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Concluding Chapter: Summary of Findings

The impact of seasonal effects on diseases and mortality has been known for more than 2000 years. Surprisingly little is, however, known about its determinants. To understand and tackle a phenomenon, it is of importance to have the current state of knowledge about it. The literature review presented in Chapter 2 showed that biomedical approaches could explain the basic annual pattern observed in seasonal mortality with a peak in winter and a trough in summer, but not the "seasonality paradox": Cold regions show consistently smaller differences between summer and winter mortality than countries where a warm or moderate climate prevails. Thus, social and cultural influences play an integral part in mediating seasonal fluctuations in mortality and, consequently, also in reducing the annual number of cold-related deaths. The historical literature review has shown the importance of those non-biological factors already in the past. The literature claims that, nowadays, avoiding indoor as well as outdoor cold by having a warm indoor climate, and reduced time spent outdoors during cold spells, plays a crucial role for minimizing the risk of dying during winter.

Chapter 3 reviewed indices, tests, and time-series methods for seasonality to indicate which methods are suited best to analyze seasonal data. For "normal" applications with a smooth annual pattern with one peak and one trough, Hewitt's test [150] is suited best to test for seasonality. This test should be used in conjunction with a descriptive index like the "Winter/Summer-Ratio" to have also a measurement of the extent of differences between winter and summer since Hewitt's test is a nonparametric test based on ranks.
None of the standard methods we analyzed for seasonal time-series fulfilled our requirements. It can be generally stated that the methods X-12, SABL, STL, TRAMO/SEATS and BV4 performed well on relatively simple data patterns. For situations with a variable trend, a changing seasonal component and overdispersion, a situation which is rather common in real data, all of these approaches fail to produce satisfactory results as we have shown in simulation studies.

For our analysis of seasonality in US death counts between 1959 and 1998 (Chapter 4, page 83), we developed a new method which returned a correct estimation of the trend and the seasonal component for the same models for which the standard methods (X12, BV4, . . .) failed in Chapter 3. In our model, we allowed the trend and the seasonal component to vary smoothly over time (or age). We estimated these models in a data-driven approach (thus, we did not impose any parametric form on these components) by fitting a varying-coefficients model using P-Splines.
Our most important findings from the analysis were: cold-related mortality increases with age which supports previous findings in the literature. Seasonal mortality over time increased slightly since the 1970. This reflects probably the widespread introduction of air conditioning which makes summer mortality decrease at a faster pace than mortality is decreasing during any other season of the year.
We discovered that women and men do not differ considerably with respect to seasonal fluctuations in mortality. This has been found in previous analyses. Nevertheless, the question remains how it is possible that women face lower mortality risks than men throughout their life course — which corresponds to lower susceptibility to adverse environmental conditions — but show the same relative response to seasonal effects as men do.
It should have been assumed from comparative European studies that warmer regions in the US show larger fluctuations in seasonality than colder regions. We found, however, no differences. Especially the trend over time shows a slightly converging pattern which could reflect a tendency towards similar living conditions in all regions of the United States.
Our investigation pursued a novel approach by analyzing the effect of education as a proxy for socio-economic status and marital status on seasonal mortality. Both constitute important determinants for differential mortality in the United States and elsewhere. We did not find support that marital status has an important influence on seasonal mortality. We discovered, however, a social gradient by education in seasonal mortality. The less years spent in formal education, the higher are the annual fluctuations in mortality. This is an effect which has not been discovered elsewhere.

Besides the analysis of death *counts* in the US American data over time and age, we investigated the determinants of excess winter mortality in Denmark using an event-history approach. This country represents the “El Dorado” of all countries with respect to the quality and wealth of data: Denmark’s person registers allow to follow life courses on the individual level in a longitudinal perspective on almost any phenomenon of interest. Similar to the case of the analysis of US death counts, we found an increase with age for all-cause mortality as well as for ischaemic heart disease, cerebrovascular diseases and respiratory diseases.
While many studies as well as our analysis of deaths in the United States (Chapter 4) found no differences between seasonal mortality of women and

men, we discovered that women's excess mortality surpasses the one of men in Denmark. Most likely the explanation is specific for Denmark: Women have a higher smoking prevalence there than in most other countries. This behavioral characteristic affects typical seasonal diseases like cardiovascular and cerebrovascular diseases but in particular respiratory diseases. Women with the highest smoking prevalence in Denmark were born between the two World Wars and constitute a major part of the female population in our data. Despite our findings for the United States, we could not detect any effect of socio-economic status on seasonal mortality in Denmark. This could be explained by the homogeneity of the Danish population being on a relatively high level rather than by a general absence of an effect of socio-economic conditions on seasonal mortality. More importantly, concerning the amount of excess winter mortality in Denmark is the question whether somebody is living alone or not, rather than socioeconomic status or marital status. If people are living alone they have higher relative mortality risks in winter than women and men who share an apartment with at least one more person.

Our analysis has shown that the most vulnerable groups are old people, people who are living alone and people of lower socio-economic status. Public health policies which aim to reduce the annual number of cold-related deaths in a country should therefore focus on these groups. In Chapter 6 we used US data for the year 1998 to estimate the maximum theoretical gains in life expectancy if those public policies were successful. We calculated that at age 50 about 0.8 years of life years could be won for women and about 1 year of life for men. Although these gains sound only moderate in size, they may have a huge economic impact on national wealth in absolute numbers.