

SOCIOECONOMIC DETERMINANTS OF MALE MORTALITY IN EUROPE: THE ABSOLUTE AND RELATIVE INCOME HYPOTHESES REVISITED

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Abstract.

This paper investigates the association between both absolute and relative income and male mortality from several important cause-of-death categories in Europe from around 1980 to the late 1990s. Although multilevel modelling is considered the preferred research design, there is still no alternative for a large international setting. However, with certain methodological considerations, that includes analysing causes of death and Western and Eastern European countries separately and introducing possible confounding variables with appropriate time lags, at least some of the limitations of ecological analysis are reduced. Results showed that absolute prosperity was more often significant than relative prosperity in Eastern than in Western Europe and vice versa for relative income. Another important East-West difference was that effect on non-cancer mortality in Eastern Europe was immediate, while a lag time of 15 years was needed to observe the strongest association in the Western European models.

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1 Introduction

During the last 30 years, both the levels of life expectancy and the levels of socioeconomic development have improved in Western Europe, albeit in a non-uniform way across countries. Previous studies, however, have shown that there is, at best, only a weak *direct* link between living standards and total mortality among wealthy nations at the international level. Already in 1975 Preston wrote that *“it is widely believed that mortality has become increasingly dissociated from economic level because of a diffusion of medical and health technologies, facilities and personnel that occurred, in large part, independently of economic level”* (Preston, 2007). Other explanations for mortality differences between wealthy nations have also been provided. For instance, Mackenbach and Looman (1994) suggested that *“the mortality increasing effects of urbanisation and industrialisation obscured the mortality lowering effects of high living standards”* as well as that country-specific factors such as dietary habits acted as confounders, while Wilkinson (1992) argued that *“among the developed countries, it is not the richest societies that have the best health, but those that have the smallest income differences between rich and poor”* as he found strong evidence of a negative association between income inequality and life expectancy for nine industrialised countries. Almost a decade later Lynch et al. (2001) casted doubt on the results by Wilkinson (1992), as the association disappeared after including more countries in the same analysis. In an editorial by Mackenbach (2002) it was suggested that a better understanding of the potential importance of contextual factors for population health may come from data on mortality that permit a simultaneous analysis of effects of income on mortality at the individual and aggregate level. However, based on the results of three such studies published in the same issue of the British Medical Journal (Osler et al., 2002; Shibuya et al., 2002; and Sturm and Gresenz, 2002) he had to conclude that the correlation between income inequality and population health is slowly dissipating. According to Subramanian et al. (2003), though, a consistent factor in these and other studies with similar results was their small level of aggregation (parishes, wards, municipalities, counties), as analyses at US state-level showed a more consistent effect of income inequality on health (e.g. Kaplan et al., 1996; Kennedy et al., 1996). A similar conclusion was provided by Wilkinson and Pickett (2006). Based on their review of 155 peer reviewed research papers, they concluded that *“income distribution is related to health where it serves as measure of the scale of the social class differences in a society”* and suggested that the few findings that were unsupportive of the relation between income distribution and measures of population health occurred when inequality was measured in areas too small to reflect the scale of social class differences in a society. Other reasons they gave for the lack of evidence in some of these studies was that they controlled for factors

which, rather than being genuine confounders, are likely either to mediate between class and health or to be other reflections of the scale of social stratification and that the international relationship was temporarily lost (in all but the youngest age groups) during the decade from the mid-1980s when income differences were widening particularly rapidly in a number of countries.

From this overview of the debate it may be concluded that the absolute versus relative income hypothesis is still undecided. This paper adds to this discussion by introducing a number of methodological innovations into the empirical analysis. First, a distinction is made between western and eastern European countries. Next, we study not only all-cause mortality, but make a distinction between relevant causes of death. Third, we allow for a time lag in the effect of mortality factors. Finally, we use a pooled cross-section and time series framework to study the mortality trends at the national level of European countries.

A number of authors have advocated the use of multilevel methods in studying the relationship between income and mortality (e.g. Wagstaff and van Doorslaer, 2000; Lochner et al., 2001; Subramanian et al. 2003; Dahl et al., 2006). This research design would require the availability of mortality data at the individual level. Although such a framework would greatly enhance the understanding of relevant factors on mortality, such data are not yet available at the international level (Lochner et al., 2001), and therefore beyond the scope of the current paper. The analysis reported here is at the macro level, and, since it is an ecological study, no causal relationship may be inferred at the individual level from the association that is established between the variable and the mortality outcome (Valkonen, 1993; Gravelle, 1998). Nevertheless, the associations are expected to be in line with what has been documented at the individual level.

2 Absolute versus relative income

Absolute income

Perhaps the most common indicator of the living standards of a country is per capita Gross Domestic Product (GDPc), a measurement of the average income of a person in a population. The fact is well established that there is a positive relationship between GDPc and health, as high-income countries are likely to consume more commodities that have a direct impact on the quality of life, such as housing, dietary and health care factors. Consequently, a changing state of the economy will also affect the health of a population. However, evidence is quite clear on the fact that the international relation between Gross National Income per capita and life expectancy not only grows progressively weaker as countries get richer, but disappears altogether among the richest

(Marmot and Wilkinson, 2001; Wilkinson, 1997; Wilkinson and Pickett, 2006). One important reason for this diminishing returns with growing income is the effect of confounding factors which negate the positive association between income and health. For instance, lifestyle factors, industrialisation and urbanisation were found to partly confound the income-mortality association in Western Europe (Mackenbach and Looman, 1994).

Relative income

Although at the country-specific level, both life expectancy and economic development in Western Europe have increased virtually incessantly throughout the last 40 years, the life expectancy in wealthy countries such as the Netherlands and Germany have been surpassed by less wealthy countries such as Greece and Spain. To explain the differences between countries within Western Europe, one therefore has to look elsewhere. Wilkinson (1996) proposed that “*what matters within societies is not so much the direct health effects of absolute material living standards so much as the effects of social relativities*”. If that is the case, then variations in the *distribution* of income will become an important determinant of health differences between countries. Wilkinson and Pickett (2006) suggest that the studies on income inequality and mortality are most supportive in large areas because in that context income inequality serves as a measure of the scale of social stratification, or how hierarchical a society is. A more unequal society becomes more dominated by status competition and class differentiation and suffers a more widespread health disadvantage as a result. Therefore, larger class differences lead to a steeper social gradient in health. Recent evidence from Italy and top industrialised countries also shows this, where income inequality had an independent and more powerful effect on life expectancy at birth than did per capita income and educational attainment (Vogli et al. 2005).

As to why income inequality is positively associated with mortality, Lynch et al. (2000) mention three possible explanations. According to the individual income interpretation, aggregate level associations between income inequality and health reflect only the individual level association between income and health. Secondly, the psychosocial environment interpretation argues that income inequality affects health through perceptions of place in the social hierarchy based on relative position according to income. Such perceptions produce negative emotions such as shame and distrust that are translated “inside” the body into poorer health via psycho-neuro-endocrine mechanisms and stress induced behaviours such as smoking. Lastly, the neo-material interpretation sees health inequalities to be the result from the differential accumulation of exposures and experiences that have their sources in the material world, reflecting a combination of negative

exposures and lack of resources held by individuals, along with systematic underinvestment across a wide range of human, physical, health, and social infrastructure.

While Lynch et al. (2000) accept the link between income inequality and life expectancy in rich countries, they reject the first two explanations in favour of the neo-material interpretation, arguing that a society with greater income inequality will have a higher percentage of people with low incomes, and that this higher prevalence of poor people accounts for the relation with poor health, not the relative income differences (which is why, as Marmot and Wilkinson (2001) state, Lynch and colleagues argue that even in rich countries an association exists between average income and life expectancy). Marmot and Wilkinson (2001) reason, however, that psychosocial factors mediate the relation between income inequality and mortality at the population level, and don't see that if you would provide everyone with the material needs that the psychological effects of relative (social) deprivation (e.g. control over worklife) remain untouched, as these factors influence health by the socioeconomic structure and by people's position within it. They go on by providing evidence of how psychosocial factors are linked to ill health and follow a social gradient, even within the same social class (e.g. as shown by the Whitehall II study), or that the poorer health of black people in the United States compared to Costa Rica must have more to do with the psychosocial effects of relative deprivation—such as educational disadvantage, racism, gender discrimination, social and family disruption, and fear of crime—than with the direct effects of material conditions themselves, given that Costa Ricans have lower incomes and a greater proportion of very poor people. Finally, even in a welfare state country as Norway where income inequality is lower than in most other Western European countries and markedly below the USA level, according to one multilevel study by Dahl et al. (2006), mortality levels increased with higher regional income inequality. The authors, however, point out the importance of area size as in similar Danish and Swedish studies smaller units were used and no association was found.

West-East differences

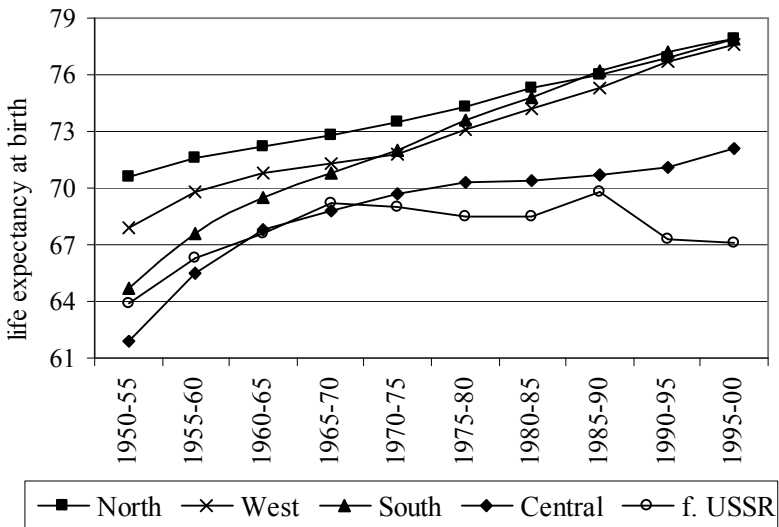
European countries are not homogeneous with respect to the effects of absolute and relative income on mortality. First, there are large differences in absolute income between European countries, particularly between western and southern countries on the one hand, and Eastern European countries on the other³. In the past, large differences also existed between southern and western European countries. While the West progressed in terms of economic development, much of

³ Throughout this paper a distinction is made between 'western' and 'Western' Europe, in which the former excludes countries of northern and southern Europe. When reference is made to 'Eastern' Europe it pertains to the countries of both 'central' Europe and 'the former Soviet Union' (see also note in Figure 1).

Eastern Europe lagged behind even though, in the early 1960s, levels of GDPc did not differ that much between the two parts of Europe. After communism collapsed, an economic transition occurred very rapidly that led to large decreases in economic productivity, which prompted the emergence of unemployment, something that the population had not experienced before. This caused enormous stress for the residents of the Eastern Bloc, not only because jobs were no longer guaranteed, but also because many aspects of the social welfare system also collapsed (Leon and Shkolnikov, 1998). The repercussions on the health of the population were devastating: between 1990 and 1994, life expectancy for men decreased by six years to 57.7 years and for women by three years to 71.2 years – an unprecedented rate of deterioration in a country not at war.

Compared with the current East-West mortality differences, differences within Western Europe are much smaller. During the course of the last 40 years, mortality rates have been converging as southern countries (with the exception of Portugal) have caught up or even surpassed most other countries of Western Europe (Figure 1). However, in terms of economic development, absolute differences have been remarkably consistent throughout the same period, even though the four largest southern European countries have all joined the European Union well before the turn of the last century (Italy in 1950, Greece in 1981, Spain and Portugal in 1986). Coincidentally, western and northern Europe had virtually identical levels of GDPc throughout this period (see Figure 2).

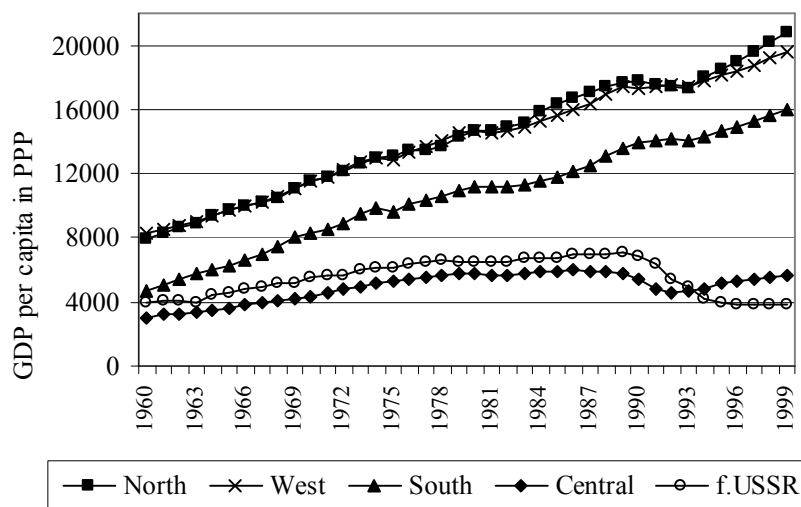
Figure 1 Life expectancy at birth in European macro-regions^a, 1950-2000



Data source: United Nations (2001).

^a North: Denmark, Finland, Norway, Sweden; West: Austria, Belgium, Switzerland, Germany, France, Ireland, Luxemburg, Netherlands, United Kingdom; South: Spain, Greece, Italy, Portugal; Central: Albania, Bulgaria, Croatia, Hungary, The Former Yugoslav Republic of Macedonia, Poland, Rumania, Slovenia, Slovak Republic, Yugoslavia, Bosnia and Herzegovina; former USSR: All of the 15 former Republics.

Figure 2 GDP per capita for the European macro-regions^a, 1960-1999



Data source: See Appendix 2

^a See Figure 1 for the countries that belong to each macro-region.

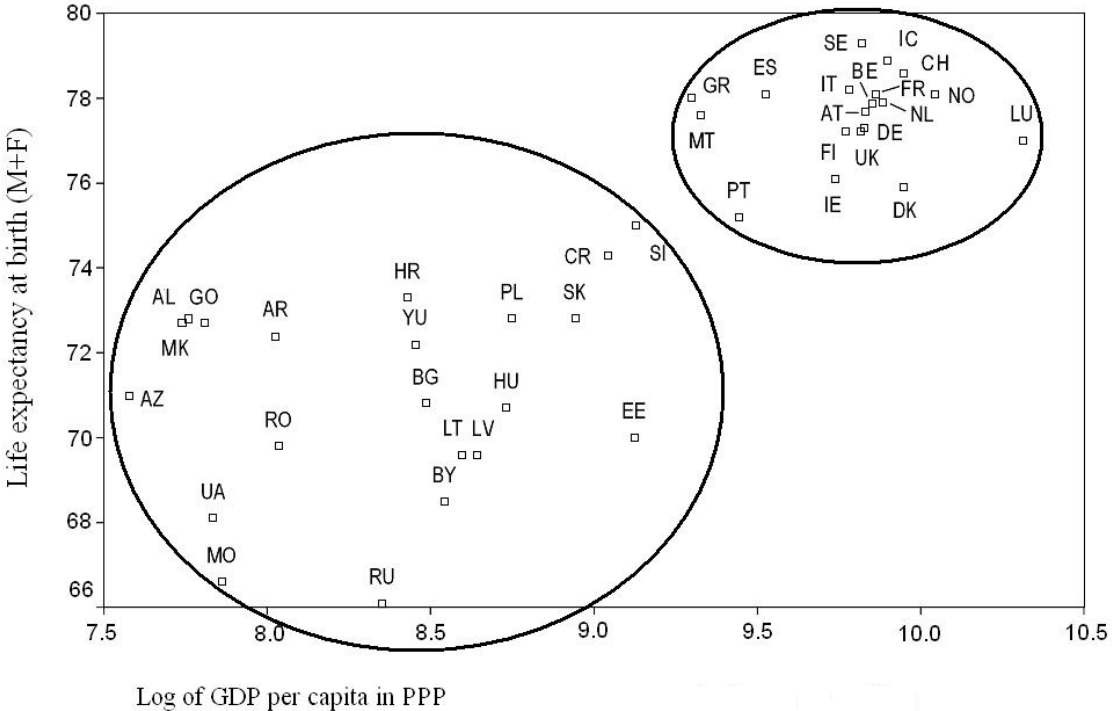
Therefore, the absolute income hypothesis should not be discarded for all European countries, at least not for the period up to the mid- to late 1990s. With respect to relative income Eastern and Western European countries have had quite different histories. Until the collapse of the communist system by the end of the eighties income inequalities in the east were quite small compared to western countries, but inequality has increased dramatically since then.

Both absolute and relative income may not be able to explain all the differences between East and West. Institutional differences are an important source of explanation as well. From the 1960s to the 1980s, Spain and Portugal (the two least developed countries in Western Europe) made great strides in life expectancy, while countries in Eastern Europe showed little progress (Guo, 1993). One reason for this development was that in the former Eastern bloc the communist party controlled all political and economic activity including the health care system. In order to compete with the West, these countries concentrated most of their effort on heavy industry and often ignored the non-economic sectors. Furthermore, the state-controlled media did not cover the popular health movement in the West, and this prevented the middle aged in Eastern Europe adapting beneficial behavioural changes. The effectiveness of the prevention and treatment of cardiovascular diseases had been largely responsible for the increased life expectancy in the West, and the difference in mortality between adults in Western Europe and those in Eastern Europe were attributed to differences in this area.

Given the historical differences in economic development within Europe, it is expected that separate models for the effects of income on mortality are required, one for the Western and one for the

Eastern European countries (labelled ‘West’ and ‘East’). Recent empirical evidence also supports this division: in the late 1990s all Western European countries both observed higher life expectancies *and* higher levels of GDPc than the best performing Eastern European country (Figure 3).

Figure 3 Association between the log of GDP per capita and life expectancy at birth for all European countries with a population greater than 250,000, 1995-2000 (pooled)



Data sources: Life expectancy: United Nations (2001); GDPc see Appendix 2. The data for GDPc refer to the period 1995-99.

Distinguishing mortality by cause of death

Total mortality trends are the outcome of different and sometimes even opposing cause-specific trends. Over time, cause-specific disease trends are the product of changes in the prevalence of exposure to its determinants (e.g. changes in tobacco consumption, dietary habits), a better control or elimination of disease determinants (e.g. as a result of improved hygiene, the discovery and application of vaccines) or the appearance of new ones (e.g. AIDS), or improved medical technology that eliminates, cures or has a palliative effect on the disease itself.

It is therefore considered that analysing cause-of-death groups is preferred to all-cause mortality because disease trends can be linked to trends in their risk factors that are sensitive to age- and cohort patterns (Tabeau et al., 2001). This becomes especially relevant when a particular cause of death dominates the total mortality pattern due to its high prevalence like the case of heart disease,

as an all-cause model will be structurally biased towards it and other important developments may remain unobserved.

Moreover, disease determinants don't necessarily have the same effect on each cause of death. Alcohol consumption, for instance, may alleviate the risk of ischaemic heart disease (IHD) in the long term (Rimm *et al.*, 1996), but augment the risk of stroke (Hart *et al.*, 1999; Yuan *et al.*, 1997) and sudden IHD if it concerns heavy drinking (Britton and McKee, 2000), and certain, but not all types of cancer (Clinton *et al.*, 2000). Other determinants may affect certain diseases more than others, in which case, due to other disease determinants that are operating, overall mortality trends may be in opposite directions. For example, smoking is an important disease determinant of both lung cancer and heart disease. However, between the late 1970s and the mid-1990s there was a concurrent decline in heart disease and increase in lung cancer among southern European men (WHO, 2001, own calculations).

Finally, although the acute political and economic changes that took place in Eastern Europe provoked large temporary declines in life expectancy during the first half of the 1990s, it did not affect each cause of death to the same extent. For instance, cancer mortality rates were much less sensitive to the sudden societal changes than stress-related diseases such as heart disease and chronic liver disease and cirrhosis (from here on cirrhosis), which is a logical outcome given the longer lag period between exposure and outcome as regards to cancer.

Using lagged values of explanatory variables

The influence of economic and other variables on mortality patterns is usually not contemporaneous, but the result of many years of exposure. A common example of this is smoking and lung cancer. Epidemiological research has indicated that, for individuals, a substantial decline in smoking levels instigates a fall in IHD mortality approximately 15 years later, while for lung cancer the lag is approximately 30 years (Ruwaard and Kramers, 1993). Sometimes, a mortality factor may have both a short-term and a long-term effect, and this lag may also be different between Eastern and Western European countries. For instance, alcohol has a long-term protective effect in Western Europe and a short-term detrimental effect in Eastern Europe. GDP_c was given a zero lag in the Eastern European analysis and a value of 15 years in the Western European analysis under the assumption that a change in prosperity would have an immediate impact on mortality.

In summary, it is therefore hypothesised that differences in mortality in Western Europe are primarily related to relative income, whereas differences in mortality in Eastern Europe are more due to absolute income.

Both total mortality and a selection of the most important causes of death are analysed given that these two income measures are both associated with important disease determinants such as alcohol and tobacco consumption that affect some of the most prevalent causes of death. In this we consider that splitting up total mortality into several main causes of death better “isolates” the effect of the macro-economic indicators.

3 Data and method

The main source for the national age-, sex- and cause-specific mortality data and age- and sex-specific population data was the *WHO Mortality Database*. Both the mortality and population data were already in, or could be aggregated to, the required 19, generally five-year, age intervals (0, 1-4, 5-9, 10-14, ..., 80-84, 85+). The mortality data contained causes of death that were coded according to the 8th, 9th or 10th revision of the International Classification of Diseases (ICD).

Six cause-of-death categories were chosen, namely lung cancer, heart disease, cerebrovascular disease (stroke), respiratory system diseases, cirrhosis and suicide, which selected on the basis of their proportion to total mortality and known association with income inequality⁴ (e.g. Turrell and Mathers (2001) for lung cancer; Kennedy et al. (1996), Turrell and Mathers (2001) and Kim et al. (2008) for heart disease and stroke; Kennedy et al. (1996) and Turrell and Mathers (2001) for pneumonia and bronchitis (important respiratory system diseases); McIsaac and Wilkinson (1997) for cirrhosis; and Rodriguez (2005) for suicide). They cover, respectively 63% and 68% of male total mortality in selected Western and Eastern European countries from the late 1970s/early 1980s to the late 1990s (see Appendix 1). With regard to heart disease, a general category was formed by subtracting the stroke deaths from the entire circulatory system disease category, instead of analysing IHD and other forms of heart disease (OHD) separately, which is more commonly done. This is because these two cause-of-death categories and the combined remainder of the circulatory system diseases were not deemed internationally comparable. Similar aggregation of heart diseases has also been done in the past (e.g. Law and Wald, 1999; Murray and Lopez, 1996). Moreover, the most important macro-determinants of the specific heart diseases, as well as the symptoms and

⁴ Not all previous studies show significant associations between income inequality and male mortality from the cause-of-death categories selected here. For instance, in the study by Lynch et al. (2001), the gini coefficient was insignificant or showed an opposite than expected association with regard to all six cause of death categories as well as all-cause mortality. However, besides being a cross-sectional study, the only adjustments that they made were for population size and GDPc.

proximate causes (e.g. hypertension and smoking) are similar. Finally, at this stage only male mortality was analysed because it is more to social, political and economic changes than female mortality.

The explanatory variables for which data could be obtained are, together with their sources, listed in the Appendix 2. Data on pollution, unemployment, smoking, dietary factors (fruit and vegetables; and cereals) and government health expenditure in purchasing power parities (HCPPP) and as a percentage of GDP (HCGDP) could only be acquired for Western Europe. The cause-specific age-standardised death rates (SDR) that were calculated using the 1970 WHO standard population for Europe served as the dependent variable. Pooled cross-section and time-series analysis with country-specific fixed effects was employed to analyse the data, using the statistical programme EViews. Time-series data for each country were pooled in order to obtain a data set of N*T observations. By treating time and space as one dimension, the model explains the cross-country and inter-temporal variations in mortality simultaneously, producing a single effect for each independent variable. In order to capture some of the country-specific elements, fixed effects were calculated (i.e. distinct intercepts estimated for each country). When results showed serial correlation in the error-term of the model, as indicated by the Durbin-Watson (DW) test, a first-order autoregressive term (AR(1)) was included⁵. Each model also includes a term representing mortality at time t-1 because the level of mortality largely depends on the level of the previous year. Cross-sectional heteroskedasticity was removed by including cross-section weights.

Before starting the pooled cross-section and time series analysis, lags were calculated for the exogenous variables. This was done for the same reason as when, for example, the effect of smoking or animal fat consumption and serum cholesterol on mortality is analysed (e.g. Alderson and Ashwood, 1985; Law and Wild, 1999), but which is rarely applied to absolute or relative income, i.e. that a certain time period elapses before an effect of a change in income on mortality can be established (an exception is the study on the effect of income inequality and cardiovascular disease by Kim et al. 2008⁶).

⁵ A significant AR(1) term means that the probability of a positive/negative error term at time t, following a positive/negative error term at time t-1, is larger than that of an error term with a reversed sign. In the event of positive autoregression, an error-term at time t that is under- or over-estimated will be similarly under- or over-estimated at time t+1. Negative autoregression indicates the opposite: an under- or over-estimation of the error-term is followed by an over- or under-estimation.

⁶ In this study, each selected Gini coefficient preceded the respective outcome by a 5- to 10-year lag to correspond to a plausible latency period for income inequality effects as suggested by Blakely et al. (2000).

Because lags vary according to the a priori outcome, i.e. the cause of death, establishing the correct time lags is a difficult process and therefore they have been determined by a combination of theoretical reasoning (life course perspective and the aetiology of the disease), the available time series and empirical tests. The method employed was to conduct a pooled cross-section and time-series analysis for a range of lags for each variable separately, including mortality at time $t-1$, AR(1) (if needed) and the cross-section weights, but excluding the other covariates. The various results were then compared and the lag corresponding to the highest value was taken as the 'true' one. Due to the rapid economic transformation and fluctuations in life expectancy in Eastern Europe, it was decided to conduct this lagging exercise separately for the two European analyses. GDPc, for instance, was given a zero lag in all but lung cancer in the Eastern European analysis under the assumption that a change in prosperity would have an immediate impact on mortality. Similarly, when analysing all-cause and heart disease mortality results showed that alcohol had, overall, a long-term protective effect in Western Europe and a short-term detrimental effect in Eastern Europe⁷. In the same way, as stroke deaths are also associated with heavy drinking (Yuan et al., 1997) and often occur within several days of a weekend of binge drinking (the so-called Monday peak; Hart et al., 1999), it was a-priori decided not to introduce a time lag for alcohol consumption in the model for stroke. By the same token, as previous research has shown that a decline in alcohol consumption leads to an almost immediate decline in cirrhosis mortality (Ryan, 1995), lags greater than three years were not considered⁸. Lags relating to external causes of death are also generally no more than a few years. Conversely, as cancer develops gradually, lags are longer and assumed to be similar in the West and East analyses.

The final lags used for the analyses are given in the Appendix 3. As initial analyses showed a high correlation between government health expenditure in PPP and GDPc and between the consumption of fruit & vegetables and cereals, the variables HCPPP and cereals were not further tested in the multivariate analysis.

⁷ No data could be obtained on drinking patterns, only on total consumption. This was unfortunate given that moderate consumption protects against the development of IHD (Rimm et al., 1996) but elevates the risk of sudden IHD when consumed in large amounts over a short period in time (Britton and McKee, 2000).

⁸ There were also country-differences in the way the amount of pure alcohol consumed was estimated (WHO, 2002) and few estimates of (illegal) home-made alcoholic beverages, tax-free purchases, smuggled spirits and alcohol consumed abroad. The underestimation of home-made alcoholic beverages particularly affects Eastern Europe (except Russia for which estimates exist and were used to approximate alcohol consumption levels in other former Soviet Republics; see Spijker, 2002). In the case of Estonia, where since the break-up of the former Soviet Union Finns have been known to spend the weekend consuming vast amounts of alcohol (Huang, 2000), and holiday destination countries in Southern Europe, national consumption levels may be overestimated.

To sum up, the final model equation has the following form:

$$SDR_{i,t}^c = \alpha_i^c + \sum_j \beta_j^c X_{ij,t-r}^c + \mu_{i,t}^c$$

$SDR_{i,t}^c$ = the standardised death rate for cause of death c in country i at time t

α_i^c = fixed effect (country-specific effect)

$X_{ij,t-r}^c$ = the value of the independent variable X_j for country i for cause of death c at time t , with lag r

β_j^c = the coefficient of the independent variable X_j for cause of death c

$\mu_{i,t}^c$ = the disturbance term⁹

4 Results

For the purpose of this paper, only the results for GDPc and income inequality are presented here.

As shown in Table 1, the models fitted the data very well as the adjusted R^2 values ranged from 95.2% to 99.8% in the West analysis and between 92.9% and 99.8% in the East analysis. The high R^2 can be explained by the inclusion of mortality at time $t-1$ (needed to prevent high negative autocorrelation¹⁰), cross-country weights (needed to eliminate cross-section heteroskedasticity) and fixed effects (needed to account for country-specific factors that are not represented by the variables).

The model coefficients for Western Europe showed that GDPc was significant ($p < 0.10$) with respect to all-cause mortality, lung cancer, CRB and respiratory system diseases. With the exception of lung cancer, the associations were in the expected direction, thus indicating that at the population level higher absolute income leads to lower mortality. Although lung cancer still appears to be a ‘welfare disease’ in terms of mortality, had one not controlled for other variables, in particular the proportion of industrial workers and consumption of fruit and vegetables, then the association between GDPc and lung cancer would have been significantly negative¹¹. There were also other

⁹ When the autoregressive term AR(1) is included in the model, $\mu_t = \rho\mu_{t-1} + \varepsilon_t$, where ρ is the first order serial correlation coefficient and ε_t the innovation in the disturbance. In effect, the AR(1) model incorporates the residual from the past observation into the regression model for the current observation (see Quantative Micro Software, 1994: pp. 301-3).

¹⁰ The Durbin-Watson tests showed that all models had an acceptable level of autocorrelation, i.e. values were either within or very close to the 5% significance level (cf. Savin and White, 1977).

¹¹ To check for multicollinearity between a particular variable and the other variables in the model, each other variable was removed and subsequently returned from the model to ascertain the variable with the largest

instances where the omission or inclusion of a variable had a considerable effect on the association between GDPc and mortality. In particular it appeared that the inclusion of smoking and alcohol in the remaining cancer model made GDPc insignificant; the addition of alcohol consumption and industrial employment in the heart disease model more than halved the effect of GDPc and made GDPc statistically insignificant; including agricultural and industrial employment in the suicide model caused GDPc to become insignificant; while by including divorce and pollution in the model for respiratory system diseases the coefficient for GDPc doubled. In other words in the case of heart disease and suicide it was not wealth itself, but the underlying changes and differences in the employment structure causing the wealth differences that are associated with mortality, while the negative effects of divorce and pollution obscured the positive effect that GDPc has on respiratory system diseases.

In the analyses for Eastern Europe, the models indicated that GDPc was an important discriminating factor in total mortality, heart disease, respiratory system diseases, LDC and suicide for which the association was significantly negative. Also in these analyses one or more of the other variables included in the models clearly influenced the association between GDPc and mortality. For instance, its association with lung cancer disappeared when education and industrial employment were included in the model and to a certain extent this also applied to education in the model for respiratory system diseases. Neither was the GDPc coefficient longer significantly negative in the LDC model after introducing the variable representing alcohol consumption.

The relative income indicator (i.e. the Gini coefficient) was significant in four of the Western European models, namely for heart disease, respiratory system diseases, LDC and suicide. However, it was not significant in the total mortality model after the introduction of both GDPc and smoking, while alcohol consumption caused its association with remaining cancer to disappear. It may be that in these instances, GDPc is higher and smoking and alcohol consumption lower in the more egalitarian countries or time periods.

In the Eastern Europe analysis, model results showed that the income inequality indicator was only significant for heart disease and LDC. The lack of associations in the case of the other natural causes of death may be because external influences take longer to have an effect. We know that income inequality was very low before the political and social changes that took place there and a large part of the disease-related mortality is the result of an accumulation of exposures across the life course,

influence on the coefficient of the variable of interest. This variable was then deleted from the model and the procedure repeated until no removal would produce a large change in the coefficient of the variable of interest.

which are in turn powerfully affected by the social and economic experience of the individual (Davey Smith, 1997, Kuh *et al.*, 1997).

Table 1 Results from the pooled models for the various causes of male deaths

	Total mortality	Lung cancer	Heart diseases	CRB	Respiratory sys.dis.	Chronic liver diseases + c.	Suicide
‘West’ analysis							
GDPc	-0,0041 ***	0,00023 **		-0,00084 ***	-0,0017 ***		
GINI			0,6166 **		0,3598 ***	0,0632 ***	0,0453 ***
Durbin-Watson	2,09	2,13	2,35	2,00	2,21	1,99	2,25
R2 adjusted	98,86	99,80	98,95	98,34	95,18	99,59	98,23
AR(1)	YES	YES	NO	YES	YES	YES	
‘East’ analysis							
GDPc	-0,0518 ***		-0,0093 ***		-0,0027 ***	-0,0002 **	-0,0012 ***
GINI					0,3785	0,1577 ***	
Durbin-Watson	1,92	2,15	1,74	1,99	1,90	1,58	1,80
R2 adjusted	99,54	99,75	99,58	98,55	92,95	97,18	97,74
	YES	NO	NO	NO	NO	NO	NO

* p< 0.10; ** p<0.05; *** p<0.01 (one-sided).

Method: GLS (GLS using Cross Section Weights; see Quantitative Micro Software, 1994: p. 560).

Sample: ‘West’ analysis = Austria, Belgium, Switzerland, West Germany, Denmark, Finland, France, Greece, Italy, Norway, Sweden, United Kingdom; ‘East’ analysis = Bulgaria, Belarus, Czech Republic, Czechoslovakia, East Germany, Estonia, Hungary, Latvia, Russia, Slovak Republic, Ukraine.

Total panel (unbalanced) observations: ‘West’ analysis: 243; ‘East’ analysis: 206. Maximum range in years 1977-1999 in ‘West’ and 1981-1999 in ‘East’ analysis.

Notes: Controlled for mortality at time t-1; country-specific (so-called fixed) effects; and when significant: education, primary sector employment, secondary sector employment, divorce, alcohol consumption, pollution, urbanisation, unemployment, smoking, fruit consumption, health care expenditure as a percentage of GDP and/or an AR-term.

Data sources and definitions: mortality: WHO (2001) and main text; exogenous variables: see Appendix 2.

While certain factors are more sensitive earlier in life than later in life, such as the so-called foetal and early childhood origins of adult disease (Barker, 1995, Leon and Ben-Shlomo, 1997), the socioeconomic work and life environment during adulthood are also associated with health-damaging exposures or health-enhancing opportunities, whose influence may be more critical or relevant at certain ages or show an associated age gradient. For these reasons a brief analysis was performed for the late working-age (45-64) and the retirement-age (65+) groups, in which the same

models were used as for all ages. The results (not shown here) indicated few age differences in the association between absolute income and mortality in Western Europe. The effect of relative income on mortality, which was in any case small, also did not show any noticeable age difference, with the exception of respiratory system diseases, where the detrimental effect was considerable among the late working-age group. With regard to the Eastern European analysis, there were few age-differences in the coefficients of the absolute income variable, while the relative income variable, that was only significant in the LDC model, only showed an effect among the 45-64 year age group.

5 Discussion

The main objective of this paper was to consider the influence of absolute and relative living standards (GDPc and income inequality) on mortality differences between European countries and over time and to see if the effect would change when other variables were included. Rather than analysing all selected countries at once, Western and Eastern European countries were analysed separately. This was prompted in part due to their long period of diverging political and economic systems, which made it impossible to compare certain factors that were relevant for this study. For instance, until the beginning of the transition period unemployment did not officially exist in most of Eastern Europe and education was not an important factor in obtaining a well-paid job. This was because the state subsidised those branches that had high levels of unskilled labour and allocated resources to produce the greatest possible returns to the economy and society, particularly in terms of producer goods. Moreover, the industries were oriented towards a restricted market (in particular the former USSR) and insulated from technological and economic competition (Večerník and Matějů, 1999; OECD, 1996). Due to such differences with Western Europe, performing an explanatory analysis with variables that are conceptually different in some of the countries made little analytical sense. Before performing the analyses, lags were introduced in the exogenous variables. This was done for the same reason as when the effect of smoking or animal fat consumption and serum cholesterol on mortality is analysed (see, for instance, Alderson and Ashwood, 1985 and Law and Wild, 1999), but rarely applied to absolute or relative income, i.e. that a certain time period elapses before an effect of a change in income on mortality can be established (an exception is the study on the effect of income inequality and cardiovascular disease by Kim et

al. 2008¹²). The optimal lags were obtained by means of empirical testing, but within a theoretical range. For instance, while it is possible that sudden changes in the level of GDPc have an almost immediate impact on mortality levels from certain external causes, this is unlikely to happen with cancer mortality rates. Neither could changes in the average level of education in a population show contemporaneous effects on mortality. The lagging of exogenous variables was, in a sense, a way of accommodating life course factors and indeed results would have been different in many instances when different lags were applied (and thus challenging the conclusion that was made in a similar study by Or (2000)). A large lag suggests that it is the accumulation of exposure to risk factors and contextual experiences over a period that are important in determining mortality differences between countries and over time. This appeared to be more often the case in Western than in Eastern Europe. Conversely, there were more instances in the Eastern European models where a variable had the strongest association with a particular cause of death when no lag was introduced. In particular, it seemed that the recent economic and social transitions in the East had a more immediate impact on certain causes of death, as sudden changes in the level of both GDPc and alcohol consumption caused abrupt changes in mortality. It seems therefore that the optimum latency periods may differ according to the political and economic situation of the group of countries.

These analyses showed that absolute prosperity, expressed as GDP per capita, was more important than relative prosperity, although absolute income played a greater role in Eastern Europe than in Western Europe. That the effect of GDPc on mortality was greater in Eastern Europe where absolute standard of wealth is lower was not unexpected as it is conform the study's second hypothesis. GDPc and mortality were not linearly associated with each other, i.e. health gains in the East will be greater for a given amount of extra wealth than in the West (although the within-group association showed much less non-linearity). More surprisingly was that absolute income was also an important variable for Western Europe, even for total mortality. Although this may appear to go against the proposition of Wilkinson (1992) that developed countries who have the smallest income differences between rich and poor have the best health instead of the richest societies as both types of income indicators appear to be important, an important methodological difference in this study has been the simultaneous analysis of time and space that determined a single effect for each independent variable. As shown in the first part of this paper, the effect of absolute or relative income at one moment was in most cases different for the three time periods and two groups of

¹² Each selected Gini coefficient preceded the respective outcome by a 5- to 10-year lag to correspond to a plausible latency period for income inequality effects as suggested by Blakely et al. (2000).

countries studied. Needless to say that the selection of countries and the choice of time dimension (i.e. cross-sectional vs. longitudinal) influences any result. Therefore, as the *real* effect of the same amount of income on mortality should, *ceteris parabus*, be the same whether this is estimated using different countries or time periods, more data points should produce a more accurate estimate of the effect. However, such an analysis should be conducted with the consideration of other potentially confounding factors, as was done in the second analysis, but largely overlooked in the past.

One important East-West difference in the relationship between GDPc and mortality was the immediate effect of GDPc on non-cancer mortality in Eastern Europe, while a lag time of 15 years was needed to observe the strongest association in the Western European models for natural causes of death. The question is therefore whether an improvement in the Eastern European economy will lead to a similar type of association between GDPc and mortality as in Western Europe, i.e. that the main independent health benefits of GDPc will also be long-term rather than short-term. In the near future, a switch to predominantly long-term effects does not seem likely as, in 1999, country-specific levels of GDPc were still well below Western European levels and even below the peak levels recorded in the late 1980s. This conjecture was briefly tested by analysing each country separately and including GDPc twice in the model: once with a time lag of 15 years and once without a time lag. From the results it appeared that GDPc has a predominantly short-term effect up to the \$10,000 level, after which the effect either disappears or is long term (not shown). However, as many Eastern European countries have recently joined the European Union, and as a consequence, are receiving different forms of financial aid that aims to reduce the wealth gap with its Western members, it will be worthwhile to look at the situation again in a few years time.

One of the most interesting results from the main analysis was that GDPc was significant in two of the models for Eastern Europe that pertained to causes of death that have been linked with psychosocial factors, namely heart disease (Hemingway and Marmot, 1999) and suicide (McLoone and Boddy, 1994), as these causes of death were only associated with relative income in the Western European analysis¹³ and suggests that in these instances the effect of income on health appears to be different in the two Europes. It may be that people in Eastern Europe, especially when income inequality was much less widespread, experienced their absolute living standards as relative, provoking (almost) immediate changes/differences in psychosocial wellbeing and behaviour when absolute living standards abruptly changed/showed large countries differences. LDC, respiratory

¹³ With regard to suicide, McIsaac and Wilkinson (1997) report that it tends to be more common in egalitarian countries, although they did not consider the possibility of a latency period for income inequality before it has an effect on mortality, as the results presented here and that of Blakely *et al.* (2000) suggest that a contemporaneous effect is unlikely.

system diseases and traffic accidents were the other causes of death that were associated with relative income in Western Europe, whereby LDC has also been linked with psychosocial elements in the context of income- or socioeconomic-inequality (Lynch *et al.*, 2001). The insistence by Wilkinson and others in the past that relative income is the more important income indicator therefore only seems to be valid for certain causes of death: the relative change in the mortality rate as a consequence of the relative change in income inequality (elasticity) was only higher than the relative change in absolute income with regard to heart disease, LDC and suicide and only in the Western European models¹⁴.

However, the fact that during the period 1981-99 income inequality appeared to have had little influence on Eastern European mortality seems to be because during the socialist period there were few country differences in income inequality. It is likely, however, that it will have a larger impact on future mortality levels in Eastern Europe as the difference between rich and poor continues to increase.

When investigating the effect of absolute or relative income on mortality at the macro level, other variables should also be considered as has been done here because both absolute and relative income are products of different, but interrelated, factors. Introducing other factors in the model therefore filters out at least some of the multicollinearity: for instance, on several occasions results indicated that the employment structure, above all the proportion of industrial workers, caused the association between GDPc and mortality to disappear or diminish. This is plausible as GDPc is partly a function of the employment structure (the added value of a service product is generally higher than that of an industrial product) and industrial workers tend to have higher mortality rates than those who work in the agricultural or service sector. Mortality may therefore simply decline because the industrial sector is declining, even though occupational mortality differences remain the same. Although occupational mobility has been shown to affect an individual's health (Cambois, 2002), a large part of this structural explanation is a cohort effect, because the lower demand for industrial workers has resulted in fewer people entering the labour market as industrial workers (but often opting for a career in the service sector instead). It is therefore obvious that future research of this kind should focus on specific age groups, including obtaining age-specific data for the

¹⁴ To test this all selected variables were used, not just the significant ones (results not shown). In both the Western and Eastern European model for respiratory system diseases the elasticities of absolute income were higher than for relative income. This agrees with previous research that suggests that the direct physiological effects of low absolute material circumstances that are known risk factors of the disease, such as poor diet, damp housing and inadequate heating, are more important than relative material circumstances (Walda *et al.*, 2002; Wilkinson, 1996, Wolleswinkel-van den Bosch, 1998).

explanatory variables and implementing age-specific lag times, as this would both improve the accuracy of the calculated effect of variables and their interpretation, in particular because the same variable may be an indicator of different phenomenon depending on the age to which it is related. For instance, additional analyses not presented here showed that the greatest effect of the proportion employed in industry factor on total mortality was found for both infants and 45-64 year olds. While the former must clearly be related to pre-birth and childhood contextual circumstances, the latter is linked to health-damaging factors that are directly and indirectly associated with the actual occupation.

In the attempt to estimate the effect of relative and absolute income on mortality controls were also made by adding several other potentially important variables, namely dietary factors and other important proximate determinants of specific diseases that include smoking and alcohol consumption. As these factors are culturally embedded in society, reflected by both the persistent international differences in the consumption patterns of these commodities (WHO, 2002) and their influence on specific causes of death (Spijker, 2004), they are therefore likely to remain important explanatory factors of international mortality differences. Nevertheless, data permitting, it would be worthwhile exploring the effects of additional indicators of psychosocial stress, such as control over work and life, social isolation, self-esteem and optimism over one's health, which have also previously been linked to East-West mortality differences (Bobak and Marmot, 1996; Kristenson et al., 1998). Additional dietary factors, in particular past levels of animal fat consumption and serum cholesterol that is strongly correlated with mortality from heart disease in developed countries (Law and Wald, 1999), are also likely to improve on the explanation of mortality differences between countries and over time in Europe.

Although it may be that data from aggregate-level studies of the effect of income inequality on health are largely insufficient to discriminate between competing income hypotheses (Wagstaff and Doorslaer, 2000), there is still no alternative for a large international setting. However, with certain methodological considerations, that includes analysing mortality by cause of death with longitudinal data sets to reduce the unreliability and time-specificity of the data and introducing possible confounding variables (including proximate determinants of disease that have been identified from previous studies at the individual level) with appropriate time lags, at least reduces some of the limitations of ecological analysis.

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Appendix 1 Causes of death selected for analyses, their ICD codes and contribution to total male mortality in Western and Eastern Europe between the late 1970s/early 1980s and the late 1990s

Cause of death	ICD-8	ICD-9	ICD-10	West ^a	East ^a
Total mortality / SDR per 100000	000-E999	000-E999	A00-Y89	1065	1745
Lung cancer	161-162	161-162	C32-C34	7.8%	5.8%
Stroke	430-438	430-438	I60-I69	9.7%	14.8%
Heart diseases	Rest of 390-458	Rest of 390-459	Rest of I00-I99	32.0%	36.0%
Respiratory system diseases	460-519	460-519	J00-I99	8.8%	7.2%
Cirrhosis	571	571	K70-K76	2.4%	1.5%
Suicide	E950-R959	E950-R959	X60-X84	1.9%	2.7%

^aSee Figure 1 for the countries in each analysis.

Appendix 2 Overview of exogenous variables and their sources

Variable	Abbreviation	Measured as	Source
Per capita Gross Domestic Product	GDPC	Geary Khamis PPPs in 1990 US\$	1
Income inequality	GINI	A value between 0 and 1 indicating the distribution of income	2
Education	EDU	Number of years of education	3
Secondary sector employment	IND	% of the labour force employed in the secondary sector	4
Primary sector employment	AG	% of the labour force employed in the primary sector	4
Divorce	DIV	Divorce Rate per 100 marriages	5
Alcohol	ALC	Alcohol consumption – litres of pure ethanol per person per year (age 15+)	6
Pollution	POL	Sulphur Oxides (1000 tonnes) per km ²	7, 8
Urbanisation	URB	Percentage of the population resident in urban areas.	9
Unemployment	UNEMP	Total unemployed as % of labour force	10
Smoking	TOBAC	Tobacco consumption – grams per person per year (age 15+)	11
Fruit	FRUIT	Average amount of fruits and vegetables available per person per year (kg)	12
Cereals	CEREAL	Average amount of cereals available per person per year (kg)	12
Health Care (GDP)	HCGDP	Governmental expenditure on health as a % of GDP	11
Health Care (PPP)	HCPPP	Governmental expenditure on health in PPPs per capita	12

¹ Groningen Growth and Development Centre (2005); Maddison (2001).

² WIDER (2000); World Bank (2002). Other sources include: for Switzerland, Flückiger (2002); for Norway, Statistics Norway (1999); for several Eastern European countries, Sverjar (2001); for Russia and the Ukraine, Gregory (date unknown).

³ Barro and Lee (2000). For most countries, the data covered the period 1960–1990/2000 at five-year intervals. The intermediate years were fitted by means of a first-and-second order function.

⁴ Data for Western Europe were obtained from Eurostat (2002); for Iceland and Eastern Europe from ILO (2002); for former Czechoslovakia from Federální Statistický Úřad (various years); for the Czech Republic from Český Statistický Úřad (various years).

⁵ For most countries, data were obtained from Eurostat (2002); for the USSR successor states, Czechoslovakia and West Germany, some data were obtained from the Council of Europe (2001) and CIS STAT (1998).

⁶ OECD (2001); Tekin (2002); Trembl (1997).

⁷ Lefohn et al. (1999).

⁸ Eurostat (2002).

⁹ United Nations (2000).

¹⁰ For Belarus, Bulgaria, the Czech Republic, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, the Slovak Republic and Yugoslavia registered unemployment; source Western Europe: OECD (Main Economic Indicators) and Eurostat (Eurostatistics, ES/G-Aggregates) in: Gärtner (1999); source Eastern Europe: ILO (2002); source Ukraine and Moldova: CIS STAT (1998); source Yugoslavia: Mencinger, 1989 in Woodward (1995).

¹¹ OECD (2001).

¹² WHO (2002).

Appendix 3. Variable-specific lags (in years) applied to the variables in the pooled cross-country and time-series analyses^a

	'West' analysis													'East' analysis																															
	Gdp –	Gini +	Edu –	Ind +	Ag	Urb	Div +	Alc	Unemp +	Tobac +	Pol +	Fruit –	Cereals –	Hcgrp –	Hcpped –	Gdp –	Gini +	Edu –	Ind +	Ag	Urb	Div +	Alc	Unemp +	Tobac +	Pol +	Fruit –	Cereals –	Hcgrp –	Hcpped –															
Total	15	10	15	5	5	0	10	15	15	10	10	5	5	10	1	15	10	10	5	5	5	0	10	15	10	10	10	5	5	10	1	1	1	1	1										
Lung	15	10	15	5	5	0	10	15	15	10	10	5	5	10	1	15	10	10	5	5	5	0	10	15	10	10	10	5	5	10	1	1	1	1	1	1									
Heart	15	10	15	5	5	0	10	15	15	10	10	5	5	10	1	15	10	10	5	5	5	0	10	15	10	10	10	5	5	10	1	1	1	1	1	1	1								
Stroke	15	10	15	5	5	0	10	15	15	10	10	5	5	10	1	15	10	10	5	5	5	0	10	15	10	10	10	5	5	10	1	1	1	1	1	1	1	1							
Resp	15	10	15	5	5	0	10	15	15	10	10	5	5	10	1	15	10	10	5	5	5	0	10	15	10	10	10	5	5	10	1	1	1	1	1	1	1	1							
Cirrhosis	15	5	15	5	5	0	10	15	15	10	10	5	5	10	1	15	10	10	5	5	5	0	10	15	10	10	10	5	5	10	1	1	1	1	1	1	1	1	1						
Suicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Total	0	0	15	2	2	0	0	0	0	0	0	2	2	0	2	2	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Lung	15	5	15	5	5	0	10	15	15	10	10	5	5	10	1	15	10	10	5	5	5	0	10	15	10	10	10	5	5	10	1	1	1	1	1	1	1	1	1	1	1	1	1		
Heart	0	0	15	2	2	0	0	0	0	0	0	2	2	0	2	2	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Stroke	0	0	15	2	2	0	0	0	0	0	0	2	2	0	2	2	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Resp	15	5	15	5	5	0	10	15	15	10	10	5	5	10	1	15	10	10	5	5	5	0	10	15	10	10	10	5	5	10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cirrhosis	0	0	15	2	2	0	0	0	0	0	0	2	2	0	2	2	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

^a The sign next to a variable indicates documented directions of association. In the case of agriculture and urbanisation, there is no clear uniform pattern, while alcohol was considered to be negatively associated with heart disease and positively to the other causes of death.