increased body weight, a point that may explain the higher coefficients in BMI estimates. Clearly, in the 1980 cohort these constraints were removed also for Sardinia conscripts. On the one hand, the small percentage of workers was employed in industrial and services sectors, so that did not require people who work in them to use great physical energy; on the other hand, in line with the national statistic, the majority of them were students, a condition that on average allowed a higher BMI.

Table 2: Characteristics of the sample of conscripts born in 1951 and 1980

	1951	(95% CI)	1980	(95% CI)	Δ	Growth rate (%)
North-East						
Low education	21.8	(17.0-26.7)	22.4	(22.3-22.5)	0.6	2.8
High education	23	(19.4-24.7)	23.5	(23.3-23.7)	0.5	2.2
North-West						
Low education	22	(21.8-22.1)	22.4	(22.3-22.5)	0.4	1.8
High education	22.1	(21.7-22.5)	22.33749	(22.2-22.4)	0.2	1.1
Centre						
Low education	22.3	(22.3-22.4)	23	(22.7-23.3)	0.7	3
High education	22.3	(22.2-22.4)	22.8	(22.5-23.1)	0.5	2.1
South						
Low education	21.8	(21.8-21.9)	23.2	(21.9-24.4)	1.4	6.4
High education	21.9	(21.8-22.0)	22.5	(21.9-23.0)	0.6	2.7
Islands						
Low education	21.4	(21.3-21.4)	22	(21.9-22.1)	0.6	2.8
High education	21.1	(20.9-21.2)	22.2	(22.1-22.3)	1.1	5.2

We confirm that younger people in Italy born in modern wealthier society benefited from social and economic changes, experiencing a significant increase in BMI. The changes that determined a mean reversion process of BMI across regions seems to be partly leaded by education. Linked with the results of the previous sub-section, the results indicate the existence of a trade-off in health well-being in which subjects with low SES and, in particular, with low levels of education, by a higher prevalence of obesityM.C. et al. (1999), Rasmussen et al. (1999), Huot et al. (2004).

4 Adult BMI and individuals' health

The increasing trends in BMI and consequently the prevalence of overweight and obesity reported in Western developed societies represent a threat for public health, as obesity is related to several morbidities and disabilities. If there is an association between BMI and health concerns, studies of variations in BMI may also help in defining variations in current and future health prospects. There is growing evidence that excess of weight is associated with chronic diseases and all-cause mortality. Correlations are found with major causes of metabolic, cardiovascular, neoplastic, digestive tract and several other major diseases, and with premature mortality (Calle et al. 1999, 2003, Bianchini et al. n.d., Kenchaiah et al. 2002, Adami & Trichopoulos 2003, Hedley et al. 2004, Flegal et al. 2005, McGee 2005). For example, it has been shown that the prevalence of hypertension and diabetes mellitus is significantly higher among obese Israeli conscripts, and higher with respect to the female population (Bar Dayan et al. 2003).

Here, we investigate the association between individual BMI and some medical pathologies recorded at the medical Army selection procedures, as the persistence of health concerns, that for a large part of conscripts determined to be unfit for military service. Although the datasets related to the cohorts of the 1951 and 1980 are not strictly comparable in the population, the large dimensions of the observations allows us inferring about the evolution of the health determinants in the well-being of young adults and, more in general, of the changes of health diseases of the Italian society in the post-World War II era.

In light of this, the dataset can be considered as an extraordinary data source to determine the changes in health profile of a young adult male population in which BMI represents a valid indicator of these effects. Thus, investigating the health status of two cohorts of conscripts in terms of BMI that experienced the same exposure to risk factors near at the time when health status is assessed (period effect), should reflect their socio-economic position, correlated with the changing in health risk factors to which they had been subjected.

4.1 Data and descriptive statistics on conscripts' health

To feature the health status of conscripts, we used medical information based on the diagnoses according to which young adult men were classified as fit or unfit for military service; the latter who were unlikely to be restored to fitness within one year, were medically discharged. Since we were interested in knowing whether a young man suffered from a specific disease and not whether he was declared unfit. We examined all the pathologies recorded by physicians and not only the reasons for temporary and permanent unfitness. However, our data in disease outcomes of military conscripts are not perfect.

First, the number of subjects to be recruited has changed radically over time, in relation to the needs of the armed forces, whereas recruitment policies have also played a key role in establishing recruitment regulations, causing variations in the requirements for being declared fit or exempted from military service. For the 1951 cohort, discharge for medical reasons was not easy to obtain, due to the diplomatic and political tensions in the 1970s related to the international situation, whereas for the younger generation born in the 1980s, who preceded the abolition of compulsory military service, medical discharge was one way of not wasting time to complete their studies.

Second, some information is missing. In fact, men suffering from serious illnesses or impairments could obtain exemption from military service from the ''Consiglio di Leva". However, this was not frequent, in view of the age and of the healthy status of the majority of conscripts.

Third, developments in medical science and disease diagnostics may make questionable the reliability and detail of diseases across cohorts; this implies the difficulty to use a single classification for both cohorts. In according to the correct assessment of conscripts' health status, it should be noted that the two cohorts were subjected to different laws, covered by the ''List of physical impairments and diseases for being declared unfit for military service". Specifically, the Decree of the President of the Republic (DPR) no. 496 of 28 May 1964 was applied to those born in 1951, whereas the standards set out in the Ministerial Decree (DM) of 29 November 1995 were applied to those born in 1980. Recoding the articles of DPR 1964 carried out by a team of professionals on the basis of 1995 DM, allowed the health status of the two cohorts to be compared. In spite of the above limitations, these data recorded by physicians provide a unique picture of conscripts' health status in that period; more importantly, information about diseases is not biased, as in the case of self-reported data, and represents the first time that the whole dataset has been used for scholarly research.

According to the Decrees, the causes of being declared unfit (temporarily or permanently) for military service were summarised in thirteen categories listed in the Table 3, in which are described the corresponding articles of Decree associated with the reasons of unfitness[6]. Table XX also reports the percentage of conscripts affected by the specific disease. Focusing on the cohort of 1951, physical health disorders (disarmonie generali) were the most frequent disease group along with diseases related to the cardiovascular and digestive-urogenital systems, whereas the high level of the category ‘’others” is not to easy to disentangle in term specific incidence although includes disease in locomotor system. Note that, impairments of the locomotor system and skin diseases, which were the most common pathologies in conscripts, also comprised severe deformities of both upper and lower limbs, suggesting the after-effects of polio. In Italy before the introduction of compulsory vaccination for newborns with live attenuated vaccines (law of 4 February 1966), polio was an endemic disease in most of the population in asymptomatic form but, for a small proportion of seriously affected people (2-5%), it could lead to paralysis of the limbs. Those who survived the more serious forms of polio had high levels of disability, i.e., inability to use their limbs and physical deformities.

Table 3: Disease categories for rejection from military service according to Italian laws (issued in 1964 and 1995)

Code	**Reasons for unfitness**	**Articles DM 29/11/1995**	**Articles DPR n. 496 28/05/1964**	**Unfit for military service (%)**	
		(1951 cohort)	(1980 cohort)	1951	1980
1	Physical health disorders	1	1-4	21.23	31.91
2	Metabolic and endocrine disorders, enz.	2-4	5-6	0.39	13.7
3	Immuno-allergology; infectious disease	5-8	7-10; 12-13	0.28	8.94
4	Cancers	9	14	0.16	0.8
5	Skull and maxillofacial complex	10-13	24; 57-61	0.58	0.57
6	Cardiovascular system	14-17	70-73	16.27	6.71
7	Respiratory system	18	11; 68-69	6.1	1.08
8	Digestive-urogenital system	19-23	63; 74-85	11.56	6.31
9	Neurology, nervous system	24-28	25-26; 30	1.68	3.38
10	Psychiatry	29-35	27-29; 31	3.12	10.74
11	Ophthalmology	36-44	33-49	6.06	4.86
12	Otolaryngology	45-47	50-56; 62; 64-66	3.52	1.47
13	Dermatology, locomotor system, others	48-58	15-23; 32; 86-93	29.05	9.54
				100	100

Notes: we report the two different Italian Laws to which conscripts were subjected to. The abbreviation DM states for Italian Ministerial Decree, while DPR states for Decree of President of Republic. Notes: the number of conscripts declared unfit for military service was 9,187 for 1951 birth cohort and 7,403 for 1980.

Looking at the diseases and disorders recorded for military conscripts born in 1980, we note that the epidemiological scenario has substantially changed, reflecting the im-

[6] A Table in Appendix lists the principal sub-diseases within the reasons for unfitness.

proved socio-economic and health environment in which they grew up. The ‘’physical health disorder” is the first most common cause of unfitness for military service (31.9%), although an analysis of the diseases or imperfections reveal that ‘’frail constitution” or ‘’debility” no longer appear but several cases of obesity do. As noted above, young conscripts born in the wealthy 1980s had an excessive and unbalanced intake of calories and a life-style characterised by sedentary and reduced physical exercise. Conversely, cardiovascular, respiratory and digestive-urogenital diseases have consistently fallen in percentage. Diseases of the locomotor system and skin pathologies have also been substantially reduced. Nor do we find any cases of polio, thanks to the almost complete coverage of vaccination against it. Of particular interest is the distribution of psychological disorders, which increased substantially with respect to the 1951 cohort from 3% to about 11%. Diseases such as ‘’oligophrenia” or general mental impairment, but also schizophrenia, epilepsy and Down’s syndrome, appear in this category; psychological and behavioural disorders are also frequent. One group of conditions which merits separate examination is ‘’Metabolic and endocrine disorders, and enzymopathies”, which increased substantially, from 0.4% to 13.7%. Diabetes mellitus was the most common diagnosis in this group; although it is difficult to distinguish between the relative contribution of modern medical technology, resulting in a greater degree of diagnostic precision than was possible 30 years before, and a true epidemiological increase. However, the progressive increase of diabetes is well documented in the medical literature (Cherubini et al. n.d.). Lastly, we found that immuno-allergological diseases also rose from 0.3% to 9%, particular bronchial asthma, perhaps caused by increasing pollution.

4.2 Empirical issues

The quantile regression represents a model that consistently estimates the relationships between individual health status and well-being at different distribution quantiles, and with respect to OLS estimator, does not require any assumptions regarding error term distribution (Koenker & Bassett 1978, Koenker & Basset 2001). That is, we can carefully examine the determinants of BMI throughout conditional distribution, with particular focus on people distant from normal weight, which are arguably of the greatest interest. For example, in analysing BMI, both lower (underweight) and upper (overweight) quantiles are considered as indicators of lacks in health standards. First, consider a linear model of

BMI related to $f(\bullet)$ written as:

$$BMI(i,t) = f(D, EDU, A)\phi + \epsilon(i,t), \;\; i = 1,2,...n, \;\; t = 0,1 \tag{1}$$

where the arguments of this function $f(\bullet)$ include D variables of health status, education (EDU) and geographical macro-area (A) of Italy. These variables controls for different propensity of well-being indicator to SES groups (e.g., with respect to the previous discussion, here we define three categories of education level: *high*, *middle* and *low* education) and specific conditions of the environment (e.g., dummy for the 5 Italian macro-areas), respectively; these variables are associated with the vector of parameters ϕ, while $epsilon(i,t)$ is the error term. Basically, the objective function of individual BMI, under OLS, is expressed as:

$$\sum_{i=1}^{n} \left(BMI(i,t) - f(\bullet)\phi\right)^2, \tag{2}$$

where the estimated vector $\hat{\phi}$ is the solution to the minimization of the sum of squared residuals presented in equation (2). Equation (1) can be estimated also using a quantile regression approach, that is a direct generalization of the least absolute deviation (LAD) technique proposed by Koenker & Bassett (1978), Koenker & Basset (2001). The regression specification for the θ-th conditional quantile of BMI can be expressed as:

$$BMI(i,t) = f(\bullet)\phi^{\theta} + e^{\theta}(i,t), \;\; i = 1,2,...n, \;\; t = 0,1 \tag{3}$$

where θ is the quantile of interest chosen in the interval (0, 1), ϕ^{θ} is the vector of parameters which now depend also on θ, and e^{θ} is the corresponding error term. The solution is obtained by minimizing the asymmetric weighted sum of absolute deviations conditioning on specific quantiles:

$$\min_{\phi \in \Re^k} \left[\sum_{i:BMI(i,t) \geq f(\bullet)\phi} \theta \left| BMI(i,t) - f(\bullet)\phi^{\theta} \right| + \sum_{i:BMI(i,t) \leq f(\bullet)\phi} (1-\theta) \left| BMI(i,t) - f(\bullet)\phi^{\theta} \right| \right], \tag{4}$$

where $f(\bullet)\phi^{\theta}$ is an approximation of the θ-th conditional quantile of the BMI distribution. As shown by Koenker & d'Orey (1987), the parameters of estimation are then carried out by some slight modifications of the minimization problem by simplex methods.

If θ is equal to 0.5, equation (4) turns into the LAD estimator and $f(\bullet)\phi^{\theta}$ describes the effect of the variables of interest at the median of the BMI distribution. In addition, if θ is chosen from the upper tail of BMI distribution, $f(\bullet)\phi^{\theta}$ will characterise the behaviour of obese individuals.

We followed the epidemiological studies to feature the main health determinants of BMI, grouping health categories of Table 3 from thirteen to five whereas, we include in BMI estimates a residual category of disease which collapse all pathologies for which a clear association is not shown (e.g., *Physical health disorder*; *Metabolic disorder*; *Immuno-allergological disease*; *Psycological disease*; *Others*); we use dummy variables to differentially account for the effect of conscripts subjected to diseases with respect to those that fit for military service (reference group).

Figure 4 empirically shows the estimates of Epanechnikov kernel density functions BMI conditional distribution on the distribution of disease dummy variables to justify the use of quantile regression in each sample cohort for the four specific disease variables. That is, as a first result, we examine whether the conditional distributions maintain the OLS assumptions (i.e., normality of the conditional distribution) to estimate consistently the parameters of the covariates of interest. The empirical conditional distributions of BMI in the figures are very far from Gaussian distributions in each cohort and they do not appear to meet the theoretical features.

Kernel distribution of BMI for conscripts with physical health disorders are very different with respect to the conscripts that fit for military service. The weaker physical constitution of the 1951 conscripts, probably due to a lack in the balanced composition of the food supply, is shown by a low median BMI around 19, three points below the median of conscripts without physical health disorders. This picture is partly confirmed for the younger cohort. Underweight characterises conscripts with physical health disorders (disarmonie generali), although these differences with respect to healthy conscripts were not largely significant. Instead, clearly recorded is the onset of the prevalence of conscripts with weight problems, as shown from the hump around the limit defining obesity (BMI > 30).

We focus attention now on metabolic disorders and immune-allergological diseases presumed to affect body weight in modern and more developed societies, respectively. Conditional BMI distribution in the 1980 cohort confirms that these diseases, arising from industrialisation and changes in modern society, are partly responsible for increased body weight. We can also extend these considerations to differences in conscripts with or without psychological disorders. Whereas the group with psychological disorders showed significant BMI differences in the overweight region (BMI $>$ 25) in groups in the 1951 cohort, this finding was emphasised for the 1980 cohort.

4.3 Estimates

We proceeded to estimate models in BMI equation () by quantile regressions, and use OLS estimates to compare results (Table 4). In line with our expectations, the older cohort living in southern and central Italy tended to show a higher BMI in OLS and quantile estimations, whereas obese conscripts born in 1980 were prevalently concentrated in the South, recording a significant value of 3.188 (s.e.= 0.065) with respect to those living in the reference macro-area (e.g., Sardinia). Conscripts born in 1980 and living in the North-East were the thinnest, although this result may depend on upon the characteristics of the BMI indicator which, with height squared as the denominator, tended to decrease for very tall conscripts, like those living in the North.

As expected, OLS estimates for the cohort of the 1951 indicate higher education is positively correlated with BMI, whereas middle education shows an humped shaped prediction of BMI. We found a growing relationship across the quantile regression between BMI and education for conscripts born in 1951, although middle educated people under the median of the distribution had a lesser body weight with respect to those low educated. As already argued by Padez (2006), this result is partly explained by from the influence of occupation on anthropometric measures in an economy not completely developed as Italy, since the majority of conscripts were employed (65%) in manual work and only 32% were still students, with a greater muscle mass, which determined an increase body weight in the low part of BMI distribution. A positive impact on BMI at 75th and 90th percentiles indicates that more highly educated conscripts were more likely to come from wealthy families, in which education could be guaranteed.

In line with the evolution of the concept of economic living conditions, which were not reflected in a higher BMI in 1980 we find that, with respect to low educated BMI, this is lesser in the higher quantiles. Focusing on obese (in our dataset the obese conscripts start at the $80th$ percentile), the estimates across the $75th$ and $90th$ percentiles are better in

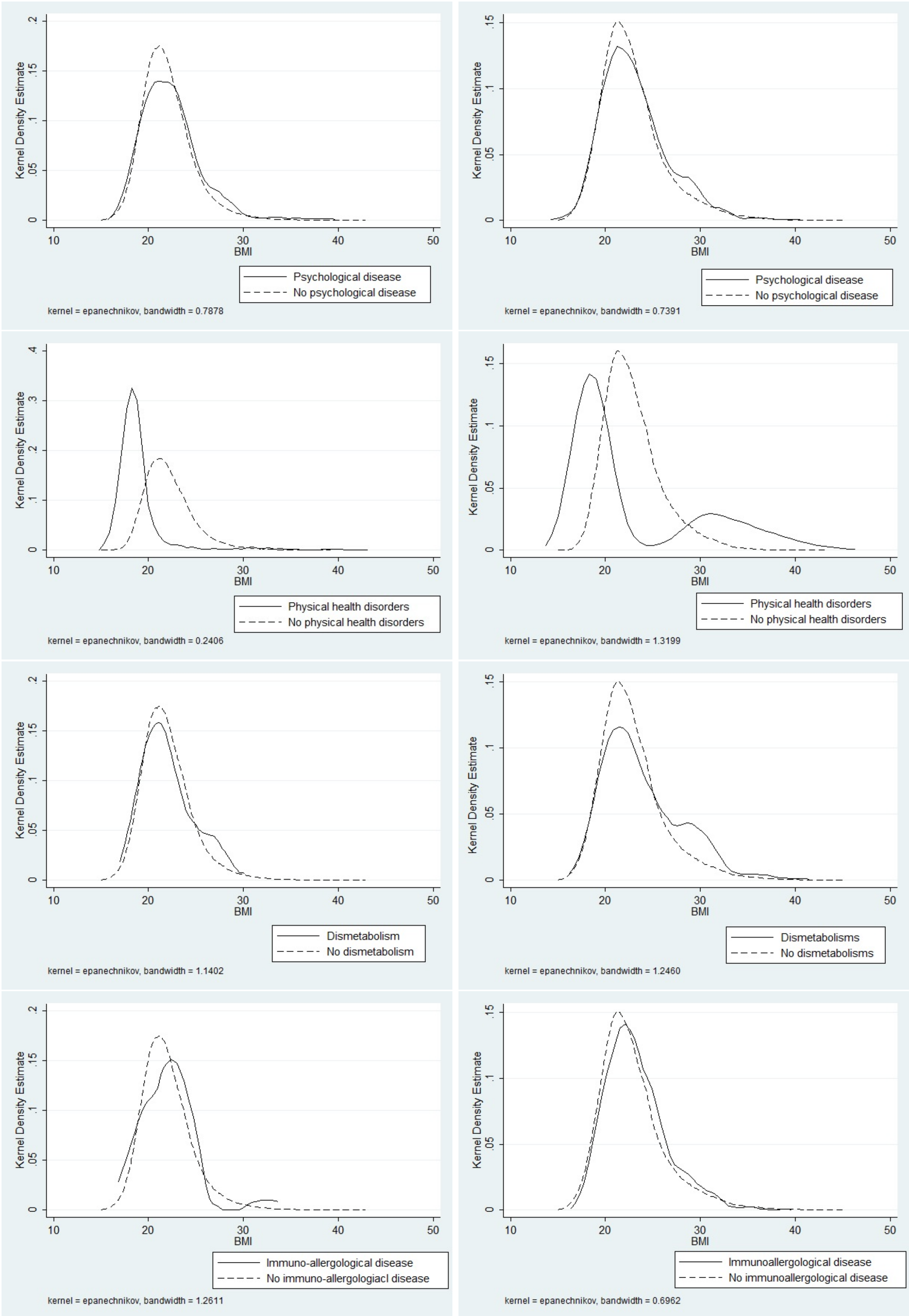

Figure 5: Kernel density estimates of BMI by disease/non_disease indicator and cohort

health status, since higher educated people have about (-) 2 points of BMI with respect to lower educated.

Table 4: BMI: OLS and quantile regression

	1951 cohort					1980 cohort				
	OLS	$Q_{0.25}$	$Q_{0.50}$	$Q_{0.75}$	$Q_{0.90}$	OLS	$Q_{0.25}$	$Q_{0.50}$	$Q_{0.75}$	$Q_{0.90}$
Region										
North-East	0.309	0.057	-0.129	0.221	1.391	-1.007***	0.313***	0.366**	-0.786***	-0.24
	(0.339)	(0.414)	(0.296)	(0.411)	(1.759)	(0.167)	(0.117)	(0.152)	(0.209)	(0.504)
North-West	0.339**	0.203**	0.311**	0.284**	0.544**	-0.324***	0.057	0.048	-0.069	0.604***
	(0.173)	(0.088)	(0.133)	(0.132)	(0.255)	(0.103)	(0.07)	(0.096)	(0.158)	(0.198)
Centre	0.72***	0.143***	0.537***	1.032***	1.702***	0.424***	0.706***	0.848***	0.917***	1.753***
	(0.039)	(0.088)	(0.037)	(0.044)	(0.071)	(0.092)	(0.07)	(0.083)	(0.134)	(0.176)
South	0.348***	0.132***	0.282***	0.51***	0.761***	0.189	-0.438	3.45	1.468	3.659
	(0.038)	(0.026)	(0.034)	(0.038)	(0.071)	(1.835)	(3.526)	(3.736)	(2.712)	(2.79)
Island (reference)										
Education										
High	0.344***	0.152***	0.297***	0.493***	0.787***	-1.212***	-0.051	-0.437**	-1.969***	-2.553**
	(0.047)	(0.02)	(0.052)	(0.051)	(0.091)	(0.361)	(0.363)	(0.19)	(0.467)	(1.119)
Mid-level	-0.011	-0.098***	-0.062*	0.038	0.105*	-0.804***	-0.051	-0.377*	-1.035***	-0.787***
	(0.027)	(0.018)	(0.034)	(0.04)	(0.062)	(0.148)	(0.11)	(0.217)	(0.238)	(0.237)
Low (reference)										
Health										
Fit (reference)										
Physical health	-3.188***	-2.808***	-3.358***	-4.115***	-4.506***	0.256***	-2.872***	-3.203***	5.306***	7.511***
disorder	(0.065)	(0.037)	(0.03)	(0.044)	(0.132)	(0.083)	(0.033)	(0.089)	(0.224)	(0.296)
Dismetabolism	-0.083	-0.206	-0.168	0.233	1.577	1.161***	0.057	0.536	2.454**	4.03***
	(0.465)	(0.586)	(0.465)	(1.222)	(1.224)	(0.27)	(0.31)	(0.454)	(1.049)	(0.701)
Immunoallerg,	-0.461	0.147	-0.181	-0.328	-1.235***	0.315**	0.02	0.143	0.636***	0.641**
	(0.569)	(0.813)	(0.597)	(0.598)	(0.282)	(0.137)	(0.135)	(0.13)	(0.206)	(0.301)
Other diseases	-0.096***	0.038***	0.041***	-0.045	0.135	0.26***	-0.09	0.047	0.518***	0.672***
	(0.036)	(-0.25)	(-0.188)	(0.062)	(0.216)	(0.08)	(0.07)	(0.09)	(0.121)	(0.197)
Psychological	0.109	0.165	0.12	0.164	0.532	0.14	-0.18*	-0.08	0.361***	0.93***
disease	(0.152)	(-0.11)	(0.08)	(0.231)	(0.39)	(0.12)	(0.098)	(0.14)	(0.138)	(0.306)
Cons.	21.64***	20.32***	21.4***	22.645***	24.03***	23.512***	20.33***	22.18***	24.817***	26.448***
	(0.032)	(0.024)	(0.021)	(0)	(0.046)	(0.16)	(0.133)	(0.218)	(0.226)	(0.296)

The set of regressions show a disease-specific association with BMI. The analysis of these OLS results show that only ''physical health disorders", among the four specific diseases, is negatively correlated with BMI, reducing of more than 3 points the size of this indicator. The main motivation is that there is a small proportion of young men in the cohort of 1951 affected by this type of diseases, also when we extend the analysis for the estimated quantiles. The exception is the result of the negative impact of immuno-allergological disease that reduce the well-being for people with large body weight (e.g. $90th$ percentile, the parameter is -1.235 with respect to the reference group).

This picture changes completely in the cohort of 1980. Young people are massively observed to be affected by metabolic disorders (e.g., dismetabolism); this category includes conscripts with diabetes, a health disease important in the recent cohort of conscripts that accounts for the increasing phenomenon of ‘’diabesity”, and evidences the close association between diabetes and obesity. The increase of BMI of 1.61 in OLS estimates is largely determined from the group of obese that at the $75th$ and $90th$ percentiles of BMI (BMI=2.54 and BMI=4.03, respectively).

As expected from non-parametric estimation, the quantile estimates in the youngest cohort of immune-allergological diseases group show a positive correlation with men's BMI at the .75 and .90 quantiles. Although this result confirms a close association, we cannot infer a causal relationship between asthma, the main problem registered in this disease category, and overweight because, for example, longitudinal data would be needed for identification.

Another interesting result is the significance of psychological disease in BMI conditional distribution. While in the 1951 cohort quantile estimates do not affect BMI of conscripts with psychological diseases, with respect to men fit for military service, a ‘’diversion mean (or median) process” is at work in the 1980 cohort, where point estimates above and below the median have different sign. As a health indicator, underweight or overweight (or obesity) is significant for conscripts with psychological problems. Differences in BMI indicate a point estimate of -0.18 at the 25^{th} percentile, while conscripts with psychological diseases have a BMI exceeding 0.93 at the 90^{th} percentile. It is predicted that the risk of being overweight or obese increases with psychological diseases, a result which is explained in the medicine literature by a reduced physical activity, due to the tendency to isolate oneself, or to develop unsuitable dietary habits.

More interestingly, our estimates show that the association between the disease group ‘’physical health disorders” and BMI in the two cohorts summarizes the onset of negative effect of "‘modern diseases"’ linked with the weight gains of young adults. Starting from the 1951 cohort, we find a negative linear association, becoming larger when estimated at the quantiles of .75 (BMI=-4.11) and .90 (BMI=-4.51). This means that conscripts affected by physical health diseases are more likely to have a systematically lower BMI with respect to healthy people; that is, the negative effect on BMI indicates a problem of underweight. Comparing these results with the specification estimated for the 1980 cohort, we note a different trend. Specifically, BMI at the 75th and the 90th percentiles is significantly higher (e.g., +5.16 and +7.55 BMI points with respect to the BMI of those without this disease). This result suggests that people born in a modern wealthier society benefited from the positive social and economic changes in Italy, experiencing a significant increase in BMI, which in turn contributed to exemption from military service for physical health diseases.

5 Conclusions

This paper exploits the richness of micro-data on Italian conscripts between two generations (1951 and 1980) to investigate the trend of the BMI as well-being indicator and to feature the evolution of the standard of living within the North-South geographical areas. These measures are a mirror of how well the human organism thrives in its socio-economic and epidemiological environment, such as we cannot reject that BMI represents a marker of the well-being of the evolution of Italian population, predicted by higher level of education or from to convergence towards higher level of BMI steady state; however, we also show that this improvement generates a negative externality with a large increase of the share of overweight in the generation of conscripts born in 1980. Our results seem to reflect the commonly held hypothesis that, in a not uniformly developed economic and social context, overweight and underweight tend to be concentrated in high and low health and socio-economic status groups, respectively. However, it is only during and after the transition to a modern wealthier society that the burden of overweight is posited to shift to low health status groups, as evidenced by our data and by several studies in Italy, which have shown that low health groups are exposed to a burden of overweight and obesity (Gallus et al. 2006). In particular, conscripts born in 1980, with respect to the 1951 ones, experienced substantial health changes, with irrelevant infectious diseases and the rising prevalence of chronic degenerative diseases, immune-allergological issues and diabetes, due to behavioural and environmental factors. Mention for some major events occurring in Italy during that period that have favoured the transition has been the beginning of vaccination campaigns, such as those against diphtheria (1931), tetanus (1968) and poliomyelitis (1966) or the establishment of the Ministry of Health, separate from the Ministry of the Interior in 1958, which implied growing public interest in safeguarding the health of the population (De Iasio & Corsini 2006).

As a novelty in this literature, we gather information on specific pathologies through the medical report at the military examination, according to which conscripts were declared unfit for military service. We empirically test the correlation of specific diseases on BMI distribution serving to compare changes in Italian society between generations distant 30 years. Using quantile regressions, the results show that in the recent cohort overweight and obese conscripts respond more to metabolic disorders or physical health diseases, and become significant immune-allergological and psychological diseases, categories linked with the modern society and environment. These heterogeneous effects on BMI should be considered when developing modelling and policy that is designed to reduce overweight, suggesting that a targeted and tailored approach would be most effective. A key issue for future research is utilising data designed to capture the effect of various potential policy changes in some diseases upon BMI. The recent increase of diabetes mellitus in young people addresses to control for it, policies promoting, for example, physical activities may be tools for diminishing the excess of body weight and, in a complementary view, the cost of the National Health System.

References

Adami, H. & Trichopoulos, D. (2003), 'Obesity and mortality from cancer', *The New England Journal of Medicine* **348**, 16231624.

Araar, A., Levine, S. & Duclos, J.-Y. (2009), Body mass index, poverty and inequality in namibia, Paper prepared for central bureau of statistics, namibia.
URL: *http://www.the-eis.com/data/literature/Namibia_nutrition_2009.pdf.*

Atella, V., Pace, N. & Vuri, D. (2008), 'Are employers discriminating with respect to weight?: European evidence using quantile regression', *Economics & Human Biology* **6**(3), 305–329.

Auld, M. C. & Powell, L. M. (2009), 'Economics of food energy density and adolescent body weight', *Economica* **76**(304), 719–740.

Bar Dayan, Y., Elishkevits, K., Grotto, I., Goldstein, L., Goldberg, A., Shvarts, S., Levin, A., Ohana, N., Onn, E., Levi, Y. & Bar Dayan, Y. (2003), 'The prevalence of obesity and associated morbidity among 17-year-old israeli conscripts', *Public Health* **119**(5), 385–389.

Bianchini, F., Kaaks, R. & Vainio, H. (n.d.).

Bolton-Smith, C., Woodward, M., Tunstall-Perdoe, H. & Morrison, C. (2000), 'Accuracy of the estimated prevalence of obesity from self-reported height and weight in an adult scottish population', *Journal of Epidemiology Community Health* **54**, 143148.

Boström, G. & Diderichsen, F. (1997), 'Socioeconomic differentials in misclassification of height, weight and body mass index based on questionnaires data', *International Journal of Epidemiology* **26**(4), 860866.

Burkhauser, R. & Cawley, J. (2008), 'Beyond bmi: The value of more accurate measures of fatness and obesity in social science research', *Journal of Health Economics* **27**(2), 519–529.

Calle, E., Rodriguez, C., Walker-Thurmond, K. & Thun, M. (2003), 'Overweight, obesity, and mortality from cancer in a prospectively studied cohort of us adults', *The New England Journal of Medicine* **348**, 1625–1638.

Calle, E.E.and Thun, M. P. J., Rodriguez, C. & Heath, J. C. (1999), 'Body-mass index and mortality in a prospective cohort of us adults', *The New England Journal of Medicine* **341**, 10971105.

Cherubini, V., Carle, F.and Gesuita, R., Pinelli, A., Kantar, A., Cerutti, F., Pagano, G., Bruno, G., Mazzella, M., P., B., Lorini, R., Devoti, G., DAnnunzio, G., Tenconi, M., Frongia, P. & et al. (n.d.), Incidence variation and trends of childhood type 1 diabetes in italy, Nature and nurture of genes and public health issues of diabetes, or-210:22 ridi coordinating centre, university of ancona, italy, Satellite Symposium International Diabetes Epidemiology Group IDEG (XVII International Congress of Diabetes Federation).

Classen, T. (2005), Intergenerational obesity transmission and correlations of human capital accumulation, Technical report.

Corsini, C. (2008), Per una storia della statura in italia nellultimo secolo, Technical report.

Costa-Font, J., Fabbri, D. & Gil, J. (2009), 'Decomposing body mass index gaps between mediterranean countries: A counterfactual quantile regression analysis', *Economics & Human Biology* **7**(3), 351–365.

Dauphinot, V., Wolff, H., Naudin, F., Guguen, R., Sermet, C., Gaspoz, J.-M. & Kossovsky, M. (2009), 'New obesity body mass index threshold for self-reported data', *Journal of Epidemiology and Community Health* **63**, 128–132.

De Iasio, S. & Corsini, C. (2006), La banca dati delle leve militari italiane del 1951 e 1980, Unpublished.

Ezzati, M., Martin, H., Skjold, S., Vander Hoorn, S., Christopher, J. & Murray, C. (2006), 'Trends in national and state-level obesity in the usa after correction for self-report bias: analysis of health surveys', *Journal of the Royal Society of Medicine* **99**(5), 250–257.

Flegal, K., Graubard, B., Williamson, D. & Gail, M. (2005), 'Excess deaths associated with underweight, overweight, and obesity', *JAMA* **293**, 18611867.

Gallus, S., Colombo, P., Scarpino, V., Zuccaro, P., Negri, E., Apolone, G. & La Vecchia, C. (2006), 'Overweight and obesity in italian adults 2004, and an overview of trends since 1983', *European Journal of Clinical Nutrition* **60**, 11741179.

Garca, V., Jaume & Quintana-Domeque, C. (2009), 'Income and body mass index in europe', *Economics & Human Biology* **7**(1), 73–83.

Garcia, J. & Labeaga, J. M. (1996), 'Alternative approaches to modelling zero expenditure: An application to spanish demand for tobacco', *Oxford Bulletin of Economics and Statistics* **58**(3), 489–506.

Gil, J. & Mora, T. (2011), 'The determinants of misreporting weight and height: the role of social norms', *Economics & Human Biology* **9**(1), 78–91.

Hedley, A., Ogden, C., Johnson, C., Carroll, M., Curtin, L. & Flegal, K. (2004), 'Prevalence of overweight and obesity among us children, adolescents, and adults, 19992002', *JAMA* **291**, 28472850.

Heineck, G. (2006), 'Height and weight in germany, evidence from the german socio-economic panel, 2002', *Economics & Human Biology* **4**(3), 359–382.

Huot, I., Paradis, G. & Ledoux, M. (2004), 'Factors associated with overweight and obesity in quebec adults', *International Journal of Obesity* **28**(6).

Kan, K. & Tsai, W.-D. (2004), 'Obesity and risk knowledge', *Journal of Health Economics* **23**(5), 907–934.

Kenchaiah, S., Evans, J., Levy, D., Wilson, P., Benjamin, E., Larson, M., Kannel, W. & Ramachandran, S. (2002), 'Obesity and the risk of heart failure', *The New England Journal of Medecine* **347**, 305–313.

Koenker, R. & Basset, G. (2001), 'Quantile regression', *Journal of Economic Perspectives* **15**, 143–156.

Koenker, R. & d'Orey, V. (1987), 'Computing regression quantiles', *Applied Statistics* .

Koenker, R. W. & Bassett, Gilbert, J. (1978), 'Regression quantiles', *Econometrica* **46**(1), 33–50.

Linares, C. & Su, D. (2005), 'Body mass index and health among union army veterans: 18911905', *Economics and Human Biology* **3**(3), 367387.

M.C., S.-M., J., K., M., D., G., D. B. & Kornitzer, M. (1999), 'Sociodemographic and nutritional determinants of obesity in belgium', *Int J Obes Relat Metab Disord* **23**(Suppl 1), 1–9.

McGee, D. (2005), 'Diverse populations collaboration body mass index and mortality: a meta-analysis based on person-level data from twenty-six observational studies', *Annals of Epidemiology* **15**, 8797.

McLaren, L. (2007), 'Socioeconomic status and obesity', *Epidemiologic Reviews* **29**, 29–48.

Molini, V., Nub, M. & van den Boom, B. (2010), 'Adult bmi as a health and nutritional inequality measure: Applications at macro and micro levels', *World Development* **38**(7), 1012–1023.

Niedhammer, I., Bugel, I., Bonenfant, S., Goldberg, M. & Leclerc, M. (2000), 'Obesity and risk knowledge', *International Journal of Obesity* **24**(4), 1111–1118.

Paci, R. & Pigliaru, F. (1997), 'Structural change and convergence: an italian regional perspective', *Structural Change and Economic Dynamics* **8**(3), 297–318.

Peracchi, F. & Arcaleni, E. (2011), 'Early-life environment, height and bmi of young men in italy', *Economics & Human Biology* **9**(3), 251–264.

Pradhan, M., Sahn, D. E. & Younger, S. D. (2003), 'Decomposing world health inequality', *Journal of Health Economics* **22**(2), 271–293.

Rasmussen, F., Johansson, M. & Hansen, H. (1999), 'Trends in overweight and obesity among 18-year-old males in sweden between 1971 and 1995', *Acta Paediatrica* **88**(4), 431437.

Sahn, D. E. & Younger, S. D. (2009), 'Measuring intra-household health inequality: explorations using the body mass index', *Health Economics* **18**(S1), S13–S36.

Sanna, E. (2002), 'Il secular trend in italia', *Antropo* **3**, 23–49.

Sobal, J. & Stunkard, A. (1989), 'Socioeconomic status and obesity: a review of the literature', *Psychological Bulletin* **105**(2), 260–275.

Steckel, R. H. (1995), 'Stature and the standard of living', *Journal of Economic Literature* **33**(4), 1903–1940.

Ulizzi, L. & Terrenato, L. (1985), 'Nature-nurture relationships: the secular trend of stature is reaching in italy its final phase', *Acta Medica Auxologica* **17**(1-2), 119–124.

APPENDIX A

Table A.1: Overview of Italian Provinces included in the study for 1951 and 1980 cohorts

Province	Region	Military district	N	N
North-East			1951	1980
Belluno	Veneto	Padova	497	1244
Padova	Veneto	Padova	1841	1832
Rovigo	Veneto	Padova	605	190
Treviso	Veneto	Padova	2078	1115
Venice*	Veneto	Padova	508	917
North-West				
Pavia	Lombardy	Pavia	1001	2977
Centre				
Arezzo**	Tuscany	Florence	1469	783
Florence**	Tuscany	Florence	3201	2025
Prato**	Tuscany	Florence	595	596
Pistoia**	Tuscany	Florence	932	598
Perugia	Umbria	Perugia	3601	2996
Terni	Umbria	Terni	1300	1114
Rome	Lazio	Rome	18198	14842
South				
Bari	Apulia	Bari	9096	7920
Brindisi	Apulia	Lecce	2926	1826
Foggia	Apulia	Foggia	4022	4008
Lecce	Apulia	Lecce	5605	3856
Taranto	Apulia	Lecce	4342	2426
Cosenza	Calabria	Cosenza	3319	3923
Catanzaro	Calabria	Catanzaro	2588	2027
Crotone	Calabria	Catanzaro	1299	1144
Reggio Calabria	Calabria	Reggio Calabria	3660	3198
Vibo Valentia	Calabria	Catanzaro	1346	988
Island				
Cagliari	Sardinia	Cagliari	3879	2380
Carbonia Iglesias	Sardinia	Cagliari	1455	662
Medio Campidano	Sardinia	Cagliari	1099	634
Nuoro	Sardinia	Cagliari	1481	914
Ogliastra	Sardinia	Cagliari	483	284
Oristano	Sardinia	Cagliari	1663	785
Otranto	Sardinia	Cagliari	835	568
Sassari	Sardinia	Cagliari	2481	1558

*Sources: database on military conscripts PRIN 2004 (Corsini); our processing. * Data refer to municipalities west of province of Venice, not to whole province of Venice.** Data for north-east Tuscany refer to cohort of 1950, not 1951, since 1951 data were not available.*

APPENDIX B

Table B.1: Mean of BMI by cohort and province

	1951		1980			
Province	Mean	SD	Mean	SD	Δ	Growth rate (%)
Belluno	22.1	0.9	22.3	2.6	0.2	1
Padua	22.6	0.8	22.6	2.4	0	0.8
Rovigo	-	-	22.7	2.6	-	-
Treviso	21.4	2	22.7	2.4	1.3	3.7
Venice*	22.4	1.4	22.7	2.6	0.3	1.5
Pavia	22	2.8	22.3	3.3	0.3	1.6
Arezzo**	22.3	2.7	22.4	3.3	0.1	0.5
Florence**	22.5	2.7	22.7	3.4	0.2	0.9
Prato**	22.3	2.5	22.7	3.5	0.4	2
Pistoia**	22.4	2.7	22.5	3.5	0.1	0.6
Perugia	22.3	2.8	23.4	3.7	1.1	4.9
Terni	22.6	2.9	23.4	3.7	0.8	3.6
Rome	22.3	3	23.2	3.6	0.9	4.2
Bari	22.1	2.5	22.6	3.3	0.4	2
Brindisi	21.7	2.5	22.7	3.2	1.1	4.9
Foggia	21.9	2.4	22.6	3.3	0.7	3.2
Lecce	21.8	2.4	22.4	3	0.7	3
Taranto	21.5	2.5	22.8	3.3	1.3	6
Cosenza	22	2.6	23.4	3.5	1.4	6.4
Catanzaro	22.1	2.4	23.5	3.6	1.4	6.2
Crotone	21.9	2.2	23.3	3.5	1.4	6.2
Reggio Calabria	22.3	2.6	23.8	3.7	1.5	6.9
Vibo Valentia	21.9	2.3	23	3.4	1.2	5.3
Cagliari	21.2	2.5	22	2.9	0.8	3.6
Carbonia Iglesias	21	2.1	22	2.8	1	4.7
Medio Campidano	21.3	2.1	22.2	3.1	0.9	4.1
Nuoro	21.6	2.1	22.4	3.1	0.8	3.6
Ogliastra	21.4	1.9	21.7	2.6	0.3	1.2
Oristano	21.5	2.1	22.1	2.8	0.6	2.6
Otranto	21.5	2.5	22.2	2.9	0.7	3.3
Sassari	21.2	2.2	22.1	2.9	0.9	4.2

*Sources: database on military conscripts PRIN 2004 (Corsini); our processing. * Data refer to municipalities west of province of Venice , not to whole province of Venice. ** Data for north-east Tuscany refer to cohort of 1950, not 1951, since 1951 data were not available.*