Chapter 8

DISCUSSION

8.1 Introduction

The improvements that have taken place in life expectancy in Western Europe during the latter part of the 20th century have been mainly due to rapidly declining death rates in the advanced age groups, as mortality at young ages was already at a very low level. Epidemiologists consider this period of change to be a fourth phase in the epidemiological transition and have labelled it the ‘age of delayed degenerative diseases’ (Olshansky and Ault, 1986). During this period, a cause-of-death shift has occurred within the group of degenerative diseases, with the proportion of cancer mortality slowly increasing and a corresponding fall in circulatory system diseases. Conversely, in Eastern Europe, countries have remained in the third transition phase of the epidemiological transition, i.e. the age of degenerative and man-made diseases: between the early 1970s and the late 1990s life expectancy at birth stagnated and sometimes even declined in countries of the former Soviet Union. As a consequence, current East-West mortality variations are reflected in differences in circulatory system diseases as well as in external causes of death (Myers, 1996).

Given that each disease has its own aetiology (i.e. cause), reductions in behavioural risk indicators, and improvements in health care, have been identified as the main determinants of these epidemiological changes. Analysing mortality by cause of death is a logical initial step in the understanding of mortality differences over time or space. However, although the majority of the most prevalent causes of death have several risk indicators in common, a change in one risk indicator does not affect each cause of death to the same degree, as each cause of death may have one or several significant risk indicators. Moreover, there may also be different delays between exposure to a particular risk indicator and the effect on various diseases becoming apparent. These are important considerations in both the analyses of mortality differences and in making projections.

While the third and fourth stages of the epidemiological transition serve as the general context within which the current mortality patterns in Europe are placed, in order to obtain a clear overview of the important factors that affect health, the various analyses were set within the framework of the life course. Although the studies were essentially ecological in design, it was assumed that, at the
population level, determinants of health related to the life course could also be identified. Moreover, the propensity to smoke or expose oneself to other types of risk does not occur randomly, but is determined by a wide range of distal factors throughout life, many of which have a socioeconomic basis. For instance, it has been consistently shown at the level of the individual that manual workers exhibit greater adverse risk behaviour, and are thus expected to have a shorter lifespan than non-manual workers. Therefore, a change, or difference, in the composition of the population in terms of economic structure is likely to result in changes or differences in behavioural risk factors, and this will eventually be reflected in cause-specific mortality patterns.

The word “eventually” is quite crucial as, besides the identification of health determinants, the life course approach has been applied in this research because of the importance of time and age to the health determinants that are associated with mortality differences. This is because it is not “any one factor which has a major long-term influence on health, but a number of comparatively small differences which become linked into a chain of disadvantage” (Blane, 1999). In other words, risk accumulates over time and, in order to take this into account, cause-specific time lags were therefore calculated for each variable used in the analysis.

The research goal of this thesis was “to assess the importance of socioeconomic factors in the explanation of cause-specific mortality differences in Europe”, with the objective of improving current mortality projections that have so far suffered from a lack of integration. Other factors were only considered if they either demonstrated a clear independent effect or confounded the association between socioeconomic factors and mortality. Due to the multicollinearity of many disease determinants it was only possible to approximate the independent effect, which was achieved by including a wide range of variables. Moreover, in ecological studies it is simply not possible to control for other factors in the same way as in individual-level studies. However, as each multivariate analysis included a reasonable selection of exogenous variables, the established associations were unlikely to be spurious if they coincided with similar results found at the individual level, but the possibility of ecological fallacy cannot be ruled out. It is reasonable to expect that all the results should be in line with individual-level findings, and any failure to replicate an individual-based study at an ecological level suggests that the factor of interest may not be important at the population level. This is an important result for scenario making, even if part of the result is due to statistical artefact.

8.2 Summary of results

Before the main analyses were made for Chapters 4 to 7, the causes of death to be investigated were selected, based on several criteria, in Chapter 3. Firstly, prevalence was a selection criterion, i.e. the most important causes of death in terms of standardised death rates (SDRs). Eurostat’s “European
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Shortlist” (Eurostat, 1998) formed the basis of this selection process given its relevance to European mortality patterns and projections. Nineteen causes of death were selected in this manner. However, as the research goal was to assess the importance of socioeconomic factors in the explanation of cause-specific mortality differences in Europe, three causes of death where the epidemiological evidence did not consistently purport the existence of socioeconomic mortality differences were then excluded (i.e. colon cancer, lymphatic cancer, and signs, symptoms and ill-defined causes). A final aspect to be considered was the international comparability of the cause-of-death statistics. Perhaps the best aggregate measures that reflects international differences in the accuracy of the cause-of-death statistic are the heterogeneous categories ‘signs, symptoms and other ill-defined conditions’ (ICD-9 780-799) for natural causes, and ‘events of undetermined intent’ (ICD-9 E980-E989) for external causes. After considering the figures for these causes, several countries were excluded from the main analysis in Chapter 4, the most important of those being Poland, Romania and Portugal. Furthermore, it was decided to use the total number of deaths from circulatory system diseases less those from CRB as a proxy for IHD in the analyses in Chapter 4, because of known problems with the reliability of the registration (diagnosis and certification) of IHD deaths, particularly in Germany, Spain and Belgium (Murray and Lopez, 1996; Mackenbach et al., 1990).

As regional differences within a country in the diagnosis of a disease are almost certain to be smaller than international differences, and the underlying cause of death in most countries is centrally determined and coded from the death certificate, regional differences in the quality of mortality data are likely to be small. Therefore, the official figures for IHD were valid for analysis in the Dutch regional study.

Four analyses were conducted, each making a distinct contribution to the thesis, and each with its own set of research questions. The first analysis (Chapter 4) is seen as the most important given its relevance to the umbrella project “Towards a scenario model for economic determinants in population dynamics”, where it feeds in model-based assumptions on mortality parameters based on socioeconomic determinants. The analysis considered the influence of economic factors, particularly absolute and relative living standards (GDP and income inequality), on mortality differences between European countries and over time. The study was extended to include the effect of other variables. Considering the time and space parameters, a cross-country and time-series method of analysis was considered to be the best option, and this had the advantage that it determined a single effect for each independent variable by treating time and space as one dimension. However, because different political and economic pathways were followed in Eastern and Western Europe during most of the second half of the 20th century, several of the exogenous variables that were obtained had different meanings attached to them in different contexts. This was one of the reasons for conducting separate analyses for Western and Eastern Europe. For instance, up until 1990 unemployment did not officially exist in the then communist countries, with many jobs being ‘created’ resulting in a very inefficient workforce and little job diversity. Although the psychosocial
situation of someone unemployed in Western Europe might not differ that much from an underemployed Eastern European worker, with the data available it was not possible to control for job dissatisfaction. Similarly, particularly during the communist period, education had a different status in the East than in the West. In the East, more women than men were employed in professions with academic prerequisites, while men were ‘encouraged’ to do arduous labour as the government pushed for high levels of industrial production in the absence of market mechanisms, which the state owned enterprises rewarded through higher wages.

Another factor considered in the analyses of Chapter 4 was the fact that the influence of economic and other variables on mortality patterns are usually not contemporaneous, but the result of many years of exposure. Although this clearly applies at the individual level, it may also be extrapolated to society: if nobody smokes in a certain country at some stage in the future, the levels of lung cancer will be much lower than in a country where everyone smokes, given the fact that smoking is the most important risk indicator of lung cancer. For this reason, before starting the pooled cross-section and time series analysis, lags were calculated for the exogenous variables. In a way this also linked the concepts of the life course to mortality at the level of society, since it was considered that lag effects could also be applied to contextual factors such as economic development (measured here as GDP per capita (GDPc)). The argument being that it also takes time before working condition improvements and increases in total prosperity affect the health of individuals (for instance through the construction of better housing or the import of certain types of food products such as fruits and vegetable oils that are not cultivated or produced in one’s own country, but which have the potential to ameliorate dietary patterns). Economic development also has the potential to reduce stressful situations associated with adverse economic circumstances. Different latency periods were found in the East and West analyses, with results showing that economic development took much longer to have an effect on mortality levels in Western Europe than in Eastern Europe. This suggests that in less stable societies the effect is more immediate.

After a certain level of economic development is reached, the benefit of extra income in terms of health benefits becomes less, and the scale of income inequalities within a society becomes more important (Wilkinson, 1995). For this reason, the effect of income inequality on mortality was also tested. In addition to these two economic determinants of health, other variables were also included in the analyses, namely education, employment structure, unemployment, divorce, alcohol consumption, urbanisation, smoking, fruit and vegetable consumption, pollution and government health expenditure. Data on the last four variables could only be obtained for Western Europe, which was another reason why the analyses were split into two. GDPc was by no means the critical factor in causing mortality differences over time and across space, as each variable that was tested showed an independent effect, particularly alcohol consumption. The association between GDPc and mortality also vanished, or reduced substantially, in some instances, after controlling for other factors, particularly divorce, alcohol consumption, urbanisation and the proportion of the workforce employed in industry.
Based on the proposed hypotheses, the most important results can be summarised as followed:

**H1. Differences in mortality in Europe can partly be explained by differences in absolute income.**
This was true for total mortality in both Western and Eastern Europe. The contemporaneous effect of GDP in Eastern Europe was greater than the lagged effect in the West. In terms of causes of death, not all of the established associations were negative: positive ones were found for prostate cancer, lung cancer in Western Europe and traffic accidents in Eastern Europe. These anomalies were explained by, respectively, ageing, a cohort effect and an association with a welfare disease (as cars are not yet affordable to everyone).

**H2. Differences in mortality in Europe can partly be explained by differences in relative income.**
Due to the link with psychosocial factors, it was not surprising that income inequality was significant in the models for heart disease, LDC and suicide, although in terms of all-cause mortality the variable was not statistically significant. As income inequality was low and varied little in Eastern Europe during the period of socialism, a long latency period could not be examined, which therefore ruled out cancer categories from the analysis. Nevertheless, there were significant results in terms of LDC and remaining external causes (including homicides).

**H3. The share of secondary sector employment in total employment is positively associated with mortality**
The results showed that employment structure was an important explanatory variable in both Western and Eastern Europe for most of the causes of death that were analysed. The positive association means that even after controlling for several potentially important confounders, such as alcohol consumption and GDPc (and in Western Europe also smoking), certain detrimental health effects of industrial employment were left unexplained. While some of the excess mortality risks may be related to occupational hazards, the significant result for suicide in both parts of Europe suggests that psychosocial factors are also likely to play a role. While further declines in arduous manual labour in Eastern Europe are likely to bring about positive effects on health, this will to an extent be due to cohort effects, with younger cohorts less likely to take up careers in industry.

**H4. Unemployment is positively associated with mortality.**
Given the average lagged levels of unemployment were low in the countries studied, the effect of unemployment at the population level was found to be low. A very high relative risk would be needed for low unemployment levels to influence international mortality differences and changes over time. However, unemployment may become a more important factor in Eastern Europe, since the transition to a market economy has resulted in the emergence of unemployment, which in many countries has risen to more than 10% of the workforce (ILO, 2002).

**H5. Education is negatively associated with mortality.**
In Eastern Europe, education was found to have an independent negative effect more often than in Western Europe (including for heart disease and total mortality) when GDP was also significant in the model. This seems to suggest that, even at the population level, education leads to the acquisition of knowledge regarding health-damaging behaviour and is not only an indicator of economic
development. However, with regard to prostate cancer and traffic accident mortality in Eastern Europe, the association was positive. The former result suggests a substitution effect: mortality from prostate cancer increases as death from more preventable diseases decreases; and education is negatively associated with total mortality. As with GDPc, the result for traffic accidents may be related to prosperity.

**H6.** Air pollution is positively associated with total mortality, lung cancer, remaining circulatory system diseases and respiratory system diseases. 

This hypothesis could only be tested for Western Europe, and results only showed a significant effect on respiratory system diseases, even after tobacco consumption was included in the model.

**H7.** Divorce is positively associated with mortality.

Although the elasticities were generally low, divorce was significant in a large number of the models. Given that divorce is still a relatively new phenomenon in southern Europe, and that there is a latency period between divorce and its effect on health, it is likely that one will see a negative impact on mortality levels in the south in the future. The fact that elasticities were highest in Eastern Europe may reflect the higher general levels of psychosocial stress that are known to exist there in comparison to the West (Kristenson et al., 1996).

**H8.** Smoking is positively associated with mortality from all-cause mortality and the natural causes considered in this study, with the exception of LDC.

This hypothesis could also only be tested for Western Europe. Results agreed with the hypothesis for all but CRB, although elasticities were somewhat low, perhaps because age-specific data could not be obtained. Nevertheless, given the different stages of the smoking epidemic (see also section 8.3.5), it would seem that the effects of smoking on mortality in southern Europe are only just beginning to be felt.

**H9.** Alcohol is negatively associated with total mortality and mortality from heart disease.

In Western Europe, alcohol was found to have a protective effect in terms of heart disease; while in Eastern Europe the association was contemporaneous and positive (i.e. drinking increases mortality) for both mortality categories.

**H10.** Alcohol is positively associated with mortality from lung cancer, remaining cancer, CRB, respiratory system diseases, LDC and external causes of death.

With the exception of lung cancer in Western Europe, this hypothesis could not be rejected. This shows the importance of extricating the positive and negative effects of alcohol. A better model for total mortality might be one which includes alcohol twice in the model: with and without a time lag (indeed additional results not reported here showed a significant positive coefficient for alcohol consumption without a lagged effect in Western Europe, and a significant positive coefficient for alcohol not lagged and lagged by 15 years in Eastern Europe).

**H11.** Fruit and vegetable consumption is negatively associated with mortality from natural causes.

This hypothesis was only tested for Western Europe. Results showed that while elasticities were small, it was significant in the models for total mortality, the three cancer categories and respiratory
system diseases. This implies that in most non-Mediterranean countries, where consumption levels are still relatively low, health gains can still be made. With regard to Eastern Europe, the recent ending of trade barriers and the future expansion of the European Union will make fruit and vegetable products more accessible and affordable, as has previously occurred in western and northern Europe.


The last hypothesis was again only tested for Western Europe, but appeared to be of little importance. In hindsight, this might have been due to the way it was measured. An index of the proportion of avoidable deaths may be a more suitable (but time consuming) alternative, as this would enable countries to be identified as suspected of having less effective health care.

In quantifying the effect of the variables on mortality, elasticities were calculated. Results showed that these were considerably larger in the models for Eastern Europe than for Western Europe, particularly those for education and urbanisation. Even in the model for total mortality, elasticities of −0.36 and 0.22 were observed respectively. Most elasticities in the cause-specific models of Western Europe had an absolute value below 0.1.

The same exogenous variables were used in the analysis for women as had been for men, with the exception of the smoking estimates that were sex-specific. This did not always prove optimal, for instance, in the case of unemployment, the association with remaining cancer in Western Europe was negative. On the other hand, the positive association between GDPc and lung cancer in both Western and Eastern Europe was less surprising, as the smoking epidemic started much later among women than among men, and may therefore still be considered as a welfare disease. Another sex difference was with regard to education in the Western European analysis, which was only significant in the suicide model (and not, for instance for, heart disease). The remaining results were similar for men and women.

As the results of Chapter 4 showed that the effects of the exogenous variables were greatest in Eastern Europe, it seemed worthwhile investigating the reasons for mortality differences in more detail by performing a regional analysis for one of those countries. This was because country-specific elements which may confound possible associations, such as differing economic and educational systems, health policies and cultural factors, particularly those associated with lifestyle (e.g. diet), are less relevant in a regional context because regions are more homogeneous than countries. The interpretation of results is therefore less open to ecological bias. Although regional studies for one country cannot be generalised to other countries, potentially important factors that could be applied in international studies may be identified. Another point of interest was the fact that social gradients in mortality in former centrally-planned economies are generally less well known (Bobak et al., 1999). The economy in the East operated through different forces than in the West,
and was mainly dictated by government policy directed towards industrial production and equalising regional development that, in the case of central Europe, was also influenced by the Soviet demand for raw materials. As a result, industrial-type occupations, particularly mining, were rewarded with higher wages than professionals; and such state-socialist redistribution policies resulted in both lower levels of income and smaller income differentials than in market societies (Atkinson and Micklewright, 1992). However, although the socialist ideal of creating an equal and homogeneous society had some success, regional differences in socioeconomic development remained, in part due to a long historical background of regional economic and social differentiation (Burcin and Kučera, 2000; Hampl, 1999). With this in mind, and using the Czech Republic (CR) as a case study, the main objective of the research reported in Chapter 5 was to ascertain whether the regional differences in socioeconomic development in a former communist country can be associated with regional differences in mortality in a similar fashion to that found in traditional market economies. A second point of interest here was whether regional mortality differences had increased during the period of transition: would the establishment of market mechanisms augment regional socioeconomic differentiation?

The study was basically split into two parts. Regions were first clustered according to socioeconomic characteristics. In doing so, the variables used were also checked for their association with mortality. It appeared, as had been found earlier by Bobak et al. (1999) and Rychtaříková and Dzúrová (1992), that while regions with the highest levels of education had the lowest levels of mortality, the results for wages were more ambivalent. Seven clusters of regions were eventually constructed: Prague, Brno/Plzen, 11 mainly urban regional centres, 14 light to medium industrial regions, 6 mining regions, 26 rural and light industrial regions and 16 rural regions. Using a decomposition method, and Prague as the standard population, life expectancy differences were calculated by age and cause of death for men and women separately for the periods 1987-90, 1991-93 and 1994-97. Results showed that, during each of the three periods, cluster differences in life expectancy were largest between Prague and the six coal mining regions in northern Bohemia and around Ostrava: with the differences being about 3 years for men, and about 1.5 years for women. Since the two clusters enjoyed the highest wages, a material explanation for the mortality differences would not be justifiable. Education seems a more likely contributing factor as, like Prague, the Brno/Plzen cluster also experienced high levels of both education and life expectancy. Over the period studied, life expectancy in the CR actually increased by 2.10 years for men and 1.74 years for women; a different trend to that seen in most other Eastern European countries during the period of transition. However, contrary to expectations, the transition did not lead to a large increase in cluster mortality differences among men: in fact only 0.25 years. A change in the rank order did take place for women: during the first period, mortality levels were lowest in Brno/Plzen and the two rural clusters, while about a decade later mortality was, as with males, lowest in Prague. Not surprisingly, a fall in circulatory system diseases was mainly responsible for both the increase in life expectancy in general and the cluster differences in
particular, although among women higher levels of cancer and external causes of death were found in Prague. Further, Prague also saw the highest increases in male mortality from external causes between the first and last periods. In terms of age-specific differences, there were also differences between the sexes, as both cluster differences and time changes were largest among the 65+ age group in the case of women whereas, with men, the working age group was dominant although, over time, the older age group did become relatively more important. Considerable improvements were also seen in infant mortality, particularly in Prague where boys gained 0.55 years, but further sizeable declines are unlikely there as levels are close to the biological limit of 3-4 deaths per 1000 live births (Van der Veen, 2001). However, there is still room for improvement in the other regions.

Since the mortality data had been obtained for relatively small homogenous regions, it was considered worthwhile to further investigate the age, sex, region and time interactions in the mortality data and to see if regional and time differences in mortality could be explained in more detail by a number of exogenous variables, including non-socioeconomic ones, that might be non-uniformly associated with age and sex. For instance, old-age mortality might have improved faster than working-age mortality in terms of cardiovascular diseases, with certain variables only influencing mortality after many years of exposure and therefore showing the greatest effects in the older age groups. Similarly, certain causes of death may demonstrate regional differences in their sex-ratios, which could possibly be explained by a particular variable. This was the topic covered in Chapter 6. The analysis was again conducted in two parts. Firstly, a model for each cause of death was developed that well described the mortality data while maintaining a sensible balance between model fit and parsimony. The various model specifications were derived from log-linear regression analyses. Although it is clearly apparent that age- and sex-specific differences exist in cause-specific mortality, the main question to be answered was whether the Czech data showed any regional and/or time differences in the age- and sex-mortality patterns, and if so were these patterns identical for the different categories of causes of death that were studied, i.e. cancer, circulatory system diseases, respiratory system diseases, digestive system diseases, external causes and remaining causes of death. As the age structure of mortality was also analysed, cause-of-death categories that are more specific were not considered. A number of hypotheses were formulated and the results can be summarised as followed:

**H1. The age structure of mortality is identical across regions.**

This hypothesis was found not to be true in each cause-specific model. The best fit was with respiratory system diseases where additional analysis showed that the 75-84 age group was responsible for the regional mortality pattern.

**H2. The regional mortality pattern is stable over time.**

With respect to circulatory system diseases, respiratory system diseases, external causes and remaining causes of death, mortality patterns changed significantly between 1987 and 1997. In terms of respiratory system diseases, the three largest cities plus North-Moravia and East-Bohemia
performed worse than the Czech average over time, with rural areas in particular doing much better. With regard to circulatory system diseases, Prague was the only region that observed both one of the lowest levels of circulatory system disease mortality during the 11 years, and one of the largest declines. The relative decline in external causes was largest for several of the mining regions, while mortality from remaining causes of death declined everywhere, and especially in South-Moravia.

**H3. The age pattern is stable over time.**

In four of the six cause-of-death models, the age pattern was not stable over time. Results showed that cancer mortality declined among those aged below 50, while mortality from circulatory system diseases saw larger than average improvements among those aged between 35 and 74. In the cases of digestive system diseases and external causes, mortality, relative to the trend for the whole population, increased for those below the age of 60.

**H4. The male to female mortality ratio is identical in the various regions.**

This was not the case for cancer, respiratory system diseases and external causes of death. With regard to cancer, sex differences were smallest in the large cities and East-Bohemia, and largest in the rural regions of Bohemia (as seen in Chapter 5). In terms of respiratory system diseases, the mining areas in North-Bohemia and North-Moravia primarily saw the greatest differences, while the largest excess sex differences in external causes were observed in North- and West-Bohemia and the smallest in the south of the Republic.

**H5. The male to female mortality ratio is stable over time.**

Only with regard to respiratory system diseases was the male to female mortality ratio not stable over time, with the mortality rates declining more rapidly for men than for women between 1987 and 1997.

The second goal of this chapter was to determine whether the observed regional and temporal differences in mortality could be explained by a range of exogenous variables, in which possible interactions with age and sex were also considered. The results of the second set of hypotheses can be summarised as followed:

**H6. Socioeconomic factors play a more important role than other factors in explaining the variations in the data.**

Although one should not overlook the fact that there were more socioeconomic than other types of indicators, the principal covariates responsible for the regional and time specificities in the data were socioeconomic ones. Regional wage level was the main covariate in the circulatory system disease model, in the external cause of death model and in the remaining cause of death model; while unemployment was the major contributor in explaining the regional differences in digestive system diseases, and primary sector employment with respect to respiratory system diseases. Education was the most important covariate in the cancer model. Given the importance of mining in a number of regions, it was not surprising that male secondary sector employment was also significant, especially with regard to circulatory system diseases, respiratory system diseases and remaining
causes of death. In terms of circulatory and respiratory system diseases, this was expected as manual workers are known to have relatively unhealthy lifestyles. Divorce, a psychosocial indicator, was particularly important in explaining part of the regional differences and the changes over time in external mortality. The contextual (national) covariates only had a role in explaining cancer (linked to national-level wages) and digestive system diseases (linked to national-level wages and GDP). It seems that the third covariate, the national employment rate, is more an indicator of economic development than of economic uncertainty as its association with mortality was, although weak, consistently negative. Although significant in at least one model, the percentage of Gypsies in the population, smoking (or rather its proxy), pollution, urbanisation and the number of physicians were found to be relatively unimportant.

H7. The associations between exogenous variables and mortality in the CR are in the same directions as those generally found in other ecological studies.

Results agreed with the hypothesis, with the following significant exceptions. One of the largest elasticities was found for the effect of wages on digestive system diseases, and the effect was positive: the higher the wages the greater the mortality. However, recalling that the economy of regions with high average wages was often dominated by industry (and especially mining), this result could have been anticipated. A second ‘discrepancy’ was that the consequences of unemployment on health were not yet manifested to the same degree as in western countries, probably because this is still a relatively new phenomenon. However, its effect on digestive system diseases, with LDC the dominant subcategory, was substantial, suggesting that the psychosocial effects of unemployment are already evident. It is likely that, in the future, similar trends will be observed for circulatory system diseases and cancer, diseases that take longer to manifest themselves.

H8. The associations between exogenous variables and mortality in the CR are larger for men than for women.

Where sex differences were found in the associations between covariates and mortality, they were indeed generally greater for men. Little difference was observed with respect to wages (only linked to respiratory system diseases and external causes), perhaps because the supposed protective role of wages on mortality was somewhat diminished by the occupational hazards associated with the well-paid industrial jobs under the old socialist system. Manual workers tend to demonstrate adverse behaviour more often and, indeed, secondary sector employment showed sex differences in terms of both cancer and respiratory system diseases. With regard to the latter, this remained after incorporating the smoking proxy, and even larger sex differences were then found. Interestingly, both male and female secondary sector employment affected mortality levels of the opposite sex, which suggests that certain lifestyle aspects surrounding gender-specific occupations have an influence on the health of partners.
H9. **The associations between exogenous variables and mortality in the CR are larger at younger ages than at older ages.**

According to the theory of the life course, health-related exposures occur throughout life, with certain periods possibly being more critical than others. Indeed, here, the results showed that effects declined with age with regard to unemployment (digestive system diseases), wages (circulatory system diseases), primary sector employment (digestive system diseases), male secondary sector employment (circulatory system diseases), education (cancer), divorce (remaining causes) and the smoking proxy (circulatory system diseases). Conversely, the covariates that recorded the highest associations with the older age categories were primary sector employment (respiratory system diseases), male secondary sector employment (respiratory system diseases and remaining causes) and urbanisation (respiratory system diseases). It seems that respiratory system diseases, in particular, are often the result of an accumulation during one’s life of exposure to factors that affect health, and that manual workers are more exposed to these than non-manual workers. Several of the covariates actually showed a quadratic form of association with mortality. For example, in those regions with the highest smoking rates, the effect of respiratory system diseases on mortality rates was greatest between ages 55 and 74.

This study has shown that, even in a former socialist country, regional mortality differences do exist that can largely be attributed to socioeconomic factors. In fact, one could say that the rigorous economic and social planning of the past has, in part, influenced the regional pattern of mortality, with the highest levels of mortality being found in the designated industrialised regions. However, more so than in Western Europe, it is essential to take into consideration the employment structure when investigating mortality differences in Eastern Europe, because the old socialist remuneration system favoured arduous tasks over most other types of work. As seen in Chapter 5, the highest levels of mortality were found in regions with high wages and high levels of secondary sector employment, while the lowest levels were found in regions with high wages and low levels of secondary sector employment. Since average regional wages continued to show an effect on mortality even among the retired, this suggests that, for current analyses and short-term projections, this economic aspect of the socialist period should be considered, even if wage-levels are now determined by market forces.

While the life expectancy difference between men and women declined by just 0.35 years in the CR between the periods 1987-90 and 1994-97; in the Netherlands the corresponding gap closed by 1.2 years between 1980-83 and 1996-99 with the result that it now has one of the smallest sex differences in life expectancy in Europe. In Chapter 7, the final analytical chapter, an attempt was made to find out why this occurred.

Since the early 1980s, mortality differences have been declining in all Western European countries, appearing to coincide with the trends in women’s emancipation, with women now almost as likely
to be employed as men, and the educational achievements of younger women having converged with those of their male counterparts. A regional perspective was adopted because this provides an additional insight to changes over time, as it was envisaged that any demographic change would first become apparent in the ‘more progressive’ western regions before diffusing to other parts of the country.

To link changes in the position of women to changes in the sex differences in mortality, while remaining within the general life course framework of the thesis, the starting point was a series of hypotheses by Waldron (2000) that dealt with gender-specific changes in smoking behaviour, labour force participation, emancipation, and gender role modernisation.

The first part of this element of the research described the regional differences in the male-female life expectancy gap at the beginning and the end of the study period, including the age groups and causes of death that were responsible for these differences. Interestingly enough, while the 45-74 age group was particularly responsible for the narrowing of the sex difference in mortality, differences actually increased beyond the age of 75. IHD and lung cancer were the two largest causes of death responsible for the cross-sectional differences and for the overall decline. These accounted for about 40% of the gap, and actually for more than the total decline in sex differences between 1980-83 and 1996-99, with slight increases being observed for cancer of the male and female reproductive organs, respiratory system diseases and suicide. In terms of regional patterns, sex differences in lung cancer mortality declined fastest in the west of the country. Even in the region that already had the lowest mortality sex-ratio among 45-74 year olds in 1980-83 (Amsterdam), the ratio dropped by more than 70% from 7.8 to 2.2 in 1996-99. In other words, male mortality fell relative to female mortality in both absolute and relative terms. The male-female gap due to IHD mortality diminished most in the northeast, and here the sex mortality ratio also declined.

In the subsequent analyses an adapted version of Waldron’s hypotheses was used, for cross-sectional testing in both periods and dynamically between the two periods, to determine if gender differences in several direct and indirect causal factors had an effect on regional differences in the male-female gap in mortality from all causes, from IHD, from lung cancer and from traffic accidents. The results from the previous analysis (i.e. the differences in life expectancy) were used as the dependent variable and only the 45-74 age group was analysed (with the exception of traffic accidents where all ages were included). Sex-specific analyses were also performed in an attempt to validate the results. This proved useful because it highlighted that the associations between some of variables and mortality were different for men and for women. Unexpectedly, the results of the multivariate analysis suggested that regional gender differences in smoking were not sufficient to make a significant contribution to an explanation of sex mortality differences. On the other hand, the Labour Force Participation Hypothesis, which argues that employed women experience increased mortality risks because they are exposed to occupational hazards and job stresses and are more prone to adopt risky behaviours such as smoking due to increased independence and personal
income, when tested through the variables labour force participation and unemployment, showed a significant effect in the period 1980-83 with regard to total mortality and lung cancer. In the case of lung cancer, the direction of the association was the opposite to that predicted for the two sexes combined, but the sex-specific analysis revealed that labour force participation had health benefits for men, but no effect on women. Only with regard to total mortality could the Gender Roles Modernisation hypothesis, that assumes that fundamental aspects of traditional gender roles have interacted with recent changes in socioeconomic, cultural and material conditions to influence behavioural trends, tested through the variables divorce and the total fertility rate (TFR), not be rejected. For the period 1996-99, either one or both of the gender roles modernisation variables were significant in each of the models. For instance, male excess mortality was highest where gender differences in divorce rates were also highest\(^{39}\). Although the TFR was not accompanied by the expected sign in the overall models for total mortality and IHD, the sex-specific analyses revealed that the changing female gender roles, as indicated by a lower TFR, appeared to be detrimental to men’s and not to women’s health. In the later period, higher fertility rates were also associated with higher sex differences in terms of traffic accidents. The fact that the Gender Roles Modernisation variables explained more of the sex mortality differences in the late 1990s than in the early 1980s, suggests a possible change in the pathways from economic to social factors. Although a dynamic analysis was also performed (i.e. regressing the change in mortality differences between the two periods with the change in gender differences in the exogenous variables), with the exception of IHD, the comparison of the two cross-sectional analyses explained higher proportions of the variance. Given that this was a regional analysis, one possible explanation is that the regional patterns in mortality and the regional differences in the positions of men and women changed little over time.

8.3 Theoretical considerations related to mortality research

While the contribution from this thesis to mortality projections mainly relates to the identification of the most important exogenous variables, there are certain underlying assumptions that need to be taken into account when making projections, particularly if long-term forecasts are to be made. Perhaps the most important issue to be considered is to what extent the life expectancy of a population will improve. Some of the theoretical considerations with regard to this, and the associated possible future developments in the epidemiological transition are two of the themes that are briefly discussed in this section.
8.3.1 Limits of life

In the demographic debate on the limits of human longevity, current opinion is divided. One group of researchers are proponents of the limited-lifespan paradigm, and believe that there is some age beyond which there no-one can survive (Wilmoth, 1997). However, there seems to be little evidence to support this premise. In a study of four developed countries, Sweden, France, England & Wales and Japan, the trends in the maximum ages at death rose steadily during the entire period for which reliable data could be obtained. In the case of Sweden, this was from 1860 to 1990 (Wilmoth and Lundström, 1996). Of course, some proportion of this upward trend is attributable to population growth, but the apparent absence of any deceleration in this upward trend suggests that the limit is not yet in sight (Wilmoth, 1997; Oeppen and Vaupel, 2002). However, for short-term population projections an upper limit on the maximum life span is not critical, because relatively few people yet survive beyond 100. It is much more significant that most of the gain in life expectancy is occurring with the advanced age groups (Wilmoth, 1997). One therefore needs to focus on the mean life span, which may have an upper limit, although here there has also been a consistent and impressive rise in life expectancy at birth. For the past 160 years, female life expectancy in the leading country has risen by almost three months per year (Oeppen and Vaupel, 2002). Not so long ago, it was suggested that it was unlikely that average life expectancy would increase beyond 85 years (Olshansky and Carnes, 1994), as death rates at advanced ages could not be substantially reduced because of biological senescence that is unaffected by a changing cause-specific mortality structure. However, by the end of the 20th century, Japanese women had nearly achieved this life expectancy already (Oeppen and Vaupel, 2002). The question remains whether this trend will continue.

According to Vaupel et al. (1998) the reduction in death rates in the older age categories has increased the size of the elderly population considerably with studies by Kannisto et al. (1994), Kannisto (1994, 1996), Wilmoth (1997), Vaupel (1997) and Vaupel and Jeune (1995) showing that in developed countries, in 1990, there were about twice as many nonagenarians and four to five times as many centenarians as there would have been if mortality beyond the age of 80 had remained at 1960 levels. For most of the 20th century, the reductions in child mortality were the major contributors to the gains in life expectancy at birth. However, by the 1970s, mortality levels at young ages had reached very low levels, and mortality declines in the older age groups became the dominant force behind increases in life expectancy, particularly among women. A study by Boleslawsky and Tabeau (2001), who obtained detailed information on deaths after the age of 80 in France, Italy, the Netherlands and Norway, showed that from 1960-69 to 1980-89 age-specific mortality had dropped at a surprisingly regular rate, although they recognised that the rates of decline could well decelerate over time. Indeed, a robust analysis of the data used in Chapter 4 shows that the declining trend of 85+ mortality has recently started to level off among Western European women (see Figures 8.1a and 8.1b).
Associated with the continuing increase in the mean age of survival, and the decline in mortality at advanced ages, is the theoretical concept of *rectangularisation of the survival curve*. Rectangularisation is defined as a trend toward a more rectangular shape in the survival curve due to increased survival and the consequent concentration of deaths around the mean age of death (Nusselder, 1998). However, when the variance of the age at death decreases, with mortality being “compressed”, the distribution of deaths may also shift to the right (Wilmoth, 1997), thus adding further to average life expectancy. Conversely, the rectangularisation of the survival curve may also lead to a slowing down in the rate of increase in life expectancy, or life expectancy may even fall, due to diminishing returns from mortality reductions (Nusselder, 1998). Indeed, the study by Nusselder established that, in the 1980s, there was both an increase in survival to advanced ages and a reduction of the survival probabilities at advanced ages in the Netherlands. This could not be explained by smoking or the apparent liberalisation of the euthanasia policy, as the percentage of smokers (past and present) was too small to have had a significant effect on old age mortality, and physicians only very seldomly assisted death at advanced ages (<1% of all deaths at age 80+). It would therefore seem that, at least in the Netherlands, a large increase in life expectancy at advanced ages is unlikely in the near future. As mortality at young ages is already very low, such that little can be gained from improvements there, I foresee a weakening in the current rise in life expectancy at birth. Considering that, particularly among women, the maximum effects of smoking on health have yet to occur, then this comment equally applies to other countries.\(^{45}\) Smoking will become a significant factor in estimating old-age mortality, and its degree of importance will depend on how far each country has progressed through the smoking epidemic. In addition to smoking, there are other developments, particularly with regard to dietary factors (World Heart Federation, 2003), that

\(^{45}\) Even in the countries with the highest proportion of smoking-attributed deaths above the age of 70 (Denmark, Ireland and the UK) this figure is currently no more than 15%, while in Spain and Portugal it is less than 1% (Peto et al., 2003).
caution me to be less optimistic than bio-demographers, at least with regard to short-term projections of life expectancy. It therefore remains to be seen if the apparent levelling off of life expectancy in some countries is the result of laggards catching up and leaders falling behind, as suggested by Oeppen and Vaupel (2002). Moreover, for large increases in life expectancy to occur, biomedical breakthroughs in the ageing process will be required, and even if this would happen in the near future it will take some time before it has an effect on the total population. In other words, it seems that more realistic (and modest) assumptions are needed when considering whether survival rates at advanced ages will continue to improve in the short term.

Finally, although smoking is linked to various specific causes of death, and even though most of the recent improvements in life expectancy at advanced ages have been due to a delay in the onset of degenerative diseases, rather than a decline in occurrence (Nusselder, 1998), projecting old-age mortality on the basis of cause-of-death estimates does not seem to be the best approach. This is because the underlying cause of death is difficult to identify once the age of 90 has been passed, and therefore an alternative modelling method should be considered, such as the parameterisation of overall mortality (Tabeau et al., 2001) or one that incorporates theoretical concepts of future levels of ageing, such as the changing frailty model that takes into account predictions of social and economic development, environmental pollution and changes in cultural traditions (Yashin, 2001).

8.3.2 Epidemiological transition and the cause of death structure: future phases

As noted in the previous section, the bulk of mortality is occurring at increasingly advanced ages and the ageing of the population is a feature of the fourth stage of the epidemiological transition: the age of delayed degenerative diseases. According to Wolleswinkel-Van den Bosch (1998), the epidemiological transition, as originally proposed by Omran (1971), can be used to improve projections of cause-specific mortality declines in developing countries, where mortality decline started later than in western countries, if knowledge of the determinants is incorporated in the theory and models. It might therefore also aid projections for Eastern Europe, because they too lag behind the West. With regard to Western Europe, we need to consider current developments in mortality and proposals for future epidemiological stages. Recent trends in cause-specific mortality in Western Europe suggest that, if life expectancy is to increase significantly in the future, a continuation of the current transition may not be sufficient and that new types of epidemiological transitions will need to take place (Horiuchi, 1999). For instance, according to Horiuchi, mortality due to cancer has not shown a substantial reduction in developed countries during recent decades, although this trend varies considerably by cancer type and between the sexes. For example, since the beginning of the 20th century, a downward trend has been observed in deaths from stomach cancer in many developed countries (Campbell et al., 1980 and La Vecchia et al., 1992 cited in Wolleswinkel-Van den Bosch, 1998), which has contributed significantly to the overall growth in
life expectancy (Horiuchi, 1999). This trend is projected to continue such that stomach cancer will become a relatively rare and unimportant cause of death (Huisman and Tabeau, 1999). Turning to lung cancer mortality in Europe, a decline has recently been observed among men in much of the West. For women the trend remains upward or, in some countries, is beginning to level off (WHO, 2001). As most cancer deaths occur at relatively young old ages, any substantial reduction in cancer mortality will result in a marked increase in life expectancy. An exception is prostate cancer mortality, which is linked to old age. As death is increasingly occurring at older ages, people either die from the same disease as they would once have done at an earlier age, or the cause of death is overtaken by more debilitating chronic conditions (Olshansky and Auld, 1986). Prostate cancer is one such condition that has become more prevalent than it once was. Projections also suggest that this trend will continue in the near future (Huisman and Tabeau, 1999). Nevertheless, according to Horiuchi (1999) ‘the decline of cancer mortality’ may well be the next stage in the epidemiological transition. Although total cancer is already starting to decline in some countries, it is uncertain if this is a temporary phenomenon or the beginning of a long-term trend. As smoking is one of the most important proximate risk indicators of many forms of cancer, behavioural changes may be the main underlying factor in this new epidemiological stage. Indeed, results of the analyses for Western Europe in Chapter 4 highlighted the importance of both smoking and fruit and vegetable consumption in explaining the prevalence of lung cancer, prostate cancer and remaining cancers. Other factors that may be necessary to achieve substantial declines in cancer deaths are possible breakthroughs in cancer biology that result in the development of new medical technologies that will assist in curing and surviving cancer. However, such breakthroughs are difficult to predict.

If mortality levels from cardiovascular diseases and cancer are reduced to fairly low levels, the question then is what will become the most frequent cause of death. Suggested causes include respiratory system diseases, acute gastro-enteritis and congestive heart failure; what is certain, however, is that such deaths will mainly occur at very old ages and that, due to the multiple conditions found among the elderly, the underlying cause of death will be difficult to identify (Horiuchi, 1999). Furthermore, a continuation of the decline in total mortality would require declines in mortality related to ‘old age’. Given that infant mortality is already very low, deaths from ‘old-age frailty’ would have to be delayed to even older ages for life expectancy at birth to improve. For this reason, Horiuchi’s second future epidemiological transition stage is called the ‘slowing of senescence’. Although some data do suggest that the health conditions of the elderly have improved markedly in recent decades, this transition is considered to be at a very early stage, if indeed it has even started. The decline in mortality over the last few decades has been substantial throughout old age in general, but the decline has been smaller at the very old ages. Nevertheless, some further slowing down of old-age frailty may be achieved by adopting and maintaining healthy lifestyles (including exercise, a low-calorie and low-fat diet, no smoking and moderate drinking, avoidance of excessive mental stress, and active participation in social interactions) and the further development, wider availability and more efficient use of medical technology for preventing the incidence and
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progression of degenerative diseases, as well as possibly new types of medical technologies that slow the senescent processes (see *ibid.* for references).

Economic development in the 20th century did improve the health conditions of the population through various direct and indirect pathways, but the increased productivity and the wider and faster distribution of products such as cigarettes and alcohol, as well as the change to a more calorie-rich and high fat diet, also had their adverse side effects, leading to a rise in a range of degenerative (so-called man-made) diseases in the 1950s, 60s and 70s. It is therefore not unthinkable that other so-called *reverse transitions* (Horiuchi, 1999) may occur in the future. Due to expanding trade, tourism and migration, infectious diseases have become more likely to turn into global epidemics in a relatively short period of time, whereas in the past they would have been contained in local areas for many decades or would have expanded their reach only gradually (*ibid.*). Already we have seen that the emergence of HIV/AIDS has had a huge impact on both actual and projected life expectancies in many developing countries, particularly in sub-Saharan Africa (United Nations, 2003). Although in Europe it has only marginally affected life expectancy, recently there has been a huge rise in the incidence of HIV/AIDS in some of the former Soviet republics (UNAIDS/WHO, 2003). This implies that for some countries the effect of HIV/AIDS will have to be incorporated in future mortality projections. Indeed, this has been done in the most recent UN *World population prospects* where they estimated the life expectancy for the Russian Federation, with and without HIV/AIDS, for the period 2010-2015 to be 67.4 years and 70.8 years respectively (United Nations, 2003). Although recent outbreaks of other infectious diseases, such as SARS, have not had the same global impact, given the rapid international diffusion of these diseases, as well as the possibility that others that have been kept under control in the past may reappear in new strains (for instance because they have built up resistance to drugs), future epidemics remain a real possibility (Horiuchi, 1999) and will remain an area of uncertainty in mortality projections.

For the projection of cause-specific mortality trends, the epidemiological transition theory is particularly useful for countries that are lagging in the epidemiological transition. However, extrapolating cause-specific trends on the basis of a country’s position in the epidemiological transition should be accompanied by consideration of direct and indirect determinants of health and disease as, for example, prevalence rates of smoking will change over time. It would seem inevitable that the rise in female smoking during the latter part of the 20th century will have a negative effect on current mortality trends, as the consequences are only just beginning to be felt.

Another aspect that should be considered is that epidemiological change is an ongoing process of rise and fall in groups of causes of death, rather than a transition from one steady state to the next. Therefore, transitions are not necessarily consecutive: various transitions, including reverse ones, can occur simultaneously within different subpopulations of a country (Wolleswinkel-Van den Bosch, 1998). It is, for instance, likely, once material conditions, access to medical technology and
knowledge regarding the effects of adverse health behaviour have diffused down to the lower socioeconomic classes (and they make use this knowledge), that socioeconomic mortality differences from degenerative and man-made diseases will decline.

8.3.3 Applying the theory of the life course to ecological mortality studies

In chronic disease epidemiology, the life course approach may be defined as "the study of long-term effects on chronic disease risk of physical and social exposures during gestation, childhood, adolescence, young adulthood and later adult life. It includes studies of the biological, behavioural and psychosocial pathways that operate across an individual's life course, as well as across generations, to influence the development of chronic diseases" (Ben-Shlomo and Kuh, 2002). Within this approach, two types of conceptual models are distinguished: the critical period model and the accumulation of risk (ibid.). Although they are intended for longitudinal studies, it appears that some approximations can be made of the effects of critical periods or the accumulation of risks on populations from aggregated data. Another important application of the life course approach in ecological mortality studies is that it provides an opportunity to set out all the relevant variables that are associated with mortality.

A critical period is defined as “a limited time window in which an exposure can have adverse or protective effects on development and subsequent disease outcome” (ibid.) and forms the basis of Barker’s “foetal origins of adult disease” hypothesis. In ecological analyses of those adult diseases that are known to be susceptible to socioeconomic circumstances in childhood, the importance of critical periods can be studied by analysing past levels of infant mortality, since this is an indicator of living conditions and hygiene standards in early childhood. For example, Leon and Davey Smith (2000) showed that there was a strong international correlation between infant mortality in the 1920s and mortality from stomach cancer, respiratory tuberculosis and strokes in the early 1990s, even after controlling for infant mortality at the time of death. Although infant mortality has not been used as an exogenous variable in this thesis, it would thus seem to be potentially useful in the analysis or projection of the more important causes of death, particularly those from strokes.

While prenatal and childhood circumstances may play a role in the risk associated with some specific diseases, factors that raise the risk of disease or promote good health may also accumulate gradually over the life course, although there may be developmental periods when their effects have greater impact on later health than factors that operate at other times. As the number and/or duration of exposures increase, there is increasing cumulative damage to biological systems. Environmental or behavioural assaults may cause long-term, gradual damage to health in separate and independent ways (for example road accidents, subsequent unemployment and finally the death of a spouse), where each event is unrelated to the preceding one. However, it is more common for adverse exposures to be clustered. For example, children living in adverse social circumstances are more
likely to have been of low birth weight, to have a poor diet, and fewer educational opportunities. Risk factors at different life stages may also accumulate over time because of “chains of risk” where one adverse (or beneficial) exposure or experience tends to lead to another. For example, unemployment will lead to financial insecurity, which in turn will increase the likelihood of marital conflict that could lead to divorce (Ben-Shlomo and Kuh, 2002).

While, in ecological analysis, long-term effects on the risk of chronic disease from a wide range of variables cannot be measured directly, it was believed that the estimation of peak time lags would at least partly accommodate this, even though risk indicators may exert an effect throughout life. An interesting finding was that the differences in the historical development of Eastern and Western Europe appeared to result in different time lags between the variables and causes of death, with the effects of certain variables being more contemporaneous in the East than in the West. This has important implications for mortality projections, and was one reason for splitting the analysis into two parts.

8.3.4 Changing effects of socioeconomic factors on future levels of mortality

According to (Wilkinson, 1992), the association between living standards and mortality is not simply negative and linear. It has been suggested that among rich countries the relationship between income and mortality may be characterised by diminishing returns (Wilkinson, 1992), or that confounding factors exist that will negate the association between income and health (Mackenbach and Looman, 1994). Indeed, the results in Chapter 4 showed that the short-term effect of absolute income (measured as GDP per capita) on total mortality was five times higher in Eastern Europe than in Western Europe (Table 4.11a). However, the strongest relationship between GDPc and mortality in Eastern Europe occurred without a time lag, whereas in the case of Western Europe a latency period of 15 years resulted in the strongest association. The question is therefore whether an improvement in the Eastern European economy will lead to a similar type of association between GDP and mortality as in Western Europe, with the main independent health benefits of GDP being long-term rather than short-term. In the near future, such 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. However, most national economies in Eastern Europe do appear to be on a slow road to recovery. Nevertheless, irrespective of geopolitical position, whether a short or a long-term relationship between GDPc and mortality exists may depend on the level of GDPc. Indeed, if countries are analysed independently and GDPc is included twice (once with a time lag of 15 years and once without a time lag) than GDPc seemed to have a predominantly short-term effect up to the $10,000 level, after which the effect either disappears or becomes long term (see Figure 8.2).

46 There were more control variables in the model for Western Europe than for Eastern Europe.
Turning to income inequality, the analyses of Chapter 4 showed that its effects were more contemporaneous in Eastern Europe than in the West. This can be explained by the fact that, in Eastern Europe, income inequality was steady before the 1990s, after which it increased rapidly for several years, particularly in the countries of the former Soviet Union, before it again stabilised. Given the fact that the most significant results for income inequality in the model for Western Europe occurred with a time lag of ten years, it is likely that it will become a contributing factor to mortality dynamics in Eastern Europe in a few years time, when the long-term effects of income inequality will begin to be felt, especially when we consider that, in Western Europe countries with low levels of income inequality, it showed little or no association with total mortality (Figure 8.3). It is thus apparent that, from a health perspective, income inequality should be low.

A similar practical concern relates to unemployment as, within about a decade, levels rose from zero to more than 15% in many Eastern European countries, and the effects of unemployment are known to increase with its duration (Martikainen, 1990). In Spain, that had by far the highest levels and increases in unemployment in Europe (between 1974 and 1985 unemployment rose from 3% to 22%), the long-term elasticity equalled +0.22.

The proportion of secondary sector employment was found to be one of the most important factors in explaining mortality differences in time and space within both Western and Eastern Europe. As the main effect of industrial employment on total mortality is felt after about 10 years (or perhaps even longer but extended time series data are required to test this), the decline in the importance of the industrial sector in Eastern Europe, due to the change to a market economy after the collapse of the Soviet Union, suggests that gains in life expectancy are still possible from declining levels of
industrial employment. In the late 1980s, the industrial sector still accounted for around of 40% of employment in the East, while in most Western European countries the corresponding figure was about 30%. Were Eastern Europe to have the same proportion of the workforce employed in the industrial sector as in the West (i.e. a relative reduction of 25%) this would lead to a short-term decline in mortality of about 5%, increasing to about 6% in the longer term, according to the results in Chapter 4. In terms of specific diseases, the decline is even more dramatic: for example, in terms of remaining external causes of death including work-related accidents, the long-term decline is expected to be around 40%.

The final important socioeconomic variable considered in the pooled analysis was education. Although it is highly associated with GDPc in market economies, the results of the analyses revealed that, with respect to health, there are also clear independent effects that are associated with the acquisition of knowledge rather than just material benefits. This was particular the case with external causes of death and LDC. Education appeared to be most important factor in the Eastern European analyses, where it was significant in more cause-specific models than GDP. Although the popular health movements of the 1970s and 1980s did not cross the iron curtain, the average level of education among the Eastern European population was, in terms of years of schooling, higher than in the West, particularly when compared to southern Europe. A continuation in the trend of expanding education, leading to a convergence in the average level of education in all European countries, is therefore likely to produce the largest health benefits in southern Europe. It should be
noted that, as with GDPc, the health benefit associated with additional education diminishes as levels of education increase (results not shown).

To sum up: as the economic transition in Eastern Europe has led to the emergence of unemployment, to an increase in income inequality (both of which are detrimental health factors) and consistent growth in national income has not occurred, it would seem unlikely that life expectancies at birth in Eastern and Western Europe will convergence in the short term. However, given the clear link between GDPc and mortality in low-income countries, long-term prospects are better for those countries joining the EU in 2004 provided this leads to a convergence of wealth levels. Moreover, increases in trade and knowledge exchanges, as a result of an expanding EU, may also contribute to increased health-promoting behaviour, such as improved diets and increased health awareness through EU-sponsored campaigns.

8.3.5 “Leading” and “lagging” regions in terms of behaviour and mortality

Although one cannot look into the future with certainty, it may be possible to make predictions, based on patterns in countries or regions that are considered to be leading, for those that lag behind when the factor of interest appears to follow a particular trend over time. As discussed earlier, it is possible that Eastern Europe will progress into the fourth stage of the epidemiological transition at some point in the future, thus following the pattern of the established market economies. However, for this to happen, the prerequisites for a decline in mortality at middle old age, i.e. improvements in medical technology and health care, and a decline in behavioural risk factors, need to be in place.

Another important transition to consider in mortality projections is the smoking epidemic, especially given the latency period between smoking and mortality. Typically, a smoking epidemic in a population has four stages: a rise and then a decline in smoking prevalence followed, two to three decades later, by a similar trend in smoking-related diseases. Usually, the uptake, and the consequent adverse effects, of smoking occur earlier and to a greater extent among men (Peto et al., 1994b; Edwards, 2004). Currently, in both Eastern and southern Europe, male smoking levels are declining and, among women, the increasing trend in smoking has at least stagnated. In western and northern Europe, male and female smoking prevalence rates are declining towards similar levels, with male rates declining faster than female rates, but whereby, as opposed to men, female smoking-related deaths have not yet peaked. Countries where male and female smoking prevalence rates had converged by the late 1990s include Ireland, Norway, Sweden and the UK (OECD, 2001). In other words, these countries may be considered as the most advanced in the smoking epidemic, and the developments in these countries should be important considerations in mortality projections for lagging countries. As the social stigma of women smoking disappears, gender differences in smoking will also eventually disappear. Among the younger generations, this seems to have happened already in many countries. For instance, in Spain, smoking initiation rates by age had
converged by 1988-92 among 10-24 year old males and females (Schiaffino et al., 2003), even though the gender difference in smoking prevalence rates among the entire adult (15+) population was still about 25% (estimated from OECD, 2001). Although smoking prevalence rates among men and women have converged in some countries, given the latency period between exposure and smoking-related deaths, convergence in terms of cause-of-death patterns related to smoking has yet to occur.

The two case studies included in the thesis addressed the idea of leading and lagging regions in more detail. In the case of the Czech Republic, Prague clearly fulfilled the role of a “leading region” as circulatory system diseases, cancer and especially infant mortality fell faster in Prague than in the other socioeconomic clusters between 1987-90 and 1994-97, and female life expectancy increased from average to the highest level among all the clusters.

In the Netherlands, the Randstad area is similarly also considered to be the cultural and economic centre of the country. The results in Chapter 7 showed that most regions within this area saw the largest declines in both the absolute and the relative male-female mortality gaps while, concurrently, a continuation of the catching-up effect took place in the “peripheral regions” in terms of a decline in IHD mortality, a process that had started in the Randstad in the late 1970s (Mackenbach et al., 1990).

8.4 Empirical considerations related to mortality research

8.4.1 The effects of age, period, cohort and causes of death in forecasting mortality

In all societies, death rates are greatest among infants and the in the oldest age groups. The influence of age can manifest itself through biological, social and cultural factors. These are largely cohort-specific, because people of different ages and those who occupy different roles are differentially exposed to, and influenced by, such factors (Tabeau et al., 2001; Ben-Shlomo and Kuh, 2002). Moreover, a cohort may provide the opportunity for societal transformation (Ryder, 1965). Therefore, only mortality as observed by cohorts can serve to estimate the life-long effects of health-related behaviour and lifestyles which, in developed countries, together with access to health care, have become the key determinants of mortality (Tabeau et al., 2001). However, as one cannot observe cohort members during their entire lifespan but only during a relatively brief period, summary information of mortality over a short period of time, such as period life expectancy, is frequently used and provides a measure of the mortality of a synthetic cohort. This overall mortality-by-period approach does allow additional, alternative projections of a comparable statistical quality to be produced, but the outcome is strongly influenced by assumptions regarding future levels of old-age mortality. The cause-of-death approach is perhaps the most encouraging, particularly for short-term forecasting, because of the simplicity of the parameterisation functions for mortality-by-
cause and by the fact that epidemiological knowledge can be used to formulate hypotheses. However, there are certain difficulties associated with this approach as bias may result from misclassifications of deaths that could result in cross-correlations between mortality trends from different but related causes. The underlying cause of death is also less easily identified with deaths at the most advanced ages (ibid.).

Cause-of-death categories were investigated throughout the thesis, as their association with both direct and indirect determinants of disease allows a better understanding of changes in mortality over time, and differences between countries and regions. Trends in total mortality may be the sum of opposing trends in causes of death. Moreover, as the pooled cross-section and time-series analyses of Chapter 4 showed, certain mortality determinants have opposing associations with different causes of death (e.g. alcohol may alleviate the risk of IHD but augment the risk of CRB), and these may also differ under different social and political circumstances (e.g. GDP is negatively associated with traffic accident mortality in Western Europe, but positively in Eastern Europe). Factors that influence mortality often have an associated age gradient because the exposure to certain factors may accumulate over time or because they are more sensitive earlier in life than later in life. The Czech regional study in Chapter 6, and the brief analysis of robustness in Chapter 4, also showed that this applies at the macro-level. Nevertheless, more-detailed age-specific analyses are still required and, data permitting, such analyses should include age- and cohort-specific time trends in behavioural, psychosocial and socioeconomic factors and in divorce, rather than the simple, aggregated period data that were used here. Given the clear cohort-specific trends in smoking, for example, such an analysis would not only produce more accurate coefficients for the exogenous variables, but would also result in more accurate predictions of future behaviour etc. which are required when making projections.

8.4.2 Country and regional clusters

Results are not only influenced by the analytical tools that one employs, the quality of the data or the time frame in which the study is set: as in the case of the analyses presented in Chapter 4, the choice of countries to include in each pooled data set also has an effect. Adding or removing one country may make the difference between a variable being significant or non-significant, particularly when the variable has greater explanatory power for country differences than for mortality differences over time. The content of the clusters should therefore depend on the purpose of the analysis. The aim of Chapter 4 was to draw out factors that were associated with mortality differences over time and between countries in Europe. Since contemporary Europe is still distinguishable as an East and a West, i.e. market economies versus countries in economic transition, it was decided to split the analysis into two. However, alternative clusters could as easily been constructed, such as those that were used in Section 4.5 to describe recent male mortality patterns. In fact, separating Europe into northern, western, southern, central and former Soviet Union clusters would make considerable
sense because the countries within each of these clusters both share a geographical position within Europe and exhibit certain common political, socioeconomic and cultural characteristics. However, with this approach one would not uncover factors that cause mortality differences between countries in different clusters that might provide important insights into ways of reducing mortality. For example, when total mortality, lung cancer, prostate cancer and remaining cancer were modelled separately for the two southern European countries that were in the Western European analysis of Chapter 4, the coefficient for fruit and vegetable consumption was insignificant (results not shown), which is contrary to the results in the analysis of Western Europe as a whole. A likely reason for this is that the levels of consumption were already high in Italy and Greece at the beginning of the study period and changes over time were consequently small, rather than that fruit and vegetable consumption is not an important determining factor in cancer mortality rates in southern Europe. Conversely, when a similar analysis was done for the western European cluster (i.e. Austria, Belgium, Switzerland, former West Germany, France and the UK), the moderate increases in fruit and vegetable consumption coupled with the small differences between the countries resulted in an elasticity of -0.17 for total mortality, and the variable was also significant in the lung and remaining cancer models (result not shown). In other words, while fruit and vegetable consumption may not be an important explanatory variable for projection making for southern Europe, it is relevant for other clusters. To sum up, the pooling of regions with a significant range of measurable characteristics over a long period of time, and then using the technique of cross-country and time-series analysis, will bring out their differences, whereas smaller groups or single countries will give different results that may better reflect the changes over time. However, as it seems to be the case that both total and cause-specific mortality trends, and several of their determinants, are becoming more similar in the various Western European clusters, it may be that more-unified assumptions are the best option, rather than testing each variable for each cause of death in each country independently. However, separating Eastern and Western Europe did appear to be a justifiable decision.

While, in Chapter 4, the two pools or clusters were based on geopolitical differences, clusters may be based on any criteria and serve any purpose. In the first Czech regional study (Chapter 5), two types of cluster analyses were performed. The first tested a number of socioeconomic variables for their association with total mortality and provided useful information on some associations not normally found in the West. For example, the cluster of the 20% of regions with the highest wages also saw the highest mortality levels. This was due to the high level of industrial employment in many of these regions. Regions with high wages but low levels of industrial employment actually enjoyed the lowest levels of mortality, and thus were more in line with Western findings. Subsequently, a cluster analysis was performed on the 76 official regions in order to produce macro-regions with similar socioeconomic characteristics in order to establish if mortality changes that took place over the period of the political and economic transition could be attributed to socioeconomic conditions.
8.4.3 Competing causes of death and the accuracy of the cause-of-death statistics

The final two issues that need to be briefly discussed are the concept of competing causes of death and the associated problem of inaccuracies in the cause-of-death statistics. The mortality statistics that were used, in principle, reflected the underlying cause of death, i.e. “the disease or injury which initiated the train of morbid events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury” (WHO, 1977). The main advantages of using underlying cause-specific data are that they are available at the regional level for many countries, and that they make analysing huge amounts of data manageable. The main disadvantage is that one is confronted with the methodological problem of only a single cause of death being attributed to a person who dies, even though it is possible that more than one cause exists. As the population ages, the proportion of deaths with multiple causes also increases (Rosenberg, 1993; Wrigley and Nam, 1987), and at very old age death is often the consequence of a more-generalised deterioration in the capacity for life (Rosenberg, 1993). As outlined in Chapter 3, there are also other factors that may lead to inaccuracies in the cause-of-death statistics, such as the degree of contact between patient and physician, the availability and accessibility of medical technology, the ‘sensitivity’ of certain causes of death that result from adverse behaviour as well as the use of different coding systems. For these, and the earlier mentioned reasons, the cause-of-death categories ‘signs, symptoms and ill-defined causes’ and ‘events of undetermined intent’ (for natural and external causes respectively) should always be examined when conducting cause-specific analyses, as these could indicate artificial changes or differences in mortality from the true causes of death that are relevant when projecting cause-specific mortality. In particular, with ageing populations, it may be better to exclude those over the age of 90 from cause-specific mortality analyses, and limit the assessment to all-cause mortality.

8.5 Filling a gap: the social and scientific relevance of this research project

In the field of mortality modelling, there has been a shift from the traditional trend-oriented approach to a more process-oriented one in which the mechanisms of disease and mortality, rather than simple extrapolation, are used in model formulation (Manton and Stallard, 1984; Tabeau et al., 1998). As a result, there have been several epidemiological studies that have based their cause-specific and total mortality projections on behavioural risk factors (e.g. Gunning-Schepers and Barendregt, 1998; Van Genugten et al., 1997). Although such risk factors may be a reflection of contextual factors, I am aware of just two studies where contextual factors were explicitly used to project future levels of total mortality, although only in a qualitative manner (Van Hoorn and De Beer, 1998; Van Hoorn and Broekman, 1999). The purpose of this thesis was not, however, to produce mortality projections, but rather to lay down the foundations in order to enable this to be
carried out in a more integrated manner. In more detail, the contributions of this thesis, in terms of scientific and societal relevance, can be summed up as follows:

**Scientific relevance**

i. It provides the groundwork for European mortality scenarios in which economic and other variables are integrated: the goal being to produce more accurate population scenarios (Chapter 4).

ii. It uses a system-analytical approach in which assumptions at the micro-level are consistently converted to the macro-level, on the argument that macro-behaviour is the outcome of the aggregated results of micro-level decisions. This implies that exogenous variables are only identified as being relevant in scenario making if they were found to be associated with mortality at the individual level (Chapters 2 and 3).

iii. The analysis of causes of death: causes of death tell us “about biological mechanisms of disease and mortality. Trends in mortality by cause can be linked to trends in physiological and behavioural risk factors, which is useful in formulating hypotheses for the future” (Tabeau et al., 2001). In other words, causes of death provide knowledge of disease determinants and may therefore be considered as the first step in possibly explaining mortality differences (all analytical chapters).

iv. The selection of causes of death was based on a carefully designed methodology in which not only the prevalence of the causes of death were considered, but also the socioeconomic perspective of the project and the international comparability of the available mortality data (Chapter 3).

v. Results showed that socioeconomic factors played a significant role in mortality differences between regions, countries and sex. Since such factors have the potential to initiate changes in the direct determinants of mortality, an important implication is that a socioeconomic change in population structure will inadvertently affect the population’s cause-of-death structure, even if mortality differences according to the socioeconomic variable in question remains unchanged (all analytical chapters).

vi. Linking the age, sex, time and spatial structure of mortality to exogenous variables provides a more detailed explanation of mortality dynamics at the ecological level. In particular, it reveals whether exogenous variables have differing impacts depending on age and sex (Chapter 6).

vii. The idea of a diffusion process, as used by Mackenbach and Kunst (1995) in order to explain changing regional patterns of IHD in the Netherlands, can also be applied to other types of mortality patterns. In the studies presented here, Prague appears to fill the role of a so-called “leading” region in terms of Czech mortality, with its long life expectancy at birth and the gains that are evident in the retired age groups, whereas mining regions lag behind with a low life expectancy at birth, but with significant improvements now being seen in the survival rate of the working age population (Chapter 5). Similarly, the idea of a diffusion process can be
applied to the decline in the male-female mortality gap in the Netherlands, particularly when analysing specific causes of death such as lung cancer. In this case, leading regions were defined as those where women’s lifestyles (e.g. smoking) and behaviour (e.g. labour force participation) first changed (Chapter 7). At the European level, the epidemiological transition theory could be a useful framework for making mortality projections for those countries that are less advanced in the epidemiological transition. At the same time, there are clearly “leading” and “lagging” countries with regard to the smoking epidemic. For this reason, the smoking epidemic should be considered alongside the epidemiological transition when making mortality projections, particularly with regard to cancer and heart disease.

**Societal relevance**

i. The identification of macro-determinants of mortality should be of particular interest to policymakers concerned with reducing health inequalities within Europe. Any use of the findings in this thesis should, however, be accompanied by specific studies where differences in economic and other measures are evaluated for the magnitude of their effect on health differences.

ii. The fact that mortality is higher in one place than in another underlines the urgency of solving the underlying problems in those countries or regions where mortality is highest, and it suggests that improvements can indeed be made.

iii. A closer inspection of the key variables that underlie these differences could lead to general macro-level suggestions about the way in which such international differences in mortality could be reduced. For instance:

- One of the most important variables associated with changes and differences in mortality in Eastern Europe was alcohol consumption. Although the anti-alcohol campaign by Gorbachov in the mid-1980s showed an almost immediate effect on alcohol-related deaths in the former Soviet Union, such measures only tackle the symptoms, not the cause. As the level of alcohol consumption is closely related to psychosocial factors, a prime concern should be to improve social and economic conditions in these countries, rather than reducing alcohol consumption per se.

- Individual-level studies have established that divorce has a detrimental effect on health as a result of psychosocial factors, and this research has shown that it is also positively associated with a several causes of death at the aggregate level. This implies that increasing divorce rates in those countries where until recently divorce was relatively uncommon, such as in southern Europe, will have a negative effect on future life expectancies.

iv. Several specific recommendations can also be made from the two regional case studies:

- Taking the life course approach into consideration, it is more than likely that the former industrial regions of the CR, where changes are currently taking place in the employment
structure, will not fully share in the improvements that are currently being seen in life expectancy in middle and old age. This is because the option for many ex-industrial workers in former socialist countries is either early retirement or unemployment, with its negative health connotations, rather than re-employment in healthier work environments. The current increase in the educational level of young Czechs, considered necessary to create a competitive labour market no longer based on central planning, may raise health awareness as well as the affordability of a healthier lifestyle. As seen from the mortality changes between the late 1980s and the late 1990s in Chapter 5, females in Prague have benefited most from the current changes. Given Prague’s political, cultural and economic position, this was perhaps to be expected. However, in order to ensure that the positive health effects diffuse to other areas, and that mortality from ‘welfare diseases’ (e.g. traffic accidents) is restricted, health policies need to focus on those elements that have resulted in the mortality changes in the low mortality regions. From the results in Chapter 6, it is suggested that rural regions should not be allowed to continue to fall behind the wage rates and educational expansion found in the main urban areas, particularly since the working age population is the most sensitive to social and economic changes. Although a lack of funds (and insufficient interest) prevented an active regional economic policy in the 1990s, eight NUTS II regions were established in 1998 that could become eligible for Structural Funds from the European Union following membership in 2004, plus 14 NUTS III regions which are new regions with their own regional governments (Blažek, 1999). While the aim is to ease the implementation of regional development programmes, the hope is that it will also benefit the population’s health.

In all Western European countries, the mortality gap between males and females is narrowing, as women are taking over the risk factors connected to male lifestyles. The results from the Dutch regional study in Chapter 7 showed that this was in part due to the increase in the excess number of divorced women and declines in gender differences in LFP, particularly with respect to IHD. A possible change in pathways was also observed, as economic factors appeared to be mainly responsible for regional sex mortality differences in the early 1980s, whereas social factors were more important in the late 1990s. One somewhat surprising outcome of the study was that lower fertility rates, an indicator of gender roles modernisation, had a detrimental effect on men’s, rather than on women’s, health.
8.6 Conclusions

This thesis has attempted to assess the importance of various socioeconomic and other factors in mortality at the population level in three different settings: in Europe at the country level, and in the Czech Republic and the Netherlands at the regional level. Each analysis was conducted from a different perspective. The first established causes for the differences and changes in mortality over time that could assist in current European mortality projections. The second was set in a former-socialist country and covered the period from just before the transition to several years after, and provided insights into changing regional mortality differences. The focus of the third analysis was in uncovering reasons for the recent decline in sex differences in mortality.

One conclusion that can be drawn from the various types of analysis employed in this thesis is that mortality studies need to consider many different contexts and potential trends. This is even more important in making projections, given the number of assumptions involved. Since all the studies were ecological in nature, it is impossible to control for factors in the way that this is done in studies where personal information is linked to outcome. The methodology and assumptions therefore need a sound justification, the discussion in Chapter 4 with regard to the time lags introduced for the exogenous variables being an example of this.

Mortality studies have become interdisciplinary. Mortality, here, was studied by cause of death, because this provides, by definition, an initial explanation for observed differences and changes. However, in looking for additional answers, for example by incorporating direct and indirect determinants of death and disease, one needs to have some understanding of the disease mechanisms. This is because most such factors do not affect mortality immediately, but only after a certain period of time and, further, this time lag may be different for alternative causes of death or even for the same cause of death depending on the level of exposure. For example, large quantities of alcohol consumption may instigate a heart attack (IHD) or a stroke (CRB) within 24 hours, whereas moderate consumption of alcohol is thought to reduce the process of atherosclerosis, and thus protect against IHD. It is therefore important that short and/or long term effects are estimated. In the case when the effect of alcohol consumption is studied at the aggregate level using aggregated data and information on consumption patterns, the effect of the exposure on the outcome should be estimated for a range of theoretically plausible time lags, from which the one with the largest effect should be used in the analysis. In the case of alcohol and IHD, both a short- and long-term lag could be incorporated in the model equation.

Throughout the thesis, reference has been made to the life course approach because current mortality differences are the result of many years of differential exposure to both health-damaging and health-promoting factors. The direct factors, such as smoking and alcohol consumption, are often embedded in socioeconomic factors and, as a consequence, political, social and economic changes will invariably impact on future levels of mortality. We have seen the immediate impact on health of the transition in Eastern Europe, but the full effects of 40-50 years of socialism may not
Socioeconomic determinants of regional mortality differences in Europe

Disparities in mortality are unlikely to disappear for decades to come. One reason is the impact of psychosocial risk factors, rather than the standard risk factors such as smoking, that appear to be of major importance in explaining East-West differences in IHD mortality (Kristenson et al., 1998). It is therefore unlikely, even if all other things were equal, that health patterns in Eastern Europe would quickly catch up the West, even if they were to enter the fourth stage of the epidemiological transition, which is not impossible in the near future given that declines in IHD are already being observed in several central European countries. Previous trends in the “leading” countries may therefore be useful to projection makers in adopting realistic assumptions. This equally applies to trends in other phenomena that appear to follow a set of phases, such as the smoking epidemic.

One trend that does not seem to receive sufficient attention in existing mortality projections is the changes in societal norms and values, in particular with regard to their effect on female mortality. Already among most of the younger cohorts in Europe, smoking and moderate to heavy alcohol consumption are no longer an exclusively male habit, and labour force participation rates are also converging. This suggests that future sex differences in life expectancy, within a stable socioeconomic climate, will not be the seven or eight years it once was in most European countries, in particular because the full effect of smoking on mortality has yet to be seen. I would therefore expect future increases in the life expectancy of women to stagnate, particularly in southern Europe because of an even larger delay in the smoking epidemic. Turning to Eastern Europe, the future trends are more difficult to predict because many gains in life expectancy can still be made with regard to non-smoking-related deaths from circulatory system diseases, whose mortality levels are still much higher than in the West.